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**Staff Reports  
on Research  
Under Way**

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**1. ECONOMIC AND SOCIAL PERFORMANCE****Productivity, Employment,  
and Price Levels****Introduction**

These studies, financed mainly through grants to the National Bureau by the Alfred P. Sloan Foundation and the Alex C. Walker Charitable and Educational Foundation, involve both analytical and measurement problems relating to the behavior of prices and production. The studies of inflation discussed here deal with the determinants of changes in general price and wage levels and are complementary to the studies on the effects of inflation reviewed in section 6. Also relevant to these problems are the Bureau's monetary studies, described later in this section, and the Universities-National Bureau Committee Conference on Secular Inflation, held in November 1971.

The Bureau publications from this set of studies so far include *The Behavior of Industrial Prices* by George J. Stigler and James K. Kindahl, published in 1970, Solomon Fabricant's essay on "Recent Economic Change and the Agenda of Business Cycle Research," Supplement to National Bureau Report No. 8, May 1971, and Fabricant's article, "The 'Recession' of 1969-1970," in *The Business Cycle Today*, edited by Victor Zarnowitz, the first of the Bureau's Fiftieth Anniversary Colloquium volumes. John Kendrick's "Postwar Productivity Trends in the United States" has been approved by the National Bureau's Board of Directors and is in press. The manuscript by M. Ishaq Nadiri and Sherwin Rosen on "A Disequilibrium Model of Demand for Factors of Production" has been revised in

response to staff reading committee comments and should soon be ready for Board review. Phillip Cagan's manuscript, "The Ending of Inflation, 1955-59," has reached the first-draft stage.

Aside from these Bureau publications, there have been several articles published elsewhere that have been based wholly or partly on work under this program. These include Nadiri and Rosen's article on "Interrelated Factor Demand Functions," in the *American Economic Review*, September 1969, and Nadiri's "Some Approaches to the Theory and Measurement of Total Factor Productivity: A Survey," in *Journal of Economic Literature*, December 1970. Fabricant has reported on various aspects of his work in "Prices in the National Accounts Framework: A Case for Cost-Benefit Analysis," in *The Review of Income and Wealth*, June 1970; "Inflation and the Lag in Accounting Practice," in *Accounting in Perspective*, South-Western Publishing Co., Cincinnati, 1971; "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; and "Inflation and Current Accounting Practice: An Economist's View," *The Journal of Accountancy*, December 1971. Other articles are Franklin Fisher's "On Price Adjustment Without An Auctioneer," *Review of Economic Studies*, January 1972; William Nordhaus' "Recent Results in Price Dynamics," to be published in a report of a Federal Reserve Board Conference; and several papers by Gordon, mentioned in his report.

Among the new studies in this area are those by Benjamin Klein and by Fisher and Solow, both reported on below.

Robert E. Lipsey

### **The Problem of Inflation**

The volume I am preparing on the problem of inflation is taking shape. As was indicated last year, the volume will cover short- and long-term changes in the level and structure of prices; the historical relations of these price changes to business cycles and the process of economic growth; the causes of price inflation and the incidence of the burden of inflation under varying circumstances; and the practicability and social costs of anti-inflationary policies.

Of course, the drastic change in anti-inflation policy in the United States in August 1971, and subsequent efforts to implement it, must be covered in the discussion, and this is slowing up completion of the report. However, it is unlikely that the problem of inflation will vanish before the report appears. No more is promised in the current effort to deal with inflation in the United States than a reduction in the rate of increase in the general price level to 2 or 3 per cent per annum by the end of 1972.

A major objective of the volume is to explain, as simply as possible, why the problem of inflation has been, and may be expected to be, so persistent. More specifically, does the persistence of the problem reflect inadequacy of scientific knowledge, or ignorance on the part of laymen, not excluding those in positions of major responsibility, of what the experts agree upon? Or is it due to inadequacies of governmental organization which inhibit or obstruct appropriate policy, or to strong differences of opinion concerning the costs that would have to be paid, or would be worth paying, were the inflation problem to be dealt with effectively? The answer is that all play a part, and in varying proportions. A discussion of the problem, then, must necessarily deal with its social and political as well as its economic aspects in a more than cursory manner.

While attention is paid to the current episode in our country, the discussion in the volume goes well beyond it. Understanding of the current or

any particular inflationary episode requires the application of lessons drawn from a broader experience. The volume is therefore not confined to the United States—it covers a variety of other countries; nor is it focused solely on recent years or even on the post-World War II period—it ranges over a century or more, to the extent permitted by available information.

General experience cannot be used to interpret recent developments in any simple way, however. Consider the strong inflationary expectations generated during the 1966–69 period. To the surprise of many economists inside and outside of government, these expectations appear to have persisted despite the anti-inflationary policy of 1969–71. It seems that in assessing the impact of the policy insufficient allowance was made for the experience of the public with government policy in the postwar period. Here, as economists have noticed in other aspects of economic behavior, there may well have been a "learning process."

The point may be conveniently put in terms of the "game plan" in which, it will be recalled, the present Administration's Council of Economic Advisers expressed government policy early in 1969. The players in every such "game" are not only those in the government, prodding the economy in one or another direction in accordance with the plan. Facing the government side, so to speak, is another group of players, among those being prodded, who are attempting to anticipate change in the force and even the direction of government policy. How persistently, how earnestly, will stated government policy be applied?

Expectations concerning future price levels rest not only on announced policy but also on estimates of the price a government will be willing, or see itself able, to pay in order to restrain inflation. These estimates are based on experience—in this case, with policy enforcement and policy change in the past. In making the estimates, account is taken by the "opposing team" (to continue with the analogy) of the fact that the government team is not altogether single-minded. In the United States, there is not only the Administration but also the Congress and the Board of Governors of the Federal Reserve System (not to mention such groups as the

Construction Industry Stabilization Committee, among others). And each of the main branches of government is not entirely unified in its views. The "opposing team" is also aware of the fact that in the end the public is the "owner" of the government team. Political considerations—what the public will think and how it will react, not only immediately but under the cumulative pressure of any sustained policy—can never be ignored in carrying out a game plan.

The point is hardly new. It has been explicitly recognized in Britain, for example, and very likely elsewhere, in explaining the origin of and problems encountered by "stop-go" policies. It is difficult to get quantitative evidence on this determinant of expectations. That is why it has not entered the formulas that many economists use to estimate expectations. Yet it cannot be ignored.

Solomon Fabricant

### **The Behavior of Prices in the Ending Phase of Inflation**

Despite excess productive capacity in the U.S. economy since the end of 1969, the inflation which began in 1965 has proved tenacious and difficult to bring under control. Impatience with the progress attained by traditional monetary and fiscal restraint led to a wage-price freeze in August 1971 followed by the Phase Two program of wage-price controls. Although the earlier 1955–59 inflation ended without the imposition of comprehensive wage-price controls, it was sufficiently recent and similar to the 1966–72 experience to make a comparison worthwhile.

A preliminary report of a study entitled "The Ending of Inflation 1955–59" has been circulated for comments and is being revised. It analyzes the movements in prices, output, materials and labor costs, profit margins, and capacity utilization of fifteen major industries. A companion study of the 1966–72 experience with inflation is now underway, with the intention of comparing the two episodes.

The inflation that reached a peak in 1955 and began to decelerate in late 1955 and early 1956 took several years to subside completely. An index of manufacturing wholesale prices had

decelerated considerably before the onset of the business recession which began in the third quarter of 1957, but the index accelerated for a short time in the recovery following this recession, and prices did not finally stop rising until mid-1959. In individual industries, a reduction in the rate of increase in prices followed an initial slackening of demand, as evidenced by reduced growth, or an actual decline, in output giving rise to excess productive capacity. Among the fifteen industries examined, the reduction in the rate of price increase lagged behind the reduction in the rate of growth of output by periods ranging from zero to eight quarters, and averaging four quarters. While most of these price decelerations came before a comparable slowing in the rise of materials or labor costs, subsequent steps in the rate of change of prices tended to depend upon costs more closely. A deceleration of costs generally came later than the initial reduction of inflation in product prices, therefore, but was a prerequisite to subsequent slowing in industry price increases.

The process of ending inflation in 1955–59 is reflected in the behavior of profit margins. The peak rate of inflation in 1955 also saw a peak in profit margins, indicating the pull of rising demand. When demand then slackened, profit margins began a steep decline, brought on by declines in the growth of output and prices which could no longer keep up with the rate of increase in costs. The recession from the third quarter of 1957 to the second quarter of 1958 reduced profit margins further, and their decline intensified the pressure on costs. Cost cutting showed up in the recovery from the recession. At first the improvement in profit margins simply reflected the spreading of fixed costs over a rising output, but margins in most industries soon recovered to the preinflation levels of 1954, despite the further deceleration of prices. Indeed, success in controlling costs and the resulting improvement in profit margins went hand in hand with the last phase of inflation.

Although the outbreak and ending of the inflation could be attributed in its major characteristics to an expansion and then slackening of demand, the persistence of rising prices for several years despite slack demand calls for explanation. The behavior of profit margins re-

lated above does not seem compatible with "administered prices" as an important impetus to the inflation. However, two other widely discussed explanations have yet to be confirmed or disproved: (1) the ending phase reflects previous price increases that take time to work all the way through the economic system, and (2) anticipations of continuing inflation are built into wage and price decisions that tend to perpetuate for a while the prevailing rate of inflation. One purpose of comparing the inflations of 1955–59 and 1966–72 is to evaluate the relative contribution of these two influences. The first will not increase with the duration of an inflation; if anything, the time it takes for prices to adjust to cost increases will speed up as inflation proceeds, even though disparities may widen, requiring both up and down adjustments. When demand slackens, prices will continue rising by the first explanation only until all catching up is completed. By the second explanation, however, prices will continue rising until anticipations of inflation also begin to subside, and the time required for that will depend upon the public's belief in the persistence of inflation, which will undoubtedly be stronger the longer inflation lasts.

I hope to have some results from the second part of the study by the summer of 1973.

Phillip Cagan

### Labor Market Models and the Rate of Inflation

Two papers on labor markets and inflation were completed during the past year, one empirical and one theoretical.

The empirical paper, "Inflation in Recession and Recovery," published in *Brookings Papers on Economic Activity*, 1971, No. 1, explains the rapid rate of inflation during the 1970 recession by means of a wage-price econometric model. Among its major conclusions are:

1. The use of data on average compensation per manhour in previous studies of wage behavior introduced substantial errors, due to changes in overtime pay and industry mix and to erratic shifts in the compensation of executives and other nonproduction workers. A new, fixed-weight wage index I have constructed displays much more plausible behavior than the tradi-

tional measure.

2. Perry's emphasis on the rightward shift in the Phillips curve due to the changing age-sex mix of the labor force is reaffirmed,<sup>1</sup> as is the usefulness of my measure of "total unemployment of manhours" (which includes disguised unemployment and the unemployment of hours in addition to the official measure of unemployment).

3. Changes in the monetary-fiscal policy mix are introduced as an additional factor shifting the Phillips curve in the short run. Increases in either the personal income tax or social security tax have a short-run inflationary impact, in contrast to the deflationary effect emphasized in traditional national income analysis.

4. A sudden slowdown in output after a sustained period of economic expansion also tends to make inflation worse in the short run by causing labor productivity to drop below its secular trend.

5. Previous research substantially underestimated the lags in the reaction of prices to wages and wages to prices. The recession of 1970–71 failed to reduce inflation immediately because of long lags. During 1970 inflation was still increasing in reaction to the substantial excess of demand during 1968–69. Simulations with the econometric model indicate that a recession with 6 per cent unemployment would have to last four years before inflation would be reduced from 4.5 to 2.5 per cent. The simulations also suggest that a policy of 6 per cent unemployment through the end of 1972, followed by a three-year expansion of the economy to 4 per cent full employment by 1975, would produce a minor and temporary reduction in inflation at a cost of \$271 billion in lost aggregate output, in comparison with a hypothetical alternative of continuous 4 per cent unemployment throughout the 1970–75 period.

The second major portion of the inflation project is theoretical. Most recent theoretical work on labor market adjustment assumes that the firm accomplishes all adjustments in employment by means of changes in the wage rate. Wages are assumed to be perfectly flexible and

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<sup>1</sup> George L. Perry, "Changing Labor Markets and Inflation," in *Brookings Papers on Economic Activity*, 1970, No. 3, pp. 411-441.

no rationale is provided for layoffs. The labor market "Model II," which I described in my report last year, is an attempt to explain the asymmetric reliance of firms on wage adjustments in periods of excess demand for labor, and on layoffs in periods of excess supply.

My preliminary, unpublished paper, "The Choice Between Wage Cuts and Layoffs in a Model of Disequilibrium Employment Adjustment," analyzes the costs and benefits of layoffs for a firm that is faced with an exogenous reduction in labor requirements. Labor varies in ability, but screening is imperfect and employers cannot predict which employees are able and which are not until training is completed. Employers, deterred by the cost of training replacements, do not necessarily fire the less able employees when they are identified. If, in addition to costs of training and identifying high-ability workers, there are also costs of adjusting the interemployee wage structure to reflect perfectly the differences in efficiency among employees, firms will make a higher profit on some employees than on others. The main benefit of the strategy of using layoffs in a recession is the opportunity to improve the average ability level of employees, without cost, by firing low-ability workers. This benefit is set against the opportunity cost of lower wage rates for all workers, if the alternative wage-cut strategy is chosen instead. A formal analysis of cost minimization by the firm yields a prediction that the wage-cut strategy will be chosen to a greater extent as the expected duration of the recession lengthens. This is true both because the increased efficiency of workers evaporates as normal employee turnover returns efficiency to the initial prerecession level, and because a long recession causes an evaporation of the pool of laid-off workers available to be rehired without training costs at the end of the recession.

After expansion, further development, and comparison with other papers in this area, the model will be evaluated in empirical tests. The ultimate aim is a book which integrates and compares the model with several alternatives.

Robert J. Gordon

### The Measurement of Inflation

The two most common operational measures

of what economists call the price level are the Bureau of Labor Statistics' Consumer Price Index and the Commerce Department's GNP deflator. In my manuscript, jointly authored with Armen Alchian, these price indexes, which represent measures of current consumption service prices and current output prices, are shown to be theoretically inappropriate for the purposes to which they are generally put. The analysis leads to the conclusion that a price index (based on the Fisherian definition of consumption in intertemporal terms) used to measure inflation must include asset prices. In other words, a correct measure of the nominal money cost of a given utility level is a price index for wealth.

If monetary impulses are transmitted to the real sector of the economy by producing transient changes in the relative prices of service flows and assets (i.e., by producing short-run changes in the real interest rate), the commonly used current flow price indexes, which exclude asset prices, provide biased measures of changes in the purchasing power of money. They are especially poor as indicators and targets of monetary policy.

Unfortunately, although this relative price movement is theoretically considered to be a crucial part of the monetary transmission mechanism (it is emphasized by Keynes and by Friedman and Schwartz), it has not been examined empirically. This omission is due, in part, to the paucity of reliable information on current market prices of assets. I intend to survey this information and investigate the cyclical movement of asset prices relative to flow prices. In this way, I hope to obtain evidence on both the transmission of monetary changes and the extent of the cyclical bias in the measurement of the price level. A crude examination of the 1969-70 tight money episode, for example, indicates that flow indexes severely underestimate the deflationary effects of the reduction in the rate of growth of money. I intend to enter asset prices, as part of the deflator of nominal balances, in a short-run demand-for-money equation to test the commonly accepted assumption that the GNP deflator is sufficient to define real cash balances. I suspect that transitional movements of asset prices relative to flow prices may explain the fact that money supply changes are offset by

changes in velocity in the short run.

Benjamin Klein

### **Anticipated Inflation and the New Monetary Standard**

An examination of the movement of the U.S. price level over the last century indicates that the period since the end of the Federal Reserve-Treasury Accord in 1951 is unique in two ways: (a) a high average annual rate of increase of prices (2.5 per cent) during relatively peaceful times, and (b) very low variability in the rate of price change around its trend (the six-term moving standard deviation of the annual rate of change of prices has averaged less than 1 per cent since 1955). The only other similar continuous upward trend in prices was the inflation of 1897-1914, when prices rose at an average rate of nearly 2 per cent. Even during that eighteen-year period there were three years when prices actually declined. Furthermore, that inflation followed a long period of deflation.

Placed in historical perspective, this recent period can be thought of as one when a pure fiduciary managed monetary standard completely replaced a gold commodity standard. The new standard thereby destroyed long-term expectations of a stable price level and the presumption, appropriate to a commodity standard, that periods of inflation would be followed by periods of deflation. The idea that we were on this new monetary standard must have developed gradually over the last twenty-five years. The first indication was that the expected deflation did not materialize after World War II. Secondly, prices failed to fall after the Korean War and during the recessions of the 1950's and early 1960's. Finally, the adoption of the dollar as the international standard reduced the force of the balance of payments as a constraint on the United States. The last twenty years constitutes the only period of that length in our statistical record without a single year in which the price level fell.

Some of my research this year attempts to test certain implications of this very fundamental proposition that we are now operating under a new monetary standard. For example, although the current actual rate of change of prices enters

the demand for money negatively over the 1880-1970 period, it is shown to enter the demand for money positively over the 1880-1913 gold standard subperiod. The positive relationship implies that price changes in one direction created anticipations of price changes in the opposite direction. The gradual realization since World War II that rapid inflation was not likely to be followed by deflation also substantially reduced the lag in the adjustment of price anticipations and interest rates to rising prices. To explore this possibility, I extended the analysis of the effect of price changes on interest rates, performed by Yohe and Karnosky for 1952-69, back to the years before World War II. In the equation relating each interest rate to a series of earlier price changes, I found that the coefficients on the initial price changes were negative, and that the sums of the price change coefficients were often zero. This is the result one would expect under a commodity standard. A summary of much of this research, together with some additional discussion of the inefficiencies associated with anticipated inflation, will be published in the forthcoming Universities-National Bureau Committee conference volume on secular inflation.

In addition, I have completed some research using the predictability (variability) of the rate of price change as an explanatory variable in the demand-for-money function. The theoretical basis for inclusion of the variable is as an operational measure of the quality of real cash balances. The greater the predictability of prices, the greater the monetary service flow from a given level of real cash balances. The direction of influence on the demand for money from a change in the predictability of prices cannot be determined on a priori grounds. For example, the substitution-in-production effect implies that a decrease in predictability increases the quantity of real cash balances demanded for a given monetary service flow. On the other hand, the likely increase in the price of monetary services will decrease the monetary service flow demanded.

Empirically the moving standard deviation of the annual rate of change of prices is shown to affect the demand for money positively. The large postwar fall, until 1966, and the subse-

quent rise of this variable help to explain the rapid rate of increase in velocity (narrowly defined) until 1966 and the substantial decline in its rate of increase thereafter. I intend to use this variable as a determinant of the composition of nominal income changes between price level and real income changes. An increase in the predictability of prices should increase the use of implicit and explicit long-term contracts and hence the rigidity of prices. A further consequence should be that the real short-run effects of a monetary impulse are increased.

Benjamin Klein

### Aggregate Production Functions and the Theory of Wages

Recent theoretical work<sup>1</sup> has shown that the use of aggregate production functions to provide an exact or even approximate description of the production relations of a technologically diverse economy requires stringent and unrealistic conditions. Yet aggregate production functions, when estimated in practice, give surprisingly good results. Not only do such functions give good fits when estimated from output and input data but also their implications as to wages are approximately correct.

An explanation for the accuracy of the wage predictions has been attempted<sup>2</sup> by performing simulation experiments for an economy in which individual firms had individual Cobb–Douglas production functions but in which no aggregate production function existed. An aggregate Cobb–Douglas function was fitted to the resulting output and input data and wages predicted. In those experiments, it turned out that whenever labor's share of total output happened to be roughly constant, an aggregate Cobb–Douglas production function gave good wage predictions. This result suggests that the reason why an aggregate Cobb–Douglas production function appears to give good results is the relative constancy of labor's share, rather than the other way around. It is to be sharply distinguished from the obvious point that an aggregate Cobb–

Douglas production function cannot give good wage predictions if labor's share is not roughly constant.

The present project, financed under a grant by the National Science Foundation, proposes to extend those experiments to other kinds of production functions. It is planned to simulate economies in which individual firms may have CES (constant elasticity of substitution) or constant-coefficient production functions, as well as Cobb–Douglas and in which aggregate CES production functions as well as Cobb–Douglas production functions are estimated. One object is to see whether the cited result on aggregate Cobb–Douglas production functions and labor's share continues to hold when the underlying production functions are quite different. A second purpose is to see whether a similar result will hold for an aggregate CES production function, that is, whether such a function gives good wage predictions when, for whatever reason, wages just happen to turn out to be a log linear function of output per man.

Franklin Fisher  
Robert M. Solow

### Problems in the Measurement of Capital Goods

In a paper on "Measurement Bias in Price Indexes for Capital Goods," which appeared in *The Review of Income and Wealth*, June 1971, I attempted to combine the results of previous studies by other authors with recent work of my own in order to estimate a new price index for structures and producers' equipment in the United States for the period 1954–63. The paper concluded with a list of suggestions for future research, two of which involved a further investigation of the unit values derived from data collected by the U.S. Bureau of the Census.

1. Evidence on the behavior of the ratio of unit values to wholesale prices should be updated from 1963 to the late 1960's in order to determine what portion of the decline in the ratio between 1954 and 1963 was reversed during the cyclical upturn in investment spending after 1963.

2. Changes in the relative sales of different sizes of machines should be studied in order to

<sup>1</sup> Franklin Fisher, "The Existence of Aggregate Production Functions," *Econometrica*, 37 (1969), pp. 553-557.

<sup>2</sup> Franklin Fisher, "Aggregate Production Functions and the Explanation of Wages: A Simulation Experiment," *Review of Economics and Statistics*, LIII (1971), pp. 305-325.

assess the claim of a U.S. government committee that the decline in the ratio of unit values to wholesale prices is due mainly to a shift in product mix toward smaller machines.

During the past year I have been engaged in research designed to yield a more definite conclusion on the characteristics of unit value indexes and their potential usefulness as alternative price deflators. Considerable effort has gone into the collection of a greatly expanded data base. In contrast to the fifty commodities studied in the earlier paper, some of which were rather loosely defined, the new data provide annual unit values for 300 narrowly defined commodities. Annual observations are available for each commodity, and the sample period extends in many cases through the entire 1947–70 period, providing information on both cyclical and secular relationships between unit values and wholesale prices.

The investigation is concerned not only with the ratios of unit values to comparable wholesale price indexes but with the characteristics of the unit values themselves. I test the severity of aggregation bias by comparing the cyclical and secular behavior of unit values for individual, disaggregated, size classes of a given product (e.g., a "crawler mounted power crane with bucket capacity of 1.5 cubic yards") with aggregations of several size classes. I then relate aggregation bias to measures of changing product mix among size classes and to measures of the "width" of size classes, to provide guidance to potential users of unit values of product types that are not narrowly defined.

The results of the new study confirm the hypothesis that transaction prices as measured by the unit values fluctuate procyclically, relative to list prices as measured by official wholesale price indexes for the same commodity. During the slump in investment between 1956 and 1963, for instance, the aggregated unit value index drops about 10 per cent relative to the official investment price deflator, and most of the shortfall is made up during the subsequent 1963–69 expansion. The important implication is that the official data understate the cyclical variability of price and overstate the cyclical variability of output.

This new study of unit value will be combined

with the material gathered earlier and used in my paper on "measurement bias" to produce a revised and more comprehensive Occasional Paper for the National Bureau. Subsequent items on the research agenda include a long-delayed study of secular changes in utilization and service lives of capital goods, and an attempt to build an alternative price index for certain categories of producers' equipment from data available in mail order catalogues over a long historical period.

The earlier stages of the capital measurement study were supported from grants to the National Bureau by the Alfred P. Sloan Foundation and the Alex C. Walker Charitable and Educational Foundation; the unit value portion has been financed by the Federal Reserve Board Price Committee.

Robert J. Gordon

## Economic and Social Accounts

### Introduction

The major activities in this area during the past year have been the development of a proposal to the National Science Foundation for a greatly expanded program of research in economic and social measurement, and the November 1971 Conference on the Measurement of Economic and Social Performance.

We have received support from NSF for a series of four related studies. The first concerns development of the framework for economic and social accounts, and includes work on the division of output between current and future uses and between final and intermediate product. The second focuses on the use of nonmarket time; it includes studies at the analytical level, using existing time-budget data, and an experimental field study designed to obtain better measures of time-use. The third is an exploratory investigation of the economic and social costs associated with environmental change; and the fourth is a project aimed at developing a synthetic microdata base from which one would be able to replicate both the present aggregate economic accounts and an expanded set of economic and social accounts. Work on this set of related studies began on May 1 of this year.

The experimental field study on the measurement of time-use will be carried out in conjunction with the Institute for Social Research at the University of Michigan. This study represents the first formal institutional cooperation between NBER and ISR.

A second major activity revolved around the November 1971 Conference on "The Measurement of Economic and Social Performance," sponsored by the Conference on Research in Income and Wealth. Papers presented at this conference by National Bureau staff associates included: "The Intrafamily Allocation of Time," Reuben Gronau; "A Framework for the Measurement of Economic and Social Performance," F. Thomas Juster; and "A Proposal for a System of Economic and Social Accounts," Nancy and Richard Ruggles. In addition, Gilbert Ghez, John Kendrick, John Meyer, and Robert Willis served as discussants at the conference.

Other research activities during the past year include continued work by Nancy and Richard Ruggles on the microdata approach to the design of accounts, John Kendrick on investment and imputations, and Robert Eisner and his associates on the nonincome-income project. These studies are reported in detail below.

F. Thomas Juster

### **Economic and Social Information Systems**

Further work has been carried out on the development of economic and social measurement systems. A paper entitled "A Proposal for a System of Economic and Social Accounts" was presented to the Conference on Research in Income and Wealth at its meeting on November 4-6, 1971, at Princeton University.

Although research on the design of the general framework for economic and social accounts information will continue, emphasis is now being placed on developing techniques for the creation of synthetic microdata sets that can provide the basic information needed for modeling a sector of the economy. Current efforts are directed towards generating a household microdata set that will provide income statements and balance sheets related to demographic and social data about the household.

Research is also proceeding on price mea-

surement, the relation of price indexes to micro-price observations, and the use of price data in the analysis of price-cost behavior.

Nancy and Richard Ruggles

### **National Income Studies**

During 1971, estimates of total investment and capital in current and constant dollars, by sector and type, were revised and extended through the year 1969. A progress report on the findings was presented at the August meetings of the International Association for Research in Income and Wealth, held in Ronneby, Sweden. The paper, "The Treatment of Intangible Resources as Capital," is published in the March 1972 issue of the *Review of Income and Wealth*. Reprints may be obtained from the author.

The appendixes on sources and methods of estimation were completed and are being edited. During 1972 a monograph giving the findings will be prepared for submission to a Bureau reading committee. The appendixes will include approximately 100 basic tables containing the annual investment and stock estimates for the period 1929-69.

The imputations for nonmarket economic activities, not now included in the U.S. national income and product accounts, have been completed for the years 1929, 1939, and 1948 to 1969. Notes on sources and methods are complete, except for those pertaining to unpaid household services. Writing up the findings will be deferred until after completion of the monograph on total investment and capital.

Work on this project has been financed by grants to the National Bureau from the Alfred P. Sloan Foundation, the Alex C. Walker Charitable and Educational Foundation, and the National Science Foundation.

John W. Kendrick

### **Measurement and Analysis of National Income (Nonincome Income)**

Work has begun on preliminary estimates of income and product in the household sector, the government sector, and nonprofit institutions. In each case we are endeavoring to estimate flows of services and the accumulations of capital,

whether physical or human, used in producing those services. This has required a variety of assumptions as to useful lives and depreciation of assets as well as imputation of net rates of return. Efforts are also being made to estimate values of certain services, such as those of police and commutation, which are currently counted as final products but which might better be viewed, at least in part, as intermediate.

Robert Wallace has now completed a draft of his study of "Measurement of the Economic Value of Schooling Output." Making use of Project Talent<sup>1</sup> data, Wallace has estimated changes in income that are associated with schooling. His approach has involved a comparison of test scores of high school students in their ninth year, eleventh year, and twelfth year of school. He has also utilized information on the subsequent occupations of eleventh grade students in a five-year follow-up study. This information permitted estimation of the relationship between the vector of an individual's scores in the Project Talent tests and the probability of moving into a particular occupational group. On the assumption that the parameters of the probability distribution over vector traits remained constant, one can estimate how these probabilities changed for each student from the ninth through the twelfth grade. With further information from census data as to incomes associated with occupations, and assumptions as to rates of discount, it is then possible to estimate changes in the value of human capital, the latter being taken as the discounted value of expected future earnings associated with the changes in test scores from the ninth to the twelfth grade.

While it is, of course, impossible to assume that all of these differences may properly be attributed to schooling, Wallace has been able by this method to obtain some measure of changes in income that have been associated with changes in various characteristics usually related to school performance. Wallace's findings will be available in the near future in his doctoral dissertation at Northwestern University, and publication in whole or in part is anticipated.

In addition to the papers published in the

1970 *Proceedings of the Business and Economics Statistics Section* of the American Statistical Association, complete manuscript reports are now available in the form of doctoral dissertations by Michael McElroy on "Capital Gains and the Theory and Measurement of Income," Northwestern University, 1970; by Alan I. Mendelowitz on "The Measurement of Economic Depreciation," and by Wolfhard Ramm on "Measuring the Services of Household Durables: the Case of Automobiles," Northwestern University, 1971. The work by John Soloday on income and investment in natural resources and by Stephen Zabor on executive compensation is continuing.

Robert Eisner

## Business Cycles

### Introduction

It is now well-established that a recession occurred in the United States in the last quarter of 1969 and the year 1970 (see Fabricant's Supplement to *National Bureau Report* 8). Although inflation persisted so that the aggregates in current dollars continued to rise, real output declined slightly in absolute terms, as well as substantially relative to the economy's productive potential. Thus, present data confirm that the period witnessed an economic contraction rather than merely a retardation of growth. However, the distinction seems to be marginal and not very important in this case: the 1969-70 recession was certainly among the mildest on record, and such episodes have much in common with generalized slowdowns in economic activity.<sup>1</sup>

The recovery of the U.S. economy in 1971 was slower than in any of the corresponding early phases of the four previous business expansions since World War II. This sluggishness probably had much to do with the fact that the forces of inflation proved so unexpectedly strong and stubborn. When inflation is being resisted long enough by uncertain means and with uncertain results, economic expectations and activity tend to be depressed. Even vague fears of tighter wage-price controls, labor un-

<sup>1</sup> A survey of 100,000 high school students conducted by the American Research Institute (Palo Alto) in 1960, with follow-ups in subsequent years.

<sup>1</sup> As shown in the papers by Mintz and Fabricant in *Economic Research: Retrospect and Prospect*, Fiftieth Anniversary Colloquium I, *The Business Cycle Today*, NBER, 1971.

rest, international monetary crises, higher interest rates, etc., can discourage business investment and consumer capital outlay. The tolerance of inflation by the public is presumably much lower in slack than in boom times.

The U.S. recession was accompanied and followed by a sharp slowdown in the rates of economic growth of several major industrial countries: Canada in 1970, Japan and most of Western Europe later in 1970-71. Everywhere price levels continued to rise briskly, and the rather awkward term "stagflation" appears frequently as a description of these developments. Thus, industrial production in West Germany declined significantly in the second half of 1971, and real GNP seems to have failed to advance, but the pace of inflation was not greatly moderated. In Italy, the stagnation of domestic demand and output in 1970 developed in 1971 into what is by general consensus the most serious recession since World War II, yet wages and unit labor costs rose very fast, and consumer prices continued to increase at reduced but still high rates. In the United Kingdom, demand weakened and output declined in the first half of 1971, then recovered measurably; but unemployment rose and remained high, and wages kept increasing and inflation continued unabated well into the year. In Japan, the deceleration following a long period of exceedingly rapid expansion appeared particularly sharp: growth of less than 5 per cent is viewed as a major recession in an economy that has recently been growing at more than twice that rate. Some signs of moderation in the wage and price increases have appeared. In France, the slowdown has been relatively late and mild, with little systematic change in the trends of prices and wages.

Such an international diffusion of similar economic developments confirms the view that the major industrial and trading countries constitute a closely interdependent economic world. Data on interest rates and other monetary and financial aspects of the international scene give strong support to this single-world concept. The international (generally, spatial) transmission of business cycle movements, like the propagation of these movements over time, has of course long been observed. The subject has been given considerable attention in National Bureau

studies, but much remains to be learned about it, as illustrated by the remarkable parallelism of the long velocity series for the United States and the United Kingdom shown by Friedman and Schwartz in this report.

The interaction between business cycle developments and prospects on the one hand, and economic policy measures and their consequences on the other, represents another subject of basic importance that is as yet poorly understood. Policy actions are credited by some observers with the major role in causing as well as counteracting economic fluctuations, but there is much assertion and little tested knowledge on this matter. The actions taken are themselves responses to changes in business conditions, and they may be improperly timed or quantified because of faulty economic analysis and forecasting or political obstacles. Qualitatively, much more is known here, but even so there is unresolved controversy about the relative merits of fiscal and monetary policies and the value of price and wage controls. International comparisons nevertheless disclose a substantial similarity of economic policy responses to the recent developments; namely, a widespread resort to price and wage controls (incomes policies) and shifts to expansionary fiscal and monetary actions in countries faced with too high unemployment. Moreover, recent events also have given rise to fresh and increasing doubts about the effectiveness of the economic stabilization policies.

The broader problem, which embraces and transcends the issues of countercyclical policies, is that of the relative role of exogenous and endogenous factors in the causation of those fluctuations that represent substantial departures from reasonably stable economic growth. Several reports in two books published by the National Bureau in 1972, *Econometric Models of Cyclical Behavior* and *The Business Cycle Today*, address themselves to this problem, including two simulation studies by NBER authors, Zarnowitz, Boschan, and Moore, and Haitovsky and Wallace. There is evidence of the importance of exogenous disturbances, which deserves careful attention even though its value is limited by the similarity and the probable specification errors of the models included in the

analysis. Much further work needs to be done on stochastic simulation studies of various econometric models, which should incorporate the effects of external shocks as well as the influence of specific policies treated as partly endogenous, in the sense of being a response to certain economic developments.

In short, both recent economic history and recent economic research indicate that "conjunctural" movements continue to be important and in need of study. Some ideas for a broadly based program of future business cycle research at the National Bureau were noted in last year's *Annual Report*; the preceding reflections suggest some desirable extensions of that agenda. Until now (March 1972), however, the available resources have permitted little more than a continuation of past studies. Even so, the activities reported below cover a wide area. They include studies by Mintz on dating U.S. growth cycles; by Friedman and Schwartz on monetary trends and relationships; by Juster and Wachtel and by Eisner on capital outlays by households and business; and by Zarnowitz and Boschan, Haitovsky and Treyz, and An-loh Lin and Chow on forecasting and econometric models.

Victor Zarnowitz

### Dating U.S. Growth Cycles

The computational work for the revision of my study has been completed and the new findings will be reported on in an Occasional Paper.<sup>1</sup> The study's main concern is growth cycles, but it also sheds some new light on classical business cycles. A secondary aim is to experiment with the dating of reference cycles by computerized procedures, in contrast to the traditional National Bureau practice of determining cycle turns by expert judgment.

The mechanical dating of reference cycles relies on a group of economic indicators, selected for the purpose, and adjusted or not adjusted for long-run trends depending on whether growth cycles or classical business cycles are the objective. Indexes constructed from these indicators are deemed to represent aggregate economic activity and their turns are determined by a programmed process.

<sup>1</sup> For the earlier version of the study see *The Business Cycle Today*, NBER, 1971.

The choice of the indicator list is crucial. In the previous version of this study a seventeen-indicator list was used, which has now been replaced by a twelve-indicator list. The latter has the merit of representing the traditional U.S. business cycles, over the period 1947–69, even more accurately than the seventeen-indicator list did. During each of the four traditional business cycles of this period, most of the twelve series (unadjusted for trend) have risen up to the exact month of the traditional cycle peak and fallen to the month of the trough. In other words, the diffusion index of the twelve indicators makes each of the eight turns in the month previously selected by the National Bureau's traditional methods. Perfect agreement (with one exception of a single month) is exhibited also by the composite index based on the twelve series. Given this close similarity of behavior over the 1947–69 period, we may conclude that growth cycles derived from the same indicator list should be comparable to traditional business cycles, though differing, of course, in their turning points.

When we come to the 1969–70 experience, however, there is a large discrepancy between the November 1969 peak tentatively identified by the National Bureau and that of June 1970 given by the twelve-indicator indexes. At first glance it is puzzling that, after having agreed for so long, the results given by the two approaches should suddenly differ. The explanation is simple: The National Bureau's selection of the November 1969 peak was based on data adjusted to take account of the prevailing inflation, while the computerized procedure pointing to June 1970 used the same mixture of current value and other series that had been customary in the past. The Bureau experts considered the previous reliance on a mixture of indicators, including price series and current dollar values, inappropriate in the inflationary situation of 1969, and they focused attention instead on measures of "real" economic activity, i.e., series in constant dollars or in physical units. Clearly a peak selected on this basis may, in a period of rising prices, differ from a peak selected by the former standards.

For simplicity, a cycle based entirely on data in physical units or in constant dollars will be termed "deflated," and a cycle based partly on

data in physical units, partly on current dollar series, and partly also on price and interest rate series will be termed "undeflated." To evaluate the discrepancy between the peaks in deflated and undeflated classical business cycles in 1969-70, one must know the relations between turns of the two types of cycles in earlier years. For this purpose, an indicator list representing deflated cycles has been derived from the twelve-indicator list, by dropping the price and interest rate series and one current dollar series and by replacing four other current dollar series by their constant dollar counterparts. The resulting nine-indicator list was used to obtain a chronology of deflated classical business cycles.

Turns in deflated cycles will differ from turns in undeflated cycles when price movements are opposite to and larger than movements in real activity. This is likely to occur in the months that precede peaks in undeflated cycles, when a moderate decline in real activity is often accompanied by a substantial rise in prices. Hence, one expects peaks in deflated cycles to show a tendency to lead those in undeflated cycles.

In fact, we find that the diffusion index for deflated cycles leads that for undeflated cycles at three of the four peaks over the period 1948-61. The largest of these leads occurred in 1957 when the deflated cycle turned five months earlier than the undeflated one. The eight months lead of the peak in the deflated cycle relative to the peak in the undeflated cycle in 1969-70 thus appears consistent with the historical record, considering the degree of inflation in the latter years. The peak date selected in the traditional fashion by the National Bureau experts, November 1969, clearly is part of the chronology of deflated as contrasted with undeflated classical business cycles. As regards the latter, moreover, the undeflated data would leave it uncertain whether or not a classical business cycle turn took place at all in 1969-70: the June 1970 peak in the undeflated series is followed by a very mild five-month decline, milder and shorter by far than any previous recession since World War II and attributable in considerable part to the automobile strike at that time. Even a minor revision of the underlying data could erase the downturn in the undeflated series.

Deflated cycles are a useful concept but no replacement for growth cycles. This is shown by their performance in the 1960's when deflated as well as undeflated classical business cycles rose for eight and one-half years in an unbroken expansion, blurring the fluctuations of 1962-63 and 1966-67.

Turning to the growth cycle chronology, we find that the new one, based on the twelve-indicator list, is fairly similar to the one obtained previously with the seventeen-indicator list. Nine out of the fifteen turns covered were not affected by the revision. The 1953 peak and four turns in the 1960's differ by a few months depending on which list is used. The only substantial difference occurs along the flat bottom in 1963-64 where the trough is shifted forward by more than one year in the revised version.

We have also analyzed deflated growth cycles, i.e., growth cycles based on the aforementioned nine-indicator list. Deflation of classical cycles means removal of the long-run price trends as well as removal of cyclical price changes. Deflation of growth cycles, however, refers only to price cycles, since all indicators are adjusted for trend to begin with. Therefore the difference between deflated and undeflated cycles must be smaller in growth cycles than in classical cycles.

This is confirmed by our findings. Of fifteen turns, eight coincide in deflated and undeflated cycles and six are only one month apart. Also as expected, turns in deflated cycles lead, with one exception, those in undeflated cycles. Characteristically, the only instance in which inflation caused a peak in a deflated growth cycle to precede the peak in the undeflated cycle by more than one month occurred in 1969. The deflated growth cycle turned down as early as March of that year, the undeflated one only in June.

Ilse Mintz

## Money

Our research activity during the past year has been divided between (1) the study of timing relations between money, prices, and output in the post-World War II period, and (2), our main area of concentration, the draft of "Monetary Trends in the United States and the United King-

dom: Their Relation to Income, Prices, and Interest Rates."

Our attention focused on the timing issue because of current interest in the slower response of prices than of output to the tentative peak in business activity in November 1969, which we associate with the earlier peak in the monetary growth rate. Is this timing behavior exceptional, or does it fall well within the range of earlier postwar experience?

We have assembled two kinds of evidence on timing behavior, one on a monthly basis, the other on both a monthly and a quarterly basis. For each set of comparisons our basic series include two measures of money ( $M_1$  and  $M_2$ ), prices (the monthly consumer price index or the quarterly deflator implicit in GNP), output (the monthly index of production or quarterly GNP in 1958 prices), and nominal income (monthly personal income or quarterly GNP in current prices).

One kind of evidence on timing is a comparison of leads and lags in the monthly data, expressed as six-month moving averages of month-to-month changes, at reference cycle peaks and troughs relative to the lead in money. In the recession marked by the November 1969 peak, prices reacted with a lag of ten months after  $M_1$  and twelve months after  $M_2$ ; in the current expansion, prices reacted with a lag of seventeen months for both  $M_1$  and  $M_2$ , although the wage-price freeze may shift the trough to a date later than that recorded in Table II-1. After every earlier postwar peak and trough, except only the 1966 peak and 1967 trough, prices reacted decidedly later than production, and reacted with a lag varying from eleven to thirty-one months.

To check the evidence from peaks and troughs, we have calculated correlation coefficients from monthly data (all expressed as six-month moving averages of month-to-month changes) between money and industrial production, consumer prices, and personal income, for a range of leads and lags. The highest correlation for industrial production is for money leading three months for  $M_1$  and six months for  $M_2$ . By contrast, the highest correlation for consumer prices was for money leading twenty months for  $M_1$  and twenty-three months for  $M_2$ .

TABLE II-1

Lead of Rate of Change of Money Over Rate of Change of Industrial Production and Consumer Price Index (specific cycle dates)

Reference Date	Lead (in Months) of Money Over			
	Industrial Production $M_1$	$M_2$	Consumer Price Index $M_1$	$M_2$
Troughs				
8/54	10	10	13	13
4/58	1	25	11	31
2/61	8	6	17	25
5/67	7	3	6	2
11/70	9	9	17	17
Peaks				
7/53	9	9	19	19
7/57	-1	-1	17	17
5/60	17	21	22	26
11/66	2	2	4	4
11/69	4	6	10	12

*Note:* All rates of change are calculated over a six-month period from monthly data. For the latest trough (11/70) a tentative turning point in the rate of change of the consumer price index has been marked off in January 1971. This may prove to be the first of a double trough, at least in the published and calculated CPI, because of the wage-price freeze.

The 11/66 and 5/67 reference dates are not included in the NBER reference chronology. See the discussion of the "pause" of 1966-67 in S. Fabricant, "The 'Recession' of 1969-1970," *The Business Cycle Today*, V. Zarnowitz, ed., NBER, 1972, pp. 116-117.

For personal income, the highest correlation was for money leading six months for  $M_1$  and nine months for  $M_2$ . Quarterly GNP change results are similar. Clearly, monetary changes take much longer to affect prices than output, and there is nothing in the timing reaction of the current episode that is unusual by comparison with the rest of the postwar period.

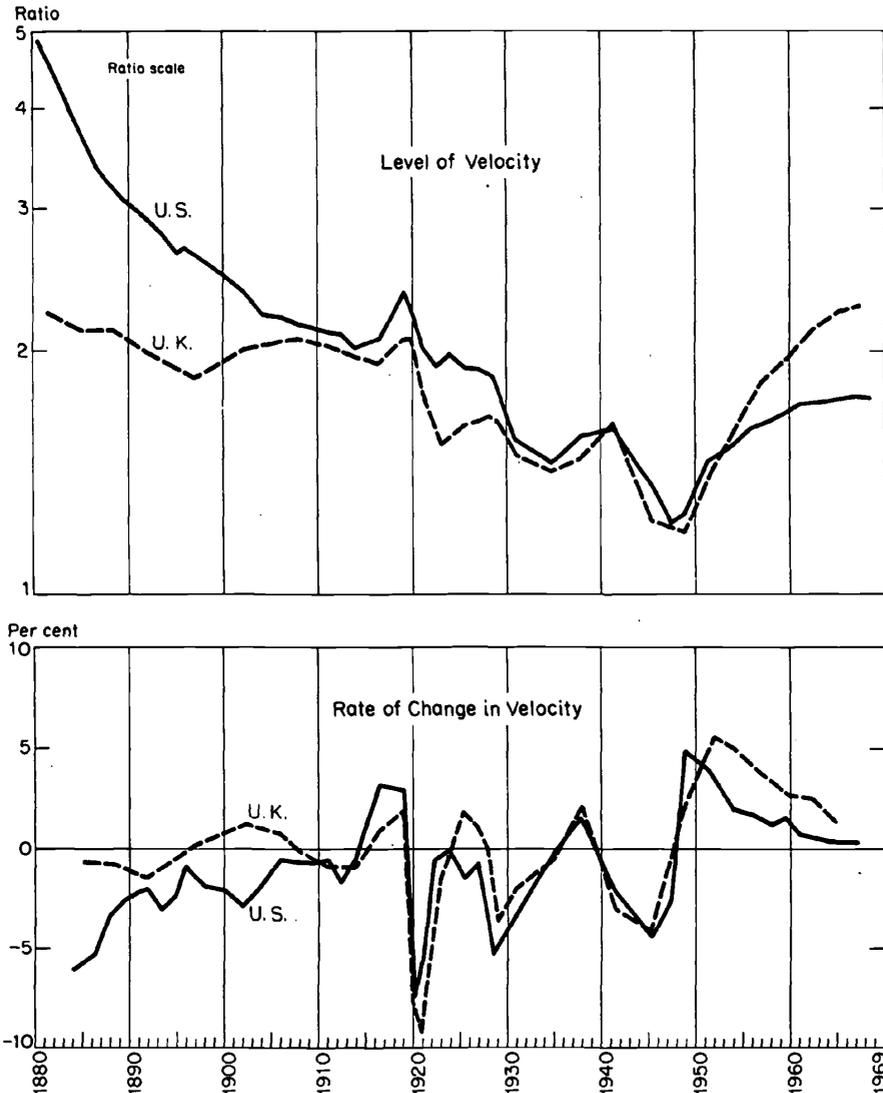
We plan an Occasional Paper to present in full the results of the study of timing relations between money, prices, and output in the postwar period.

In our study of monetary trends, our observations of levels are the average values of each variable during cyclical phases; our observations of rates of change are the slopes of least-squares lines connecting three successive phase averages. Our major analytic concern this

year was the comparative behavior of velocity in the United States and the United Kingdom, the two countries for which comparable annual data are available for the time span since 1880 (see Chart II-1). Clearly, there is an extraordinary parallelism of velocity in these two coun-

The parallelism of velocity cannot be attributed to statistical overlap—the income and money series in each country are thoroughly independent and the series for one country are clearly almost entirely independent of the series for the other. The parallelism shows up despite

Chart II-1  
Velocity in the United States and the United Kingdom



tries, especially since the cyclical phase, 1904–07, which we designate by its midpoint, 1906 (December 31, 1905). For that period, even the levels of velocity are almost identical. This finding was totally unexpected and opens up a whole new range of possibilities.

the use for each country of the reference dates for that country, so the points plotted for the two countries are for different time units.

The near-identity of velocity in the two countries presumably means that money-holding propensities have been similar in the United

States and the United Kingdom, and also that the major factors affecting the number of weeks that residents of the United States and the United Kingdom held income as money must have been largely common to the two countries for roughly two-thirds of a century. Otherwise the parallelism would have to be attributed to an accidental offsetting of differences in propensities by differences in the factors affecting the amount of money held. The parallelism therefore means that we can combine the data for the two countries in trying to identify the factors determining the behavior of velocity.

Put differently, the near-identity of the two velocity series must mean that the United States and the United Kingdom were part of a single economic world. It would come as no surprise to find that a velocity series for the Eastern half of the United States was nearly identical to a velocity series for the Western half. Presumably, the near-identity of velocity for the United States and the United Kingdom has a similar interpretation.

Of course, the single economic world must be still wider. It must include Canada and very likely some of the Scandinavian and other Western European countries. This is one direction in which further research is clearly called for by our surprising finding. But we do not plan to follow that lead, at least for the present. Instead, we are exploring more thoroughly the U.S.-U.K. linkage, as a means to get further insight both into factors affecting velocity and into the nature and closeness of the monetary linkage between the two countries.

Our estimate of the time it would take us to complete the manuscript on monetary trends has been unduly optimistic in the past so we shall refrain from projecting a date for completion. "Promise is most given when the least is said."

Milton Friedman  
Anna J. Schwartz

### Household Capital Formation

Our analysis of consumer durable goods demand models was completed during the past year, and the results will appear in two publications. One paper, "Uncertainty, Expectations

and Durable Goods Demand Models," will appear in "Human Behavior in Economic Affairs: Essays in Honor of George Katona" (North Holland, forthcoming). The analysis focuses on the specification of demand models that use anticipatory variables. Our principal finding is that a nonlinear and interactive specification of the Index of Consumer Sentiment, in conjunction with expected purchases or purchase plans, provides a superior specification for a forecasting equation.

The second paper, "Anticipatory and Objective Models of Durable Goods Demand," is scheduled for publication in the *American Economic Review* in September 1972 and will be reprinted, with appendixes added, as an NBER Occasional Paper. This paper examines the specification of nonanticipatory (objective) models of durable goods demand, compares these models with ones based partially on survey measures of consumer anticipations, and then examines the specification of an optimum joint model. The appendixes contain detailed examinations of the lag structure and parameter estimates for the objective model, a description of the basic data and sources, and an examination of the use of corrected lagged dependent variables in equations containing dummy variables that are designed to reflect supply shortages.

No additional work in this area is planned at present, although we prepared an updated version of the model for presentation at the Brookings Panel on Economic Activity in May 1972. This paper also examined the effect of the recent inflationary experience on consumer behavior.

On the experimental consumer anticipations survey, a study in which the National Bureau is cooperating with the U.S. Bureau of the Census, we presented a paper with preliminary findings at the 1971 meetings of the American Statistical Association. In this paper ("An Analysis of Ex Ante Savings Data: Some Preliminary Results") we examine both the single-time, cross-sectional predictive value of ex ante expenditure and savings measures and a cross-sectional, first difference comparison involving an analysis of changes between two discrete time periods.

In general, we find that the experimental version of the ex ante consumer expenditure variable is superior to the version presently used in

the operating Census Survey of Consumer Buying Expectations. There also appears to be substantial predictive value in ex ante data on discretionary outlays for vacation and travel. The results on ex ante savings measures were mixed. In single-time cross sections, the ex ante savings measures perform about as well as other ex ante durable goods expenditure variables, but in the first difference comparisons, the ex ante savings measures have no significant association with observed differences in savings. We hope to pursue analysis of the experimental survey data.

F. Thomas Juster  
Paul Wachtel

### Determinants of Investment

A paper on "Longer-Term Capital Expenditure Anticipation and Sales Expectations: A Micro-economic Analysis" was presented to the CIRET conference in Brussels, September 1971.

It was found that, like actual capital expenditures, longer-term capital expenditure anticipations (the four-year-ahead plans in the McGraw-Hill surveys) may be explained in terms of actual and expected sales changes, profits, and utilization of capacity. Sales change coefficients were generally significantly positive but profit variables showed a greater role in the timing of capital expenditure anticipations, as evidenced by their higher coefficients in individual-firm time series.

Past actual capital expenditures as well as short-run anticipations were shown to add significantly to the explanation of long-run anticipations but coefficients of determination in the individual-firm time series were still low. Sales change and profits variables, in their turn, contribute to the explanation of long-run capital expenditure anticipations, over and above the explanation offered by actual expenditures and short-run anticipations.

Past long-run anticipations were not positively related to actual capital expenditures in time series regressions when these included a complete set of past sales change and profits variables. There was no evidence that past plans embody any commitment or independent influence on expenditures beyond that to be found in

their exogenous determinants. Past plans did, however, account substantially for the differences, in cross sections, between firms and industries.

Long-run capital expenditure plans appear to be devoid of usefulness as forecasts of actual expenditures. Firms were apparently able to anticipate their future spending rates relative to other firms. However, their plans revealed at best no relation and frequently a perverse or negative relation to their own future expenditures.

Analysis is proceeding for the entire body of McGraw-Hill capital expenditures surveys through 1968. Substantial computations have been undertaken to update previous work and to cast further light on inventory investment and on the role of tax depreciation allowances and equipment tax credits as incentives for capital expenditures.

Robert Eisner

### Study of Short-Term Economic Forecasting

A paper entitled "Forecasting Accuracy in Relation to the Method and Time Span of Forecast" was presented to the 1971 CIRET conference in Brussels. A condensed version in German will appear this year in the *IFO-Studien* (Berlin-Munich). A chapter on "How Accurate Have the Forecasts Been?" was contributed to *How Business Economists Forecast* (W. F. Butler and R. A. Kavesh, eds.).<sup>1</sup> These papers report partial results from an analysis of an updated collection of macroeconomic forecasts. The data overlap those used in my latest NBER essays on the subject (in the last *Annual Report* and *The Business Cycle Today*); where the materials differ, the findings are still generally consistent.

Together with Charlotte Boschan, I am engaged in an analysis of the distributions of predicted changes and errors of forecasts from the ASA-NBER Quarterly Surveys of the Economic Outlook. We are also trying to establish whether there are any systematic errors in these forecasts for which useful correction procedures could be devised, and whether improved results can be obtained by combining individual pre-

<sup>1</sup> Englewood Cliffs, N. J., 1966.

dictions with suitable weights. Some interesting answers to these and some other questions already begin to emerge but they are as yet too fragmentary to merit reporting.

My other activities included participation in the Seminar on Criteria for the Evaluation of Econometric Models of the NBER Conference on Econometrics and Mathematical Economics, and preparation of "Business Cycle Analysis and Forecasting: On the Contributions of the National Bureau of Economic Research," an invited survey paper for *Wirtschaftswissenschaftliches Studium*, a new periodical directed mainly to students of economics and business in Germany, Austria, and Switzerland.

Victor Zarnowitz

### The Informational Value of Anticipations Data in Macroeconometric Model Forecasts

We reported our preliminary research on this topic at the 1971 CIRET conference in Brussels. The use of an anticipatory variable in an equation that is to be used in an interdependent macroeconometric model involves gains (or losses) that are not encountered in single equation forecasting situations. These forecasting gains come from changes in the stochastic and structural interdependence within the model. Changes in the stochastic interdependence can be found by a direct examination of the interrelationships in the structural equation residuals. However, sample period stochastic interdependencies may be poor predictors of forecast period interdependencies and therefore may not serve as a reliable guide in the selection of the specification to be used for the model forecast. The structural interdependence in a model is observable in the sample period and will carry over into the forecast period, since it is a function of the specification of the model and of the estimated structural parameters. Thus, in deciding whether or not to select an equation that includes an anticipatory variable in its specification over one that does not include such a variable, one needs to compare the structural interdependence characteristics of the model under the alternative specifications. A comparative analysis of sample period simulations and ex post forecasts with the Wharton-EFU model

standard and anticipations versions has been used to illustrate these points.

Yoel Haitovsky  
George I. Treyz

### Study of Monthly Econometric Models

The purpose of this study is to specify and estimate a monthly econometric model for the United States and to examine its dynamic properties by spectral analysis. The study will investigate the relative predictive performance of monthly and quarterly econometric models. It will also explore the consequences of aggregating an econometric model over time by a Monte Carlo approach.

Statistical methods have been developed for estimating monthly data for GNP and its components. A general method for interpolating, distributing, or extrapolating a time series was presented in my paper with Gregory Chow, "Best Linear Unbiased Interpolation, Distribution, and Extrapolation of Time Series by Related Series" (*The Review of Economics and Statistics*, November 1971). A detailed description of the method and its application to the problem of distribution was presented in my paper "Distribution, Interpolation, and Extrapolation of Time Series by Related Series" (mimeo.). Work on the application to the extrapolation problem is being prepared.

The study is being conducted jointly with Gregory Chow of Princeton University.

An-loh Lin

## Public Finance

### Introduction

The central theme in recent NBER research on public finance is the recognition of the necessity for a general equilibrium approach to the analysis of alternative public policies. To examine the effects of broad-based changes in fiscal structure requires that we extend our capabilities significantly beyond partial equilibrium analysis and explicitly identify economic interdependencies and interactions. The case for this research focus within the broader context of public finance studies is very thoroughly presented in Carl S. Shoup's review of the field for the collo-

quium on public expenditures and taxation.<sup>1</sup>

The one significant change in research strategy and focus over the last three years, a change culminating in the current applications of our efforts, is that, while we continue to recognize the importance of a systems approach to the evaluation of large-scale fiscal changes, we have also come to appreciate the need for the evolutionary development of these analytical capabilities. Each aspect of the current research program shares as a common goal the identification of the full range of important direct and indirect consequences of alternative policies, but each has the significant advantage of combining preliminary results of current policy relevance with an orientation conducive to such analytical developments. Thus, we have substantially revised the initial approach but maintained the fundamental objectives of the general equilibrium orientation recommended by Shoup and John Bossons in the National Bureau's 49th Annual Report, *New Challenges for Economic Research*.

The current research program consists of two major projects that are closely related and three other independent projects. The first two consist of analyses of a substitution of a value-added tax (VAT) for the corporate income tax (CIT) and of alternative federal revenue sharing and welfare reform proposals. In addition, analysis of tax reform proposals, a continuing study of higher-education financing, and a thesis on the determinants of unemployment patterns can be included within the purview of our public finance research.

The study of a VAT-CIT substitution was initiated in the Fall of 1970 by David Stout, now Director of Research at the National Economic Development Office, London, and An-loh Lin, in collaboration with Carl Shoup. Originally conceived as a first step toward a longer-run general equilibrium analysis of this tax substitution, the study employs an input-output model to assess the first-round price effects of the tax substitution. An-loh Lin and I have revised the basic input-output model application, extended the

study to assess, among other consequences, probable income redistribution, investment, and international trade effects, and have just completed a manuscript entitled "Substituting a Value-Added Tax for the Corporate Income Tax: First-Round Price Effects and Their Implications." Publication of this study by the end of 1972 is anticipated.

In 1970-71, in collaboration with Carl Shoup, I initiated a program of research into the implications of alternative federal tax, expenditure, and transfer substitutions. To date, this research has focused on the implications of the Nixon Administration's general and special revenue sharing proposals and of the various alternatives to these proposals which have been presented. I have been concerned with the interstate redistributive implications of general revenue sharing and related federal programs. My paper, "Federalism, Tax-Transfer Substitutions and the Distribution of Income: A Position Paper Proposing a System of Progressive Tax Credits," will be published shortly in the *Proceedings* of the National Tax Association's 1971 Conference on Taxation. James Hosek has completed a preliminary working paper, "An Analysis of the Special Revenue Sharing Proposals." Lin and I are currently developing a model for the simulation of intrastate expenditure and tax responses to alternative federal program substitutions, in which the interstate general and special revenue sharing results will be utilized.

While the revenue sharing and VAT studies initially developed somewhat independently, recent events have served to create a convergence of the research. Particularly important is the tentatively proposed linkage of a program of major federal support for education with the introduction of a federal value-added tax. Such a fiscal program, involving to some degree substitution of federal grants for local tax support of education and thus of a federal VAT for local taxes (not necessarily only the property tax), cuts across the lines of our current research. We are presently assessing the possibilities for meaningfully merging these research efforts into an analysis of the currently discussed policy menu.

Under the general heading of "Research on Federal Tax, Expenditure, and Transfer Substi-

<sup>1</sup> Carl S. Shoup in *Economic Research: Retrospect and Prospect*, Fiftieth Anniversary Colloquium IV, *Public Expenditures and Taxation*, NBER, 1972.

tutions," these studies have been supported by a grant from the Office of Economic Research of the Economic Development Administration, U.S. Department of Commerce. The studies have benefited from the continuing advice and encouragement of Edward K. Smith of the NBER. Also, Carl Shoup has provided stimulative commentary and constructive criticism, even though other commitments have precluded his continuing personal involvement in the research.

In addition to these major research efforts, John Bossons has continued his studies of the implications of proposed income tax reforms. This research was initiated under the auspices of the Carter Royal Commission on Taxation in Canada and has been continued for the NBER. Model development and an analysis of the joint distribution of income and wealth provide the focus for a monograph currently in preparation. A second study examines the initial differential incidence of alternative treatments of capital income.

Analysis of higher education financing has continued under contract support from the Ford Foundation. My paper with Robert Goldberg, "Variable Term Loans for Higher Education, Analytics and Empirics," was published in the NBER's new journal, *Annals of Economic and Social Measurement*, January 1972. A book co-authored by me and D. Bruce Johnstone of the Ford Foundation, *Income Contingent Loans for Higher Education*, to which Goldberg contributed an Appendix on "The Dresch-Goldberg Income Contingent Loan Simulation Model," will be published in 1972 as a Foundation report. Additional papers by Goldberg and by Johnstone and myself are in preparation, as is a proposal for long-run NBER research on public higher education policy. Computer simulation techniques developed for this study by Goldberg are described elsewhere in these reports.

Finally, Hosek, a graduate student at the University of Chicago, has made major progress on his thesis research, "Determinants of Unemployment Patterns." While not primarily a public finance study, his work has obvious implications for tax-transfer studies in its findings concerning the effects of unemployment compensation and other income-maintenance programs on labor force participation, on duration of bouts of

unemployment, and on related labor supply behavior.

Other more or less related work undertaken by members of the public finance group include my study of housing demand contributed to *The Detroit Prototype of the NBER Urban Simulation Model* (see Urban and Regional Studies in this report) and continuing research on monthly econometric models by Lin (described under Business Cycles).

Individual reports on current public finance research follow.

Stephen P. Dresch

### The Value-Added Tax and Changes in Fiscal Structure

A major study of the substitution of a consumption-type value-added tax (VAT) for the corporate income tax (CIT) has just been completed. Initial price effects are estimated on the basis of a 100-industry 1969 input-output matrix. Alternative degrees of CIT reduction and short-run shifting are examined, and the VAT yield criterion (a constant nominal surplus or deficit) serves to determine simultaneously the VAT rate and price changes for any given reduction and shifting of the CIT. In the detailed assessment of the initial effects of the tax substitution, it is found that (1) this change in tax structure is invariably regressive, even when income inelastic consumption commodities are exempted from VAT; (2) on the basis of a liquidity theory, rates of investment are significantly increased regardless of the degree of CIT shifting; and (3) the balance of trade effects are nonexistent, if the CIT is not shifted, and are equivalent to a 5 per cent effective devaluation, if the CIT is fully removed and shifted. Intergovernmental fiscal effects and interindustry changes in tax liabilities are also assessed. It is concluded that the only *unique* arguments in favor of a VAT-CIT substitution relate to improvements in allocative efficiency.

When this study was initiated two years ago, public policy interest focused on the VAT as an alternative to the CIT, primarily because of concern with growth, international monetary equilibrium, and factor supply effects of direct taxation, all of which were deemed to be adversely

affected by the CIT. However, current policy discussions combine the VAT with major federal initiatives for state–local fiscal and expenditure equalization and for the financing of primary and secondary education, with concomitant effects on state–local property (and other) taxation. While the present study has indirect implications for the evaluation of this fiscal menu, we are currently in the process of developing an extension of the research to assess directly the effects of the VAT and related fiscal changes in this new context. Such an extension bears an obvious relationship to the focus of our other major research project on federal revenue sharing.

We are also working on a shorter paper on the redistributive implications of alternative income tax credit devices which might be conjoined with a VAT. The central question concerns criteria for determining a VAT rate and a credit system which simultaneously achieve a pre-specified level of net-of-credit VAT revenue and maintain income distributive neutrality.

Stephen P. Dresch

An-loh Lin

### Intergovernmental Tax-Transfer Substitutions

The focus of this research has been on federal general revenue sharing and alternative direct and indirect systems of federal transfers to state and local governments. Initial efforts were concerned with the interstate redistributive consequences of the Nixon Administration's 1970 proposal, under alternative federal financing assumptions (tax increase versus categorical grant replacement). This has been extended to compare revenue sharing with such implicit transfers as federal credits for state and local taxes, under various structural forms, and federal income tax deductibility of state and local taxes. Also, alternative revenue sharing programs are being comparatively examined.

Preliminary efforts are now being made to estimate the income redistributive consequences of these programs under various state and local tax response assumptions. It will then be possible to compare transfers to governments with transfers to individuals in terms of their effects on the distribution of disposable income, by in-

come class, and geographically. Early indications suggest that, under plausible assumptions regarding state and local responses, revenue sharing programs which appear to be progressively redistributive geographically may be regressive in their effects on the distribution of income within states.

This research is also being extended to examine the differential regional effects of general national economic policies, an area which appears not to have received the attention its potential significance warrants. The basic theses are that alternative policies differ significantly in their regional impacts and that both the *effectiveness* and the relative desirability of a given policy are affected by its specific regional implications.

Stephen P. Dresch

### Implications of a Special Revenue Sharing–Categorical Grant Substitution

In 1971 the Nixon Administration submitted six special revenue sharing proposals for congressional study. These six, along with general revenue sharing, constitute a proposed restructuring of federal grants-in-aid, increasing the freedom of state and local governments and reducing the decision-making role of the federal government. The present system of categorical grants allocates funds on a case-by-case basis, employs a number of matching grant provisions, and calls for fairly extensive planning by state and local authorities in order to comply with federal regulations. Special revenue sharing legislation is characterized by awards made on the basis of general formulas, the elimination of matching provisions, and a substantial reduction in the amount of planning required to obtain an award.

To date, our analysis has been concerned with the interstate distribution of net benefits that will result if special revenue sharing is substituted for categorical grants. Net benefits are defined as the difference between the grant award and the opportunity cost of a revenue sharing program, e.g., categorical grants foregone or increased federal taxes. Two cases have been treated in some detail, with net benefits being determined both absolutely and per cap-

ita. In the first, each special revenue sharing package is assumed to replace the set of categorical grants designated in the legislation. The categorical grants are made equal in size to the revenue sharing packages. In the second case, special revenue sharing is made larger than the set of categorical grants and is financed by funds from the grants to be replaced, supplemented by a surcharge increase in the federal income tax sufficient to make up the difference. The results indicate that net benefit distributions are quite sensitive to the financing assumption adopted. Further, the distributions show that the proposed policy substitution can generate sizable changes in the aggregate amount of money flowing to state and local units, and in the amount by program. This raises the question whether formulas are an efficacious means of redistributing funds, from the viewpoint of either allocative efficiency or income equity. Unfortunately, data limitations make it very difficult to draw solid conclusions on these matters.

The substitution of special revenue sharing for categorical grants is likely to induce changes in both the amount and type of public activities undertaken by state and local units and in their tax systems. These changes were ignored in producing the interstate net benefit distributions. However, we are now attempting to develop a framework for treating them, and are planning to analyze several states intensively.

James Hosek

### The Effect of Federal Grants on State and Local Taxes and Expenditures

The purpose of this phase of our research, sponsored by the Economic Development Administration, is to identify the effects of alternative federal grant programs (unrestricted, restricted, and matching) on state and local expenditure and tax behavior. The models developed will then be applied to an evaluation of various federal revenue sharing programs and related proposals. The study, building upon earlier work by Dresch, includes formulation of a general model for the determination of state and local public and private expenditures, examination of the implications of the model under alternatively structured grant-in-aid programs, estimation of

the model, and reassessment of previous theoretical and empirical work on the subject. Specifically considered is the feedback effect of federal financing of aid programs on state and local fiscal behavior.

Initially, the model is being applied at the aggregate state and local level. Further refinements concerning the impact of federal grants to states and to localities on state and local fiscal relations are planned; these will permit the assessment of such features of proposed federal programs as mandatory pass-through of federal grant funds to localities. Questions concerning, for example, the degree to which federal grant funds simply replace state grants to localities, or effectively substitute for direct state (and/or local) taxes of various types, will be addressed.

Stephen P. Dresch

An-loh Lin

### The Initial Incidence of Alternative Income Tax Systems

The purpose of this project is to analyze the redistributive impact of alternative ways of restructuring the income tax system. The primary focus of the research is on how income from shareholdings should be taxed, because this is the key question in income tax reform.

There are several reasons for this. From an economic viewpoint, it is in this area that a change in tax structure can have greatest impact on the potential rate of economic growth consistent with a given degree of redistribution of income. From a political viewpoint, a change in the way in which incomes from shareholdings are taxed is the most sensitive aspect of tax reform—in part because its incidence is primarily upon high-wealth individuals whose political influence is naturally disproportionate to their numbers. Because of this political sensitivity, it is of great interest to examine the redistributive and revenue costs of alternative political compromises.

The orientation of my work on this project has been strongly influenced by the political vicissitudes of the tax reform program proposed in Canada by the Carter Royal Commission on Taxation and adopted in much modified form in December 1971. Work over the past year

has included the following papers: "The Ontario Proposals for a Small Business Tax Incentive," and "Economic Overview of the [1971] Tax Reform Legislation."

The first paper, a review of a proposal for a tax credit against personal income tax as an incentive for shareholder investments in small companies, was published in the May-June 1971 *Canadian Tax Journal*. The importance of the topic is reflected in the fact that the inadequacy of the Canadian government's proposals in this area was one of the two tactical errors that was chiefly responsible for the substantial weakening of the government's tax reform program subsequent to publication of its 1969 White Paper. The second paper, published in the Canadian Tax Foundation, 1972 *Conference Proceedings*, is a preliminary analysis of the differential impact incidence and the effects on economic growth of the tax reform legislation finally adopted in Canada.

Two monographs are currently being prepared to summarize the empirical work done on this project. The first is an analysis of the joint distribution of accrued income, taxable income, taxes, and wealth, together with a detailed description of the simulation model required to analyze the differential impact incidence of alternative tax substitutions. The second is an analysis of the differential impact incidence of alternative tax structures as applied to income from shareholdings.

John Bossons

#### **Determinants of Unemployment Patterns— A Progress Report**

Empirical work is under way on the determinants of unemployment patterns for a sample of individuals who experienced some unemployment in a given period. Both weeks alone and weeks per spell of unemployment have been used as dependent variables; independent variables include wage rate, years since school completion, education, unemployment insurance coverage, nonlabor income, and others. In the model being tested, an individual is assumed to be able to exercise control over the form and extent of his unemployment; he does so by acquiring market information about job openings and terms of

employment. This job search is carried on throughout the individual's lifetime, not only during unemployment. The amount of time spent in search, like the amount of time spent at work or in home production, is dependent upon the variables mentioned above. The 1967 Survey of Economic Opportunity serves as the data base for research.

Preliminary results, based on regressions using weeks of unemployment in 1966 as the dependent variable, indicate that wage rate has a negative coefficient while schooling and years since school have strong positive coefficients. The wage effect is weakest for workers who tend to enter and leave the labor force relatively frequently, yet schooling and years since school retain their significance. An unemployment insurance dummy typically has a positive, significant coefficient, which is consistent with the idea that unemployment benefits reduce the opportunity cost of time during unemployment. In the context of the model, if weeks of unemployment are accepted as a proxy for the time input into search, then benefits can be interpreted as lowering the per unit cost of the input and inducing an increase in the quantity demanded. Regressions are being run for the four race-sex groups, and Chow tests will be used to determine whether behavior patterns differ across groups.

James Hosek

#### **Financing Higher Education**

As reported last year, this research was initiated at the request of the Ford Foundation for an analysis and evaluation of income-contingent student loans and their potential role in the financing of higher education. The products of this research include a major paper and a book-length manuscript to be published for the Foundation. To date, the effort has focused on the identification of the structural features of these instruments and the trade-offs between alternative terms and conditions, assuming as given the characteristics of borrowing students, particularly in terms of constant-dollar future incomes.

We are currently in the process of extending this work in two directions. First, within the con-

finances of income contingency, we are attempting to integrate endogenously the characteristics of borrowers as a function of income-contingent loan characteristics, on the one hand, and alternative available financing options, on the other. Initially pursued in theoretical and simulation terms, this aspect of the research will be tested empirically as data from the recently launched Yale and Duke experiments in income-contingent borrowing become available and are supplemented by other demonstration programs now being planned.

Second, we are applying our existing models to the assessment of the trade-offs between existing public programs for higher education and alternative income-contingent loan programs, attempting to estimate the changes in the distribution of benefits that would be implied.

Ultimately, we hope to relate these elements, supplemented by models and evidence con-

cerning student (and nonstudent) behavior, into an analysis of the effects of alternative systems of financing higher education, identifying differences between these systems in terms of enrollment and retention rates, the socioeconomic composition of student bodies, the distribution of students over types of institution and fields of study, etc.

To permit continuation of this work we are currently engaged in discussions with several potential sources of support for long-run research in this area.

In the course of the past year, advice and technical assistance have been given to a number of institutions and associations interested in, or contemplating inauguration of income-contingent loan programs.

Stephen P. Dresch  
Robert D. Goldberg

## 2. URBAN AND REGIONAL STUDIES

### Introduction

The NBER urban and regional studies program reached maturity during the past year with the publication of one Exploratory Report and the completion of several other manuscripts.

*Empirical Models of Urban Land Use* by H. James Brown, J. Royce Ginn, Franklin J. James, John F. Kain, and Mahlon R. Straszheim is the first urban and regional studies volume to emerge from the exacting process of research, manuscript preparation, and review that marks NBER publications. This report surveys the state of the art in land use modeling and provides fairly detailed descriptions and critiques of major land use modeling efforts in five metropolitan areas.

A monograph that will initiate a new NBER series on Urban and Regional Studies, "The Detroit Prototype of the NBER Urban Simulation Model," by Gregory K. Ingram, John F. Kain, and J. Royce Ginn, with contributions by H. James Brown and Stephen P. Dresch, is now in press. Development of the NBER Urban Simulation Model has been a major objective of the urban

and regional studies program since its inception. Two versions of the NBER model exist: the Detroit Prototype and Pittsburgh I. The Detroit Prototype volume is primarily concerned with the first version of the model, although it includes a brief description of Pittsburgh I and outlines our plans for extending and elaborating the model. Pittsburgh I, which was completed by Ingram and Ginn, is described in their report below.

Research on the NBER Urban Simulation Model has reached an important watershed. The results of preliminary experiments and limited testing of the two versions of the model are quite auspicious, and convince us of the promise of this endeavor. However, further testing of present versions of the model, and extensions and elaborations of it and its application to problems of public policy will depend on the availability of additional funding. The most probable directions of development in the near future are: (1) further development of the supply and demand mechanisms in the model and its application to the analysis of problems of private market investment and disinvestment in core areas of

the city; and (2) the introduction of racial discrimination, that is, the use of the model to examine both the processes and costs of racial discrimination to various groups in our society and the effect of policies that would eliminate present segregated living patterns.

Most of the remaining research of the NBER urban and regional studies group falls under two categories: econometric studies of urban housing markets and industry location studies.

Seven studies of the housing and locational decisions of urban households and the behavior of urban housing markets have been completed or are being prepared for staff review. These include: (1) Mahlon Straszheim's recently completed study, "An Econometric Analysis of the Urban Housing Market"; (2) John F. Kain and John M. Quigley's recently completed study, "Discrimination and a Heterogeneous Housing Stock: An Economic Analysis"; (3) Stephen K. Mayo's Ph.D. dissertation on the determinants of residential location of Milwaukee households; (4) H. James Brown's and John F. Kain's analysis of housing choices by San Francisco households; (5) Stephen P. Dresch's housing demand analysis for the Detroit Prototype of the NBER Urban Simulation Model; (6) John M. Quigley's Ph.D. dissertation dealing with housing demand and residential location decisions in Pittsburgh; and (7) H. James Brown's analysis of moving behavior by San Francisco households.

Book-length manuscripts have been completed of both the Straszheim and the Kain-Quigley study, and they are currently being reviewed by staff reading committees. John Quigley is finishing his Ph.D. dissertation and expects to submit a manuscript to an NBER staff reading committee in September. Brown has completed his analysis of the moving behavior of San Francisco households and he is preparing a manuscript. The Brown-Kain analysis of the housing choices of San Francisco households and Dresch's demand analysis for Detroit will be published in "The Detroit Prototype of the NBER Urban Simulation Model." Dresch's study of housing demand by Detroit households was limited to whites. He and Robert Goldberg have begun to extend the analysis to black households. A brief outline of that work is included in this report, as are descriptions of the

Straszheim, Kain-Quigley, Brown, and Quigley studies. Stephen Mayo has completed his Ph.D. dissertation and is now preparing a manuscript for possible publication by the National Bureau. Mayo's study is described fully in previous annual reports.

The determinants of industry location comprise the second major object of empirical research by the urban and regional studies group. Two studies have recently been completed in this area: (1) Robert Leone's analysis of industry relocation patterns in the New York area; and (2) Raymond Struyk and Franklin James' analysis of the movement of manufacturing firms in the metropolitan areas of Boston, Cleveland, Minneapolis-St. Paul, and Phoenix. Leone's manuscript has completed the processes of staff review and revision, and should be published in the coming year. Struyk and James have been completing revisions of their manuscript and it should be available shortly after Leone's.

The data base analyzed by Leone and Struyk and James has been adapted to two further studies of manufacturing location patterns. The first, by Ginn and Leone, will assess the impact that changes in the availability and price of water have had on the water usage levels and locations of manufacturing firms. This study for the Army Corps of Engineers will also enable us to test on a national level several important location hypotheses that have emerged from the intrametropolitan location studies. In the second study, Roger Schmenner is attempting to measure the effect that different local government taxation policies have had on the intrametropolitan location decisions of manufacturing firms. These studies are reported on more fully below.

John F. Kain

## The NBER Urban Simulation Model

The urban simulation model developed at the Bureau has provided an integrating focus for much of the econometric work carried out on both housing markets and industry location. Although most of the econometric studies have not provided direct parameter estimates for the model, many of the questions raised during the

period of model development have been addressed. The results of these studies have, in turn, suggested alterations in the model design. During the past year a new version of the NBER model, Pittsburgh I, has been calibrated on data from Pittsburgh, and we were able to incorporate some features in this version that were absent from the Detroit prototype.

The most notable difference between the two versions of the model is the introduction of neighborhood quality as a dimension of the housing types in Pittsburgh I. This dimension of the housing bundle is required if zonal characteristics such as school quality or the level of public services are to influence housing choices in the model. In addition, the effects of the racial composition of an area upon housing choices could be represented within this framework. Several of the econometric studies suggest that households respond to zonal attributes as well as dwelling unit attributes when making housing choices.

Several other alterations were made in the design of Pittsburgh I to make it more efficient, and the introduction of different types of neighborhoods also reduced the computer running time of the new version of the model. As a result, Pittsburgh I operates in half the time required for the Detroit prototype.

After Pittsburgh I was calibrated to the Pittsburgh data base, several sensitivity tests and experiments were carried out. These experiments revealed that the model's behavior satisfied several important criteria. For example, if the model is operated in the absence of exogenous changes, it tends to converge to an equilibrium. In addition, the supply side of the model distributes new units in locations and amounts that are comparable to recent experience in the Pittsburgh area. Finally, sensitivity tests on the housing demand equations confirmed our suspicion that the model's behavior is strongly affected by variations in the equation parameters.

In the past few months, we have stopped testing the model and concentrated upon model documentation and description. In conjunction with John Kain, we have completed a manuscript destined for publication by the Bureau that describes the Detroit prototype in detail and discusses the alterations that were incorpo-

rated in Pittsburgh I.

More recently we have begun to develop plans for extending Pittsburgh I so that the model can be used to consider and evaluate some problems of public policy. Although the model has been used primarily as a research tool to date, its application for policy impact studies has always been a major reason for its development. The two particular areas of public policy that we hope to examine with the model are housing stock abandonment in core areas and the effects of racial discrimination on the performance of the metropolitan housing market. The first area will require further development of the supply side of the simulation model; the second requires the explicit introduction of racial subgroups into the model. Our progress in these areas will depend upon the availability of funds.

Gregory K. Ingram  
J. Royce Ginn

## **An Econometric Analysis of the Urban Housing Market**

Traditional models of the urban housing market treat housing services as a one-dimensional commodity and assume perfect markets. Most attention has been devoted to analyzing land rents and housing density, assuming housing prices exogenous. The density of residential development consistent with profit maximization by housing producers can be derived.

This approach is misleading. Density or lot size and other characteristics of the stock are important in households' preferences for housing. Moreover, the stock of housing changes only slowly. Shifts in demand for housing with particular characteristics occur much more quickly than the adaptation of that stock; this leads to changes in prices and neighborhood incomes. Since the housing stock is modified only very slowly, traditional models which focus on the determination of the appropriate stock in the long run miss one of the most critical dimensions of the urban housing market: how the existing stock is utilized, i.e., who lives where and pays what price. In addition, all existing econometric research has used neighborhood incomes as an independent variable in equa-

tions to explain housing prices. A simultaneous equation bias exists, since prices and income are jointly determined; the real issue concerns why high-income households outbid low-income households at a particular location.

The author's model assumes that urban housing services are multidimensional, with many attributes of housing services closely related to the characteristics of the residential capital stock. Since the characteristics of the existing stock vary substantially across locations in a city, "the urban housing market" is a misnomer. Many submarkets exist with different prices for particular housing attributes.

Prices are determined by both demand and supply conditions in each submarket, including households' tastes, housing stocks, neighborhood characteristics, and racial discrimination. Exogenous variables include access to employment, the quality of public services, housing stock characteristics, the supply of units available, and the racial composition of the submarket. Racial discrimination is explicitly recognized; the race variables reflect the flight of whites to the suburbs as well as the effects of discrimination on black choices. The effect of race independent of neighborhood differences, such as public services and access to employment, can be determined by the model.

The estimates of the model reveal that incomes will tend to be higher if the area is close to employment, has a new, low-density housing stock, good public services, and excludes blacks. Conversely, a plentiful supply of housing holds prices and incomes down. The neighborhood income elasticity is least with respect to the access-to-employment variable. Well-developed transport systems and dispersed employment reflected in the 1965 sample explain the limited role played by employment. In contrast, neighborhood incomes are much affected by the quality of local education. Lot size and age elasticities assume intermediate values, and housing supply has a significant effect on prices and incomes. Suburban areas are attractive by reason of new, low-density housing and good public services, relative to the core where housing characteristics are just the reverse. That housing prices in the ring are not bid up because of their attractiveness reflects the

greater supply of newer housing and the higher rate of development in recent years.

The special role played by race in urban housing markets is evident in analyzing black-white housing differences and estimating black housing demand functions. The importance of discrimination in explaining housing differences between blacks and whites is the subject of some dispute. At one extreme, analysts have assumed the existence of a perfect housing market. Under this assumption, differences in black and white housing consumption are attributed to socioeconomic differences or differences in tastes. Blacks are poorer than whites, have more single and separated households, and may prefer to acquire less housing than whites at any given income level, or may prefer to live among blacks. The existence of older, lower-quality housing in the core provides housing most suitable to the majority of blacks under the above assumptions. An alternative viewpoint stresses the importance of racial discrimination in housing markets and suggests that blacks are discouraged from entering higher-quality, suburban markets by higher prices, high costs of search, and high noneconomic costs. This view attributes the concentration of blacks in central ghettos largely to the preferences of whites for a segregated market. Little hard evidence has been brought to bear on this dispute.

The author's analysis lends strong support to the latter point of view—that blacks face very substantial discrimination barriers. A stratification of San Francisco households by household type, income, and race reveals that there are large differences attributable solely to race. Dramatic differences exist in the probability of home ownership, in the age and quality of the structure, and in lot size.

Discrimination proves to explain most of the variation by race. The housing market is very compartmentalized, with more than half of the black population living in less than 10 per cent of the area's census tracts. Housing in those black submarkets is twelve years older, and lot sizes 40 per cent smaller than in white submarkets. Prices are also increased, independent of neighborhood income, by the existence of a captive black demand.

The supply restrictions and higher prices re-

sulting from entry discrimination against blacks affect both the type and location of housing consumed. Only the wealthiest blacks escape the black ghetto. Income, prices, and supply rationing variables all prove significant in explaining black housing consumption. For example, black married households with children live in housing 4.85 years older if they are confined to a black ghetto submarket, *independent* of income and housing prices paid. They are 10 per cent less likely to be home owners. These differences reflect nonprice rationing. In addition, blacks living in the ghetto pay higher prices, holding income constant.

Two conclusions emerge from these models. First, the dynamics of change in housing supply and stock characteristics, in local public services and tax burdens, and in racial boundaries are critical in understanding the role of the housing market in the process of metropolitan development. The nature of housing stock adjustments over time will have a significant effect on prices and incomes by neighborhood. Incentives affecting local communities' zoning, entry controls, public service offerings, and taxes will also be important.

Second, the fortunes of blacks in the urban housing market are much affected by racial discrimination. The estimated black demand functions and the model of housing prices reveals that raising black incomes to levels equal to whites in the same life cycle class will reduce the gap between blacks' and whites' housing consumption by only 10 to 20 per cent. One consequence of raising black incomes in the context of continued discrimination and supply constraints is to increase housing prices for blacks. The future for blacks lies in open housing and other antidiscriminatory measures.

Mahlon R. Straszheim

## Discrimination and a Heterogeneous Housing Stock: An Economic Analysis

This project tests a number of hypotheses about the nature of the housing bundle, particularly its complexity and heterogeneity, and about the determinants of household's demand for specific attributes of this bundle. The research, which

emphasized the effects of the durability and heterogeneity of the housing stock and of racial discrimination on the behavior of urban housing markets, includes econometric analyses of the determinants of home ownership; the valuation of the bundle of residential services; and the demand for (or consumption of) residential services by urban households.

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

The analyses are 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 the housing consumed. Particularly significant is the 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 empirical analyses have been completed and a draft manuscript is now being reviewed by a staff reading committee. Two papers based on this research have been published.<sup>1</sup>

John F. Kain  
John M. Quigley

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

## Residential Location Decisions with Multiple Workplaces and a Heterogeneous Housing Stock

Current theories of residential location typically assume that all employment is located at a single point and that housing services are producible in any quantity at any location in an urban area. This analysis explores the theoretical and empirical significance of an alternative and more realistic model of residential choice. The existence of multiple workplaces in an urban area and the existence of identifiable submarkets for housing services are incorporated explicitly into the analysis. It is shown that only if the housing market is in long-run equilibrium can the current monocentric models of residential location be generalized to address the existence of multiple workplaces.

Based upon a sample of more than 24,000 households and dwelling units in the Pittsburgh area, the analysis describes the location-specific prices of some thirty types of residential housing. The spatially distributed prices of these housing types, or housing submarkets, are defined as the average prices at some 130 geographical locations of housing units classified according to size, density, and quality.

For a subsample of 7,000 households that recently relocated, the analysis tests two behavioral hypotheses. Assuming that workplaces and incomes of households are exogenously determined, the hypothesis that households choose the geographical location that minimizes the total cost (housing plus journey-to-work costs) of consuming their chosen housing types is evaluated in some detail. Under alternative assumptions about the value of travel time, the results indicate that between 40 and 50 per cent of housing consumers choose locations that minimize gross housing expenditures.

Households' choices among housing types are analyzed in terms of these gross prices by estimating demand equations relating choice of housing type to the set of gross housing prices that vary by workplace and income class within the urban area. The results indicate that the intrametropolitan prices, which reflect housing stock availability and transport costs, when viewed from alternative workplaces, exert pow-

erful effects upon residential choice. Subsequent analyses will investigate the implications of this work for model choice and public goods consumption in the urban area.

John M. Quigley

## Metropolitan Household Moving Behavior

During the past year my empirical analysis of the determinants of intrametropolitan moving by households has nearly been completed. The objectives of this work are to provide parameter estimates for the NBER Urban Simulation Model and to test some key behavioral assumptions of theoretical residential location models.

Most theoretical models of residential location assume that workplace location has a significant effect on the type and location of housing selected by households. This assumption has many implications that can be empirically tested. For example, the research described by Quigley and by Straszheim reveals that workplace-specific housing prices strongly affect both the type and location of units chosen by households. In studying moving behavior, the major implication of this assumption I have tested is that changes in workplace location should be associated with changes in residence location.

Of course, there are many other reasons that might prompt a household to move. In addition to changes in workplace location, a household might alter its residence because of a change in family size, family composition, income, wealth, or neighborhood characteristics. All of the above factors must be controlled for when studying the determinants of household moves.

Past research on the determinants of moving by households has attempted to represent all of the factors mentioned, and the literature on household intrametropolitan moving behavior unanimously reports a lack of association between job change and local residence change. This finding raises serious questions for the theoretical work on residence location and for the present structure of the NBER model.

The analysis I have carried out was based on data from the Bay Area Transportation Study Commission that are uniquely suited to examin-

ing the relation between workplace change and residence change. From these data, estimates of the determinants of moving show a strong association between workplace change and residential movement. Households with workplace changes have annual moving rates more than twice as large as those of households without workplace changes. Households whose new workplace location implies an increased commuting distance of one mile or more have annual moving rates nearly three times as great as the moving rates of households without workplace change.

Those researchers who have rejected workplace change as an important reason for moving have argued that the most important reason for moving is change in family size. The regression models I have estimated show that workplace location change has at least as much association with residence change as change in family size. In addition, for households that own their residences, a job location change has a much higher association with moving than family-size change.

During the next year, I will complete the analysis of the choices made by moving households and prepare a monograph reporting my results.

H. James Brown

## **Incorporating Race into the Detroit Housing Market Study**

The structure and initial parameter estimates for the demand submodel of the Detroit prototype of the NBER Urban Simulation Model were developed in a study of housing demand and residential location based on Detroit metropolitan area data. Because these data were very weak in dimensions of particular importance to the model (small-area housing prices and stock characteristics), the demand submodel was recalibrated on Pittsburgh data. However, while Pittsburgh, San Francisco, and other data bases are superior in a number of dimensions, the Detroit survey retains a major advantage in that it includes a substantial proportion of black households. In addition, data for two survey years are available: 1953 and 1965.

With these data it is possible to examine: (1) the changing geographic patterns of total

white and nonwhite employment over the twelve-year period; (2) the effects of housing and labor market restrictions on employment location adjustments of black households; (3) the distortion in housing consumption patterns of black households resulting from housing market discrimination; and (4) the changes in the magnitudes of housing and labor market discrimination over the period.

This study builds very naturally upon the previous Detroit housing demand study, which found that workplace in addition to family characteristics had a significant influence on both the type and location of housing consumed by white households. The findings of this study provide a benchmark for initially assessing the sources and magnitudes of the differences between the white and nonwhite housing submarkets.

Preliminary estimates of cross-section (1965) housing demand differences have already been made. In addition, the 1953 survey data, adjusted to spatially correspond to the 1965 survey, have been acquired.

Stephen P. Dresch  
Robert D. Goldberg

## **Industrial Water Consumption Study**

The Bureau has recently contracted with the Army Corps of Engineers to perform a study of the impact on industrial water-users of changing price, quality, and availability of water. The Corps wishes to know how the demand for water affects both the technical configuration of water-using processes and their spatial location. Most existing projections of industrial water demand assume a fixed coefficient technology and that spatial locations are exogenously determined. In this study, we hope to identify the existence of trade-offs in process design, spatial location, and water consumption.

One issue involved here is quite obvious: the maintenance of environmental quality demands that water be conserved and that waterways remain relatively free of pollution. To this end, there is much discussion of the imposition of effluent charges on industrial polluters. Such charges could substantially affect total operat-

ing costs and thereby influence the location decisions of firms. Local governments may be reluctant to impose pollution restrictions unilaterally for fear of inducing firms to move. This study should indicate the extent to which that is a valid fear.

Another issue concerns the accurate projection of future water needs by national subregions. These projections are critically important to sound public investment decisions. Since the capital costs of major water systems are enormous (estimates often approach \$100 billion!), it is essential to have more accurate projections of water needs. Further, such investments are often justified on the grounds that low-cost water stimulates regional economic development. If it is the case that firms are insensitive to water costs, then this particular objective might require reconsideration.

The Bureau study will involve three rounds of analysis. The first round is now underway and involves using Dun and Bradstreet establishment data to identify the major water-using manufacturing establishments and their recent location behavior. Analysis is restricted to about 3,000 establishments in eight 4-digit industries, representing over 66 per cent of the nation's industrial water demand.

Thus far, we have identified seventy-five heavy water-users that have recently relocated. We expect to carry out detailed interviews of the management and technical personnel in a number of these establishments in the second round of analysis. The objective is to determine changing water and space requirements with particular emphasis on recent adjustments in their processes to recycle water.

The output of this second round will be a third-round survey questionnaire on water usage. Responses will be solicited from the entire population of heavy water-using establishments identified in the first round.

This study is particularly appropriate at this time because it permits the testing on a national level of several important location hypotheses that have emanated from the Bureau's intrametropolitan location studies.

Further, as part of the first-round analysis, approximately thirty 4-digit industries that are not heavy water-users are being examined.

Analysis of this control group will represent a major contribution to the understanding of changing industrial location behavior, and provide a background for better understanding the behavior of heavy water-users.

J. Royce Ginn  
Robert Leone

## City Taxes and Industry Location

Little is known of the influence of different levels and kinds of taxation on the location of manufacturing industry within a metropolitan area. Some would say that tax differentials are a crucial factor in the location decision of the manufacturer. Others allege that factors such as space requirements weigh much more heavily in the location decision. And still others assert that manufacturers can shift most of their taxes to consumers in any case. Knowledge of tax influence on spatial organization is certainly desirable. Central city governments are finding it increasingly difficult to finance the services they provide. Their dilemma is a cruel one: higher taxes may drive out the very tax base they realize they must keep, yet there seems to be no other way to raise the required revenues. Clearly, they would favor taxes on manufacturing firms which could be completely shifted to the rest of the world. Such taxes would offer no incentive for firms to relocate out of the city. Any relocation would be the result of other factors acting for decentralization.

The present study is an attempt to ferret out fact from fiction with regard to local taxation and industry location. Recent location patterns of manufacturers are being investigated in metropolitan areas whose central cities offer a variety of taxes on industry and whose suburbs present different competing tax systems. Specifically, the experience of cities that have supplanted a portion of their taxes on manufacturing real estate and property with income taxes on business profits and/or employee earnings will be compared with the experience of cities that strictly tax property. To the extent that capital-profit ratios and capital-employment ratios vary across manufacturers, one would expect different metropolitan location patterns for various industries to depend on the nature of the tax

systems of the central city and its surrounding suburbs. If the taxes themselves offer different shifting characteristics, one would expect varying paces of citywide decentralization of industry.

The study addresses these questions in the metropolitan areas of Cleveland, Cincinnati, Kansas City, and Minneapolis–St. Paul for the years 1967 through 1971. The main body of data is derived from the Dun and Bradstreet industry location files. Suburban and central city tax in-

formation is gathered directly from the metropolitan areas involved. Measurement of changes in the location patterns of industry will be based upon changes in the stock of employment and numbers of firms in the suburbs relative to the central city, as well as the frequency of relocation for various subgroups of manufacturers. Some care will be taken to control for influences other than tax policy on the location of industry.

Roger Schmenner

### 3. HUMAN RESOURCES AND SOCIAL INSTITUTIONS

#### Education and Other Studies on Human Capital

##### Introduction

The Bureau's research program in education and human capital has proceeded about on schedule during the past year. In last year's Annual Report, I indicated that the series of studies originally sponsored by the Carnegie Commission was close to completion: The first of these studies, *Mental Ability and Educational Attainment*, by Paul Taubman and Terence Wales, has been published; the Taubman–Wales book, "Education As An Investment and a Screening Device," has been revised by the authors and is now undergoing final review before going to the directors' reading committee; the collection of essays on Education and Human Behavior, that I edited, is now complete and will shortly be going to the Bureau's directors and to the Carnegie Commission for review; the Occasional Paper by Lewis Solmon, "Education and Savings: An Example of the Indirect Effects of Education," is about ready for review by the directors, and the Occasional Paper by Sherwin Rosen on "Knowledge, Obsolescence, and Income" is close to completion. The reader is referred to last year's Annual Report for a more complete description of these studies.

Two other collections of essays are close to completion. One involves a set of four essays, all now in draft form, on the human capital earnings function and the distribution of income. The volume will have an introduction by Jacob

Mincer, who has also edited the volume, and essays by Mincer, Gary Becker, Barry Chiswick, and Mincer and Chiswick. This volume applies the earnings function originally developed by Becker and augmented by Mincer to a variety of both cross-section and time-series data. The second set of essays examines the allocation of time between market and nonmarket activities over an individual's lifetime. Becker and Gilbert Ghez are the contributors to this volume.

The research undertaken during the past year grows out of the work described above. We have obtained grants from the Office of Education to study the effect on earnings of differences in the quality of education, from the National Science Foundation to study the determinants of the distribution of income and earnings, and from the Office of Economic Opportunity to study labor market participation, labor supply functions, and earnings functions with special emphasis on poverty problems.

Two of these study areas, the Return to Educational Quality and the Determinants of Income and Earnings Distributions, rely heavily on the NBER–Thorndike–Hagen sample of Air Force veterans, which is described in previous annual reports. The third study also makes some use of that sample. Briefly, the sample comprises some 5,100 Air Force veterans who took a series of aptitude tests in 1943, and for whom the NBER obtained follow-up information on earnings history, educational background, attitudes, family background, etc., in 1969. During the past year we have conducted a further follow-up study of

these men, and have obtained detailed information on the labor force participation and educational background of respondents' parents as well as additional information on health status, present and prospective educational attainment for the respondents' children, and better information on mobility. This last follow-up has yielded an exceptionally high response rate of over 84 per cent of the 5,100 men in the completed NBER-TH sample. Returns are now being edited, coded, and prepared for transfer to tape.

We have also, during this year, expanded our basic information on the sample by extracting substantially more data both from the 1969 NBER follow-up and from the 1955 Thorndike-Hagen follow-up. We have now extracted all of the available information on earnings rate, labor force participation, schooling, and armed forces training subsequent to World War II from the original Thorndike-Hagen follow-up, and have transferred all of the quite detailed earnings data from our own 1969 follow-up to the basic tape. We have also done some reanalysis of the aptitude tests, and will have more refined measures of a synthetic IQ variable shortly.

The study by Finis Welch and Robert Evenson on agricultural production functions, in which they are attempting to relate productivity in agriculture to farm operator educational level and the amount and diffusion rate of agricultural technology, has focused on the development of richer empirical materials during the past year. The original timetable has thus been pushed back somewhat. The project is supported in part by a grant from the National Science Foundation.

Staff additions during the past year in the education and human capital area include James Heckman, who was appointed Research Associate last year and will be a Research Fellow during the coming year; Arleen Leibowitz, who was a predoctoral fellow and then Research Associate this past year; and Paul Wachtel, who was appointed a Research Associate during the year. Heckman and Leibowitz are both working with Mincer, on labor supply functions and labor force participation rates among married women, respectively. Wachtel is working with Solmon on the returns to educational quality.

F. Thomas Juster

## The Human Capital Earnings Function

My contribution to a volume on *Human Capital and Income Distribution*, coauthored by Becker, Chiswick, and myself, has been rather thoroughly revised during the past year. The contents of the study and some of the research findings were described in the last two annual reports. Briefly, my work concerns the development of an econometric human capital earnings function and its application to the distribution of labor incomes. The earnings function is capable of generating separate returns to schooling and to postschool, job-related, investments. It also distinguishes between contributions of human capital investments to wage rates and to annual earnings. Finally, it allows a flexible specification of various components of human capital investments, such as schooling, experience, health, and mobility, and of some standardizing variables. In the present study the earnings function is used mainly for a distributional analysis of the male earnings structure.

In a joint investigation with Barry Chiswick, the earnings function has been applied to a time series of changes in income inequality in the United States since 1939, with projections to 1985. Measured by explanatory power, the earnings function performs better than the few available ad hoc analyses of the observed changes. The major conclusions are: (1) aside from cyclical fluctuations, changes in the distribution of schooling and of work experience have significant effects, but they are small because the changes were small; (2) the decline in inequality between 1939 and 1949 was mainly a result of changes in employment conditions. The projection to 1985, based on labor force and school enrollment projections, indicates no significant prospective changes in income inequality. Two variables have the greatest potential power to affect income inequality: the rate of return and the distribution of employment. The extrapolation may well be insecure on both counts. The time series analysis appears in the May 1972 issue of the *Journal of Political Economy*.

Further research centering on the human capital earnings function is in progress, including application of the model to observed differentials for geographic area, occupation, race,

and sex. Also, replications of previous analyses, using the 1970 Census data, will soon be feasible. A short review of findings and some of the agenda in this program of work is contained in my paper, "Education, Experience, and the Distribution of Employment and Earnings," in a proposed NBER volume for the Carnegie Commission on Higher Education.

I have also contributed two papers to the NBER Survey of Research into Poverty Labor Markets, commissioned by the U.S. Office of Economic Opportunity. One, entitled "Poverty and the Labor Market," explores the changing family structure of the poor population and its relation to work and welfare. Problems of employment and of child care are also discussed in the paper. The other study deals with "Employment and Unemployment Effects of Minimum Wages." Some of the findings were described in last year's Annual Report.

Jacob Mincer

### Determinants of Distribution of Income and Earnings

The distribution of income can be represented by an earnings function which includes an exhaustive list of personal attributes as well as "luck." Using the NBER-TH sample, I have been trying to answer two questions within this framework. First, what is the relative importance of certain measurable characteristics such as the quantity and quality of education, mental ability, and family background? Second, to what extent do relative changes in earnings over time for the same people confirm stochastic (luck) and Mincer's on-the-job training theories?

My report with Terence Wales last year provided information about the relative importance of certain measurable characteristics. Besides updating and refining this work, I have been examining the effects of internal migration. Migrants are defined as those who changed their state of residence between the years they were in high school and 1969. The migration rate rises from about 25 to 50 per cent as education extends from high school to graduate work, but there is practically no relationship between migration and mental ability. A covariance analysis of equations for 1969 earnings does not reject

the hypothesis that the equation (and thus average earnings for any set of personal attributes) is the same for migrants and nonmigrants. However, in some other equations, a variable that indicates migration after 1955 is significant. There are some differences in earnings for current region of residence in the United States, but earnings are not related to the region in which high school education was received.

To answer the second question, the distribution of growth rates in earnings between 1955 (average age about 33) and 1969 (average age about 47) classified by earnings in 1955 have been examined and tested. Neither the stochastic nor the on-the-job training models are completely verified, since both predict that the mean growth rate in earnings should be independent of the starting position. While this is true for those in the 20-90th percentiles in 1955, those in the top tenth in 1955 had a much smaller growth rate, and those in the bottom tenth a much larger growth rate. Moreover, those in the top 30 per cent in 1955 contain a greater fraction of people in both tails of the distribution of growth rates than those in the bottom 70 per cent. (These distributions are significantly different when subjected to the Komogorov-Smirnov test.) The same results are obtained within education groups, and, in addition, the mean growth rate for any starting level of earnings increases with education. Finally, regression analysis indicates that the structure of the growth rate equations differs by 1955 earnings percentile. Besides education, dummy variables for religious preference, age, and year of first job are important in these growth rate functions.

Paul Taubman

### Knowledge Obsolescence and Income

During the past year I have finished a revised version of my paper on obsolescence and income, titled "Measuring the Obsolescence of Knowledge." This paper outlines a method for determining obsolescence and depreciation rates of knowledge and skills, and presents preliminary estimates of identifiable parameters for white male high school and college graduates for 1959. The model is based on the familiar conception of knowledge as a kind of capital

embodied in human agents of production, on the hypothesis that individuals learn from their working experience.

The innovation of the model lies in the construction of an implicit market for learning opportunities that is tied to the market for jobs. Implicit prices for learning are revealed to workers and firms through the emergence of equalizing wage differentials on jobs offering greater or lesser learning opportunities. The principles of optimal capital accumulation are applied to the worker's decision problem and yield a simple parameterization of age-earnings profiles that identify depreciation-obsolescence rates and several other parameters of interest. The model is sufficiently general to yield implications for a wide variety of observed labor market activity, including, for example, life-cycle occupational mobility and several aspects of employee turnover.

At present, the data are too crude to identify all the parameters of interest. The estimates suggest, however, that college graduates face lower rates of interest than high school graduates. A more important finding is that college graduates appear to be more efficient learners, relative to their depreciation-obsolescence rates, than high school graduates. The relatively greater learning capacity of college graduates is one of the factors that could account for their higher lifetime human wealth.

Sherwin Rosen

### Analysis of Cohort Data on Earnings

Most empirical studies of the distribution of earnings and the life cycle of earnings within a human capital framework have been based on cross-sectional data. Some hypotheses (such as conjectures about the variance of earnings as a function of job experience) can be tested, and some key parameters (such as rates of return from schooling) can be estimated from such data. However, the resolution of other problems requires detailed information on the covariance structure of earnings over the life cycle; this information can be obtained only from cohort data. It is important to determine the dominant and stable intertemporal characteristics, both for testing current theories about

the earnings profile and its dispersion and for guiding further theoretical work in relevant directions.

In addition to the NBER-TH sample and several other samples of cohort data obtained by the Bureau, arrangements have been made to obtain computations from an important data tape prepared for the *Låginkomstutredningen*, an official group that has been intensively investigating the distribution of income and earnings in Sweden. These data include annual taxable income for the period 1951-66, along with extensive background information including age, schooling, occupation, and health. The large number of annual observations for each person is particularly useful for statistical work, since it allows one to assess the importance of transitory variations in income and to reduce the influence of such variations on systematic covariances over time by aggregation.

Two studies based on these samples of cohort earnings are in process. The first is an attempt to evaluate some theoretical and empirical issues in the analysis of discounted lifetime earnings. One interesting preliminary result suggests that the discounted earnings of people with high schooling attainment have much more relative variability than those with low attainment. In one sample, the standard deviation of the logarithm of discounted earnings is always at least 30 per cent greater for those with more schooling than for those with less. The second study is an empirical investigation of the extent to which differential increases in on-the-job productivity are responsible for the dispersion of earnings along the earnings profile.

John C. Hause

### 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 adult males. In earlier studies, a simple investment-in-schooling model was used to generate an earnings function, which was found to be quite powerful for explaining interstate differences in the inequality and skewness of personal income.<sup>1</sup> In the pres-

ent 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.<sup>2</sup> Preliminary analyses for all males, white males, and nonwhite males indicate that the independent variables can explain (adjusted  $R^2$ ) 90 per cent of the interstate variations in relative income (or earnings) inequality. North-South differences in inequality are reduced by three-fourths. The most important explanatory variable is the (estimated) rate of return, followed by the relative inequality of weeks worked, the distribution of experience, and the distribution of schooling.

The income distribution implications of alternative models of racial discrimination are incorporated into the theoretical analysis and tested empirically for white and nonwhite males.

Differences in the level of income are analyzed by relating the average level of the log of income (i.e., the log of the geometric mean) to the levels of schooling, experience, and weeks worked. Differences in the ratio of nonwhite to white incomes are examined using the ratio of the respective earnings functions. The model is more powerful for explaining earnings than income. For white males, schooling is by far the most important variable for explaining state differences in the level of income and earnings. For nonwhite males, both schooling and weeks worked are very strong explanatory variables.

Barry R. Chiswick

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<sup>1</sup> See B. R. Chiswick, "An Interregional Analysis of Schooling and the Inequality of Income," proposed NBER Occasional Paper and "An Interregional Analysis of Schooling and the Skewness of Income," in *Education, Income, and Human Capital*, W. L. Hansen, ed., Studies in Income and Wealth 35, NBER, 1970.

<sup>2</sup> This formulation was also used in Chiswick and Jacob Mincer, "Time Series Changes in Personal Income Inequality, the U.S. Experience Since 1939 with Projections to 1985," *Journal of Political Economy, Supplement* (May/June 1972).

## An Integrated Model of Consumption and Market Activity

During the past year I have been trying to formulate a dynamic version of the model, described in last year's Annual Report, which would take life-cycle considerations into account. The approach is not based on a priori restrictions on the utility function, as is frequently done in the existing literature. Instead, use is made of the static results obtained for the effect of children of different ages on labor force participation and consumption, which has very clear life-cycle implications. I have also experimented with possible interactions between the optimal paths of labor force participation and consumption.

On the empirical side, I have been analyzing some Israeli data and expect the results to be incorporated into the final draft of the study. Of special interest is a comparison of the parameters obtained from Israeli and American data, in view of the existence in Israel of almost free day-care centers. The existence of such institutions should have an impact on the labor force participation of family members, and on family consumption.

Michael Landsberger

## The Returns to Educational Quality

The NBER has begun an extensive study of the returns to the quality of educational institutions. The NBER-Thorndike data set has been augmented by adding, for each individual, information on a variety of characteristics of the high schools and colleges he attended. The first study, conducted by Lewis Solmon and Paul Wachtel, aims to see if incomes are affected by type of college attended. The classification is that of the Carnegie Commission, which believed that there were important distinctions among eight groups of colleges classified according to commitment to research, types of programs offered, and selectivity of admission of students.

In subsequent work we abandoned grouping schemes in order to study effects of differences among individual schools. Lewis Solmon has been studying returns to college quality by inserting data on a variety of attributes of particu-

lar colleges into the human capital earnings function, using several different specifications.

Paul Wachtel has been developing measures of high school quality. Since work to date shows powerful effects of college quality, there is every reason to believe that differences in attributes of high schools should play an important role in income determination as well.

Progress in these three studies is reported in more detail below.

### *The Carnegie Classifications*

In this study we ask whether lifetime earnings patterns of people differ according to the type of college they attended. The classification scheme is the one developed by the Carnegie Commission on Higher Education; a report on the results has been prepared. The research indicates that part of the variation in the return to education is related to college type; that is, returns to schooling differ depending upon which of the eight college types was attended. Other determinants of the rate of return are under study and

some preliminary results will be discussed. The income histories of the NBER-Thorndike respondents are related to college type and other variables which are alleged to influence earnings.

In order to understand the variability among Carnegie classes of colleges, we present in Table II-2 mean values of various attributes of colleges distributed according to this scheme of classification. There are significant differences by Carnegie class in many of these variables.

Analysis of variance tests indicates that, for the sample as a whole, the initial income patterns are not significantly different by Carnegie college type attended, whereas current incomes do differ significantly. The latter result is largely due to the extreme values found for graduates of "other liberal arts" colleges (Group 8, mean 1969 income for those with sixteen years of school, \$14,577) and the "highly selective" colleges (Group 7, mean of \$21,172). There is evidence, however, that these differences are not entirely due to differences in the colleges them-

TABLE II-2  
Attributes of Colleges by Type

Carnegie Class	Average Faculty Salary (1)	SAT Verbal (2)	SAT Math (3)	Total Expenditure Per Full-Time Equivalent Student (4)	Overall Gourman Index (5)
1. Leading research universities	11,536	599	628	2,368	597
2. Other research universities	9,561	536	575	1,459	495
3. Large doctoral granting institutions	9,087	533	561	1,306	440
4. Small doctoral granting institutions	8,945	538	556	1,229	426
5. Comprehensive colleges with a substantial selection of programs	8,359	508	524	960	382
6. Comprehensive colleges with a limited selection of programs	8,043	503	525	938	358
7. Highly selective liberal arts colleges	9,502	571	589	1,599	427
8. Other liberal arts colleges	7,856	509	525	1,154	368
Per cent of schools responding	74.3	60.2	60.2	95.8	100.0
F test for differences in means	45.9	18.2	20.3	40.8	125.4

Note: Not all data are available for each school. The means are based only on available data. For a description of the Carnegie classes, see *Dissent and Disruption*, A Report of the Carnegie Commission, June 1971, Appendix C.

Sources: Col. 1, American Association of University Professors, "The Economic Status of the Profession," *AAUP Bulletin*, Summer, 1964. Data are for 1963-64; cols. 2 and 3, J. Cass and M. Birnbaum, *Comparative Guide to American Colleges*, Harper and Row, 1969 (Scholastic Aptitude Test scores of entering freshmen, 1967-68); col. 4, Unpublished data for 1963-64, from U.S. Office of Education; col. 5, J. Gourman, *The Gourman Report*, a subjective overall evaluation of colleges, each being assigned a value from 200 to 800.

selves but rather to the way students are sorted into colleges according to socioeconomic status and innate ability.

To sort out some of these effects, earnings functions were estimated by regression. The functional form suggested by the human capital model is given by:

$$\ln Y_{it} = a + rs_i + b_1j_{it} + b_2j_{it}^2 + u_{it}, \quad (1)$$

where  $Y_{it}$  is earnings;  $j_{it}$  is the experience of the individual  $i$  in the labor force at year  $t$ ;  $s_i$  years of schooling of the  $i^{\text{th}}$  individual; and  $u_{it}$  is the residual. The coefficient on years of schooling ( $r$ ) is the rate of return when opportunity costs are assumed to be the only cost of schooling and the specification of experience is that suggested by Mincer's model of on-the-job training. To increase the explanatory power of the model, other variables such as ability, occupation, and socioeconomic background can be added to the earnings function as shift variables accounting for individual characteristics.

We conclude that the earnings function, or the relationship between income and its determinants, does differ depending upon college type. There are different returns to extra years of schooling, different rewards to IQ, different rewards to occupational choice, and indeed, differing effects of college quality, depending upon the type of college we are considering.

The study of the effects of college type led to an examination of the rate of return to schooling for the NBER–Thorndike respondents. The return to college education implied by the basic human capital model (equation 1) is 5.25 per cent. When a measure of ability is introduced as a shift variable, this rate of return is reduced by 13 per cent, or .69 percentage points. The well-documented relation between schooling and ability is of importance in determining the efficiency of investment decisions; our results suggest that marginal rates for individuals of different ability (or at different types of schools) are not equal. This was tested directly by specifying separate schooling variables for individuals in each ability quartile. The estimated rates of return increased markedly with ability (2.82 per cent, 3.62 per cent, 5.53 per cent, 6.38 per cent).

Finally, the model has also been used to test for differences in the rate of return by college type. The coefficient of the schooling variable for undergraduate students of each college type varied from 7.14 per cent, 6.96 per cent, and 6.89 per cent for large doctoral granting, selective liberal arts, and leading research institutions, respectively, to 1.22 per cent and 3.18 per cent for comprehensive colleges with limited selection of programs and other liberal arts colleges, respectively. The estimating equation included the ability variable to control for its influence on college selection. The rate of return to the private and social components of schooling investments was shown to be 2.66 per cent and 3.84 per cent, respectively, although the breakdown of investments into private costs (opportunity costs) and social costs (all university expenditures) is admittedly imperfect.

#### *College Quality*

Lewis Solmon has been studying the effects of college quality on returns to schooling. This work is supported by the U.S. Department of Health, Education and Welfare through a grant from the Office of Education. College quality is defined and the method of its entering a model of individual income determination is studied.

Alternative available quality measures are average student quality, faculty quality expenditure data, student-faculty ratios, size of institution, and some subjective overall rankings of colleges.

Earnings functions have been estimated from data on individuals in the NBER–Thorndike sample. At first we concentrated on explaining 1969 income, which implies experience of about twenty years. Indications are that both student quality (peer effects)—measured by average level of SAT scores at a school, and faculty quality—measured by average faculty compensation, are powerful determinants of subsequent earnings, holding constant years of schooling, innate ability, and years of experience of the individual. From the work so far, several tentative conclusions can be drawn. First, individual ability complements college quality; second, additional years in school are substitutes for college quality in preparation for postschool earnings.

It appears that college quality has greater effects on students of high ability than on those of low ability. This result is seen when comparisons are made of size and significance of the coefficients on college quality derived from earnings functions, run separately for the high-ability and the low-ability halves of the sample. Quality differences also seem to matter more among colleges in the lower half of the quality distribution than among colleges in the upper half.

Tentative results suggest that additional expenditures by a college lead to quality improvements which make a significant difference in the earnings of its students twenty years later. To see whether the quality of colleges has an increasing or decreasing effect on earnings over time, earnings functions have been estimated to explain 1955 income and also income in the first year of employment for the same sample. It appears that college quality has no significant effect on initial-year income. Quality does, however, have a significant influence on 1955 earnings. Yet, no matter how quality is measured, the effect is smaller in 1955 than in 1969. It seems that the importance of college quality grows with experience in the labor force. One reason for this might be that students in better colleges are better prepared to benefit from on-the-job training in their postschool lives.

Solmon is currently working on a more complete specification of an earnings function in order to make certain that college quality is not merely a proxy for other factors influencing earning capacity. A more detailed study of the interactions among school quality, innate ability, and years of education is being conducted. The work so far has considered only quality in the last college attended. The interactions of school quality at different levels of schooling: college, postgraduate, and high school, are now being considered.

### *High School Quality*

In the past year, Paul Wachtel has begun a comprehensive examination of cost and quality differences in high school education, and their effect on income. The project will relate the income histories of the NBER-TH respondents to information about their high school education.

At this time a large data collection effort is nearing completion and the analysis will begin shortly.

It was necessary to code the information on each respondent's high school from the 1969 survey and also to collect information on the schools themselves. These data are currently being combined and put on tape for analysis. The 1937-38 Biennial Survey of Education provides data for most cities of more than 2,500 population, for urban and rural areas of each state, and for the whole state. Unfortunately, very little school-specific data could be obtained, nor could data be obtained for some countywide school districts, because the original Office of Education reports have been destroyed. Statewide data will be substituted for the missing data. The state averages for urban or rural areas are available, and the respondents' own description of the areas in which they grew up is used to identify rural areas. It is expected that intracity differences in high schools are important in only a few large cities. The median year of high school graduation in the sample is 1940, so the 1937-38 reports are representative of the time when most respondents were attending high school. An additional problem is that almost 20 per cent of the respondents neglected to write down the state in which they attended high school. The state in which the respondent's Social Security card was issued is used as a proxy. The procedure is subject to some error, but on the whole seems satisfactory.

The school data include a complete breakdown of expenditures as well as school size, teacher-pupil ratios, length of term, average days attended, number of supervisory personnel, and average teachers salary. The budget data are for the entire school system, but enrollment data and exogenous estimates of the relative costs of secondary schooling can be used to calculate high school expenditures.

Data on black schools in Southern states will be used to weight out the black component. White-only school inputs are the appropriate measure, as the respondents—our sample of World War II Air Force veterans—are all white. These calculations will be based on state average data for black schools.

Preliminary examination of the data reveals

that there is considerable variation in all school inputs. The expenditure data, however, reflect both differences in the quality of school inputs and regional price differences. Median income data for each state from the 1940 Census will be used as a "cost relative" in measuring differences in resources used in education.

School data from the Office of Education have been used in other studies to estimate school quality effects and educational production functions, but never at this level of aggregation. The data have never been applied to micro observations of long-run economic performance, nor have the locality data been used extensively. It is hoped that this study will identify the characteristics of education that determine earnings, and will thus help to define the quality of education. The microdata make it possible to distinguish school effects from other socioeconomic determinants of income.

Several lines of analysis are planned. First, the human capital investment model will be utilized to determine the rate of return to schooling investments. Second, a more general production function approach will be used to examine the various measures of high school quality. Lifetime earnings are the output of the educational process in this model. There are, however, some interesting (intermediate) outputs of high school education: the amount of additional schooling investment, and performance on the ability tests. Unfortunately the measures of ability that make the sample unique may not be exogenous in this study as the tests were taken after the respondent finished high school. A simultaneous model of high school outputs will be used to test the approach. The human capital model will be used to test the hypothesis that quality high school education shifts the demand for further schooling.

For the preliminary investigation, only the 1,200 respondents who did not attend college will be analyzed, to examine the quality and return to high school education alone. At a later stage the interaction between the quality of high school education and the return to college education will be examined.

The project is part of the Bureau's Quality of Education project, financed by the U.S. Office of Education. A preliminary report on the determi-

nants of the quality of high school education should be completed by the end of 1972.

Lewis C. Solmon

Paul Wachtel

### **Education, Research, and Agricultural Productivity**

Utilizing aggregate agricultural production functions, this study aims at exploring in some depth the role of farm operator education and of public agricultural research. The data, taken primarily from the 1964 Census of Agriculture, permit somewhat greater attention to detail than has been characteristic of earlier studies of aggregate production functions.

For example: observations are stratified by size of farm, as approximated by sales or land area, by age of farm operator, by tenure status (full or part owner, tenant, etc.) and by type of farm. Also, the input and product data are considerably improved. Since we are able to estimate quantities of feed grown and consumed on farms without having to rely exclusively on market transactions, we have the possibility of estimating separate crop and livestock production functions.

To identify sources of returns to education, we will experiment with alternative definitions of product and input. In these aggregate functions, product is measured as total revenue, and many of the classes of inputs are themselves price-weighted aggregates. By using historic rather than current price weights to evaluate the productivity of education, we can check to see if covariances between price and quantity changes are themselves functions of education. If it is true that education enhances information-using capacities, then it may enhance abilities to predict changes in market conditions as well. If so, then as relative input and product prices change, more educated farm operators should adjust activity mixes more rapidly. This adjustment should result in greater educational product, when product is evaluated at current rather than at historic prices. Direct tests are also possible: for example, Are price-constant changes in input and product shares related to covariances between changes in prices and farmer education? And are these changes affected by extension activity?

Much of our attention is devoted to evaluating the impact of agricultural research. Questions considered include:

1. Pervasiveness: Are productivity changes in state A related to research in state B? Here, we rely upon mappings of soil and climatic conditions against distributions of production to identify sources of borrowable research. The effects of within-state and out-of-state borrowable research are then compared.

2. Dimensions: Is research information scale-free, or is its impact conditioned by the number of potential users? For this, we experiment with alternative deflators. In the scale-free case, we assume that within producing regions the number of users is irrelevant. What is relevant is the size of the crop: Research into "important" crops is more productive. The alternative is that, at the margin, the value of research is independent of the product on which it focuses, but depends upon the number of users.

3. Timing: Is the impact of the research product hastened by extension activity and by farmer education? Does acceleration in the research flow increase the obsolescence rate of past research? We are experimenting with two models. In the first, the timing of the research impact is independent of the region. In the second, the timing varies, so that extension and education expedite adoption, and acceleration of the research flow increases depreciation.

Finis Welch  
Robert Evenson

## Law and Economics

### Introduction

Research on the application of economics to law is supported by a grant from the National Science Foundation to the National Bureau of Economic Research. Several studies in this project, which were described in detail in the 1971 Annual Report, have been completed. They are an empirical analysis by Isaac Ehrlich of the deterrent effects of penalties, probabilities of conviction, and other variables on crime rates in the United States, using cross-sectional data in 1940, 1950, and 1960 (to be published in *The Journal of Political Economy*); a study by Wil-

liam M. Landes on the court system (which has been published in *The Journal of Law and Economics*, April 1971); and another paper by Landes on developing rules for an optimal bail system. Two other papers, described in detail below, have been completed during the past year. Both of these studies attempt to quantify the effects of legal requirements. The first is an examination of the negligence system of accident liability by Richard Posner, and the second is an analysis of the effects of compulsory schooling legislation by Landes and Lewis Solmon.

Ongoing research, which is described more fully in the individual reports below, includes the following: Ehrlich's analysis of the trend over time in criminal offenses; Posner's work on adjudication by administrative agencies of the federal government; an analysis of the jury system by Posner and Landes; and a study of private police by Landes and Ann Bartel.

Several additional studies are being planned. Gary Becker is working on the incentives to enforce laws, in an attempt to explain differential enforcement. Melvin Reder is planning to examine the effects of malpractice litigation and insurance rates on the practice of medicine. We are also considering an empirical study of productivity in the judicial system.

Gary S. Becker  
William M. Landes

### The Time Trend of Crime

The volume of recorded crime in the United States has risen at a considerably faster rate than U.S. residential population over the past few decades. Between 1933 and 1968, the total rate of index-crimes (as classified in *Uniform Crime Reports*) committed per population approximately tripled, the rate of increase being particularly high for crimes against property in the subinterval 1958-68. Over that same period (1933-68) the number of policemen per capita doubled, and there has been a similar increase in per-capita expenditure on police activity in constant dollars, but indexes reflecting the effectiveness of law enforcement agencies in apprehending offenders and in convicting those charged with specific crimes generally show a

declining trend over time. Our research aims at identifying the basic factors underlying the trends in the various crime statistics, establishing the relevant causal relationships, and studying the interaction between the rate of criminal activity, public law enforcement through police and courts, and private self-protection by individuals and firms.

The trend exhibited by the crime statistics may be partly spurious, in that it may reflect changes in the efficiency of the F.B.I.'s reporting system, in victims' incentives to report crimes, in the definitions of specific crime categories, or in the real definitional content of crimes such as "forcible rape" and "larceny above \$50." Nevertheless, in regressing rates of change<sup>1</sup> of specific crime rates against calendar time, within the context of a multiple regression equation (to be discussed below), no systematic relationship between the two has emerged. In contrast, rates of change of specific crime rates have been found negatively and significantly correlated with estimates of the corresponding rates of change of the probabilities of being apprehended for crime and the conditional probabilities of being convicted once charged with crime. The elasticities associated with the former probabilities are relatively larger in absolute magnitude (as might be expected on a priori grounds, since arrest always inflicts certain costs on the offender which are independent of his potential cost of punishment if convicted). Rates of change of crimes against property have been found positively correlated with similar changes in per-capita "permanent income" in constant dollars (measured via Friedman's statistical method), and generally also with changes in the unemployment rate in the civilian labor force. Rates of change of civilian labor force participation rates have been

found negatively and significantly correlated with those of auto-theft rates and rates of specific crimes against the person. Finally, rates of change in the fraction of young age groups (15-25) in the population have been found positively related to rates of change in the incidence of specific crimes against persons but virtually unrelated to that of crimes against property.

The above results were based on two-stage least-squares estimates of the elasticities of three (relatively well-reported) crimes against property. Two-stage least-squares estimates were used to adjust for the assumed simultaneous relationships between crime rates and probabilities of apprehension and conviction. The results of our time-series analysis are consistent with the results of our cross-state analysis of crime variations in the United States in 1940, 1950, and 1960 (see earlier annual reports). Further work is planned in two main directions. First, we plan to investigate the effectiveness of public law enforcement activity in apprehending and convicting offenders and, thus, in controlling the rates of index-crimes over time. We will compare these findings with evidence regarding the effectiveness of law enforcement agencies and regulatory bodies in controlling other types of illegitimate activities. Second, we plan to investigate analytically the relation between public and private expenditure on protection against specific crimes, and to examine the implications of the analysis in light of the available empirical evidence.

Our work on the time trend of crime in the United States has also been extended to cover one important issue not considered in the cross-state empirical investigation, namely, the effect of the death penalty on the aggregate homicide rate. Some previous empirical investigations have concluded that the presence of the death penalty (by law or in practice) does not influence homicide death rates. This conclusion has been largely based on a simple correlation between homicide rates in contiguous retentionist and abolitionist states in the United States over the past few decades. My recent econometric analysis of crime and law enforcement suggests that simultaneous-equation estimation techniques are the correct method for determining a causal relationship between the frequency of

<sup>1</sup> Rates of change of specific crimes are measured as follows:

$$[\Delta \cdot \ln(\frac{Q}{N})]_{t-1} = [\ln(\frac{Q}{N})]_t - \rho_t [\ln(\frac{Q}{N})]_{t-1}$$

where  $(Q/N)$  is the specific crime rate (the number of offenses known to the police per civilian population), and  $\rho_t$  is the first order residual correlation coefficient estimated from the corresponding level regressions. Rates of change of all other variables in the regression were constructed in the same manner.

actual imposition of the death penalty and homicide death rates. I have attempted to explain the rates of change of murder and nonnegligent manslaughter in the United States between 1933 and 1968 by the rates of change in estimated probabilities of being arrested, convicted, and executed for murder, as well as in age composition and labor force participation rates. Our preliminary findings appear to challenge the conclusions of earlier studies in that they indicate a significant negative association between rates of change in the overall probability of execution and the homicide death rates in the United States. It is hoped that this study will be completed in the near future.

Isaac Ehrlich

### Accident Law

I have completed a study of accident law which was published under the title "A Theory of Negligence," in the first issue of *The Journal of Legal Studies*, a new journal of empirical research on the legal system. The study examines the relationship between the actual administration of accident law, based on the concept of liability for negligent conduct, and the prescriptions for an efficient system of accident control that might be derived from economic theory. The basis of the study is a sample of 1,528 appellate court decisions and a much smaller number of trial court decisions drawn from the period 1875–1905, the classic period of the negligence standard. A comparison of rules and results derived from the sample with the rules and results that an economic analysis would predict reveals a deep economic coherence in the legal system of negligence liability, and also several respects in which the system departed from the dictates of efficient allocation. The study also attempts a general comparison of law and the market as methods of resource allocation. Among other findings, the study appears to undermine the traditional proposition that nineteenth century accident law was designed and administered to promote the growth of certain enterprises, such as railroads, regardless of social cost.

Richard A. Posner

### Administrative Agencies

A preliminary study of the behavior of administrative agencies has been completed and will appear in a forthcoming issue of *The Journal of Legal Studies*. The first part develops a model, broadly resembling that developed by William M. Landes in his economic analysis of the courts, of the behavior of a rational utility-maximizing administrative agency. The model predicts how such an agency will allocate its resources as between different types of cases, how many cases of each type it will bring, how it will respond to changes in its budget, and when it will settle a case rather than litigate it. The model is tested against some empirical data drawn from the Federal Trade Commission. A principal finding is that a rational utility-maximizing agency will, under certain plausible assumptions, devote a disproportionate amount of resources to its small cases, in the aggregate.

The second part uses the model as the basis for an empirical inquiry into an important issue in administrative procedure: whether combining prosecution and adjudication in the same agency (a common practice) biases the agency's adjudicative determinations. The method of analysis used to examine this issue is to derive the implications of the hypothesis and then to test them, using data drawn from the Federal Trade Commission and National Labor Relations Board. An example of a testable implication is that members of an agency in which the functions of prosecution and adjudication are combined will be more reluctant to dismiss complaints issued during their tenure as members than complaints authorized by their predecessors in office. My tests of this and other implications of the bias hypothesis indicate that the hypothesis is not supported. The paper closes with a brief discussion of why, despite the apparent absence of bias, Congress decided to separate the functions at the Labor Board.

Richard A. Posner

### The Jury System

We are in the early stages of a study of the jury system. Formally, the jury is a representative sample of the population obtained by conscription, and jury duty may be viewed as a form of

taxation that differs among persons depending on the alternative uses of their time. In actuality, however, the jury may well be a largely voluntary and highly unrepresentative body. Data concerning the ethnic, occupational, and other demographic characteristics of jurors, their compensation for serving as jurors, and the exemptions and disqualifications from jury duty provided by law or by jury commissioners are being collected to enable a test of the hypothesis that the jury is a conscripted rather than voluntary body. One possibility is that the occupational characteristics of jurors (in comparison with those of the population from which they are drawn) will turn out to be correlated with rates of pay for jury duty in such a way as to suggest that those serving as jurors are, in fact, those for whom jury duty is relatively attractive, and that no significant element of compulsion is involved in their selection. This is plausible, since the sanctions for evading jury duty appear to be negligible. Initially, the data utilized will be drawn from previously conducted studies of jury composition and compensation, of which there appear to be a fairly large number.

William M. Landes  
Richard A. Posner

### **The Demand for Private Police in the United States**

This study was undertaken to explain the determinants of the demand for private police and guards. Between 1940 and 1969 the number of private guards and police increased by 60 per cent—from 181,468 to 289,900. Until recently, however, no attempt has been made to interpret this trend and assess its implications for public policy.

Our analysis focuses on the firm's expenditures for protection. In the model, the firm's decision to protect itself is incorporated within the profit-maximization process. The firm is assumed to face losses from theft by consumers, employees, and others. It can increase the probability of catching thieves via the employment of the entrepreneur's time and private guards. When profits are maximized with respect to capital, labor, and the probability of apprehension, a demand curve for self-protection can be

derived. The firm's decision to hire private guards is found to be a function of the cost of protection (which, in addition to the direct costs, includes the indirect costs of increases in wages that result from reducing the amount of employee theft), the size of the firm's work force, the value of the goods stolen, and the responsiveness of the amount of theft to changes in the probability of apprehension. An important implication of the model is that under certain conditions it is optimal for the firm not to spend anything on self-protection. The model can be extended to include the firm's expenditures for protection to reduce theft against its customers (e.g., the hiring of guards in apartment and office buildings). Finally, the form of punishment can also be viewed as a decision variable for the firm. One is then able to analyze the determinants of the type of punishment the firm chooses to use, i.e., whether to report the matter to the authorities, or to handle it internally through acceptance of a return of the goods stolen or dismissal of the worker. Using Census data for 1940, 1950, 1960, and 1970, FBI data on crime rates and penalties, and a survey of business losses from crime, we plan to test a number of hypotheses derived from the model.

Ann Bartel  
William M. Landes

### **Compulsory Schooling Legislation: An Economic Analysis of Law and Social Change in the Nineteenth Century**

We have recently completed a study (published in *The Journal of Economic History*, March 1972) on the effects of compulsory schooling laws in the United States during the nineteenth and early twentieth centuries. The objective of the research was to analyze empirically the determinants of differences in schooling levels both across states and over time. Not only did we attempt to resolve questions on the effectiveness of these laws, but we also provided insights into the general issue of law and social change.

Our analysis indicates that these laws did not cause the observed increases in levels of schooling in the period studied. The main evidence in support of this conclusion was derived from a multiple regression analysis of schooling

levels across states in 1880 and 1870. Here we observed higher enrollment and attendance rates, more days of attendance per school year, and longer school terms, not only in the thirteen states with schooling laws in 1880 but also in these same states prior to enactment of their laws. Therefore, the positive difference in schooling levels in 1880 between states with and without school laws could not be attributed to the presence of these laws, since equally positive and significant differences existed before they were passed. Additional evidence in support of this conclusion includes an analysis of changes in schooling levels from 1870 to 1880 and from 1880 to 1890, an examination of trends of schooling in Southern states from 1870 to 1920, and a brief analysis of state differences in the statutory provisions and enforcement of school laws in 1890. Finally, although increases in schooling and the enactment of schooling laws might appear to have occurred together in the years 1870 to 1920, our analysis reveals that relatively high levels of schooling, and probably increases in these levels, preceded the passage of compulsory school laws.

An alternative hypothesis, consistent both with the above findings and with some additional evidence which we present, is that compulsory schooling laws were in part the result of relatively high schooling levels. We developed an explanation for this causal relationship by utilizing the traditional tools of demand and supply and applying them to forces affecting the passage of legislation. On the demand side, teachers and school officials are likely to favor and promote legislation that compels persons to purchase their product; namely, schooling. As enrollment and attendance rates rise and the length of the school year increases, the number of teachers and school officials also increases. Along with a growth in their number, we expect an increase in their power to influence legislators to support a compulsory schooling law. On the supply side, the cost of passing a compulsory schooling law would be a positive function of the number of potential violators—in this case, the parents of children who would take less than the required amount of schooling. With a growth in schooling levels, the number of parents opposed to the enactment of the law

would obviously decline. In sum, the demand for a compulsory school law would increase and the costs of passage would decrease with increases in the level of schooling. Eventually, legislators would view the gains as exceeding the costs, and the law would then be passed.

We are now considering extending our work to an analysis of compulsory schooling in Great Britain in the nineteenth century.

William M. Landes  
Lewis C. Solmon

## Labor Market Studies

### Introduction

Last September the National Bureau completed a survey, commissioned by the U.S. Office of Economic Opportunity, of research possibilities within the general context of poverty and labor markets. As an outgrowth of this survey, OEO has been supporting a modest program of research into the economics of poverty, focusing around questions of labor supply, labor force participation of married women, and black-white earnings differentials. Projects supported under this program include the work of James Heckman on labor supply, Arleen Leibowitz on labor force participation, Jacob Mincer on income distribution and earnings functions, and Finis Welch on black-white earnings differentials. Three of these projects are reported separately below; the Mincer studies are described above in the section on education and human capital.

Part of the poverty research program consists of a workshop series, directed by Jacob Mincer, that capitalizes on the concentration of people interested in human resource problems in the New York area. The workshop is scheduled to meet five or six times during the year.

Finis Welch

### Studies in Household Labor Supply and Human Capital Formation

The major focus of research is on the formulation and estimation of household labor supply models. In this research, several of the traditional assumptions made in estimating labor supply

functions are relaxed. In particular, the assumptions of a household preference function and a joint pooling of income are dropped, yielding a theory of household formation and dissolution and a new set of testable predictions for empirical labor supply functions. The theory predicts differences between cross-sectional and time-series household labor supply equations based on economic theory rather than on the purely statistical differences in the two types of data. This model of the household is embedded in a life-cycle model of labor supply that explicitly allows for the effects of investments of time and money in raising the wage rate, thus systematically incorporating human capital theory into labor supply theory.

Empirical implementation of these models is under way, and, when completed, will provide a set of estimates for the effects of negative income tax programs on the supply of labor to unskilled labor markets and on household formation and dissolution.

A novelty in the empirical work is a new method of estimating income effects from cross-sectional observations, which recognizes that economic theory is cast in terms of infinitesimals while data record finite changes. This method is closely related to the concepts of equivalent and compensating variation as measures of welfare, which were proposed by Hicks in a different context. The method yields labor supply equations with parameters in accord with economic theory. A Monte Carlo study comparing the proposed method to the more conventional method suggests that the former is consistently more accurate in measuring the true labor supply parameters in cross sections, under a wide variety of alternative assumptions about underlying household and individual preference functions. Moreover, this study shows that conventional methods consistently yield statistically insignificant income effects even though the true income effects are known to be strong and negative. This finding helps to explain some of the unsatisfactory empirical findings for labor supply functions estimated by conventional methods.

A second topic of research is the estimation and specification of the human capital earnings function. Using new statistical techniques, it is possible to determine the form of the human

capital earnings function on purely statistical grounds. Preliminary results suggest that the statistically appropriate dependent variable is the natural logarithm of earnings, a procedure proposed by Mincer, and currently in wide use.

James Heckman

### Family Investments in Human Capital

Women's labor force participation and education are positively correlated over most of the life cycle, but during child-rearing years, time budget studies show that women with more education spend more time in child care than less-educated women, in spite of the fact that the price of their time is greater and the inputs of their time to other household production activities are smaller throughout the life cycle. I have completed a paper describing the differences in market and child-care time inputs by education class.

The use of time in child care can be considered an investment of resources in children. The purpose of the remainder of this study is to characterize these investments and to evaluate the return to them.

The analysis of investments in children involves an expansion of the concept of human capital to include those investments which are made in the home, in addition to those made through schooling or on-the-job training. If home investments are positively correlated with schooling, earnings functions that omit this variable will overstate the rate of return to schooling. Work is currently under way to prepare two sets of longitudinal data for testing the effect of home investment on earnings over time. The resurvey of the NBER-TH sample made in the fall of 1971 included questions that will allow estimation of human capital models that include investments of parents' time. I also have been working, in conjunction with Susan Crayne, on putting into machine readable form and recoding a tape of the Terman Sample. This survey contains forty-year earnings and investment histories of 1,500 individuals with IQ's over 140.

In studying the question of the character of time and goods investments in children, I have used the Consumer Anticipations Survey. The time costs of investments in children have been

estimated for various education levels of the mother. Regressions relating time inputs and goods inputs (ultimate schooling level desired) to price and income factors have been estimated.

Arleen Leibowitz

### **Black-White Differences in the Return to Schooling**

This work is concerned with the reasons why returns to schooling have historically been low for blacks, and examines the recent record for evidence of change. A paper summarizing the results is now available. The most important conclusions are:

1. In cross-sectional data there is very strong negative interaction between work experience and the return to schooling. In this case, the return to schooling is the proportional increase in earnings associated with completing an extra year of school. The negative interaction (returns are lowest for those with the most experience) is stronger for blacks than for whites.

2. In comparing cohorts from two cross sections (the 1960 Census and the 1967 Survey of Economic Opportunity) no evidence of attenuation (interaction) is found. Returns to schooling were constant for six cohorts over the seven-year interval—as experience increased by seven years.

The reconciliation of these observations is that the interaction results from vintage rather than life-cycle influences. Persons with one to ten years of experience in 1959 would have entered the labor force after 1949, and would have attended school in the preceding period. Those with twenty to thirty years of work experience in 1959 would presumably have gone to school and begun work anywhere from ten to thirty years earlier. That persons with more experience earn lower returns at a point in time may refer more to changes in quality of schools attended than to attributes of the individual's life cycle. That, at least, is the hypothesis presented in the paper.

The data show that interaction between schooling and experience is greater for blacks than whites. This difference in interaction is so strong that returns for persons entering the work force prior to 1950 are significantly lower for

blacks than for whites. But, for those beginning work after 1960, the opposite is true: returns to blacks exceed returns to whites.

In support of the quality of schooling hypothesis, evidence of changes in segregated school systems is considered from data published prior to the Supreme Court decision of 1954. Two points are obvious from whatever index of quality of schooling one selects. First, real inputs—student time and school resources—are increasing through time. Second, the increase has been more rapid for schools attended by blacks. At the time of the 1954 decision, there were large and probably important differences between black and white schools, but these are dwarfed by differences existing in the 1920–35 period. Evidently, fairly rapid change in relative quality began sometime around 1935.

That black-white schooling quality differentials continued to narrow after the 1954 segregation decision is evidenced both by the expenditures data, which continue to show convergence, and by independent data on reading scores. In New York City, reading scores of black third graders in *de facto* segregated schools rose from 2.7 to 3.3 years (against a norm of 3.5) between 1957 and 1969. During the same period, white scores were approximately stable.

The vintage effect will possibly be an important source of increasing relative earnings for blacks, but these effects are gradual. A fairly simple accounting of increases in relative earnings between 1959 and 1966 suggested that the lion's share of the gain was due to tightening labor markets over the period.

The future direction for this work includes a more detailed analysis of the pre-1954 data and of the reading score data for New York City. Also, the 1970 Census should contribute real insight into distinctions between vintage and life-cycle effects.

Finis Welch

## 4. ECONOMICS OF HEALTH AND POPULATION

### Introduction

The programs of research in the economics of health and population expanded during the past year. Several new studies were begun, several manuscripts were approved by the Board and sent to press, and two conferences on population were planned. The health studies, which are supported by the National Center for Health Services Research & Development, U.S. Department of Health, Education and Welfare, focus primarily on the determinants of health and the cost of medical care. The population studies, which are partially supported by a grant from The Ford Foundation, concentrate on the determinants of fertility.

Melvin Reder and Barry Chiswick have joined the health program; their respective studies of malpractice insurance and of hospital utilization are described below. Robert Michael has joined the population program; he is studying the effect of education on fertility. Marcia Kramer's study of abortion attacks questions that are of interest to both the health and population programs.

In June 1972 the National Bureau of Economic Research and the Population Council sponsored a conference on "New Economic Approaches To Fertility, Children, and Population Questions." T. W. Schultz of the University of Chicago was chairman. A second conference on this theme will be held in June 1973.

The following reports were published during the past year, or are in press, or are available in preliminary form.

1. Fuchs, V. R., "Impact of National Health Insurance Plans On Costs: A Framework for Determination," *National Health Insurance Conference Proceedings*, July 1971.

2. \_\_\_\_\_, "Some Notes on the Optimum Size of Population, With Special Reference to Health," in *Is There an Optimum Level of Population?*, S. Singer, editor, McGraw-Hill, 1971.

3. \_\_\_\_\_, "Health Care and the U.S. Economic System: An Essay in Abnormal Physiology," *Milbank Memorial Fund Quarterly*, April 1972.

4. \_\_\_\_\_, "The Financing of Health Services," *Annual on Benefit Cost Analysis*, Aldine-

Atherton, May 1972.

5. \_\_\_\_\_, (editor), *Essays in the Economics of Health and Medical Care*, NBER, in press.

6. \_\_\_\_\_, and Marcia J. Kramer, *Determinants of Expenditures for Physicians' Services in the U.S., 1948-68*, NBER, in press.

7. Grossman, M., *The Demand for Health: A Theoretical and Empirical Investigation*, NBER, in press.

8. \_\_\_\_\_, "On the Concept of Health Capital and the Demand for Health," *Journal of Political Economy*, 80, no. 2, March/April 1972.

9. Hughes, E., V. Fuchs, J. Jacoby, E. Lewit, "Surgical Workloads In A Community Practice," *Surgery*: 71:315-327, 1972.

10. Michael, R., "Dimensions of Household Fertility: An Economic Analysis," *Proceedings of the Social Statistics Section*, American Statistical Association, 1971, pp. 126-136.

11. \_\_\_\_\_, with E. P. Lazear, "On the Shadow Price of Children," December 1971 Meetings of the Econometric Society.

There are several studies reported on in section 3 of this Report, that are closely related to the programs in health and population. Of special interest are the studies by James Heckman on "Household Labor Supply and Human Capital Formation;" Arleen Leibowitz, "Family Investments in Human Capital;" and Richard A. Posner, "Accident Law."

Victor R. Fuchs

### Economics of Health

#### The Correlation Between Health and Schooling

The main purpose of this project is to test alternative explanations of the observed positive correlation between years of schooling and good health. A secondary aim is to construct and estimate a model of consumer decision-making, in which health, schooling, and wage rates are all viewed as endogenous variables.

The observed positive correlation between health and schooling may be explained in one of three ways: The first argues that there is a causal relationship that runs from increases in

schooling to increases in health. The second holds that the direction of causality runs from better health to more schooling. The third argues that no causal relationship is implied by the correlation; instead, differences in one or more "third variables" affect both health and schooling in the same direction. These three explanations were discussed in detail in last year's annual report.

I have begun to test competing hypotheses of the health-schooling correlation with data contained in the NBER-Thorndike sample. In 1955, Robert L. Thorndike collected income, schooling, and occupation information for nearly 10,000 white males who took the air cadet qualifying examination in 1943. In 1968 the National Bureau resampled these individuals and approximately 5,000 members of the original survey answered the Bureau's questionnaire. It should be noted that the men in the sample are drawn mainly from the upper tails of the earnings and schooling distributions. Everyone is at least a high school graduate, and their mean full-time salary in 1968 was approximately \$18,000. In this population, any observed effect of schooling on health represents the effect of having some college education.

In the empirical analysis, I have measured health by the response to the question: what is the general state of your health? There are four possible answers: excellent, good, fair, or poor. Although self-evaluation of health status is a subjective index of health, it correlates fairly well with a somewhat more objective measure: the number of work-loss weeks due to illness reported by the members of the sample.

Multiple regressions with health status as the dependent variable have yielded the following preliminary results.

1. With a number of potential third variables held constant, schooling has a positive and very significant effect on health status. The partial correlation coefficient between these two variables is greater than the partial correlation between health and any of the other variables in the regressions. In terms of the magnitude of the schooling effect, the schooling elasticity of health is exceeded only by the age elasticity. In addition, the beta coefficient of schooling (the partial regression coefficient multiplied by the

ratio of the standard deviation of schooling to the standard deviation of health) is exceeded only by the beta coefficient of full-time salary. I have not yet established the direction of causality implied by the health-schooling relationship. To the extent, however, that I have controlled for variables that are not present in other studies, confidence in the existence of a true relationship between these two variables should be strengthened.

2. All other things the same, an increase in father's schooling increases health and a reduction in the absolute value of the difference between actual weight and ideal weight for a given height increases health. Married men report better health than unmarried men, and younger men report better health than older men.

3. Health status is positively related to physical ability, but it is not related to mental ability. Physical ability is measured by scores on the visual perception and psychomotor control sections of the air cadet qualifying examination. Mental ability is measured by scores on the mathematics and reading comprehension sections.

4. Health status is positively correlated with an index of the degree to which a person is satisfied with his job. This relationship has two possible interpretations. On the one hand, regardless of the true state of health, someone who is satisfied with his job and with his life style in general may be more likely to report better health. On the other hand, dissatisfaction with life style may create tensions that actually cause mental and physical health to deteriorate. To the extent that the first interpretation is correct, health status loses some of its subjective aspects by including job satisfaction in the regressions.

5. An increase in full-time salary has a strong positive relationship with health status. This variable has the largest beta coefficient in the regressions. Preliminary results from the estimation of a simultaneous equations model reveal, however, that the causality implied by this relationship runs from health to full-time salary. That is, health and salary are positively correlated because an increase in health raises market productivity and not because those with relatively high salaries have a greater tendency to

invest in their health.

In future research with the NBER-Thorndike sample I will experiment with additional third variables, use alternative indexes of health, and try to establish the direction of causality implied by the health-schooling correlation. Additional third variables will include detailed occupation, mother's schooling, and occupational and social mobility. Health will be measured by work-loss weeks due to illness and by the mortality experience of the sample between 1955 and 1969. The causality problem will be handled by utilizing information on health during the years the members of the sample were attending high school. By holding past health as well as third variables constant, I should get an accurate estimate of the degree to which more schooling causes better health.

Michael Grossman

### Utilization of Surgical Manpower

The purpose of the surgical manpower project is to answer questions about possible excess capacity in surgery, the cost of surgery, and the financing of the training of surgeons. The project has been focusing on the measurement of the workloads of general surgeons in a variety of practice settings.

The measurement of operative workloads of general surgeons has been facilitated by the development of a unit of measure of surgical work, the hernia equivalent (H.E.). A hernia equivalent is defined as the amount of surgical work equal to that involved in performing a unilateral adult inguinal herniorrhaphy. This relative weighting system for surgical procedures is based on the relative values for each procedure as determined by the California Relative Value Scale, which we demonstrated was an accurate relative measurement of the operative work and the pre- and postoperative care involved in a given procedure.<sup>1</sup>

The first application of the hernia equivalent in measuring surgical workloads involved the determination of the annual in-hospital surgical workload of a population of nineteen general

surgeons, practicing in a suburban community in the New York metropolitan area.

The median weekly workload in this population (assuming forty-eight weeks of work a year) was 3.1 H.E. The mean was 4.3 H.E. per week and the range was 13.0 to 0.9. A consensus of general surgeons from a number of practice settings estimated that 10.0 H.E. per week would comprise a surgical workload sufficiently large to maintain operative skills and still leave adequate time for other professional and personal activities. The mean complexity per operation in this population of surgeons was 0.95 H.E.

In view of the relatively small surgical workloads in this population of surgeons, the question arose as to how the surgeons are spending the remainder of their professional time. To answer this question, a time-motion study was performed on this same population of general surgeons. Each surgeon was observed by Frederick V. Lorenzo, a fourth year medical student, for two randomly selected, nonsuccessive days in the late fall. The season was chosen because of the scarcity of holidays and vacations. (Observations were conducted for a six-day working week.) The observer met each surgeon at the beginning of his professional day; he recorded, until the close of the professional day, the nature and time requirements of each activity. The results are now being analyzed.

We have also measured workloads in a general surgical residency training program in a New York municipal hospital. This study shows how much of a resident's time is actually spent in doing surgery as opposed to other tasks, and enables comparisons of complexity of surgery with that in private practice.

In this residency program, both the volume and complexity of surgery (operation where resident was primary surgeon) tended to rise with each year in the program (see Table II-3). First-year residents were performing 0.9 H.E. per week of primary surgical work of average complexity, or 1.02 H.E. per operation. Chief residents, on the other hand, were performing 7.5 H.E. of primary surgery per week, which averaged 2.06 H.E. per operation. Chief residents were performing almost twice the mean volume of weekly surgery as the population of practicing surgeons. They were operating as

<sup>1</sup> Hughes, E. F. X., V. R. Fuchs, J. E. Jacoby, E. M. Lewit, "Surgical Workloads in a Community Practice," *Surgery*: 71:315-327, 1972.

TABLE II-3

## Surgical Workloads in a Residency Training Program in a Municipal Hospital

Year of Residency	No. of Residents	Total Man-Weeks Observed	Weekly Hernia Equivalent (H.E.)	Mean H.E. Per Operation
Chief Resident	6	95	7.5	2.06
Fourth Year	5	84	2.9	1.58
Third Year	5	63	2.9	1.20
Second Year	7	221	1.9	1.11
First Year	14	325	0.9	1.02

Note: Cases are those in which resident is primary surgeon.

frequently as the surgeons surveyed in the first study but their operations were more than twice as complex.

The development of the hernia equivalent as a unit of measure of surgical work enables one to evaluate the efficiency of the use of operating room facilities. Outputs of operating rooms can be measured (per unit time); and the cost of operating room support services required per hernia equivalent can be determined. We are now studying these questions in a proprietary medical center in the New York metropolitan area.

Further studies under way include measurement of the surgical workload of the general surgeons in a large prepaid group practice, and a time-motion study of the full-time general surgical faculty in a university hospital.

In collaboration with Richard J. Radna, a fourth-year student at Mount Sinai School of Medicine of the City University of New York, a study has been performed on the determinants of length of stay in a group of neurosurgical patients suffering from cerebello-pontine angle tumor. Multiple regression analysis demonstrated significant determinants of length of stay were presence of postoperative infection, number of chest films taken during hospital stay, age, and employment status. Eugene M. Lewit is an active collaborator in these studies and we have also received significant assistance from D. Fisher, C. Breckner, P. Goldberg, E. Rand, and M. Perides.

Edward F. X. Hughes

## Medical Malpractice

The initial phase of this project is concerned with determining whether the rising cost of malpractice insurance is explicable as a manifestation of generally rising costs of liability, and of insurance protection therefrom, or whether it results from forces peculiar to the liability of practitioners and institutions in the health field.

I am attempting to analyze movements in the cost of liability insurance, both for medical malpractice and for a variety of other liability risks, as among localities (in cross section) and over time. My objective is to determine a liability loss function whose arguments will include various community characteristics, such as lawyers per capita, per capita income, state legal codes, etc. It is hoped, the different types of risk will be effective dummies in explaining liability loss; medical malpractice will be a dummy to which close attention will be paid.

Contacts have been made with the Bureau of Labor Statistics and various private insurance organizations to provide data; the initial data gathering is still in process.

Melvin Reder

## An Intercity Analysis of Hospital Utilization

This project analyzes several dimensions of the utilization of general hospitals in 200 Standard Metropolitan Statistical Areas (SMSA). The variables to be examined are admissions per capita, patient days, bed occupancy rate, beds per capita and average hospital size.

An optimizing model is being developed in which hospital admissions and average length of stay (patient days per admission) are "determined" by the individual, who is assumed to view health as a commodity that enters his utility function. The cost and productivity of in-hospital care compared with out-of-hospital care are relevant for the decision. Hence, in addition to case-mix, sex, and age structure variables, the study considers the value of time, income, marital status, home amenities, climate, and health insurance. In addition, the rate of admission and length of stay may be subject to nonprice rationing by physicians and hospitals. It is hypothesized that the greater the crowding in hospitals (i.e., the higher the occupancy rate),

the lower are admissions and length of stay, other things being equal.

Hospitals are viewed as firms, and beds per capita, average (bed) size of hospitals, and average occupancy rate are viewed as being determined in an optimal manner for the SMSA. These variables are hypothesized to be related to the rate of admissions, length of stay, extent of health insurance, income, size of population, population density, and the extent to which the SMSA serves the surrounding area. In addition, the health, sex, and age structures of the population are relevant variables.

The variables measuring hospital utilization are interrelated, and the various equations are to be estimated simultaneously.

Barry R. Chiswick

### Abortion and Fertility in New York City

The legalization of abortion in New York State in July 1970 has markedly altered the external constraints on childbearing. The resulting situation presents an unusual opportunity to investigate the socioeconomic determinants of reproductive behavior. My research is directed towards three areas in which little work has been done in this country: (1) the demand for abortions, both legal and illegal; (2) the impact of abortion reform on fertility; and (3) the determinants of fertility under conditions of legal abortion. Separate analyses focus on out-of-wedlock fertility and its response to the new law.

The demand for abortion is a function of its price, income, attitudes towards abortion, and the incidence of unwanted conceptions. Because income and certain factors positively associated with preferences (e.g. non-Catholic religious affiliation) are likely to be related to contraceptive efficiency as well, their net impact on abortion demand is unpredictable. Fertility, too, is affected by unwanted pregnancies, but less so now that legalization has lowered the cost of birth control. Actual fertility should now more closely approximate desired fertility—the level that would obtain if birth control were costless—and the “true” effect of variables influencing contraceptive efficiency, as well as the demand for children, should be easier to ascertain.

The study is restricted to New York City residents. Data on legal abortions and on live births in each of the city's 347 health areas are on record with the Department of Health. Population figures and most of the independent variables are from the 1970 Census: summary statistics will be compiled on a health-area basis as soon as the tapes are released.

The total fertility rate (TFR) is the dependent variable in the analysis of births. Defined as the sum of all age-specific fertility rates, it represents the lifetime fertility of a woman, observing all age-specific rates of the given year. The corresponding variable for out-of-wedlock births (TOFR) pertains only to the population of unmarried women. In the abortion analysis the dependent variable is the total legal abortion rate (TLAR). The base period for births (*I*) is taken as October 1969–September 1970, the last year in which no births could have been averted by legal abortion (which is not recognized in the last trimester of pregnancy). The comparison period (*II*) is April 1971–March 1972, the first year in which all births could have been legally aborted from the time of conception. The demographic impact of reform is measured as the change in TFR from *I* to *II*, after adjusting the latter for the secular trend and for the cyclical effects of rising unemployment. Finally, the total illegal abortion rate (TIAR) which would have prevailed in the absence of legalization is estimated as the excess of legal abortions over the induced fall in births and the induced rise in conceptions (inferred from data on spontaneous abortions).

Regression equations explaining these variables are being designed to test a wide range of hypotheses concerning the determinants of reproductive behavior. Because of known racial differences in fecundity, the equations will be estimated separately for whites, blacks, and Puerto Ricans. The principal independent variables entering the analyses are: education; income, exclusive of female earnings and public assistance (both dependent upon fertility); the female wage rate (a major component of variation in child costs); the number of adults per household (another factor bearing on child costs); religion; nativity; median age of women at time of first marriage (related to women's per-

ceptions of nonfamilial role options); male/female educational differentials (indicative of the relative social status of women); Southern background; marital status and marital stability; male unemployment (lagged nine months); and health insurance coverage.

Preliminary figures indicate a fall in resident births from I to II on the order of 20,000, or about 14 per cent, against a rise of 2 per cent per annum from 1968 to 1970. However, nearly 65,000 legal abortions are being performed on New York City residents per year. Unless the fall in the price of abortion caused a sharp rise in the number of conceptions, it is evident that illegal abortion played a critical role in birth control efforts prior to reform.

Marcia J. Kramer

## Economics of Population

### A Theoretical and Empirical Study of Fertility in the United States

A phenomenon that has long puzzled students of population is the apparently unstable and inconsistent relationship of income and fertility. Except for the post-World War II "baby boom," American fertility has tended to decline secularly as per capita income has risen; yet, fluctuations in births are generally found to be positively correlated with short-run fluctuations in income. Furthermore, the cross-sectional relationship between family income and fertility has in the past tended to be negative; in recent years, however, the relationship has become somewhat U-shaped, first falling and then rising with income. Over the past several years I have been attempting to develop and test an economic model of household behavior that can be used to help explain the role income and other economic variables may have played in determining these puzzling patterns of cross-sectional differentials and secular changes in cohort fertility.

A brief description of my model of fertility behavior and some provisional empirical tests of its predictions were given in my paper with Warren Sanderson, which appeared in last year's Annual Report. In that paper we described a linear regression of husband's income and wife's education on fertility. The result showed

that the coefficient of husband's income had switched from negative to positive in regressions estimated from data on successive cohorts of American women born in 1881-85 to 1916-25. This apparent instability in the effect of income on fertility was explained, in terms of my theory, by the rising labor force participation of married women from cohort to cohort. According to my model, the cost of children is an increasing function of the value of the wife's time which, in turn, is equal to the wife's market wage, if she works, and is an increasing function of her husband's income, if she does not. The positive income effect on fertility caused by an increase in the husband's income is offset by a negative substitution effect resulting from the increased cost of children in households containing nonworking wives. On the other hand, if the wife's market wage is held constant, there is no offset to the positive effect of husband's income in households containing working wives. Since the labor force participation of married women is an increasing function of their own wage and, to a lesser extent, a decreasing function of their husband's income, the effect of husband's income on fertility should depend on the level of the wife's market wage, while the effect of the wife's wage should depend on the level of husband's income.

To test this explanation, an interaction term between husband's income and wife's potential wage was added to the regression model, and the parameters of the model were estimated for each of the cohorts of American women mentioned above. In every cohort, the coefficient of the interaction term was positive, as expected, and highly significant. Moreover, the parameters of the model tended to be quite stable from cohort to cohort. These results suggest that the changing pattern of simple correlations between income and fertility, both within and between cohorts, can be understood and perhaps predicted using a framework of economic analysis.

This past year I have been attempting to provide more explicit tests of the form of the fertility demand function implied by my model and its stability within and between cohorts. Empirically, this has involved using the 1960 Census one-in-a-thousand sample and the 1967 Survey of Economic Opportunity. A sample of 500,000

women from the 1940 Census (obtained from Richard Ruggles) has been edited and is now ready to be analyzed. Estimates of fertility demand functions, using these data sets, are now being made for a paper to be given in June 1972 at the NBER-Population Council Conference.

On the theoretical side, I have continued to develop the model of fertility control, described briefly in my staff report last year. I plan to use the 1965 National Fertility Survey, obtained from Charles Westoff, to test this theory. I have also become increasingly convinced that both the market and nonmarket productivity of household members can and should be treated within a human capital framework. As a first step toward doing this, I am estimating human capital earnings functions for husbands; I will use these to implement the concept of husband's lifetime income in estimates of fertility demand equations. I have also investigated theoretically the effects on the fertility demand function of regarding the wife's market wage rate as a function of her labor market experience. In this case, the price of her time will be greater than her observed wage rate and, because higher income of the husband tends to discourage market work by the wife, the price of the wife's time will tend to be a negative function of the husband's income among working wives, while it continues to be a positive function of his income among nonworking wives. The effect of making the wife's wage depend on experience is, therefore, to increase the difference in the form of the fertility demand function between working and nonworking wives. Should the quest for an empirically stable and theoretically well-grounded fertility demand function prove successful, our understanding of past and prospective population change will be greatly increased.

Our understanding of the connection between population change and changes in a wide variety of economic and social forces that impinge on the behavior of individual families would also be enhanced.

Robert J. Willis

#### **Education and the Derived Demand for Children**

Since joining the Bureau's project on the economics of population in the summer of 1971,

I have continued to work on delineating the mechanisms through which a couple's stock of human capital might affect their fertility behavior. In the context of the household-production-function framework of consumer demand theory, in which households desire a flow of child services derived from a stock of children, changes in human capital (e.g., in the form of education acquired through formal schooling) may affect the household's wealth and the value of time of its members. With an assumption about certain joint production possibilities and the relative time-intensity of activities related to children, the direction of effects of these changes in wealth and time values on the derived demand for children can be determined. Surely, a large part of the influence of education on fertility behavior works through its effects on wealth and on the household member's time value.

In addition, direct effects of education on the marginal product of time used in nonmarket production will have further wealth effects and probably relative price effects as well (see my *The Effect of Education on Efficiency in Consumption*, NBER Occasional Paper 116). These effects may also influence the household's demand for child services and the derived demand for children. When a production activity related to fertility control is introduced, increases in contraceptive efficiency across households by level of education may lower the price of avoiding "unwanted" children and thereby further affect the derived demand for children. A final mechanism through which education may affect the price of children is the relationship between the rate of depreciation of one's stock of human capital and the rate of utilization of that capital. Positing a negative relationship between depreciation and utilization rates for human capital (in contrast to the positive relationship often assumed for physical capital), labor-market-specific capital, if used relatively little in child care, may depreciate relatively rapidly while the parent is engaged in child-rearing. If so, the shadow price of the child will be higher than otherwise as a result of this "user cost" of the capital. Such a phenomenon can, I think, help explain the influence of education upon the timing and spacing of births as well as upon the

total number of children demanded by the household.

More extensive reports on the progress of this research are available. In a paper, "Dimensions of Household Fertility: An Economic Analysis," *Proceedings of the Social Statistics Section*, American Statistical Association, 1971, pp. 126-136, I indicate some of the observed partial effects of education on the number, timing, and spacing of children, and on the schooling level expected to be completed by the oldest child. These results are derived by cross-sectional analysis of suburban households from the 1968 NBER-Census Bureau's Consumer Anticipation Survey. In another paper (with Edward P. Lazear), "On the Shadow Price of Children," presented at the December 1971 Meetings of the Econometric Society, the effects on the price of children of a negative relationship between depreciation rates and utilization rates of specific types of human capital are discussed. Empirical implementation of this model, employing an endogenous earnings function and a derived demand-for-children equation, is now under way. Empirical work is also progressing on the partial effect of education on the choice of contraceptive technique, by birth interval, using the 1965 National Fertility Study.

Robert T. Michael

### Economic Determinants of Fertility Behavior

During the last year my research on the economic determinants of the fertility behavior of American women has progressed along two related lines. One line of research has been the estimation of monthly birth probabilities for cohorts of native white women by single years of age and parity. An example of the sort of data which have been generated may be seen in Table II-4. These data are now being analyzed to establish the structure of time series variations in fertility in the United States.

The other line of research has been a theoretical one. Its aim has been the creation of explicit economic models of fertility behavior which are applicable to the experience of cohorts of American women. Two sorts of models have been under investigation, both of which are modifications of Willis' economic model of fer-

TABLE II-4

### Monthly Second Birth Probabilities, Native White Women, Age 16-36

Age	Monthly Second Birth Probabilities, <sup>a</sup> (per cent per month)		Per Cent of Cohort Having One Birth at Beginning of Given Age	
	Jan. 1905	Jan. 1930	Jan. 1905	Jan. 1930
16	2.63	4.16	0.7	0.6
18	3.76	4.49	5.7	6.3
20	3.10	3.70	16.2	19.0
22	2.35	3.44	21.9	26.3
24	1.73	3.35	24.3	27.2
26	1.27	2.99	24.9	23.3
28	0.98	2.40	24.7	18.2
30	0.79	1.70	23.7	14.4
32	0.58	1.10	23.0	12.0
34	0.43	0.70	22.3	10.7
36	0.30	0.39	21.8	10.1

<sup>a</sup> This is the monthly probability that a woman of a given cohort and age, who has had one birth at least 12 months previously, will have her second birth at the given age.

tility.<sup>1</sup> The first is a numerically specified dynamic programming model of a couple's fertility, which has implications for both completed family size and child spacing. The second explains the distribution of observed fertility behavior within a particular group of people. This second type of model differs from others that determine fertility through the interaction of constraints and preferences, in that the mean fertility of the group's members is determined through the interaction of constraints and a behavioral distribution function. Our research indicates that models of household behavior that are explicitly specified for groups of individuals rather than for a "representative" individual have a number of advantages that make them potentially very useful in an economic analysis of variations in American fertility.

Warren C. Sanderson

### The Timing of Births

This project studies the effect of education on various aspects of the timing of births. One aspect is concerned with the time between suc-

<sup>1</sup> R. J. Willis, "A Theoretical and Empirical Study of Completed Fertility Control in the United States," unpublished, 1971.

cessive births, or between the first and last births. Another deals with the stage of the life cycle in which childbearing occurs, as measured by age, time since completion of schooling, or time since marriage. Also of interest in this analysis is the effect of education on the level of contraceptive efficiency, which is defined as the probability that a couple will not be exposed to the risk of conception in a month during which they practice contraception. Exposure to risk does not imply that conception necessarily occurs, for the probability of conception in a month of noncontraception is less than 1.00.

From various cross-sectional samples it appears that women with higher education complete their childbearing in a shorter period of time than do women with less education. This is observed whether or not one holds constant the number of births. (Not surprisingly, the intervals between successive births are shorter also.) Highly educated women are older at the birth of their first child, although this age increases by much less than one year for each additional year of schooling. They have been married longer at

the first birth but have been out of school (and in the labor force) for a shorter period of time. Within each category of family size, the interval between the first two births is shorter than the interval between the last two births, but this difference decreases with education.

I am attempting to explain these patterns by the effects of education on the wage rate and on the value of time in home production. Differences in education create differences in the value of time, at any given point in the life cycle and also in the profile of the value of time over each individual's life span. The problem is complicated by the differential incidence of contraceptive failure among education levels. Intervals which maximize utility (minimize cost) may not be observed, both because of the occurrence of unexpected pregnancies and because the strategies employed by couples who recognize the possibility of contraceptive failure distort their timing and spacing decisions compared with those that would be observed in a world of perfect certainty.

Sue Goetz Ross

## 5. FINANCIAL AND INDUSTRIAL INSTITUTIONS AND PROCESSES

### Financial Institutions and Processes

#### Introduction

The National Bureau's research in the financial area has been reviewed in a new publication, *Finance and Capital Markets*, John Lintner's contribution to the Bureau's fiftieth anniversary program.<sup>1</sup> This volume includes suggestions by Lintner and several other participants as to the main directions and priorities for future financial research.

The chief element in the Bureau's current financial research program is the study of the effects of inflation on financial markets. This project is reported on below by Phillip Cagan, along with other studies by Klein, Kresge, and

Troy. Related work, focusing on the determinants of the rate of inflation, is discussed in section 1 by Cagan, Fabricant, Friedman and Schwartz, and Gordon.

Two new studies were started during the year. Benjamin Klein reports on one below. In the other, Wilbur Lewellen will examine the portfolio performances of individual investors in the stock market during the 1960's. Using a random sample of accounts, provided according to his specifications by a brokerage firm, Lewellen will compare the performance of individual investors' portfolios with that of randomly selected portfolios, and will relate performance to such characteristics as the size and the composition of the portfolios.

Several earlier studies reached or neared completion during the year. The release of Edgar R. Fiedler's *Measures of Credit Risk and Experience* and Philip A. Klein's *The Cyclical Timing of Consumer Credit, 1920-67* completes

<sup>1</sup> *Economic Research: Retrospect and Prospect, Fiftieth Anniversary Colloquium IV, Finance and Capital Markets*, NBER, 1972.

the program of publications for the project on The Quality of Credit in Booms and Depressions. The series consists of five books and four Occasional or Technical Papers. Phillip Cagan's book on *The Channels of Monetary Effects on Interest Rates*, part of the Study of Interest Rates supported by the Life Insurance Association of America, was published in 1972. The last report expected from the study, on "Calculation of Yield and Value of Residential Mortgages" by Anthony J. Curley and Jack Guttentag, is being revised in response to comments by a staff reading committee.

*Institutional Investors and Corporate Stock: A Background Report*, a version of which was published as part of the Securities and Exchange Commission's *Institutional Investor Study* report, is being adapted for Bureau publication by Raymond Goldsmith and his collaborators.

Robert E. Lipsey

### The Effects of Inflation on Financial Markets

The inflation in the United States since the mid-1960's has been accompanied by extremely large increases in interest rates. This fact alone indicates that financial markets were responding to the inflation. As the inflation persisted in 1970-71, despite policies taken to curb it, attention has focused on public anticipations of continuing inflation as an important element affecting the process of inflation. Nowhere was the distinction between the effects of inflation itself and the decisions taken in anticipation of inflation more important than in financial markets and financial decision-making. A grant from the Life Insurance Association of America enabled the Bureau to undertake, in 1971, a broad study of these effects of inflation on the financial sector. The project has five parts, four of which are discussed separately below.

The first part, by John Lintner and Thomas Piper, is a study of financial institutions, primarily life insurance companies, but also pension funds, savings and commercial banks, and other insurance companies. The emphasis is on the portfolio decisions of these institutions in response to inflation. The study is making use in part of company data derived from interviews and company files made available to the Na-

tional Bureau.

The second part is a study of the effect of inflation on bond yields. Thomas Sargent is building upon his previous work on the role of anticipations of inflation in explaining the long-observed correlation between bond yields and inflation. He has found that previous methods of measuring the effect of anticipations have given biased results. The lag in the adjustment of anticipations to inflation and the accompanying effect on bond yields appeared longer than in fact it is because previous methods disregarded feedback effects of interest rates on price changes. Sargent is studying this problem further and experimenting with new methods of overcoming the bias, using data over long periods for the United States and several other countries.

The third part involves an analysis of convertible bonds in the period since the late 1950's when they began to be important in the U.S. financial market. Stanley Diller has compiled data on a sample of convertible bonds and is comparing their market yields, which incorporate the equity value of their conversion option into common stock, with the yield on comparable straight bonds of the same company. Inflation and expectations of future inflation are presumably major influences on the value of the conversion option.

The fourth part of the project focuses on household financial portfolios. Lester Taylor is examining the effect of inflation on household decisions to save and on choices between fixed and variable dollar assets. He is using household survey data on asset holdings from various sources. These survey data are particularly appealing for his purposes because they contain answers to questions about anticipations of price changes.

The fifth part involves the collection of data on common stock prices for a wide variety of countries as far back as reasonably reliable indexes are available. These data will allow an examination of how well stocks in different countries have kept pace with changes in commodity prices over long and short periods. There have been many studies of inflation and stock prices, but most concentrate on a few countries and selected periods. I am conducting this part of the

project with the assistance of Doris Preston and Johanna Stern. Naoya Takebe, an exchange associate at the Bureau in 1971–72 from the Japan Economic Research Center, has collected stock price data for Japan. The data compilation is benefiting also from the advice of Raymond Goldsmith.

Phillip Cagan

### Investment Policies of Major Financial Institutions Under Inflationary Conditions

This study deals with the impact of the high, and accelerating, inflation of 1965–71 upon the investment positions and policies of major financial institutions, and the manner in which they adapted to the stresses and strains of the period. It also deals with the shifts in the portfolio strategies and positions of these institutions as they affected the flows of funds and structure of yields in the broader financial markets. The identification and analysis of the changes in investment practices induced by inflation and inflationary expectations require a clear understanding of what the basic investment policies were—or at least what they would have been in the absence of inflation. For this reason, and to provide a more generally useful perspective, the time period covered in the study is being pushed back to 1960, or even earlier whenever possible.

The study will include a rather detailed analysis of the changing portfolio composition—in particular, the shifting mix of new investments—of a variety of institutions: life insurance companies, private uninsured pension funds, savings banks and the mortgage departments of commercial banks, and such relatively unstudied but important institutional investors as non-life insurance companies and state and local pension funds. These studies, of course, make use of all published data sources, such as the Federal Reserve's Flow of Funds Accounts (and associated balance sheet data), the S.E.C.'s *Institutional Investor Study*, and trade association reports. In order to deepen our understanding of the policies being followed, and the underlying reasons for these policies, we are conducting extensive field interviews with senior investment officers (usually several) in a cross section of companies in each type of institution. In addition,

we are obtaining a substantial body of internal data from several of the institutions for a more detailed analysis of individual company policies and responses to changing conditions. As an illustration of our work with company data, we have been collecting and analyzing the following information from a group of life insurance companies: (a) internal forecasts of future cash flows, by quarters, and by major components, including estimates of policy loans, normal insurance operations, investment income and principal repayments, which will enable us to analyze the effects of the difference between expected and actually realized flows upon current investment decisions; (b) a detailed record of outstanding commitments for different types of mortgages and private placements classified by expected take-down dates, and a corresponding classification of new commitments made each quarter; (c) liquid assets each quarter and excess over estimated minimum cash requirements; (d) the dollar volume of new commitments and purchases which have involved equity participations in some form, including warrants, convertible features, and escalator clauses in mortgage loans, together with estimates made at the time of purchase or commitment of the probable "worth" of the participation feature whenever available; and (e) the dated forecasts of future changes in interest rates made by companies which retained records of these assessments.

It is well-known that aggregated data frequently fail to reveal the underlying process and patterns of adjustment to changing conditions with any clarity or precision. We hope that we can successfully overcome this common deficiency of aggregated data by accumulating and analyzing more detailed internal data, as well as by supplementing our statistical analysis with the insights provided by extensive field interviews. All the specific information obtained in interviews and all the internal company data are, of course, being held in confidence, and will not be used in any identifiable way without specific permission. They are, however, providing very valuable inputs to our work.

All earlier studies have had to rely on publicly available information and, for lack of anything better, have always had to infer from some aver-

age of past data what decision-makers were presumably expecting future conditions to be. Then, in the absence of more reliable information, they have had to use these statistical proxies of the actual expectations to infer the effects of such judgments about the future upon current investment decisions and upon the process by which portfolios are adjusted to changing conditions and judgments. By virtue of our research design and procedures—and the cooperation of the investing institutions in our sample—we can study the portfolio adjustment process in terms of the actual projections of future cash flows or investible funds and expected yields, rather than having to base our analysis on an outsider's statistical proxy in each case. We can also examine the effect of "forecast errors" (e.g., the difference in a given quarter between the actual pool of investible funds and the amount which had been anticipated earlier) upon the process of adjusting portfolios to changing objective conditions.

Our work to date has been largely devoted to interviewing, gathering data, and making preliminary analyses of the information obtained, as well as the clarification of certain fundamental issues of a more theoretical character. This work indicates that there have indeed been substantial changes in institutions' investment behavior over the years since 1965 when inflation began to accelerate. But many of these changes seem, so far at least, to have been an adaptation to the changed patterns of fund flows and the structure of yields available in the markets, rather than any change in basic investment policy attributable to expectations of further future inflation as such. One of the most difficult—as well as, theoretically and practically, most important—issues involved in our study involves the effort to distinguish between the effects of expectations of future inflation and the effects of price changes which have already occurred. We are finding the latter effects to be of major magnitude and significance, as well as quite pervasive, but the former effects are proving to be somewhat more isolated and difficult to pin down.

Two of the more prevalent and generally significant effects of the expectations of future inflation as such involve judgments of the relative desirability of common stocks as investments

and the use of "participation features" in debt contracts. Our study of the latter has not yet reached a stage which would justify comment at this time. With respect to common stocks, however, there has been a pervasive and very marked shift in judgment and policy which goes to the heart of our research. As is generally known, most institutions were increasing (often substantially) the fraction of their funds invested in common stocks in the years 1965–68, in large measure because more inflation was expected and common stocks were thought to be good "inflation hedges." But as inflation accelerated further in the next two or three years, new investments in equities were cut back drastically because by that time the judgment was that more inflation, which was expected, would be bad for equity values.

This marked reversal of the effects of inflation—and of the expectations of more inflation—on the investment policies of these essentially long-term investors raises further issues which we are exploring in greater depth. What, under conditions of continuing inflation, is the proper role of equities in the portfolio of major institutional investors whose liabilities are denominated in terms of nominal dollars rather than in "real" terms? Is it true that beyond a certain point more inflation is necessarily and always bad for equity values? Should we rather say that the effects of inflation upon equity values depends upon the surrounding circumstances and the kind of inflation, as well as its duration and its severity? There is a large body of research at the National Bureau and elsewhere on wage rates, productivity, labor costs, prices, profits, profit margins, and interest rates which can be organized to clarify the complex channels and relations between inflationary pressures and equity values. At least one chapter of our study will be devoted to the analysis of these broader issues.

John Lintner  
Thomas Piper

### Interest Rates and Commodity Prices

My paper "Interest Rates and Prices in the Long Run: A Study of the Gibson Paradox" was presented last November at the Conference on Secular Inflation, sponsored by the Universities-

National Bureau Committee. Another paper on a related topic, "Anticipated Inflation and the Nominal Interest Rate," appeared in the May 1972 issue of the *Quarterly Journal of Economics*. I am currently extending this work by using frequency domain techniques to analyze the relationship between interest rates and inflation that is implicit in a linear, stochastic macroeconomic model. Essentially, the model consists of an "IS" curve, an "LM" curve, and a "Phillips curve." Interest rates, prices, and income are mutually determined. As a result of this simultaneity, regressions of interest rates on current and past rates of inflation do not in general permit one to recover very much information about the particular process by which inflation causes expectations of more inflation in the future, thereby causing nominal interest rates to be bid upward. Regressions of interest rates on current and past inflation have often been interpreted as yielding exactly this kind of information. It follows that such regressions have often been misinterpreted. My results provide an explanation of the "Gibson paradox" that can be viewed as an alternative to Irving Fisher's.

In some related work with Neil Wallace of the University of Minnesota, I have been investigating the process of expectations formation during hyperinflations to compare alternative ways in which expectations of inflation might have been formed. Various models of "rational" expectations are studied. In order to discriminate empirically among alternative expectations-generating schemes, we utilize a test proposed by Christopher Sims that permits us to determine the structure of feedback between money creation and inflation. Our results indicate important feedback running from inflation to money creation, a pattern that we argue helps to rationalize Phillip Cagan's "adaptive" expectations model during hyperinflations.

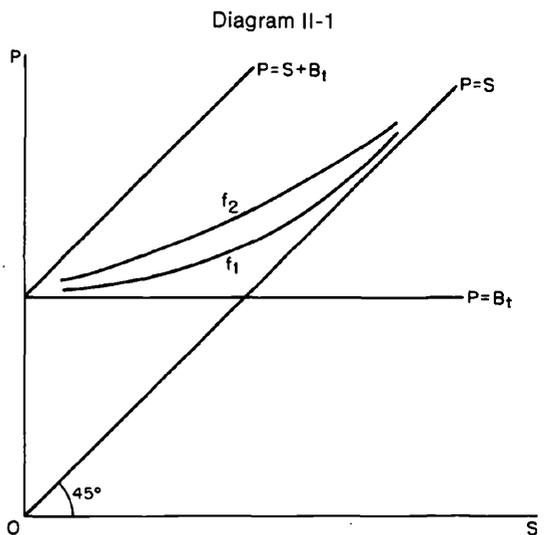
Thomas Sargent

### Convertible Bonds

The popularity of convertible bonds waxes and wanes with the degree of uncertainty in the capital markets. In principle, an interest rate quoted at a given time includes an offset to any expected changes in purchasing power between

the origination and redemption of a loan. But the greater the uncertainty associated with the expected changes in price level, the greater the danger the interest rate in question will over- or under-adjust for the realized price change, with consequent windfall gains and losses to the transacting parties. By incorporating a conversion feature, whereby a bond is exchangeable, at the holder's option, for a previously specified quantity of common stock of the same issuer, a convertible bond permits the transacting parties, in effect, to defer decision in regard to their expectations of the rate of inflation. The putative cushion against inflation that the conversion feature provides obviates the need to fix an adjustment in advance of the actual change in the price level. As explained further below, convertible bonds also help to mitigate the uncertainty associated with the equity market.

Because convertibles provide a cushioned medium for holding their embodied straight bonds and conversion stock, they command premia over their straight-bond and stock values. The extent of these premia is subject to a number of well-known influences that we can describe conveniently in the context of shifts in and movements along a curve ( $f_n$  in Diagram II-1). A brief explanation of these influences helps to



$P$  = price of convertible bond.  
 $S$  = stock value of convertible bond.  
 $B_t$  = straight-bond value at a given time  $t$ .  
 $f_1$  and  $f_2$  = members of the family of functions  $f_n$  of  $P$  on  $S$ .

clarify the market mechanisms underlying convertible bond pricing, as well as the statistical work in progress. Except for a temporary market lapse, the price of a convertible bond does not exceed the sum of its straight-bond and stock values, nor does it fall short of the higher of these two: the former because the convertible, at best, contains no more than the sum of both components; the latter because it is convertible into either component.

The curves  $f_n$ , showing the price ( $P$ ) of the convertible at a given stock value ( $S$ ) will be higher (e.g.,  $f_2$  relative to  $f_1$  in Diagram II-1) the more the convertible in question exemplifies the advantages of this type of security. Among the more important characteristics are the following:

*Variance of Stock Price.* The value of the convertible is ordinarily higher relative to that of its underlying stock (that is,  $f_n$  is higher) the greater the dispersion of the stock price. The most important reason lies in the asymmetry in the relative distances travelled by the two securities upward and downward. Whereas the upward movement of  $P$  follows  $S$  without limit (except as indicated below), the downward movement is bounded by  $B$ , which provides—in principle—a floor for  $P$ . This asymmetry increases with dispersion in  $S$ , as well as with the narrowing of the difference between  $S$  and  $B$ . (On the other hand, the value of the convertible may be negatively influenced by the increase in its own dispersion that is due to the increased dispersion of the stock. This effect, however, is usually smaller than the first one.)

*Quality of Bond Floor.* Because of its contribution to the above-mentioned asymmetry, the quality of the bond floor is an important component of the option value of the bond. In this context, quality implies not only the stability of the bond price but the extent and direction of covariation with the stock price as well. Lower variance of  $B$  and more inverse correlation between  $B$  and  $S$  raises  $f_n$ .

*Maturity.* The longer the remaining term to maturity, the more durable the option and the higher  $f_n$ .

*Leverage.* Prior to 1968, the margin requirement under regulation T permitted greater leverage for purchases of convertible bonds than of

the underlying stock, permitting bond holders to control more stock per dollar of investment than stockholders. This point is no longer true. Hence,  $f_n$  is lower than it was.

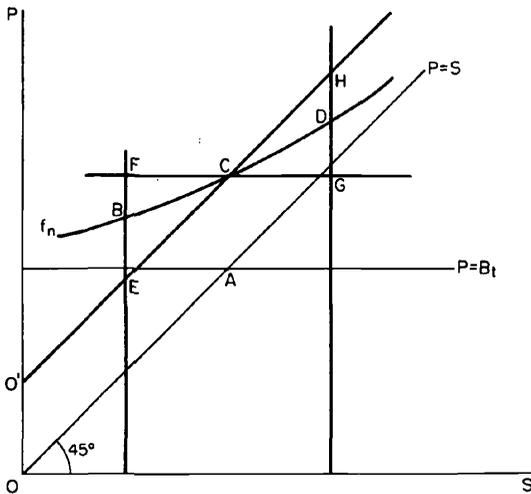
*Dividends on Underlying Stock.* Since convertible bond holders forego dividends on the underlying stock,  $f_n$  falls as dividends (and hence the opportunity costs of holding bonds relative to stock) increase.

Cross-sectional estimation of the relationship between  $P$  and  $S$  must specify these characteristics, if it is to avoid erroneous groupings of observations from different  $f_n$ . Fixing the  $f_n$ , in effect, defines a particular option quality; that is, it establishes a unit of measurement. However, the value attached to these units may vary over time, insofar as the particular properties of a convertible are more or less desired. Since these properties relate primarily to the stability of the convertible relative to the underlying stock and straight-bond values, variation in the demand for these properties is, in principle, tied to variation in the concern over stability. Hence, an estimation procedure that successfully fixed the units of option value through time would permit estimation of period-to-period variation in the level of uncertainty concerning stock and bond values.

The use of the conversion premium to estimate the degree of uncertainty appears in conflict with the idea that options are bid up in anticipation of a rise in the optioned stock. This idea has merit to the extent the option conveys leverage by giving the holder control over more stock per dollar invested. The greater risk of this position implies the expectation of greater gain through appreciation of the stock. However, the straight-bond component of a convertible offsets the leverage in its option component. Hence, direct purchases of the stock more fully anticipate increases in its value.

By far the largest source of variation in  $P$  is due not to shifts in  $f_n$  but rather to movements along it; that is, to variation in  $S$  and, to a much lesser extent, variations in  $B$ . Diagram II-2 shows the movement of  $P$  along a particular  $f_n$  for positive and negative unit changes in  $S$ . The non-linearity of  $f_n$ , that is, the tendency for the difference between  $P$  and  $S$  to decrease as  $S$  increases, is due to the following considerations:

Diagram II-2



**Probability of Call.** The probability of a call increases with increases in  $S$ . Since the imminence of a call would force conversion, the value of the bond would revert to its stock value, and the premium would be lost—hence the reluctance to pay a premium at high levels of  $S$ .

**Effectiveness of Bond Floor.** As  $S - B$  increases, the bond floor increasingly becomes academic.

**Reduction in Asymmetry.** As  $S - B$  increases, the truncation effect, and hence the option value, decreases.

The rate at which the premium declines is determined by the curvature of  $f_n$ . The greater this curvature, the more of the rise and the less of the fall in the stock value is experienced by the convertible. In Diagram II-2, for an equal rise and fall ( $CG$  and  $CF$ , respectively) in the stock value, the corresponding rise,  $GD$ , in the bond exceeds the corresponding decline,  $FB$ . The greater the curvature of  $BCD$  ( $f_1$  and  $f_2$  in Diagram II-1) the greater the disparity between  $GD$  and  $FB$ .

To estimate the relationships described above, the study has collected monthly data on a cohort of forty randomly selected convertible bonds (randomly replacing bonds as they expired) in the period 1958–71. The cohort format yields cross-sectional estimates of the relationship between, say,  $P$  and  $S$  (that is, the level and curvature of  $f_n$ ) across bonds at a given time, as well as across time for a given bond.

Chart II-2 lists monthly averages (averages of the forty bond values) of the prices of the convertible bonds, the values of underlying stock, and Moody's estimates of the underlying straight bond values ( $P$ ,  $S$ , and  $B$ , respectively). While  $P$  follows  $S$  fairly closely, the difference between the two curves clearly is inversely related to the level of  $S$ . In 1962, for example, when  $S$  plummeted,  $P$  fell considerably less, and the gap between them increased. This gap decreased as  $S$  rose in 1965–66. But when  $S$  and  $B$  fell, in 1967, they took  $P$  with them.

One objective of the study's empirical analysis is to separate statistically the variation in the units of option or security inherent in the convertible from the value the market places on these units. One approach considers the cross-sectional estimates reflective of variation in units and the time series estimates of variation in value (that is, a measure of uncertainty). Both cases require estimation of the level and shape of the  $f_n$  curves shown in Diagram II-1. Since the curves clearly are nonlinear, estimation requires both a suitable mathematical form and a stable specification. Up to now, the study has used a quadratic form, as in the following example of a sample specification for January 1967:

$$P = 52.65 + .4348 S + .0013 S^2 \quad R^2 = .9837$$

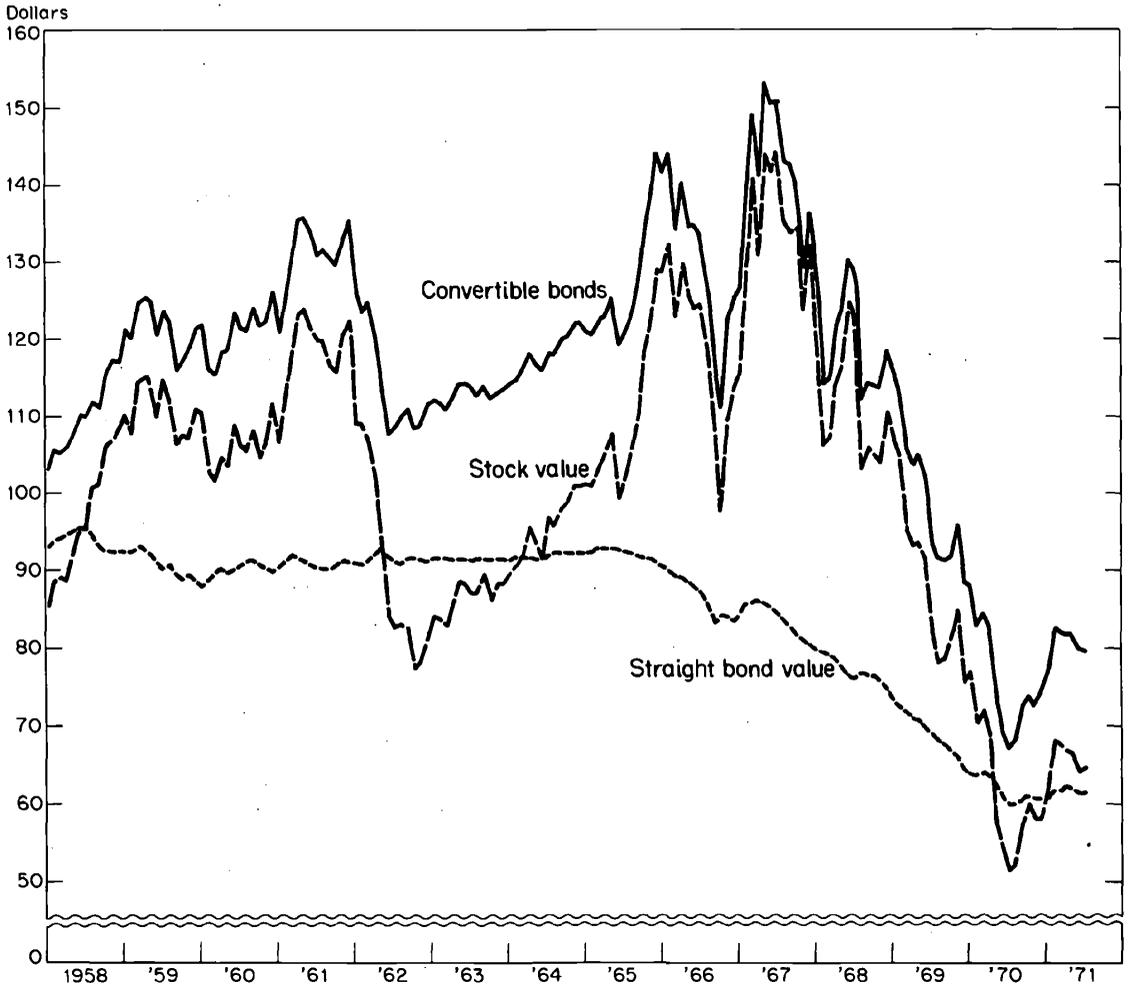
(6.11)      (6.03)

at  $S = 100, dP/dS = .6938$ .

Within the range of the data, many families of curves would fit the data adequately, provided the specification of variables permitted reasonable estimates of the parameters. However, one penalty of not having the correct mathematical curve is the uselessness of predicted values at the extremes of the curve, that is, outside the usual range of the data. For example, the intercept of the above equation is a poor estimate of the level of  $f_n$  because, at  $S = 0$ , the quadratic function is irrelevant to the data. Moreover, there is reason to believe that the second derivative,  $d^2P/dS^2$ , is itself variable, perhaps moving along a parabola concave to the  $S$  axis. The study is therefore experimenting now with alternatives to the quadratic function.

Some of the variables discussed earlier appear in the next regression, the observations

Chart II-2  
 Average Prices of Convertible Bonds and Their  
 Straight-Debt and Equity Components,  
 Monthly, 1958-71



of which are derived from averages computed for each bond over time, as well as the standard deviation of stock values and the regression coefficient (computed separately for each bond) of the bond value on the stock value.

$$\bar{P} = 49.3560 + .4654 \bar{S} + .0010 \bar{S}^2 +$$

$$.2584 SDS - 11.2612 b_{B/S}$$

(10.44)    (7.42)

(6.41)    (-3.55)       $R^2 = .9753$

where:  $\bar{S}$  = mean value of  $S$  for a given bond,  
 $\bar{S}^2$  = square of  $\bar{S}$ ,  $SDS$  = standard deviation of  $S$  month-to-month for a given bond,  $b_{B/S}$  = regression coefficient of  $B$  on  $S$ , taking month-

to-month observations for a given bond. There are as many observations as there are bonds, approximately 120. The positive influence of the standard deviation and the negative influence of the covariation of  $B$  and  $S$  are consistent with the earlier discussion.

Stanley Diller

#### The Influence of Price Expectations on Household Saving

The purpose of this study is to analyze the influence of individual price expectations on the rate and composition of household saving. Both time-series and cross-sectional data are to be

analyzed, but the primary focus will be on the data on price expectations of individual households contained in the following sources.

1. The NBER-Bureau of the Census Consumer Anticipations Survey, conducted five times in 1968-70 at six-month intervals.

2. The somewhat similar body of data collected by the Survey Research Center, Institute of Social Research, University of Michigan, four times at yearly intervals over the period 1967-70.

3. The Consumer Union Survey conducted in the late 1950's.

The time-series analysis, on the other hand, will be based on data from the national income accounts and the flow of funds, and will utilize a price expectations series constructed from the Survey Research Center's quarterly surveys of consumer anticipations.

The analysis will proceed in the framework of a model which relates household saving to income, existing stocks of real and financial assets, certain life-cycle variables, and price expectations. Both the total of household saving and its composition by broad asset class are to be analyzed. Finally, variants of the model will consider income not only in the aggregate from all sources but also disaggregated into its basic components.

Lester D. Taylor

### Competitive Interest Payments on Bank Deposits and the Long-Run Demand for Money

This research tests the assumption, frequently made in studies of the demand for money, that commercial banks do not evade the interest rate regulations governing the payment of interest on deposits (the current prohibition of all payments on demand deposits and the ceiling rate set by regulation Q on time deposits). As an alternative, I assume that these regulations are completely ineffective (i.e., are costlessly evaded) and estimate the interest payments that would be made on deposits under perfectly competitive banking conditions. If the sole *marginal* cost to commercial banks of producing deposits is assumed to be the noninterest-bearing reserves they must hold against these deposits, perfectly competitive interest pay-

ments on deposits are:  $r_D = r_I (1 - (R/D))$ , where  $r_I$  equals the marginal rate of return on the interest bearing assets in bank portfolios and  $(R/D)$  is the marginal-reserve-to-deposit ratio. If the marginal return on money,  $r_M$ , is defined as a weighted average of marginal interest on currency and on deposits; if interest on currency is assumed to equal zero; if  $(R/D)$  is also equal to the average reserve to deposit ratio; and if commercial bank deposits are defined to include demand and time deposits; then  $r_M = r_I (1 - (H/M))$ , where  $H$  is high-powered money, which equals currency plus total commercial bank reserves held against bank deposits. Inclusion of this extremely crude estimate of interest payments on money is shown to improve substantially upon previous estimates of the demand for money. Since  $r_M$  is highly positively correlated with interest rates on money substitutes, previous estimates of the interest elasticity of demand for money, which are based on regressions that do not include  $r_M$ , are shown to be severely biased downward. The significance of the  $(H/M)$  variable in the demand for money implies that one must now know how a particular change in the money is brought about to fully determine its effects. Changes in reserve requirements offset by open market operations (i.e., changes in the composition of money) will have non-neutral effects, and the demand for and supply of money are therefore much more interdependent than they were previously considered to be. A simplified version of this model, where  $(H/M)$  is merely entered into a long-run velocity function, will be published in the *Journal of Money, Credit and Banking*. A fuller manuscript, to be completed shortly, presents a more sophisticated version of the model, in which commercial bank marginal costs are modified by bank float, borrowings from the Federal Reserve System, and government demand deposits, and an attempt is made to estimate the own interest elasticity of demand for money.

Benjamin Klein

### Behavior of the Commercial Banking Industry 1965-67: A Microeconomic Study

The objective of this study, which has been financed in part by a grant from The American

Bankers Association, is to analyze bank behavior on a disaggregated basis. Particular attention is given to the manner in which banks respond to changes in monetary policy. For this purpose, the study uses call report data for each U.S. commercial bank during the period 1965 through 1967. This information is collected semi-annually, and provides estimates of approximately 150 items on the bank's balance sheet.

The results of the study fall into two general categories: (1) descriptive analysis of the behavior patterns of different groups of banks and (2) regression analysis of the behavior patterns of the individual banks within each group. The banks are classified into groups on the basis of structural characteristics which could be expected to affect bank behavior. In the final analysis, the banks are classified according to branching characteristics, size, and urban or rural location.

The analysis of the group data shows that the impact of a change in monetary policy is distributed very unevenly throughout the banking system. First, when the Federal Reserve restricts the funds available to the banking system, the effects are concentrated almost entirely on the urban banks, especially the larger urban banks. The rural banks seem to have been virtually unaffected by the pronounced shifts in monetary policy observed during the period being studied. With respect to branching characteristics, it appears that unit banks operate at a considerable competitive disadvantage during periods of tight money, when financial institutions are bidding up the rates on time and savings deposits. This effect is particularly noticeable in the data for the first half of 1966, when the large unit banks grew much more slowly than other types of banks. On the other hand, when interest rate ceilings are used as a major instrument of monetary policy, as in the second half of 1966, it is the large banks with extensive branching which are hard hit. These banks rely heavily on interest-sensitive time deposits, which were withdrawn when interest rates were restricted. It should be noted that this effect is not merely a reflection of the money market status of these banks, since comparable banks with different branching structures were not affected nearly so severely. In sharp contrast to the other groups,

the banks in states characterized by moderate branching were able to grow consistently at rates above the average. This was true throughout the entire period studied and for all sizes of banks. Although it cannot be proven from the available data, it appears that these banks have been able to achieve much of the flexibility of branch banking without expanding to the point of being exposed to some of the larger risks.

The results of the study also show that the effects of the redistribution of available funds are compounded by the fact that the different types of banks respond in different ways. There was a general tendency during tightening monetary conditions for banks to divert a larger proportion of their funds into commercial lending. This tendency was very pronounced among the large, extensive-branching banks, where massive amounts of commercial loans were made even in the face of a sharp contraction in the funds available to them. In most types of banks, the expansion in commercial lending was accompanied by a cutback in the amount of lending to households and consumers.

To carry out the regression analysis, the banks have been classified into the groups described above. The purpose of this is, of course, to provide groups that can be expected to have reasonably similar behavioral characteristics. Cross-sectional regressions have been run for each of these groups. The resulting equations provide a quantitative description of the process by which banks within each group make adjustments in their portfolios. The results for different groups of banks can be compared to identify the impact of differences in structural characteristics. In addition, the results for different time periods can be compared to see how banks modify the adjustment process in response to changes in market conditions.

At this stage in the study, the descriptive analysis has been completed, and the basic regression equations have been estimated. The remaining steps consist of completing the analysis of the regression results and producing a manuscript describing the findings of the study. This manuscript should be completed by the end of this year.

David T. Kresge

## The Financial Resources of American Labor

More than one-half of the manuscript of my study on the finances of unions has been completed. It contains sections on the wealth of unions, sources and uses of union funds, and sources, coverage and methods.

In addition to the text tables, I plan to produce appendix tables showing financial details summarized by type of union organization; that is, by local, intermediate, and national and international unions, for 1962–69. For each of the three types of union organization, the tables report, by size of receipts, the distribution of the principal items of assets, liabilities, receipts, and disbursements.

Concurrent with my study of union finances, I was able to use the financial data to develop a very substantial data bank on union membership in the United States. Within the next few months, I will have data on the membership of unions, by local organization for unions in the private sector, identified by affiliation, state, county, and zip code for the years 1962–72 inclusive. State summaries for each of the leading unions in the public sector were calculated independently of the tapes used in the financial study. Data by local will be available for over 50,000 organizations per year.

Leo Troy

## Industrial Institutions and Processes

### Introduction

The National Bureau's research program on industrial processes is currently composed of several projects approaching completion and three new ones. In the former category are two studies of product diversification and so-called conglomerate growth of firms. I, in collaboration with Henry Grabowski and Robert McGuckin, focus both on recent trends in product diversification, as seen through aggregative data, and on the determinants of diversification, as seen through data for individual firms for the late 1960's. Thomas Wilson focuses on the relation of diversification to size of firm and to the structural characteristics of industries through an analysis of Census data for large multi-unit

firms for the years 1954 and 1958.

A study on advertising and marketing was started this year by Henry Grabowski. This study proposes to examine the effect of advertising expenditures on market shares, rates of return to advertising across brands and firms, and the effects of advertising on the interindustry distribution of consumer expenditures. M. Ishaq Nairi is proceeding with a study of the dynamics of price formation through an analysis of disaggregated data for industries. He is concentrating on the "spillover" effects of disequilibrium in one market on others.

A study on the economics of research and development expenditures is scheduled to begin this summer with Henry Grabowski and Dennis Mueller as the senior investigators. This study will extend the National Bureau's continuing work on technological change. In this field, John Meyer and Guy Herregat have completed their study of the diffusion of the basic oxygen process in steelmaking (reported in greater detail in the subsequent section on international studies).

Michael Gort

### Diversification and Integration in American Industry

Our study consists of three principal parts. The first, which is largely completed, concerns the analysis of firm diversification patterns through data for industry aggregates. A second section carries the analysis of diversification further, with the help of a new body of data for firms; a third section deals with product innovations.

The analysis through published Census data for industry aggregates shows that product diversification by firms continued to increase between 1958 and 1963. Industries that were most attractive as diversification outlets in 1958 drew a higher rate of entry from diversifying firms between 1958 and 1963 than did other industries. On the other hand, industries that were a primary base for firms that showed less than average diversification in 1958 were associated with a proportionately greater than average increase in the secondary activities of the firms in the 1958–63 interval. Thus, it appears that product diversification by companies is becoming a more

widespread phenomenon but that the outlets for diversification tend to be concentrated in selected segments of the economy.

Conclusions on sources and directions of diversification presented in the study, *Diversification and Integration in American Industry*, published by the National Bureau in 1962, were substantially confirmed by the later data. High technology industries continued to be the most attractive as diversification outlets, and firms primarily based in the relatively concentrated industries (those in which leading producers had high market shares) continued to be more diversified than average. Several tests were devised to measure technical propinquity between diversification outlets and the primary activities of firms. All pointed to the importance of common resources needed for production as an explanation of choice of diversification outlet.

Some preliminary work employing data for individual firms was published in the first issue of the *Annals of Economic and Social Measurement* under the title "Firm Data and Industry Aggregates in the Analysis of Diversification and Integration." We have now developed, for a sample of roughly 600 firms, data from Dun and Bradstreet, which permit measures of change in diversification for the period 1967-71. Financial data contained in the Compustat tapes have been merged with the Dun and Bradstreet data for the 600 firms, and we have also compiled information on a number of variables pertaining to the managerial characteristics of the firms. We are currently devising measures of managerial aggressiveness. The principal questions we hope to answer in the context of data for firms are: (1) To what extent can differences in diversification be explained by managerial aggressiveness? (2) Alternatively, to what extent is diversification a defensive move in response to limited opportunities within the primary activities of firms? (3) What has been the impact of diversification on the relative growth in earnings and sales of companies?

A final section of the study examines product innovations in the context of the rate of entry by manufacturers. The questions raised are: (1) Is there a characteristic pattern for entry rates over time? (2) Are there consistent differences between the early innovators and the later en-

trants? (3) What is the relation between entry rate, on the one hand, and sales prices, advertising, and changes in technology subsequent to the innovation, on the other? The analysis is being carried out for the following list of product innovations, for each of which an annual record of producers has been compiled beginning with the year the product was introduced: Beta ray gauges, electric blankets, cathode ray tubes, Freon compressors, DDT, zippers, home freezers, heat pumps, penicillin, photo-copy machines, electric shavers, tubeless tires, transistors, and gas turbines.

Collaborating with me in the study are Henry Grabowski of the staff of the National Bureau and Robert McGuckin of the University of California at Santa Barbara. We expect that our manuscript will be completed this summer.

Michael Gort

### Studies of Advertising and Marketing Activities

The main focus of this research is on the intra-industry and interindustry effects of advertising expenditures. Among the questions being investigated are: (1) the relation between advertising expenditures and market shares in various consumer-oriented advertising-intensive industries; (2) the distribution of rates of return to advertising across brands and firms in these industries; (3) the effect of advertising on the inter-industry distribution of consumer expenditures.

The models used to investigate these questions treat advertising as an investment activity (Nerlove and Arrow, *Economica*, May 1962; Grabowski, *Quarterly Journal of Economics*, May 1970). This leads to empirical formulations in which market share and other performance measures are related to advertising in a distributed-lag fashion. To date, distributed-lag relationships have been used to study the effects of advertising on market share in the following industries: cereals, gasoline, beer, liquor, soft drinks, and cigarettes. In general, such models perform well for these six industries. They support the hypothesis that a firm's own advertising outlays as well as its rivals' expenditures will have a significant cumulative effect over time on realized market shares.

Using the estimates from these distributed-lag relationships, together with estimates of other relevant parameters, a rate of return to advertising can be computed. The estimated rates of return vary significantly across firms and brands within these industries. Research is currently being undertaken to test for systematic relations between a firm's estimated rate of return to advertising and various other characteristics (i.e., firm size, media allocation, managerial characteristics, etc.).

Similar investment-type models will be used to study the effect of total industry advertising outlays on the interindustry distribution of consumer expenditures. To date, time-series data have been collected on consumption expenditures, advertising, and prices in approximately fifty four-digit industry classifications. An empirical study of interindustry advertising effects, using these data, will be one of the main topics of research during the coming year.

Henry Grabowski

### Dynamics of Price Formation

Existing models of price formation tend to suffer from two deficiencies. First, they generally fail to recognize explicitly the presence of adjustment costs and intermarket feedbacks. Second, very few systematic studies of industrial prices are available at the disaggregated level of the two- or three-digit SIC classification. The importance of recognizing these deficiencies and of developing better measures of differential movements of industrial prices needs to be stressed. For one thing, stability of commodity prices as well as inputs critically depends on the dispersion of industry prices. Second, changes in these prices have major distributional effects through their influence on patterns of consumption and income distribution. Finally, the possibility of developing effective anti-inflationary policies, such as an incomes policy, hinges on accurate knowledge of how prices behave at the disaggregated levels.

The analytical approach taken in the present project is in sharp contrast to that employed in previous econometric price studies. It can be characterized as a generalized disequilibrium model linking commodity and input prices in a

unified framework. It is a dynamic model, which traces the "spillover" effects of disequilibrium in one market on others. Four markets are distinguished: commodities, labor, capital, and inventories. Prices in any one of these markets depend on the excess demand prevailing in that market and also on excess demand persisting in other markets. Thus, commodity and input prices continually interact with and modify each other over time.

The model makes use of quarterly time series for the U.S. total manufacturing sector. All inputs, including capital stock, are treated as variable; they differ only in their speed of adjustment. Thus, the rental price of capital is considered as an integral part of the price formation process and, by taking it into account, a direct link between short-run and long-run price behavior (inflation) is established.

Adjustment costs involved in changing the rate of acquisition of inputs for future production are explicitly considered. The feedbacks among prices arise because such adjustments of quantities of inputs and outputs to their desired levels in the production process are not instantaneous.

The adjustment properties of prices across industries and over time can provide information about the characteristics of each industry which will be of crucial importance for policy purposes.

We hope to estimate the model initially by using time-series data for fifteen two-digit industries for the period 1947-72, and then use the available time-series data for three-digit industries. By reformulating the model slightly, we hope to take account of specific considerations particular to a given industry. The model will be used to forecast and simulate, under specified conditions, the paths of wholesale prices, wage rates, rental prices of capital, and prices of materials for a few years beyond the sample period for each industry. The transitory and long-run behavior of these prices will be examined in some detail, and tests for homogeneity of their behavior across industries will be performed.

M. Ishaq Nadiri

## Mergers, Diversification, and the Growth of Large Companies

This is a quantitative descriptive study of the extent and sources of change in industrial diversification between the Census years 1954 and 1958. The data analyzed are for the universe of large multiunit firms covered by the industrial censuses (all multiunit firms with more than 2,500 employees in each year). Census data on value added, payroll, employment, and sales, distributed according to the four-digit SIC classification of their establishments in each year, form the primary data on each firm.

Alternative indexes of diversification have been constructed for each firm, and multivariate techniques (correlation and principal component analysis) have been used to study the interrelationships between these alternative measures and to select measures used in the subsequent analyses.

A major focus of the study is upon the relationship between diversification, size of firm, and the structural characteristics of industries. Changes in diversification between the two Census years are also analyzed in relation to growth, size of

firm, and other variables.

Since merger activity was fairly intensive over the four-year period, and since the basic data are coded to identify mergers between the larger multiunit firms, the data are used to study the characteristics of such mergers that occurred over the period. Particular attention is devoted to an examination of the role of mergers in the growth of firms and in affecting average industrial diversification. In addition, the organization of the basic data permit us to identify cases of entry into new industries, via merger and otherwise, by firms already established in other industries, as well as to identify cases of rapid expansion in industries outside the home industry of the firm.

Finally, data on research and development expenditures are available for the year 1958, thereby permitting an analysis of the relationship between research and development activity, firm size, and diversification in that year.

The statistical work required for this study is virtually complete, and the drafting of chapters for a monograph is now under way.

Thomas A. Wilson

## 6. INTERNATIONAL STUDIES

### Introduction

One of the principal areas of interest in the National Bureau's international studies concerns the foreign exchange problems of the less developed countries and the effects of their policies in this regard on their economic development. This project, financed by the Agency for International Development, is under the direction of Jagdish N. Bhagwati (Massachusetts Institute of Technology) and Anne O. Krueger (University of Minnesota), who report below on the status of the work and plans for completion.

The National Bureau has now completed its study of the basic oxygen process in steel-making, undertaken as part of a cooperative project with several European research institutes, on rates of diffusion of technological innovation. John R. Meyer and Guy Herregat sum-

marize below the methodology employed in the Bureau's study and the conclusions emerging from it.

In addition to other reports by Irving B. Kravis and Robert E. Lipsey (the role of prices in international trade) and by Lipsey and Merle Y. Weiss (relation of U.S. manufacturing abroad to U.S. exports), it may be noted that two studies are now in full draft, and are being reviewed by reading committees at the staff level and revised by the authors. These manuscripts are George Garvy's study of money, financial flows, and credit in the Soviet Union and that by Raymond F. Mikesell and J. Herbert Furth on foreign dollar balances and the Eurodollar market.

Hal B. Lary

## The Role of Prices in International Trade

The completion of the study, *Price Competitiveness in World Trade*, published in 1971, provided a large quantity of new information on international trade price levels and price movements. Since the primary aim of that study was to develop methods of price measurement, very little substantive use was made of the new measures. The present project is an effort to reexamine the role of prices in international trade, taking advantage of the more relevant data now available.

Two preliminary reports on this work have been prepared. The first, "The Elasticity of Substitution as a Variable in World Trade," was published in *International Comparisons of Prices and Output*, Volume 37 of *Studies in Income and Wealth* (NBER, 1972). The second, "International Prices and Price Proxies," was given at the National Bureau's Conference on The Role of the Computer in Economic and Social Research in Latin America, and will be published in the proceedings of that Conference. The first of these papers suggests tentatively that the elasticity of substitution between countries in international trade is not constant over time, commodities, or markets. It varies substantially with different circumstances, such as the direction of changes in price competitiveness and the proportion of the market held by each exporter. The second paper compares disaggregated wholesale price and unit value data, frequently used as proxies for international prices, with the international transactions prices collected in the *Price Competitiveness* study and, for later years, by the Bureau of Labor Statistics. Our conclusion is that the individual commodity unit values show virtually no relation to transactions prices, and the individual wholesale prices only a very weak relation. A consequence of the low quality of the proxy variables is that past studies of international trade price elasticities, necessarily based on these proxies, have probably estimated elasticities quite inaccurately. Some experiments we performed, using the proxy variables and the transactions prices in identical equations, showed that elasticities measured from the proxy variables were invariably lower

than those based on our international price indexes.

With the aid of a new grant from the National Science Foundation, received early in 1972, we are now extending our analysis of the role of prices in trade in several directions, examining both industry cross sections and time-series data.

The cross-sectional analysis is an attempt at explaining differences among industries in the relation of foreign to U.S. price levels on the basis of characteristics of the individual industries. The industry characteristics we plan to use include capital-labor ratios, the intensity of research and development, the skill mix of the labor force, and other variables that have been used in recent years to explain trade patterns without using price differences as an intermediate step in the analysis.

Much of the work will continue, as before, on time-series data. Our ability to derive analytical results from the *Price Competitiveness* study was limited by the fact that the indexes covered only six years, 1953, 1957, and 1961-64. We plan to compile, for each country, uniformly weighted wholesale price indexes and, where the requisite official information is available, export price indexes which will run annually from 1953 to 1971. These will be used to interpolate and extrapolate the indexes published in the *Price Competitiveness* volume to give the best approximations to annual international price indexes presently possible. The resulting annual indexes covering eighteen years should open up many new possibilities for analysis.

With these various sets of time-series data we plan to investigate the response to positive and negative price or price competitiveness changes, the relation between the size of the price change and the degree of response, the influence of price level differences, and relationships between domestic and international price changes. Marianne Lloris will continue to assist us with data collection and programming.

Irving B. Kravis  
Robert E. Lipsey

## Exchange Control, Liberalization, and Economic Development

This project, financed under a contract with the Agency for International Development, is now entering the concluding phase. Drafts of the country studies, at varying stages of completion, were reviewed at the third working party on February 24–26, 1972. The participants were the country authors, the directors of the project (the authors of this report), Hal Lary from the National Bureau, and Constantine Michalopoulos from AID.

Complete drafts of all the country studies are expected to become available during the second half of 1972. The countries studied and the authors are: Brazil, Albert Fishlow (Berkeley); Chile, Jere Behrman (Pennsylvania); Colombia, Carlos F. Diaz-Alejandro (Yale); Egypt, Bent Hansen (Berkeley); Ghana, J. Clark Leith (Western Ontario); India, T. N. Srinivasan (Indian Statistical Institute) and Jagdish N. Bhagwati (M.I.T.); Israel, Michael Michaely (Hebrew University); Philippines, Robert E. Baldwin (Wisconsin); South Korea, Charles R. Frank (Princeton); and Turkey, Anne O. Krueger (Minnesota).

In addition to the country studies, two shorter papers have been commissioned under the project: Lawrence J. White, Princeton University, is producing a short paper on the Indonesian Foreign Exchange System: 1966–70; and Ipeei Yamazawa, Hitotsubashi University, Japan, is writing on Japan's Protectionism and Economic Development: 1900–39.

Finally, the project will result in a summary volume in which we (Bhagwati and Krueger), will draw on the findings of the country studies and endeavor to develop conclusions of wider relevance on the issues of exchange control, liberalization, and development.

Jagdish N. Bhagwati  
Anne O. Krueger

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

This study, which has at various stages been financed by funds from the National Science Foundation and the Ford Foundation, is an analysis of interrelationships between the foreign

manufacturing activity of affiliates of American companies and the export trade of the United States. Plans for the study were described in "The Relation of U.S. Manufacturing Abroad to U.S. Exports: A Framework for Analysis," 1969 *Business and Economic Statistics Section Proceedings* of the American Statistical Association.

Most of the investment in the study so far has gone into the assembling of data on an individual company level from both private and government sources. For parent firms these data relate to the balance sheets, income accounts, exports, total employment, industry distribution of employment, capital formation, and other characteristics. For the foreign affiliates of these firms, the data cover local sales, exports, imports from parent companies, various income and capital flows, capital formation, and a classification by industry and by product.

In order to measure the relation of investment to trade, it is necessary to know something about other influences on trade. We therefore took some time to study the determinants of ocean transport cost for different commodities, using data from the Bureau's earlier study of *Price Competitiveness in World Trade* and from a Census Bureau study of differences between official valuations and landed costs of U.S. imports. We found that we could explain a substantial part of the intercommodity variation in transport cost in terms of the unit value (value per ton) and the stowage factor (cubic feet per ton) of the commodity, the proportion of shipments that were under two tons, and the distance shipped. A preliminary report on this aspect of our work was published as "Estimating the Structure of International Transport Costs," 1971 *Business and Economics Section Proceedings* of the American Statistical Association. A revised and more complete version is being reviewed by a National Bureau staff reading committee. Susan Tebbetts has assisted us in data collection and computation on transport costs.

The first, very preliminary, substantive results from our work, using only the data collected by the National Bureau itself, were discussed in a paper at the December 1971 meetings of the Econometric Society. They seemed to indicate that, in the industry chosen for an experiment with the data, even variables as crude as the

number of nonmanufacturing and manufacturing affiliates and the change in such numbers were significantly related to U.S. and other countries' exports to particular destinations and to the change in such exports. Furthermore, it appeared evident that some measure of relative distance or transport cost was a necessary ingredient of any explanation of trade shares.

We plan to report further on the study at the 1972 meeting of the American Statistical Association and are aiming at a summer 1972 completion date for this phase of the project.

Because we have linked the foreign and domestic activities of U.S. firms, the data we have gathered should be valuable for a much wider range of studies of the multinational firm, including an examination of the motives for the establishment and expansion of foreign affiliates. For example, one could relate the growth of affiliates to rates of growth of parent firms' total sales or to sales in individual markets, or relate affiliates' plant and equipment expenditures to those of parent companies. One could trace the effects of changes in tariffs or other restrictions on trade, or the effects of the establishment of affiliates by rival American firms, to which a company might react defensively. The data permit comparisons between returns on foreign investment and overall returns for the same companies, subject, of course, to the vagaries of internal accounting practice. It would be possible, also, to relate the stock price performance of individual firms to the extent and form of, and the growth in, their participation in foreign markets.

No studies outside the trade-investment relationships are presently under way at the Bureau, but these topics represent possible future avenues of research on multinational firms.

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. During this last year of the project, these institutes completed their studies on special presses

in papermaking (Industriens Utredningsinstitut, Stockholm), shuttleless looms in textiles (National Institute of Economic and Social Research, London), continuous casting in steelmaking (Osterreichisches Institut fur Wirtschaftsforschung, Vienna), numerically controlled machine tools (IFO-Institut for Wirtschaftsforschung, Munich) and tunnel kilns in brickmaking (Istituto per lo Studio della Congiuntura, Rome). At the National Bureau, the work on the international diffusion of the Basic Oxygen Process (BOP) in steelmaking was completed.

Our basic hypothesis was that BOP diffusion was actually a two-stage process. Given an investment decision reflecting the rate of expansion of markets available to a firm or industry, the increase in BOP capacity then was determined by the relative technological and factor price advantages of that technology.

We also attempted to calculate a reasonably direct measure of managerial motives and aspirations in order to determine if these, too, might have some influence on BOP adoption. For this purpose we adapted some techniques of factor analysis, as commonly applied to psychological or educational testing. Specifically, we construed certain of the values (those that seem to be particularly under the control of individual managements) taken from individual firms' balance sheets and income statements as being "scores," indicating the possible orientations of the managements involved. Using analysis by principal components, we estimated an index of management motivation, which we called an "aggressiveness score." Common factor estimation by "image" factoring showed that about 50 per cent of the common variance in the definitional variables was explained by that profile after cross-sectional variations and errors of observation had been taken into account. In the explanation of investment behavior, this index was dominated only by liquidity flow measures.

In the study of BOP diffusion itself, we found that the rate of investment, or some similar proxy measure of market growth, was often the dominant variable in explaining BOP diffusion, particularly in intranational or firm differences.

Factor prices were also influential. In particular, while their significance varied widely from

sample to sample and circumstance to circumstance, variables measuring the availability or attractiveness of direct electric production and the availability of scrap materials as a factor input seem to relate fairly systematically to BOP diffusion, and in the expected manner. There was less evidence of market scale effects upon BOP adoption.

We also tested our aggressiveness index as an explanatory variable for BOP diffusion. Unlike our results for investment, we did not discover, in almost any plausible formulation of the functions, any discernible direct influence of the aggressiveness score upon BOP adoption. The influence could, however, be indirect. Specifically, certain productivity measures, operating quite independently of our aggressiveness score, turned out to be the best or second best of the variables used in the individual regressions for BOP diffusion, and these productivity measures could be construed to be a proxy for management "dynamism." Moreover, the importance of investment in the BOP regressions may indirectly relate BOP adoption to our ag-

gressiveness score through the impact of that characteristic on investment. Essentially the same conclusions were verified also when we analyzed the individual firm data by discriminant analysis.

In sum, observed national and firm differences in BOP diffusion rates can be fairly readily and objectively explained by differences in the economic environments in which different firms and industries have operated. To a major extent, moreover, these objective differences trace back to technological characteristics of the BOP diffusion process, which make that process more or less attractive depending upon factor prices and rates of market expansion. Nevertheless, we cannot and would not rule out the possibility that certain attitudinal or managerial differences were also at work conditioning the rates of diffusion. But there is nothing in the *direct* evidence to suggest that these influences were of anywhere near the same scale as the more directly observable economic effects.

John R. Meyer  
Guy Herregat

## 7. MEASUREMENT METHODS AND OPERATIONS

### Introduction

Two years ago we reported on a major change in the operations of the Data Processing unit: the increasing use of the E.D.P. specialists as consultants and a reduced demand for their services as originators of general purpose programs. This was explained in part by the fact that, for most standard techniques, satisfactory programs existed or could easily be adapted.

During the last two years the spreading of computer use and of programming skills has led to a further transformation of the functions of our unit. The new generation of the Bureau's research assistants has often had some prior acquaintance with computers and programming, or is eager to acquire competence in this field, since a large part of present research involves work with computers.

The trend described tends both to decrease

and to increase the responsibilities of professional programmers. On the one hand, they do not have to engage in elementary routine operations; on the other hand, they must make sure that the many operations performed by non-specialists are done efficiently. The specialists must advise on the relative merits of alternative approaches, programs, computers, and operating systems; they must be able to explain their considerations to the research staff; they must be able to find the bugs in the programs and systems used. And for larger programs, they should also supervise debugging procedures, and assist in determining the most economical mix of machine time, core requirements, and programmer's time.

An extrapolation of these developments leads to certain implications for hiring and training research assistants and programmer-specialists. If programming and data processing are to be

a major task of research assistants, emphasis should be placed on their experience or at least on their capability in this field. This would mean a gradual upgrading of standards. Furthermore, a flexible but systematic training program should be developed and put in operation. The degree of discretion and the responsibility for major projects given to individual research assistants must be in a reasonable relationship to their capabilities. Some orderly way of developing independence and responsibility should be mapped out.

For the programming unit itself, the expected changes also augur increased standards of competence. The professional programmer in the Bureau should become a programmer–statistician–economist, or programmer–statistician–mathematician, with outstanding analytical capabilities and a flair for teaching and communicating. The major job of the future members of the unit should be consulting, trouble shooting, and teaching. In principle, one might think that an increase of programming skills in the ranks of research assistants would permit a reduction in the size of the professional unit. Whether this will indeed be the case, depends on the need for training and supervision, which, in turn, is related to the quality and size of the staff as a whole.

The above argument regarding the future need for higher standards for both research assistant and programmer is not invalidated by the continued need for some assistants and data processors with lower skills. This demand, however, is not likely to pose any serious problem.

During the past year the Bureau's computer operations have expanded territorially. Apart from the work with the Bureau's IBM-1130, the various time-sharing systems, Columbia's 360/91 and Yale's 360/67 and 7094, we have expanded our resources to include MIT's 360/67. Operations in New Haven, under the general supervision of Orin Hansen, are more or less unchanged except for the usual periodic systems changes. Our dealings with Columbia's 360/91 are aided by Susan Crayne and Tedi McDermott, and 1130 operations by Martha Lichtenstein, Antonette Delak and Irene Abramson. The MIT installation serves primarily as a vehicle for the Bureau's Computer Research Center, which Ed

Kuh reports on in Part I of this report.

Our data bank activities increased in scope and membership. Peggy Cahn bears the brunt of these developments and reports on them below. Another major data collection effort aims at the establishment of a library of tapes, containing primarily cross-sectional microdata.

Some of the major new programs developed in the Bureau are described below by Susan Crayne, Robert Goldberg, and Finis Welch.

Charlotte Boschan

## NBER Data Bank

Now in its third year, the NBER machine-readable time series data bank is functioning smoothly. Apart from internal usage, we now have some fifty subscribers who have access through three commercial time-sharing systems: Rapidata, Interactive Science Corporation, and General Electric's Information Management and Projection System (MAP). Each of the subscribing users compensates the Bureau for a part of the cost of maintaining the data base.

A second version of the data bank has been made available on magnetic tape. This version is brought up to date about once a quarter. It is used by the TROLL system, described elsewhere in this report, by about twelve universities, and by nonprofit institutions such as the World Bank. In the near future, tapes will be updated on a monthly basis for distribution to commercial systems. Participating systems will be Scientific Time Sharing Corporation (which also has the Canadian Government's data bank), The Service Bureau Corporation, and others.

In 1971 we released two editions of a "Directory to the Data Base," prepared in cooperation with Rapidata and General Electric. A new edition will shortly be published by NBER, and bi-monthly supplements will be sent to subscribers. It is also planned to include information about the data bank in NBER's new journal, *Annals of Economic and Social Measurement*. We are working on additional source documentation and have developed a format which will enable us to keep documentation on line, consistently and economically.

The content of the data bank is constantly changing as we try to supply new series to meet

the shifting demands of our users. For instance, we have recently added many additional interest rates, chain price indexes, and balance-of-payments series. At the moment we are also working towards loading the flow-of-funds data of the Board of Governors of the Federal Reserve System.

We are trying to make the most of our resources by division of labor and specialization; Hanna Stern is working on the documentation project; Constance Lim specializes in financial and labor force data; Wan-Lee Hsu maintains the data base on GE's MAP system; Antonette Delak does the necessary programming and some maintenance work for Rapidata's system, and Clare McDermott tends the data bank stored on the ISC system. We also have had the help of three college students on work projects.

Peggy M. Cahn

## Special Computer Programs

A program was written to derive monthly values from quarterly data by spline function interpolation of cumulated quarterly data. Between each two successive data points, a third degree polynomial is used to obtain intermediate values. The parameters of the polynomials are determined subject to the constraint that the first and second derivative of each successive pair of polynomials meeting at a data point be equal. This makes the arcs "join smoothly." Cumulative monthly values are interpolated on this curve. The resulting monthly time series is then decumulated to obtain the final monthly values, which are then printed and punched with the number of places after the decimal point specified by the user. A similar program is available to derive quarterly data from annual data. These programs run on the 360/91 at Columbia. Versions are available for TROLL and other users of our data bank.

We are now in the process of decoding a tape containing the Terman "Study of the Gifted." The tape will be used in connection with studies on the relationship of education and income distribution. The task is particularly challenging because there exists no conversion program to decode the existing 9-track (rather than 7-track) column binary tape. The problem could only be

solved because of the existence of a key: the Terman study people had the foresight to make the first record of the tape a "Rosetta card," which contains all possible punch combinations in a specified order. Hence, one can determine the correspondence between a given combination of holes punched in the original card and a hexadecimal (or binary) representation of the tape content, by making a hexadecimal print-out of the Rosetta card. With the help of this information, we read each character on the tape in hexadecimal (or binary) and converted it to a pattern of punches. An unusually expanded intermediary tape had to be made, which required 12 characters (consisting of 0 or 1) for each original card column. This tape is now being decoded to produce a final tape which can be read by standard regression programs.

REGEN (a regression generation program for multivariate observations in linear regression equations), originally written by Sidney Jacobs for the 7094 and 1130 computer, is now being adapted to the 360/91. This process has entailed finding or creating subroutines for the 360 (corresponding to the assembler language subroutines for the 7094), which generate random variates with user-specified distributions.

Susan Crayne

## Variable-Term Loan Simulation Model

As an aid for the understanding and design of income-contingent variable-term loan programs, we constructed a two-part computer model, which we call the Dresch-Goldberg VTL simulation model. The first part, the financial projection submodel, keeps track of the projected accounting for the fund (from which the loans are made) and for the individual borrowers, classified by income groups. Its final result is the profit or loss of the fund.

Since it is extremely difficult to set all the parameters so that a specified profit condition is obtained, a hit-or-miss procedure must be followed, which consists of running the model, checking the "profit," changing parameters, and repeating the process until a satisfactory solution is found. This technique is slow, inefficient, and not highly educational. We, therefore, de-

signed the second part of the model, the analytical submodel. This submodel starts with a given profit goal and derives the proportion of income that must be returned to the fund (tax rate) in an interactive process. The linkage between the two submodels results in financial projections and profits that satisfy predetermined conditions.

The analytic procedure is efficient, and can be used to generate a system of solutions (spectral solutions) by varying the values of the inputs. It can be used as a heuristic tool in analyzing the effects of the different factors on specified-profit loan programs, as has been done in Dresch-Goldberg, "Variable Term Loans for Higher Education, Analytics and Empirics," in *Annals of Economic and Social Measurement*, January 1972.

The computer program was designed for the IBM 1130 disk computing system. Since the IBM 1130 is a small system (8K), it was necessary to carefully design the programs for maximum efficiency and a minimum of storage space.

But the implementation on the IBM 1130 has provided an excellent interactive tool which could be used by the researcher to "play games" with alternative loan schemes. By inputting the policy and control vector through the keyboard, responsive decisions could be made by the user and further loan programs generated. This procedure is similar to those available to time-sharing users.

Robert D. Goldberg

## Microdata Processing and Joint Estimation of Parallel Cobb-Douglas Production Functions

In the course of my research it has been necessary to develop two programs that are currently being generalized for addition to the Bureau's computer library. The first is a microdata processing package for regression analysis. The second is a technique for jointly estimating parallel Cobb-Douglas production functions, for which parameters are independent but the allocation of one of the inputs between the competing products is not known.

The microdata processing package consists

of two programs. The first is designed to collect simultaneously a number of cross-products matrices as the sample is partitioned into subsamples. An observation can be deleted from, or stored in, one or more subsamples. Variables are defined in a user-supplied subroutine.

The program is most efficient when moments for many subsamples are simultaneously collected and when large numbers of dummy variables are required. The cross-products computation using dummies is efficient, since locations for additions are determined and multiplications by 0 or 1, as well as additions of 0, are avoided. For example, suppose an observation consists of  $M$  dummy variables of which  $N (< M)$  dummy variables equal 1 and  $M - N$  equal 0. Suppose there are also  $K$  continuous variables. In the dummy stub of the moment matrix,  $N(N+1)/2$  (fixed point) additions of 1 occur, and in the intersection between the dummy and continuous variables  $NK$  additions occur. In a standard program there would be, respectively,  $M(M+1)/2$  and  $MK$  multiplications and additions. Output from this program includes the moment matrices plus summary statistics for the subsamples.

The second program is a regression package that is restricted to matrix input. It allows linear combinations of variables and addition of moment matrices, i.e., pooling of samples. It also allows partial pooling of samples. Consider, e.g., two samples with associated structural equations,

$$Y_1 = X_1\beta_1 + X_2\beta_2 + u_1$$

$$Y_2 = Z_1\gamma_1 + Z_2\gamma_2 + u_2.$$

To constrain  $\hat{\beta}_1 \neq \hat{\gamma}_1$  with  $\hat{\beta}_2 \neq \hat{\gamma}_2$ , it is necessary to pool the moment matrices for the two samples so that the  $X_1$  and  $Z_1$  moments are added,  $X_2$  and  $Z_2$  being orthogonal. This option is available.

For the joint estimates of parallel Cobb-Douglas production functions, consider the equations:

$$\ln Y_1 = \ln A_1 + \gamma_1 \ln X_1 + \beta_1 \ln Z_1 + u_1$$

$$\ln Y_2 = \ln A_2 + \gamma_2 \ln X_2 + \beta_2 \ln Z_2 + u_2$$

Suppose that  $Y_1$  and  $Y_2$  are produced simultaneously, but that production is technologically independent. Suppose also that  $Z_1$  and  $Z_2$  (other

Inputs in the two processes) are known, but that only the sum,  $X = X_1 + X_2$ , is known, and that the allocation of  $X$  between its competing uses is unknown. Given the quantity,  $X$ , efficient allocation for competitive producers occurs whenever  $X_1/X_2 = \gamma_1 Y_1 P_1 / \gamma_2 Y_2 P_2$  ( $P_1$  and  $P_2$  refer to product prices). By adding the constraint that  $X$  is efficiently allocated, the functions are jointly estimated. First, an instrumental variable option is included to allow auxiliary regressions to predict  $Y_1 P_1 / Y_2 P_2$ . Then, using this instrument, maximum likelihood estimation of the equations is permitted that includes differential weighting factors for the two equations. The recommended weighting factors are the instruments,  $(P_1 \hat{Y}_1)^2$  and  $(P_2 \hat{Y}_2)^2$ , which give minimization of sums of squared errors in estimating revenues as the objective function.

This program was developed to permit joint estimation of agricultural production functions for crops and livestock. The data allow reasonable allocation of nonlabor inputs between these competing uses, but the allocation of labor is not known.

Finis Welch

## Research on Distributed Lags

Two papers arising out of the work described in the last Annual Report have been completed: "Are There Exogenous Variables in Short-Run Production Relations?," carried in the first issue of *Annals of Economic and Social Measurement*, and "Money, Income, and Causality," scheduled for the September 1972 issue of the *American Economic Review*. These two pieces, together with an extended discussion of the relation between the statistical concept of exogeneity in time series and notions of causal ordering in economics, will be presented in a longer publication in the near future.

Another paper, "Seasonality in Regression," gives an analysis of the biases arising from seasonal noise and from seasonally adjusted data in time-series regressions. The analysis shows: (a) that one can foresee the nature of biases to be expected from use of raw data contaminated by seasonal noise; (b) that use of published deseasonalized data will quite commonly result in

worse bias than use of raw data; and (c) that deseasonalization procedures can be chosen for a particular regression in such a way that bias due to seasonality is very small. This paper is available in a mimeographed draft.

Christopher Sims

## Regression from Grouped Observations

I have completed a monograph entitled "Regression Estimation from Grouped Observations," which will be published in Griffin's *Statistical Monographs and Courses*, under the editorship of Alan Stuart. It is based mainly on a paper of the same title which I wrote while a research fellow at NBER, and which won the C. Oswald George Award in Applied Statistics. It deals with a common procedure used in publishing cross-sectional surveys of economic and demographic data, that is, to summarize the observations and to report only the statistics for groups of observations located within specified intervals. The recommended procedure is to assign each observation the mean value of its group or, alternatively, to weight the group means by the group frequencies. It is well-known by now that the regression coefficients estimated with the weighted variances and covariances are not only unbiased, but also that homoscedasticity is restored by weighting, and that there is only a slight loss in efficiency when the data are grouped according to the explanatory variables. If only the interval limits are reported, the textbook procedure is to use the midpoints of these intervals instead of the group averages. By analogy with the previous case, the frequencies provide the weights for computing means, variances, covariances, and regression coefficients.

The last chapter, which was only recently completed, investigates the bias and efficiency properties of the weighted midpoint method for estimating the coefficients of the simple regression model,  $Y = a + bX + e$ , where the observations on the regressand and regressor are grouped into a bivariate frequency table and the cell midpoints and joint frequencies are reported (or can be derived from the limits of the individual cell intervals).

It is found that when the marginal distributions of the regressor and the regressand are symmetric and unimodal, the slope coefficient estimated by the least-squares method, using midpoints, is biased upward if the number of categories by which the regressor observations are grouped exceeds the number of categories for the regressand; conversely, when the number of regressand categories exceeds the number of regressor categories, the slope coefficient will be underestimated. In the special case when the number of categories is the same for both, the estimates are unbiased. The direction of the bias of the slope coefficients is reversed when the distribution is symmetric and U-shaped rather than unimodal. When, on the other hand, both variables follow a uniform distribution, the slope coefficient is slightly underestimated. It is also underestimated when the regressand follows a uniform distribution and the regressor a symmetric unimodal one. Conversely, it is overestimated when the regressand is uniformly distributed and the regressor follows a symmetric unimodal distribution. The application of Shepard's correction to the estimated variance computed from midpoints is useful in reducing the bias only when the slope is underestimated.

Finally, an expression for the loss of efficiency due to grouping is derived for the maximum likelihood estimator for grouped observations. It is shown that the minimum loss of efficiency is attained, for a given number of groups, when the number of categories into which the regressand is grouped equals that of the regressor, thereby reinforcing the previous result, namely, that one should group the data so that the number of categories of both variables is equal regardless of whether one is interested in unbiased regression estimators or in minimizing the loss of efficiency.

My work with Professor P. J. Verdoorn of the Dutch Central Planning Bureau and University of Rotterdam on "First Differences in Economic Analysis and Forecasting" is near completion.

Yoel Haitovsky

## Limits on Arbitraging of Prices

If and when the price quoted on some competitive market has been arbitrated efficiently, no policy of buying and selling should exist that leads to expected returns greater than the average returns on the market. In mathematical terms, under a few additional assumptions, it is well-known that such a price should follow a martingale. A great deal of empirical work continues to be devoted to the precise degree of validity of this prediction, and, more specifically, to the question of whether or not price follows a very special martingale called "random walk." Notably, my work using the new technique, called "R/S analysis,"<sup>1</sup> (see the preceding two annual reports of the Bureau) has indicated that deviations from martingale behavior are incontestable. A priori, however, such deviations may be rational. It might be the case that the assumptions which underly the martingale model are invalid. Alternatively, the assumptions might hold but perfect arbitraging might be impossible. An example of the latter situation has been discovered: I have shown<sup>2</sup> that perfect arbitraging is inconceivable in one important and realistic case, namely when the nonarbitrated price exhibits very strong range dependence manifested by nonperiodic "slow cycles" of all kinds. Such dependence is of course quite common among economic series other than prices. An attempt to approach perfect arbitraging would lead to a price series whose degree of discontinuity would tend to approach infinity as the approximation improves.

Two issues acquire, in the above context, a new flavor: the issue of whether anticipation is stabilizing, neutral, or destabilizing, and the possible contradiction between the specialist's functions as arbitrageur and as insurer of the continuity of the market. The study of both aspects continues.

Benoit B. Mandelbrot

<sup>1</sup> Mandelbrot, B., Statistical Methods for Nonperiodic Cycles: from Covariation to R/S Analysis; *Annals of Economic and Social Measurement*, Vol. 1, no. 3, 1972, pp. 257-285.

<sup>2</sup> Mandelbrot, B., When Can Price Be Arbitrated Efficiently? A Limit to the Validity of the Random Walk and Martingale Models; *Review of Economics and Statistics*, Vol. 53, 1971, pp. 225-236.