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INTRODUCTION AND PREVIEW

The present volume is intended primarily to update the estimates and analyses contained in my earlier *Productivity Trends in the United States.*[1] As stated in the opening sentence of that volume: "The story of productivity, the ratio of output to input, is at heart the record of man's efforts to raise himself from poverty." After a discussion of concepts and methods of measurement, we traced the productivity story for the U.S. economy and its major industry divisions for the period 1889 to 1957. The impacts of productivity change on economic aggregates and structure were quantified and causal factors discussed.

The current study focuses on postwar productivity trends, by industry groupings, for the period 1948-66, with preliminary aggregate estimates through 1969. The earlier estimates for aggregates have been revised for the period since 1929, and the industry estimates have been revised beginning with 1948.

With additional data for another decade or so, it has become possible to discern more clearly the trends and relationships that have emerged since 1948, when the post-World War II readjustment period was largely completed. We are now in a better position to see to what extent the postwar trends represent a continuation of earlier trends or a break with the past, and to analyze the relationships between productivity change and other variables in the postwar period and compare them with the relationships in earlier periods. At least as important as our findings on these matters are the new output, input, and productivity estimates in the appendix, for use by other economists in their analyses.

[1] John W. Kendrick, assisted by Maude R. Pech, *Productivity Trends in the United States*, Princeton, Princeton University Press for the National Bureau of Economic Research, 1961. Hereinafter, that volume will be referred to as *Productivity Trends*.

The Continuing Significance of Productivity Advance

At the time of publication of the earlier volume in 1961, economic growth was a widely accepted national goal. There was considerable concern in the United States over the slowdown in the growth rates of real gross national product and productivity that appeared in the latter 1950s. In the presidential election campaign of 1960, both major parties pledged an accelerated rate of economic growth, "to get America moving again," as John Kennedy put it.

During the following decade the intellectual climate changed appreciably. No longer is economic growth accepted uncritically as a national goal. Increasing emphasis is being placed on the costs of growth, in the forms of pollution and other environmental deterioration and the social disorganization attributed by some in part to technological advance and other dynamic economic changes. Some commentators would even slow down or level off the growth of real income per capita.

It is our view that the more critical attitude toward economic growth reduces neither the importance of productivity change nor the desirability of understanding more about it. With regard to the need to counteract the deterioration of the physical and social environment, the most acceptable approach would seem to be to divert more resources toward this objective. A continued strong rate of growth in output and productivity will be necessary to make possible substantial improvements in the quality of the environment while continuing to increase real product per capita. Actually, diversion of resources from the production of final goods to the intermediate outlays required to combat pollution and other environmental deterioration will somewhat reduce the measured rate of advance in productivity and real product per capita, since real gross national product estimates fail to reflect most changes in the quality of life.

With regard to the issue of the "desirable" economic growth rate, it must be pointed out that, in a democratic society with a predominantly free economy, the realized rate of economic growth depends on the saving propensities of individuals as individuals and as owners of businesses, on the expected rates of return on investment, and on public policies reflecting the composite aspirations of citizens. It is my judgment that the overwhelming majority of Americans desires continued substantial increases in real product and income per head, and will take the appropriate individual and collective economic action to secure this result. But even if basic values and aspirations gradually change in the decades ahead in such a way as to retard the rate of

economic growth, this would neither reduce the significance of productivity change nor the importance of understanding more about its causes and economic impacts.

Whatever the economic growth rate that emerges as a result of the interplay of the forces mentioned above, productivity advances would make possible the attainment of rising real product with a progressive saving in labor, capital, and natural resources compared to the quantities required with a static technology. In particular, increases in total factor productivity and further substitution of capital for labor would continue to make possible the progressive reduction of the workweek and the workyear, which has clearly been an objective of the labor force along with rising planes of living.

In fact, it is the very cost savings associated with productivity advance that induce the expenditures designed to enhance the productive efficiency of the tangible human and nonhuman factors of production. In Chapter 4 we emphasize that, whereas there are also other forces behind productivity advance, it results to a major degree from "intangible investments" in research and development, education, training, health, and mobility, all of which raise the quality of the factors in which the resulting intangible capital is embodied. So long as the community generates net saving, some of it will flow into productivity-increasing outlays, as well as into tangible capital outlays—ideally, to the point where the prospective rates of return on the various types of investment are equalized (after allowance for differential degrees of risk, nonpecuniary returns to human investment, and so on).

Consequently, whatever the rate of economic growth, productivity advance will remain one of its important components and contribute to the chief goals it serves—rising planes of living, increased leisure, adequate national security, and provision for future growth. Further, as rates of advancing productivity differ in the various industries, this will be an important element in the changing industrial structure of the economy. The estimates described in this volume are intended to enhance our understanding of these matters.

The Basic Conceptual Framework

The same basic concepts of productivity and similar estimating methodology are employed in this volume as in *Productivity Trends.* This is desirable to provide continuity with the long historical series presented there. More fundamentally, we believe that our approach is still a useful one, despite the subsequent development by others of alternative conceptual schemes. Here we shall review briefly the basic concepts and methodology, particularly for

the benefit of those who may wish to skip the detailed discussion in Chapter 2, in order to proceed directly to the substantive discussions beginning in Chapter 3.

Our index numbers of "total factor productivity" are based on ratios of net output (real product) to weighted averages of the human (labor) and nonhuman (capital) tangible factor inputs. The weights represent the shares of factor income accruing to each of the two major factor classes in successive base periods. Labor input is measured in terms of man-hours worked. Capital input is assumed to move proportionately to the real stocks of tangible capital assets.[2] The inputs are estimated without allowance for changes in their "quality" or marginal physical productivity, so that changes in the ratios of output to input may be interpreted as reflecting all the diverse forces that affect the quality, or "productive efficiency," of the factors. In addition to total factor productivity, we present the more conventional measures relating output to man-hours and to capital individually. Movements of these "partial productivity" ratios reflect substitutions between factors as well as changes in productive efficiency.

Rather extensive use has been made by other economists of our earlier estimates. The divergence in the growth of output relative to the growth of the combined tangible factor inputs has challengingly been called a "measure of our ignorance" by Abramovitz,[3] and Domar[4] has termed it more simply "the residual." The movements of total factor productivity have served as a point of departure for a number of studies of economic growth involving attempts to explain away the residual.

Some of the investigations have sought to narrow the residual, or differences between rates of change in output and the tangible factor inputs, by expanding the inputs to include various qualitative elements that have improved the productive efficiency or intensity of use of the human and nonhuman factors of production. Thus, Denison adjusted labor input (man-hours) so as to reflect the effects of increasing educational attainments of the work force and the assumed increase in man-hour output occasioned by

[2] The asymmetry in the treatment of labor and capital inputs has been criticized by Stanley H. Ruttenberg in his "Director's Comment," *Productivity Trends*, pp. 224-27. The author's rationale was presented in that volume on pp. 31-32, and is elaborated below, pp. 25-27. Nathaniel Goldfinger, member of the Directors' reading committee for the present volume, has also expressed continuing reservations concerning the author's total factor productivity concept.

[3] Moses Abramovitz, "Resource and Output Trends in the United States since 1870," *American Economic Review*, May 1956, p. 11.

[4] Evsey D. Domar, "On the Measurement of Technological Change," *The Economic Journal*, December 1961, p. 709.

declines in the average number of hours worked, per week and per year. He then attempted to quantify the contributions of the other variables which he believes explain the increase in total factor productivity, with his final residual representing "advances in knowledge."[5]

More recently, Griliches and Jorgenson not only adjusted labor input for the factors selected by Denison but also adjusted capital inputs for qualitative improvements and for changes in rates of capacity utilization, and corrected for several other alleged "errors" in the measurements of outputs and inputs.[6] By these means they have reduced the increase in total factor productivity almost to the vanishing point.[7] Indeed, they even question the usefulness of the concept of technological advance or economic growth.

These and other studies which have sought theoretically and statistically to explain the growth of output over and above the growth of tangible inputs have helped to reduce our ignorance concerning this important subject. But I remain convinced that measures of tangible factor inputs, unadjusted for quality changes, and the associated total and partial productivity measures remain a useful point of departure for analysis of growth and change in economic aggregates and structure. In the last analysis, it is not crucial whether we count certain variables as inputs or as part of the statistical explanation of the productivity residual—so long as we correctly sort out and identify the significant forces at work.

For example, some analysts still prefer to use output-per-man-hour measures, in which case productivity changes must be explained in terms of changes in real tangible stocks and associated input per man-hour, as well as in terms of all the other forces that produce changes in total tangible factor productivity.[8] At the other extreme, I have attempted, in another study, to estimate the total real capital stocks and inputs that result from all invest-

[5] Edward F. Denison, *The Sources of Economic Growth in the United States and the Alternatives Before Us*, Supplementary Paper 13, New York, Committee for Economic Development, 1962.

[6] Dale W. Jorgenson and Zvi Griliches, "The Explanation of Productivity Change," *The Review of Economic Studies*, July 1967, reprinted with correction in *Survey of Current Business*, May 1969, Part II. See also the work of Robert J. Gordon in which he attempts to improve estimates of fixed capital outlays and stocks, in *Fiftieth Annual Report*, National Bureau of Economic Research, September 1970, pp. 29-30.

[7] In a later article, Jorgenson (with L. R. Christensen) revised his earlier estimates, and concluded: "...We estimate that changes in total factor productivity are substantial for 1929-1967 and for both the subperiods we have considered. The conclusion of Jorgenson and Griliches that productivity growth is negligible must be revised accordingly." L. R. Christensen and D. W. Jorgenson, "U.S. Real Product and Real Factor Input, 1929-1967," Discussion Paper 109, Harvard Institute of Economic Research, February 1970.

[8] See "Director's Comment," *Productivity Trends*, pp. 224-27.

ments, intangible as well as tangible, designed to increase income- and output-producing capacity. In this case, movements in the ratio of output to total input reflect only the variables not associated with investments, such as changes in scale, allocative efficiency, and other variables enumerated in the concluding section of Chapter 4. In between, the scope of the input estimates may be more or less comprehensive, producing different measures of the productivity residual.

In the present study, however, we continue to use estimates of output, tangible inputs, and productivity employing basically the same concepts, sources, and methods used in the earlier *Productivity Trends* volume. Those investigators who found my conceptual framework useful will welcome the extension of the former series on a comparable basis. Those who wish to adjust or modify the productivity series or their components to accord with alternative frames of reference can do so, since all the component output and inputs series are shown, permitting reshuffling to taste.

Plan and Preview of the Study

The first section of the present chapter introduced the study and stated its objectives. This section will help guide the reader through the organization of the rest of the volume and highlight some of the findings of Chapters 3 through 6, which comprise the descriptive and analytical materials.

Review of Concepts and Methodology (Chapter 2)

Since the interpretation of movements in productivity and its relationship to other variables depends on the concepts of productivity and its component variables and on methods and sources of estimation, the next chapter is devoted to these matters. Stress is placed on our concept and estimation of total factor productivity, within the framework of the national economic accounts, as the ratio of real product to the associated real factor costs. The relationship of movements of total factor productivity to those of the "scalar" in statistical production functions and to the "residual," or difference between rates of change in output and in a weighted mean of the associated inputs, is reviewed briefly, with references to the growing literature on the subject. The concepts and measures employed for the constituent series of output, or real product, labor input, and capital input, and the weighting schemes used to obtain the aggregates of each are discussed in relation to some of the alternatives that have been developed. Summaries of

the underlying sources and methods are brief, since they are treated in some detail in the statistical appendix, which also contains the basic tables.

National Productivity Trends (Chapter 3)

In Chapter 3 we are concerned with the rates of change during the postwar period of productivity in several variant forms in the economy as a whole (or major segments thereof). We examine most closely the trend rates of growth in total factor productivity in the private domestic economy, which is free of the artificial assumptions involved in estimates of real product and productivity in the general government and foreign sectors. This examination leads to the conclusion that there has been no significant acceleration in the trend rate of growth in total factor productivity since World War II, at 2.3 per cent a year, compared with the earlier epoch beginning around the time of World War I, when the rate of advance had picked up markedly. (See Chart 3-1.) The rates of advance in real product per man-hour and per unit of "labor input" (weighted man-hours), however, have shown further acceleration since World War II, due to a much faster rate of increase in capital per unit of labor input than prevailed during the interwar period.

We also examine variations in rates of change in the productivity ratios between cycles, and from year to year. While the variations are considerable, it is significant that they are markedly smaller than in earlier epochs. This is due chiefly to the steadier pace of economic growth generally since World War II. The lesser variability may also be interpreted as reflecting a broader and more persistent rate of technological advance.

National Productivity and Economic Growth (Chapter 4)

In Chapter 4 we first quantify the contribution of productivity to economic growth, as measured by the trend rate of increase in net national product. Ever since World War I, gains in total factor productivity have accounted for more than half of aggregate economic growth. The period since 1948 has been no exception. The trend rates for total factor productivity and economic growth have been estimated to be 2.3 and 4.1 per cent a year, respectively. From 1948 to 1966, gains in total factor productivity accounted for almost all the increase in planes of living, as measured by real NNP per capita, which rose at an average rate of 2.4 per cent a year. Total input per capita rose only fractionally, as substantial increases in capital input relative to population did little more than offset a persistent decline in labor input per capita.

Of interest from the viewpoint of the functional distribution of income in the private domestic business economy is the fact that real average hourly labor compensation rose at an average annual rate of 3.3 per cent between 1948 and 1966. This growth rate exceeds that of output per unit of labor input by 0.2 percentage points, a difference that can be deemed a measure of the proportionate rate of increase in labor's share of factor income originating in the business economy–from 69.7 in 1948 to 72.5 in 1966. This represents a continuation of the 1929-48 drift. It is associated with a historical elasticity of substitution between capital and labor input of around 0.66, reflecting the relationship between the relative rates of growth of the factor inputs and the relative rates of change in their real prices. Measured in this way, elasticity is also influenced by the nature of the innovation and possibly other factors.

Chapter 4 is concluded by some observations concerning the causes of productivity advance. It is my hypothesis that the chief proximate determinant of the rate of growth in total factor productivity is the rate of growth in the real stocks of intangible capital embodied in the tangible factors. These intangible investments enhanced the "quality," or productive efficiency, of the factors. Reference is made to a current study by the author in which estimates are made of the total real stocks of capital, which show a significant increase in intangibles relative to tangibles. Other possible causes of productivity change are discussed, including changes in economic efficiency, scale, the inherent quality of resources, and rates of capacity utilization.

Industry Patterns of Productivity Change (Chapter 5)

In looking at changes in productivity of more than thirty industry groups, we find that the degree of dispersion is considerable for the post-1948 period, but no greater than in earlier periods of comparable length. No group for which estimates were constructed showed declines in total factor productivity, while some showed increases of up to 8 per cent a year, on the average. Dispersion was somewhat greater in subperiods measured between cycle peaks; some groups showed productivity declines in one of the four subperiods covered, while a few other groups showed increases of over 10 per cent. There was also considerable variability in industry productivity movements over subperiods and from year to year, but as in the case of the private economy as a whole, variability was considerably less after 1948 than before.

Chapter 5 also presents rates of change in the partial productivity ratios by industry, as well as summary measures of their dispersion and variability. Since capital per unit of labor input rose in almost all industry groups, the

rates of increase in labor productivity generally exceed those in total factor productivity, while rates of increase in the output-capital ratio are lower. Industry dispersion in rates of change in the partial productivity ratios are much the same as pre-1948, with the dispersion in the capital-output ratio higher than that in labor productivity. Variability in the output-capital ratio is still much higher than that in labor productivity, reflecting the greater difficulty in adjusting fixed capital to output over the short run than adjusting man-hours employed. As would be expected, variability and dispersion in rates of change are greater the wider the degree of industry detail studied.

While of some interest in their own right, industry differentials in productivity advance are of particular value as a means of analyzing economic impacts and causal factors on a cross-sectional basis. This is the objective of the sixth and final chapter.

Interrelationships Among Rates of Change in Productivity, Output, and Associated Variables (Chapter 6)

As was discovered for earlier periods, there is a significant positive correlation for the period 1948-66 between rates of change in productivity and in output for the manufacturing groups, and for the broader set of thirty-two two-digit industry groups (which do not include agriculture, construction, finance, and services). Additional regression analyses indicate that this relationship may be explained by the fact that relative changes in productivity are negatively correlated with relative changes in output prices by industry (since there is no significant degree of correlation with input prices), and that relative industry changes in prices and in output are likewise negatively correlated, indicating that the effects of price elasticities of demand are not outweighed by other factors. The relationship between relative industry changes in output and in productivity is somewhat closer than is explained by the price factor, suggesting that the relationship is reciprocal, and that relative scale economies in the faster-growing industries augment other forces producing above-average productivity advance in these industries. Similar results were reported by Fuchs for seventeen industries in the trade and service sector.[9]

Our results also confirm Fuchs's findings that changes in productivity and in output are not positively correlated for the one-digit industry groups, including extractive industries and the service sectors, for reasons which we

[9] See Victor R. Fuchs, *The Service Economy*, New York, National Bureau of Economic Research, 1969, Chapters 3 and 4.

adduce. As a result, employment in the service sector, which had below-average productivity advances, showed large increases, while the opposite was true of the extractive sector. In the two-digit industry sectors, however, relative changes in productivity and in employment were not negatively correlated in 1948-66, and in earlier periods there was a mildly significant positive correlation.

For the twenty-one two-digit manufacturing groups, we assembled estimates of a number of possible causal variables. A matrix of simple correlation coefficients is presented. Due to a high degree of multicollinearity among the variables as well as incomplete specification of all the significant variables, it is felt that the results of multiple regression analysis are questionable. Cross-sectional industry analyses are also complicated by the fact that the productivity advance of any given industry is affected by variables at work in the industries from which purchases are made, as well as by forces promoting technological advance from within the industry. Additional work is needed to estimate more comprehensively all the chief factors, direct and indirect, affecting productivity in the various industry groupings and thereby the industrial structure of the economy.