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The Formation and Stocks of Total Capital

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The Formation and Stocks of Total Capital

NATIONAL BUREAU OF ECONOMIC RESEARCH

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(Resolution adopted October 25, 1926, as revised through September 30, 1974)

Contents

Tables

Appendix A

Appendix B

Appendix C

Tables on Microfiche

Note: Tables B-2a through B-20b, Part 1 are on microfiche card 3, and the remainder, on card 4.

Appendix B

Charts

Preface

The following pages offer a somewhat personal account of this study's genesis, a brief outline of its overall plan and contents, and a sincere acknowledgment of the contributions made by all those who helped bring it to fruition.

Genesis

My work of the mid-1950s on total factor productivity resulted in the provocative finding that only about half of the long-term economic growth in the United States—and even less than that since World War I—could be explained by the growth of intangible human and nonhuman factor inputs. The other half or more was ascribed to increases in total tangible factor productivity, resulting largely from "technical change or innovation," "variations in the rate or scale of production," and "changes per factor unit in the services of immaterial capital accumulated in order to increase the efficiency of resources in future periods."[1] As I then noted, immaterial capital ". . . is largely the technical knowledge of individuals, accumulated by investment in education and research, and its services are manifested through the application of know-how by individuals directly in productive activity, or through the instruments of production."[2]

1. John W. Kendrick, "Productivity Trends: Capital and Labor," *Review of Economics and Statistics,* May 1956; reprinted as Occasional Paper 53, New York, National Bureau of Economic Research, 1956.

2. Ibid.

My subsequent book on productivity presented estimates of the major types of "hidden investments" (so called because they were not identified in the national income and product accounts as investment) in research and development, education, and health.[3] I noted their significant growth relative to national product and to tangible investments, but did not attempt at that time to estimate the growth of the associated intangible capital stocks and related services or inputs into production.

In his introduction to my book Solomon Fabricant noted that, if we included along with tangible resources the intangibles, broadly defined, "... it would probably follow that much (not all) of the increase in product would reflect increase in resources." He itemized the other factors, such as changes in scale and the degree of competition, which would affect the productivity "residue" in addition to the contributions of the several forms of intangible capital.[4]

Abramovitz, in a paper which appeared the same year as my earlier study, and making use of much the same estimates, also remarked on the significant rise in total factor productivity in the United States since 1870. He, challenging, called it a "measure of our ignorance" concerning the sources of economic growth other than the increases in tangible inputs, and "an indication of where we need to concentrate our attention."[5] Ever since the mid-1950s, an increasing amount of attention has been devoted by economists to exploring the areas of ignorance concerning growth and narrowing "the residual," as Domar later termed the productivity variable.

In his work on technical change and aggregate production functions, Solow stressed the importance of technological improvements embodied in tangible capital goods. By separately weighting the various vintages of capital goods used in production, he was able to estimate statistically the effect of the changing age-mix of tangible capital stocks on productivity advance.[6] He noted that changes in average age tended to be associated with changes in growth rates of tangible capital, and cited Johansen's argument that capital growth facilitated the adaptation of productive processes to technological change. Other investigators emphasized the importance of research and development outlays in producing the technical advances that are

3. John W. Kendrick, *Productivity Trends in the United States*, Princeton, Princeton University Press for NBER, 1961, Chapter 4.

4. Ibid., p. xlviii.

5. Moses Abramovitz, *Resource and Output Trends in the United States since 1870*, Occasional Paper 52, New York, NBER, 1956.

6. Robert M. Solow, "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics*, August 1957, pp. 312–320.

largely embodied in tangible capital. Terleckyj, for example, established a significant positive correlation between R&D spending as a percentage of revenue and rates of productivity advance in manufacturing industries.[7] No one attempted to measure the intangible stock of productive knowledge resulting from R&D complementary to the tangible capital stocks, however.

Attention to human investments designed to increase the efficiency or "quality" of tangible labor inputs received a major impetus by the work of Schultz in the latter 1950s,[8] and particularly by his presidential address to the American Economic Association in December 1960, entitled "Investment in Human Capital."[9] Although recognition of the importance of human capital has long roots in the history of economic thought, Schultz's work resulted in what Blaug has called "a sudden acceleration of research . . . and . . . proliferation of publications" in the area of human investment and capital.[10]

An early result was the Exploratory Conference on Capital Investment in Human Beings of December 1961, sponsored by the Universities-National Bureau Committee for Economic Research. The eight papers presented there were published in an October 1962 supplement to the *Journal of Political Economy*, and covered investments in education, training, health, and selected aspects of mobility. Since then there has been much additional work in all of these areas, as well as in the R&D area noted earlier. As I stated at a 1963 OECD conference:

> Economic growth is now seen largely to result from investments. This perhaps should be obvious when investment is defined as current outlays designed to enhance future income. But progress has been made in identifying and exploring the various types of investments made by the several economic sectors.[11]

Yet no one undertook to assemble estimates of all types of investment, or of the stocks of all the types of capital, intangible as well as tangible, resulting from the investments. This would have been necessary, of course, for assessing the contribution of total capital to eco-

7. Referred to in Kendrick, 1961, pp. 177–188. See also the recent study by Nestor Terleckyj, "Effect of R&D on the Productivity Growth of Industries," Washington, National Planning Association, 1974.

8. See, for example, Theodore W. Schultz, "Human Wealth and Economic Growth," *The Humanist*, 2, 19, 1959, pp. 71–81.

9. *American Economic Review*, March 1961, pp. 1–17.

10. Mark Blaug, ed., *Economics of Education*, Vol. 1, Baltimore, Penguin Books, Inc., 1968.

11. John W. Kendrick, "Comments," in *The Residual Factor and Economic Growth*, Paris, OECD, 1964, p. 109.

nomic growth and ascertaining how much of a final residual was left to be explained by noncapital variables. A number of economists, beginning with Denison,[12] had attempted to partition the economic growth rate among various contributing factors, starting with the tangible factor inputs, but none had approached the task in terms of estimating the contributions of real intangible capital stocks and inputs in addition to the tangible ones.

To fill this gap, I began to develop estimates of total investment and capital in the academic year 1964–1965, aided by a grant from the National Science Foundation, with subsequent support from the National Bureau of Economic Research. Since then I published several papers which represented progress reports, summarizing tentative findings.[13] This volume represents the first publication of the full set of estimates, together with a reasonably comprehensive description of results. Owing to time limitations, the analysis is far from definitive, but I believe that the material presented here will be of use to others who seek to understand more fully the relationship of saving, investment, and the associated increases in capital of all types to the growth processes of real income and product.

Plan

The conceptual and statistical foundations of the study are explained in Chapter 1. Starting with basic definitions of investment and capital and their relevance to growth analysis, we go on to operational definitions of each of the major types of investment included in our totals. Chapter 2 describes the economic accounting framework within which the saving and investment estimates are presented in order to ensure consistency of the investment and associated capital estimates with the flows of income and product. The sources and methodology employed in preparing the total gross and net investment and capital estimates (by sector and type, in current and constant prices) are also briefly summarized.

12. Edward F. Denison, *The Sources of Economic Growth in the United States and the Alternatives before Us*, New York, Committee for Economic Development, 1962.

13. John W. Kendrick, "Restructuring Economic Accounts for Growth Analysis," *Statistisk Tidskrift*, Stockholm, 1966, 4; "The Treatment of Intangible Resources as Capital," *Review of Income and Wealth*, March 1972; and "The Accounting Treatment of Human Capital," *Review of Income and Wealth*, December 1974. The first section of chapter 2 was drawn from the last-mentioned article.

In Chapter 3 we look at the movements of total investment and saving in the national economy—overall, by type of investment, and by sector—from 1929 to 1969, across peak years of the business cycle as well as between peak years and following troughs. First we examine the trends in the ratios of total gross investment (or saving, saving being equal to investment, by definition, at the national level) to (adjusted) GNP and of total net investment to NNP, in current and constant dollars. Changes in the ratios of each major type of investment, and thus in the composition of investment, are also examined.

As to the ratios of sector investment to GNP, since changes here depend on those in the ratios of sector investment to sector disposable income as well as of disposable income to GNP, we examine both aspects. Changes in the composition of total investment in each sector are also presented.

Chapter 4 consists of an analysis of trends and movements in the stocks of capital and in capital coefficients, by type and by sector of use. Cross-tabulations of stocks by type within each domestic sector are also shown. In addition to the average capital coeffecients, we also calculate and discuss changes in incremental capital coefficients between business cycle averages.

In Chapter 5 we present some calculations concerning the contributions of total capital, by major type, to the economic growth of the United States during the 1929–1969 period, and identify the usual residual reflecting the net effect of noncapital variables. In the private domestic business economy, we examine not only capital coefficients but also the ratios of current dollar income to capital stocks, by functional category, in order to appraise trends and movements in average and incremental rates of return. In addition to using estimates of total capital stocks, gross and net, we also consider variant stock estimates adjusted to include only the employed portions of intangible capital.

Chapter 6 offers a summary of the study highlighting its major findings, as well as some suggestions for strengthening the estimates and extending the analysis.

Appendixes A and B contain detailed notes on the sources and methods used in preparing the estimates, together with basic tables containing time series for all or selected years of the period 1929–1969.

Late in 1975, when the manuscript was already in press, I had occasion to update some of the key investment and capital estimates through the year 1973 for publication by a Congressional committee.[14]

14. "Economic Growth and Total Capital Formation," a study prepared for the use of the Subcommittee on Economic Growth of the Joint Economic Committee, Congress of the United States (Washington: U.S. Government Printing Office, February 18, 1976).

These estimates, together with a brief discussion of recent trends, have been incorporated in the volume as Appendix C. This new material is particularly timely since it appears that the movements of total capital formation and stocks over the subperiods 1966–1969 and 1969–1973 have deviated significantly from the earlier trends.

Acknowledgments

Before this study came under the sponsorship of the National Bureau of Economic Research, my work was directly supported by two grants from the National Science Foundation for the period 1964–1968. At the Bureau it was grouped with several other studies in a project entitled "The Measurement of Economic and Social Performance," also supported by the NSF. (The findings and conclusions are, of course, those of the author and are not attributable to the National Science Foundation.) The project was under the supervision of Thomas Juster until mid-1973 and of Richard Ruggles and Robert Lipsey thereafter. I am indebted to them and to NBER's president, John Meyer, for their continuing encouragement.

During this volume's long gestation period I was assisted by quite a few individuals in preparing the basic estimates. The largest contributions were made by Jennifer A. Rowley and Yvonne Lethem, whose assistance is recognized on the title page. Jennifer Rowley was on the project staff full-time from 1965 to 1971. She prepared estimates of education and training outlays and stocks, was in charge of the computer work necessary for summarizing the entire set of estimates, and assisted in some other areas as well. Yvonne Lethem worked part-time on the study from 1966 to its completion in 1974. She was responsible for the mobility cost and stock estimates, and was instrumental in extending the other estimates from 1966 through 1969. Both wrote several sections of the appendixes and helped assemble the tables.

The tangible investment and stock estimates and the imputed rentals on nonbusiness capital were prepared by Anthony F. Japha, Raymond Sheppach, and Ralph R. Young. The research and development outlay and stock estimates were prepared and written up by Leonore Wagner, who also worked on the rearing cost estimates. The medical, health, and safety estimates were prepared by Ki-Hoon Kim, Kunio Hidaka, and Calvin Shelton. Dorothy Klein, Kilman Shin, and Hi-Whoa Moon worked in several areas in the early stages of the project. Eric Howe was helpful in the final stages.

My research assistant at NBER, Elizabeth Simpson Wehle, rendered substantial assistance in preparing the manuscript for review by the reading committees. The NBER editor, Hedy D. Jellinek, readied the manuscript for publication with care and understanding. Irving Forman drew the charts with his customary skill.

The staff reading committee consisted of Michael Boskin, Robert Eisner, and Michael Gort; the directors' reading committee, of Thomas D. Flynn, Robert M. Solow, and Willard L. Thorp. All of them contributed constructive comments.

Thus, like most major research undertakings, this study is the product of many people, to whom I am grateful.

John W. Kendrick