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CHAPTER 1

The Significance of Productivity Change : Introduction and Preview of Study

THE story of productivity, the ratio of output to input, is at heart the record of man's efforts to raise himself from poverty. The record for the United States begins mainly in the latter part of the nineteenth century. This is a relatively brief segment even of modern history, but it is a period and a setting in which efforts to raise productive efficiency were notably successful. Of the fourfold increase in real net national product per capita between 1889 and 1957, productivity advance accounted for about three-fourths. This meant not only a large gain in the plane of living, but an increase in the quality and variety of goods and an expansion of leisure time, while increasing provision was made for future growth and for national security. It is the purpose of this volume to describe these United States productivity trends and to indicate some interrelationships between productivity change and changes in economic aggregates and the economic structure.

The Growth of Interest in Productivity

Almost from the beginning of the modern scientific-technological era economists have been concerned with the effects of technological advance on economic development. It has only been in the last generation, however, that concern with productivity advance has become widespread.

Adam Smith gave classic expression to the role of productivity advance in national economic growth when he wrote:

The annual produce of the land and labour of any nation can be increased in its value by no other means, but by increasing either the number of its productive labourers, or the productive powers of those labourers who had before been employed . . . in consequence either of some addition and improvement to those machines and instruments which facilitate and abridge labour; or of a more proper division and distribution of employment.¹

¹ Adam Smith, *An Inquiry Into the Nature and Causes of the Wealth of Nations*, New York, Random House, 1937, p. 326. Various mercantilist writers before Smith had noted the importance of productivity in national economic growth (see E. A. Johnson, *Predecessors of Adam Smith*, New York, Prentice-Hall, 1937).

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David Ricardo and John Stuart Mill, who dominated economic thought over much of the nineteenth century, likewise recognized the importance of productivity change in economic development, but did not share Smith's optimistic view of the future. They theorized that as population grew and pressed against limited natural resources, productivity in agriculture and mining would decline and offset any rise in industrial productivity, thus tending to check population growth. Ricardo recognized that the "stationary state" might be postponed by technological advance, but he held that over the long run the tendency towards a diminishing return in the extractive industries would prevail. Naturally, some economists disagreed with this dismal prognosis. Henry C. Carey, John Rae, and Henry George in America, for example, asserted that productivity advance rather than diminishing returns accompanies economic expansion. Even Marx clearly recognized the capitalist dynamic that promotes cost-reducing innovations, although he mistakenly predicted that workers would not share in productivity gains.²

In speculating about economic change, it is obvious that the theorists were badly handicapped or misled by lack of economic data. It became generally apparent by the latter part of the nineteenth century that the Ricardo-Mill thesis was wrong, at least for relevant time periods. As Henry Sidgwick judiciously concluded ". . . our evidence does not enable us to lay down any concrete law."³

With the development of marginal analysis, the focus of economics shifted to value theory which, with its assumptions of static technology, tastes, and resources, does not depend on economic time series for its content. Yet many economists continued to be intrigued by the "high theme of economic progress." Alfred Marshall himself, although one of the architects of static equilibrium theory, cautioned that "economic problems are imperfectly presented when they are treated as problems of static equilibrium, and not of organic growth. For though the static treatment alone can give us definiteness and precision of thought . . . it is yet only an introduction."⁴ But major progress in the study of economic change had to await a new impetus that would spur the development of the body of economic statistics necessary for fruitful analysis.

That impetus came with the great depression of the 1930's and was heightened by subsequent events. Odd as it may seem to the postwar generation, interest in obtaining data on productivity and related economic

² "Capital must revolutionize the technical and social conditions of the labour process itself, before the productivity of labour can be increased." Karl Marx, *Capital*, trans. from 4th German edition, New York, International Publishers, 1929, p. 328.

³ Henry Sidgwick, *Principles of Political Economy*, pp. 154-155 (quoted in Edmund Whittaker, *A History of Economic Ideas*, New York and London, Longmans, Green, 1940, p. 345).

⁴ Alfred Marshall, *Principles of Economics*, 8th ed., London, Macmillan, 1920, p. 461.

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variables arose out of concern with the labor-displacing role of technology and with the possibility of secular stagnation. With World War II and the postwar era, concern with technological unemployment and stagnation evaporated and interest in productivity shifted to its income-expanding aspect. Strong advances in productivity were recognized as necessary to increase output and national security potentials during both the war and the "cold war" that followed. Productivity gains were seen as vital for the reconstruction of war-torn nations and for the development of economically backward countries in which there was increasing pressure for economic growth. Productivity advances were also regarded as a means of mitigating the inflationary tendencies arising from the generally buoyant demand situation in the postwar era. Union leaders viewed productivity increase as a major argument for raising wage rates and as the chief means of increasing real labor income. The establishment of productivity centers in many countries of the world and the visits of "productivity teams" to the United States to study our practice are evidence of the degree to which productivity-mindedness has spread in the past decade.

Interacting with the growing consciousness of the important role of productivity advance in meeting major challenges of the period was the accelerated development of a body of economic statistics concerning output, inputs, productivity, and related variables. The obvious need in the 1930's for improved economic intelligence in order better to devise policies to combat depression led Congress to step up appropriations for the expansion of statistical work. Of potential importance for productivity estimation was the beginning of regular official national income estimates in 1932. The Department of Commerce was aided in this work by technicians from the National Bureau of Economic Research, which had begun national income studies more than a decade earlier and had expanded its own work in the field in the 1930's. The national income estimates were later transformed into the broad set of national economic accounts, including estimates of the real product of the economy and several major sectors, published in the 1950's. Price deflation of current values was made possible by expansion and improvement in the collection of price data by the Bureau of Labor Statistics, and by the Bureau's preparation of detailed index numbers of both wholesale and retail prices. The Bureau also improved its estimates of current employment and hours, while the employment data that emerged as a by-product of the social security programs provided a more reliable continuous basic record than was ever before available.

Direct studies of productivity trends and technological changes in many industries of the economy based on census data were undertaken by the National Research Project of the Works Progress Administration. Upon liquidation of that agency in 1940, the task of continuing the productivity

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estimates was turned over to the Bureau of Labor Statistics. The Bureau had made occasional studies previously, but the importance of continuing estimation and study of productivity change was recognized by the creation of a Division of Productivity and Technological Developments within the Bureau.

The National Research Project studies of farm productivity and technology were carried forward in the Department of Agriculture. The National Bureau of Economic Research also began in the 1930's studies of output, employment, and productivity in various industries of the economy; and after World War II, it expanded its earlier studies of capital formation to include real stocks. It is largely from previous National Bureau and federal government studies that the estimates underlying this volume were derived. This continuing cumulation of economic time series is providing the basis for a deeper understanding of the dynamic processes of economic growth.

The Productivity Concept

The term "productivity" is generally used rather broadly to denote the ratio of output to any or all associated inputs, in real terms. Ratios of output to particular inputs may be termed "partial productivity" measures, the most common of which is output per manhour. Partial productivity ratios, while useful for measuring the saving in particular inputs achieved over time, do not measure over-all changes in productive efficiency, since they are affected by changes in the composition of input, i.e., by factor substitutions. In order to measure net savings in all inputs and, thus, changes in productive efficiency as such, we have attempted to relate real product in the economy and in thirty-three major industry groups to total factor input, as well as to labor and to capital (including natural resources) separately. This and the following section will develop in more detail the concept and meaning of total factor productivity.

THE PRODUCTION FUNCTION

Underlying the estimation of output-input relations stands the concept of the production function, i.e., the notion that the physical volume of output depends on the quantities of productive services, or inputs, employed in the production process and the efficiency with which they are utilized. The output, or real product, of the economy as a whole is generally measured in terms of final products only. Intermediate goods and services consumed in the production process are netted out through consolidation of the accounts of individual producing units. This procedure yields an unduplicated total, for the value of the intermediate goods is already included in the value of the final products. The inputs associated with the national product reduce to the services of the factors of production, which

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can be usefully classified into the two broad groupings of human and non-human capital.

Industry output, however, is frequently measured gross, in that no deduction is made for purchases from other industries. In this case, the associated inputs are the basic factors plus the intermediate-product inputs. To be consistent with the economy real-product estimates, however, the purchased intermediate goods should be netted out of the real gross value of output in order to obtain the net output (value added) or real product originating in an industry. Then the associated inputs reduce to the services of the basic factors, as in the economy case.

Change in the "productiveness" of the services of tangible factors cannot be measured directly. It can only be indirectly estimated by relating real output to the time-flow of services of real tangible stocks taken *net* of changes in efficiency. The concepts and measures used for outputs and inputs are explained in greater detail in Chapter 2, since the meaning of the ratios is obviously influenced by the precise content of the constituent elements. At this point, however, it is apparent that the productivity measure reflects, to an important extent, the excluded input of the *intangible* capital accumulated in order to increase the efficiency, i.e., the productive capabilities, of the tangible factors. But this and other qualitative elements cannot be independently measured in a satisfactory way.

Another aspect of production theory that we must note, since it affects the interpretation of individual productivity ratios (and creates a weighting problem as well), is that the composition of inputs, as well as of outputs, varies over time. A given quantity of output, with given technical knowledge, can usually be produced with differing combinations of inputs. The actual combination used will tend to be the least-cost combination, at given relative input prices. The combinations are subject to change as a result of changing relative input prices, changing technical knowledge, or changing output (if returns to scale are not constant).

Changes in factor combinations mean that ratios of output to particular inputs, even to a major class of inputs such as labor, cannot be used as measures of changing productive efficiency. Such partial productivity ratios are revealing as measures of the saving achieved over time in the use of particular inputs per unit of output. This meaning is perhaps more clearly revealed by inverting the ratio to read "input per unit of output," in which case the decreasing unit real cost, or the saving in the use of the input, is indicated by a declining ratio. But changes in the partial productivity ratios are affected by factor substitutions reflected in changing input combinations, as well as by changes in productive efficiency generally. Output per manhour, for example, may go up as a result of the substitution of capital for labor (increased capital per manhour) as well as because of the increased efficiency of production generally.

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To measure the *net* saving in factor inputs and thus the increase in overall productive efficiency, it is necessary to relate output to *all* associated inputs. The effects of factor substitutions cancel out in the total productivity indexes. Output-labor ratios were more adequate measures of changing efficiency when capital was quantitatively less important than it has since become. The growth of the real stock of capital in relation to the labor force means that "labor productivity" measures have an upward bias as efficiency indexes. However, because capital per worker has grown in almost all industries, the measures of output per manhour tend to provide fairly accurate measures of the rankings of the various industries with respect to productivity change.⁵ Increasingly in recent years, investigators have sought to estimate productivity change in terms of a complete production function. Although regression equations may be fitted to the output and input data to reveal the coefficient of technological progress, we have chosen to work in terms of productivity ratios, which provide greater flexibility for the analysis of movements and of relationships with other variables.⁶

WEIGHTING

In order to determine the changes in aggregate outputs and factor inputs, and thus productivity, it is necessary to combine unlike types of output and of input units by weights that indicate their relative importance for the purpose at hand. If all types of outputs, or of inputs, moved proportionately, weights would make no difference and partial productivity ratios would measure changes in efficiency. But this case is improbable. With changing output and input proportions, the extent, or even the direction, of productivity change cannot be determined without appropriate weights. As Tinbergen has written:

Technical progress occurs when new combinations become possible that are cheaper than the cheapest combinations before, at the given level of prices. . . . The fact of technical progress can easily be established if there is a reduction in the use of each of the factors of production; sometimes, however, a decrease in the quantity of labor may be accompanied by an increase in the quantity of capital used. If the increase in capital represents less

⁵ Cf. George J. Stigler, "Economic Problems in Measuring Changes in Productivity," *Output, Input, and Productivity Measurement*, Studies in Income and Wealth, Volume 25, Princeton University Press (for NBER), 1961.

⁶ References to other works that use a total-productivity approach are contained in John W. Kendrick, *Productivity Trends: Capital and Labor*, Occasional Paper 53, New York (NBER), 1956. A fuller discussion of the theoretical basis of the total-productivity concept is contained in the author's doctoral dissertation, *The Meaning and Measurement of National Productivity*, George Washington University library, Washington, D.C., typescript, 1955.

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sacrifice as measured by current prices than the decrease in the quantity of labor, there is a net reduction in sacrifice.⁷

Types of weights. It is generally held that for purposes of productivity analysis, outputs should be weighted by product prices at factor cost, and inputs should be weighted by unit factor compensation (factor price).⁸ By this method the values of output and of input are equal in the base period; the unit values of the outputs are proportional to the values of the factor services required for their production; and the unit values of the inputs are proportional to the shares of the value of outputs which they obtain for their services. Under competitive conditions the prices of the factors represent the relative values of their marginal contributions to output, in equilibrium.

Market price differs from factor cost by the value of capital consumption and of indirect business taxes less government subsidies.⁹ With factor cost weights, the relative importance of different goods is not necessarily proportional to their marginal utilities; rather it is proportional to the relative volume of embodied factor service.

Under competitive conditions, factor price may be interpreted as representing the marginal value products of the various types of factor inputs, on the one hand, and the relative marginal disutility of work or saving, on the other. The marginal products indicate what the producer can *afford* to pay for the quantities used, while the marginal disutilities indicate what he *has* to pay in order to induce people to work rather than to enjoy additional leisure, and to save and invest rather than to enjoy additional consumption or liquidity. Although productivity analysis has to do with physical volumes of output and input, we cannot get away from the psychological elements involved in the mutual determination of prices of both outputs and inputs since relative prices are necessary to aggregation.

The weight-base. Perhaps the most serious problem of measurement is introduced by variations in the relative prices of outputs and of inputs. Inputs in perfectly competitive factor markets are utilized up to the point at which the values of their marginal products are equal to their prices. So their prices indicate the ratios at which units of the inputs may be

⁷ Jan Tinbergen and J. J. Polak, *The Dynamics of Business Cycles*, Chicago, University of Chicago Press, 1950, pp. 27-28.

⁸ See J. R. Hicks, "The Valuation of the Social Income," *Economica*, May 1940, p. 105.

⁹ In practice, we use market prices for combining the physical volumes of production of different commodities within the industry and the economy. This is done because of the statistical difficulties involved in estimating the factor cost of goods. But in the United States it is probable that for most goods and services relative market prices are not far different from relative factor costs. And in combining output indexes of industries (see the Appendixes) we have used value-added or national income originating weights, which approximate closely factor cost. See John W. Kendrick, "The Estimation of Real National Product," *A Critique of the United States Income and Product Accounts*, Studies in Income and Wealth, Volume 22, Princeton University Press (for NBER), 1958; and also *Introduction to Output, Input, and Productivity Measurement*, Studies in Income and Wealth, Volume 25, Princeton University Press (for NBER), 1961.

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substituted for one another at the margin. So long as the relative prices and marginal rates of substitution are constant, use of relative factor-price weights yields an unambiguous net change in the total volume of input. If relative prices change but factor proportions in real terms remain constant, a change in total input can also be measured precisely.

But if, as is generally the case, there occur relative changes in both factor prices and proportions and these are intercorrelated to any significant extent, the degree, or even the direction of change, in total input may be ambiguous. That is, it may not be clear whether production functions have shifted or whether producers have merely shifted position on a given isoquant, i.e., have changed factor proportions under existing technical knowledge. There is, of course, no ambiguity as to direction if the same or a larger volume of output is produced by a smaller quantity of one or more of the inputs, and no more of the others. But if one input decreases and another increases, while their relative prices change in inverse relation, the direction of movement may also differ depending on whether base-period or given-period price weights are used. The same problem is encountered in aggregating different types of output when there have been relative changes in quantities and prices.

At best, one can compare the changes in aggregate output and input in two periods using the prices of each as weights in order to bracket the range of uncertainty. In time-series comparisons, one might make alternative computations using the most extreme sets of weights. In order to simplify analysis, we have generally used average prices in the terminal years of the various subperiods as weights. By this method of periodically changing weights, productivity changes in each subperiod are made to reflect the concurrent economic structure. In practice, the differences in movement of the productivity ratios using alternative weights are not large relative to the total change, partly because both output and input are similarly affected by alternative weight-bases (see Chapter 2). But it should be kept in mind that proportionate changes in productivity cannot be measured uniquely, and the changes shown in this study are to some extent a function of the weighting conventions used.

The Meaning of Productivity Change

Total factor productivity may be thought of as the ratio of real product in the economy or in component industries (preferably at constant unit factor cost) to the associated real national income deflated by factor prices. That this ratio can be used to indicate changes in productive efficiency was observed by Morris Copeland at the first meeting of the Conference on Research in Income and Wealth in 1936:

Income derived from an area may be deflated to show changes in the physical volume of services of labor and wealth

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employed by the economic system from time to time. If we may neglect net income from abroad as relatively small, the deflated distributive shares may be compared with the deflated consumed and saved income to show changes in the efficiency of operation of the economic system.¹⁰

If standard output and input units of a given period (II) are weighted by the unit factor costs and unit factor compensations (prices), respectively, of a base period (I), then the meaning of changes in the ratio may be stated as follows. We are comparing what the outputs of II would have cost at the factor prices and unit factor requirements of I (real output) with what they did cost in constant I factor prices but at the II level of productive efficiency (real input). Alternatively, we are comparing the actual real output of II with what the output of the factors would have been in II had the productive efficiency of I (real input) prevailed.

Although we may define changes in total factor productivity as changes in "productive efficiency," this is a broad term which needs further clarification to give it more definite meaning. Productive efficiency may change as a result of technological innovation, changes in scale of output, and changes in the rate of utilization of capacity. It may also reflect changes in inputs of "intangible capital" designed to increase the quality of the input of the tangible factors, and such change is not readily susceptible to measurement. Mere *description* of the components of changing productive efficiency does not, of course, *explain* the causes of the changes.

For example, the volume of technological innovation designed to reduce costs is influenced by economic conditions in any given period. But over longer time periods, the volume of innovation depends essentially on the quantity and quality of resources devoted to increasing scientific and technical knowledge and developing commercial applications. Still more fundamentally, the relative volume of resources devoted to research, development, and innovation depends on the basic values and motivations of a people and on the efficacy of the rewards and penalties provided by prevailing institutions for success or failure in the efforts to improve productive efficiency.

Some innovations in the organization of production are made possible by growth in the scale of output of the industry and the economy. That is, as output increases, certain overhead-type inputs or activities do not need to be increased proportionately, and the growing specialization of plants or firms in various industries tends to lower real costs per unit of output.¹¹ Such "external economies" may be offset to some extent by a tendency

¹⁰ Morris A. Copeland, "Concepts of National Income," *Studies in Income and Wealth, Volume 1*, New York (NBER), 1937, p. 31.

¹¹ See George J. Stigler, "The Division of Labor is Limited by the Extent of the Market," *Journal of Political Economy*, June 1951.

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towards "diminishing return," in the extractive industries, as land and other proven natural resources are worked more intensively or as inferior natural resources are brought into production. Even in the extractive industries, however, tendencies towards rising unit costs may be countered by increasing returns from organizational improvements as well as from autonomous innovation. The productivity ratios for these industries, as for the whole economy, reflect the *net* effect of changes in scale as well as innovations that are not associated with changes in scale.

Changes in the volume of output are a rough measure of the opportunities afforded for organizational innovations; the associated productivity advance depends on managerial alertness and flexibility in adapting to the cost-reducing possibilities. Inevitably, some invention is induced when production is organized on a scale not previously experienced. It should also be noted that were it not for autonomous innovation, there would be a slower growth of output and, therefore, fewer attendant economies of scale. It is not readily feasible, however, to split a given change in productivity between the part resulting from innovations induced by changes in scale and the part resulting from autonomous innovation.

The rate of utilization of capacity chiefly affects productivity over the business cycle. In each plant there is some most efficient rate of utilization of the fixed capital. Substantial departures from this rate result in increasing costs per unit of output. Productivity in the industry and economy, as weighted averages of productivity indexes for individual plants, reflect the net effect of changes in rates of utilization of many plants. The net effect of this variable between years of high demand should not change significantly, assuming no great difference over time in entrepreneurial foresight in anticipating demand changes and planning capacity accordingly.

Our analysis of productivity trends is based largely on productivity estimates for "key years" of relatively high-level economic activity in order to minimize the effect of changing rates of utilization of capacity. The productivity trends over intermediate and longer time periods thus reflect primarily the impact of innovation on the organization and technology of production, including that induced by changes in scale. Cyclical fluctuations indirectly affect the secular productivity trend, however, since they affect the cumulative volume of investment in both tangible and intangible capital. The milder the fluctuations, the higher the growth rates are likely to be.

The Significance of Productivity Change: Preview and Plan of Study

Although informed people the world over are more productivity-minded today than ever before, the social and economic ramifications of productivity change are often not fully appreciated. We shall try to indicate the

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main ways in which productivity is related to other significant economic variables, reviewing briefly the areas treated in this study and summarizing some of the findings. This will be done in the same sequence as the material is developed in the rest of the volume in order to provide a guide for the reader.

In this chapter we have already discussed the productivity concept in general terms. But the movement of the productivity ratio will depend on the precise definitions given to its component output and input terms, the methods used to estimate the several variables, and the reliability of the underlying data. Chapter 2, which is a review of these matters, will be of primary interest to the technician. Although trend movements are more accurate than shorter-period changes, and estimates for recent decades are more reliable than those for earlier years, we believe that the estimates are good enough to support the general picture of productivity change presented in later chapters. This appraisal is more credible in that the over-all and relative productivity movements appear to be broadly consistent with the movements of related variables.

AGGREGATE ECONOMIC DEVELOPMENT

Part II is devoted to a description of productivity change in the economy as a whole and its interrelationship with aggregate economic growth. Chapter 3 is largely a description of productivity movements in the private domestic economy, since the estimates of real product and productivity for the private domestic economy are more reliable than those for the total economy including government.

Between 1889 and 1957 total factor productivity in the private domestic economy grew at an average annual rate of around 1.7 per cent. Output per unit of labor input rose considerably faster than the output-capital ratio, since capital per unit of labor input increased at an average rate of 1 per cent a year. It is nevertheless significant that savings in capital as well as in labor inputs were achieved—particularly after 1919.

There is some variability in the rates of change in total productivity from one decade to the next and much more variability in the annual changes that are shown to be associated with the business cycle. The variability in the movements of the two partial productivity ratios is greater than that of the total productivity measure. The most striking fact to emerge from the time series is a pronounced acceleration in productivity advance to an annual rate of 2.1 per cent beginning around the time of World War I.

What has been the contribution of productivity advance to aggregate economic growth, and what are some of the chief developments that have promoted the technological progress that underlies productivity gains? These questions are treated in Chapter 4. The contribution of productivity

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to economic growth differs according to the growth measure employed. Thus, whereas productivity gains account for almost half the increase in real net national product between 1889 and 1953, they account for three-quarters of the increase in real product per capita. More complex measures of economic progress are also analyzed.

Examination of the composition of inputs and outputs yields evidence as to the causal forces at work in the process of productivity advance. Estimates are presented showing the marked rise in outlays designed to increase the quality of productive resources. Growing relative outlays for education and for health have increased the average productive powers of the population; and rising outlays for research and development have improved the organization, processes, and instruments of production. Consumption of basic materials per unit of output has declined significantly.

Rising productivity has meant that the prices of final goods and services have risen less than the prices (average unit compensations) of the factors of production. It is in this way that the fruits of productivity advance have been distributed to those who provided the factor services—the theme of Chapter 5. The relative shares of labor and capital in the productivity increment have depended on the relative price movements of these factors. Owing in part to the increase in capital per worker, the relative price of labor has risen, real average hourly labor compensation has grown at a somewhat higher rate than productivity, and the labor share of national income has increased.

CHANGES IN ECONOMIC STRUCTURE

In Part III we go behind the national average rate of productivity advance to look at the different rates of change experienced by major industries and the effect of these differential rates on the economic structure. The descriptive material of Chapter 6 makes it clear that there was considerable dispersion of industry rates of change in total productivity and in the partial productivity ratios, and that these rates have varied more over time than indexes for broader aggregates. This has been partly due to the differing relative amounts of resources devoted to research and development, to different rates of change in scale of output, to differing degrees of cyclical fluctuation, and to other factors too complex for complete analysis. But we should also recognize that almost all industries showed advances, which testifies to the strength of the basic forces in our economy conducive to material progress.

The differential rates of productivity advance by industry have had profound effects on the economic structure—the focus of Chapter 7. Those industries with larger than average productivity increases have generally shown relative price declines. Although relative price is only one of several

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factors influencing demand, the output of the more progressive industries has tended to rise more than the real national product as a whole—and enough more to provide for the absorption of an increasing proportion of the labor and capital available to the private economy.

PROSPECTS

Although we do not attempt to project productivity changes into the future, it is clear that the study is of relevance in this regard. We can be reasonably certain, for example, that short of the devastation of war, total factor productivity will continue to grow in the economy and most of its industries. Rates of growth will vary from one decade to another, but major acceleration or deceleration in economy rates of growth is unlikely unless there are major changes in basic forces not presently apparent. We can also be reasonably certain that future rates of productivity change will differ considerably from one industry to another (although narrowing of dispersion is not unlikely), and that the ranking of industries with respect to productivity change will differ from one period to another. As long as competition remains strong, we can expect the technologically more progressive industries as a whole to continue to grow more than the average and to continue to absorb an increasing share of available labor and capital resources.

Uses and Limitations of Productivity Estimates

Productivity estimates have proved useful in economic analyses and projections as a background for public and private policy decisions. However, they have also been used for purposes for which they are not appropriate, or without regard to their inherent limitations. In this concluding section, we discuss both the uses and possible abuses of the measures.

USES

The measurement of productivity increases our understanding of an important aspect of the modern economy. But what “practical” use may be made of the estimates? The applications of important bodies of statistics develop slowly, and it is likely that new uses for productivity estimates will continue to evolve. However, we shall suggest some of the major types of application. These relate to productivity indexes as measures of performance and thus as a means of motivating improved efficiency; their use in the analysis of factors that promote productivity advance as a basis for prediction and policy formation; and their use in the analysis of dynamic economic relationships, again as a background for prediction and policy decisions. Increasing use is being made of productivity estimates at the company level, as well as at the industry and the total economy levels.

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The existence of productivity estimates increases productivity-mindedness by inviting comparisons with the historical record or with the records of other countries or firms. Within the firm, productivity comparisons may be made of similar plants for use as a management tool. Intercompany comparisons may reveal unfavorable trends sooner than would the profit-and-loss statement and may suggest ways in which management can improve the technological performance of the business. Comparisons of national economy and industry productivity trends with those of other countries may likewise prove the need and provide the motivation for improved performance. With an increasing body of estimates relating to other countries, international comparisons will become more important.

Understanding of the interrelationships between productivity and causal variables is necessary both to project productivity change and to take appropriate measures to influence it. Quantitative analysis is probably of limited applicability in this area, but it can be a useful supplement to qualitative analysis (see Chapter 6). Hitherto, productivity projections have largely been made by extending past trends, with reasonably good results.¹² But the forecaster should at least be aware of the complex of factors whose net effect he assumes will be the same in the future as in the past; he should also be alert for possible indications of significant changes in important causal factors.

Understanding of the interrelationships between productivity changes and changes in related economic variables is necessary for consistent prediction of the related variables, and for the selection of appropriate measures to influence one or more of the variables. In long-range, macroeconomic models, projections of productivity and factor supplies make possible projections of the real national product. National product projections are indispensable for national planning and policy purposes, and serve as a basis for projecting the sales and output of particular industries and firms. In short-range national projections, output is usually forecast on the basis of demand forces, and input requirements are derived as the quotient of the output and productivity projections. The same technique is used in long- as well as short-range industry and company projections. Here, the productivity projection is a means of estimating requirements for labor, capital, and materials.

Given projections of productivity and factor prices, the implied change in product prices can be derived. Or, given the productivity and product price projections (or objectives), the consistent change in factor prices can be derived. At the industry or company level, the projected relative price change is, of course, an element that must be taken into account in the sales and output projections.

¹² See James W. Knowles, "An Appraisal of Productivity Projections," *Journal of the American Statistical Association*, June 1959, p. 580.

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LIMITATIONS

Certain limitations on the use of productivity measures must also be noted. Such measures are not precision tools of analysis, but are subject to unknown and probably not inconsequential margins of error. Their meaning must be interpreted carefully in the light of knowledge as to their construction. Their relationship with other variables must likewise be interpreted cautiously, particularly regarding inferences of causality. They are clearly not "all-purpose" indexes, but must be used in conjunction with other measures in order to assess progress in the broader realms of social and economic efficiency as contrasted with the narrower realm of technological efficiency.

The question as to the accuracy of productivity estimates is treated in the next chapter; all we need say here is that significance should not be attached to small changes or differences in productivity ratios. Our earlier analysis of the meaning of changes in productivity as it is now measured indicates clearly the complexity of the variable. Partly as a supplement to the earlier discussion, this section will point up some of the things that the indexes do *not* measure as a warning against some of the more common misinterpretations.

In the first place, it bears repeating that the *partial* productivity ratios, somewhat misleadingly labeled "labor productivity" or "capital productivity," do not measure changes in the efficiency of a particular resource nor changes in productive efficiency generally. They are influenced by the latter factor (of which the former is a part), but also by factor substitutions.

An even cruder fallacy is to confuse productivity with production or capacity measures. Total-productivity measures provide an index of efficiency in the use of resources, but do not allow for the degree of utilization of available resources. Productive efficiency may be rising, but if part of the output potential is lost by underutilization, this is an offset which must be taken into account in any over-all appraisal of the economic system. Actually, productivity indexes are affected by cyclical fluctuations, as noted earlier; but this is only part of the waste involved in lapses from relatively full employment of resources.

The productivity ratios cannot be used in any simple manner to indicate the degree to which average hourly labor compensation in the economy can rise consistent with a stable general price level. As a matter of fact, real average earnings of employees have risen proportionately more than total factor productivity over the period we have surveyed, and more than output per unit of labor input in some of the subperiods. The magnitude of noninflationary wage increases depends, of course, not only on productivity advance but also on the movement of the return on

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capital relative to changes in the output-capital ratio. Even if real product per unit of capital were constant, average hourly labor compensation could increase in proportion to real product per manhour and still provide a constant rate of return on capital. The complexities of these interrelationships are discussed in some detail in Chapter 5.¹³

Measures of productivity also *do not* provide an index of "economic efficiency" as such.¹⁴ That is, we cannot tell from productivity measures whether or not the various types of resources are employed in their most productive uses at each given stage of technology, resource development, and wants. To the extent that there are monopolistic practices or impediments to the mobility of resources, the relative prices of products differ from those that would prevail under perfect competition; the allocation of the factors is somewhat distorted; and the factors do not receive the exact value of their marginal products. Changes in economic efficiency affect productivity measures only indirectly. Over long periods in a dynamic economy with as much economic freedom and mobility as prevails in the United States, the gains to be realized from tightening up economic efficiency are probably minor compared with those that accrue from the increases in technological efficiency, which are primarily reflected in the productivity measures. Nevertheless, a continuing appraisal of economic efficiency and the adoption of policies designed to promote it remain important objectives, particularly in less advanced economies.

The productivity index numbers likewise do not measure changes in economic welfare. As is demonstrated in Chapter 4, increases in real input per capita have proceeded at a slow rate in this century; so it is true that productivity gains have accounted for the bulk of the increases in real national product per capita. But real product per person cannot be construed as measuring changes in material welfare. In the first place, changing proportions of real product are devoted to consumption goods, the type of goods that bears most directly on welfare. It is true that investment is designed to promote future welfare and that both national security and capital outlays absorb resources that could be potentially transferred to the production of consumption goods. But real product per person, at best, gives only an indication of changes in the *potential* welfare of individuals.

Then there are the many reservations that attach to measures of real consumption expenditures per capita as indicators of welfare changes,

¹³ See also John W. Kendrick, "The Wage-Price-Productivity Issue," *California Management Review*, Spring 1960.

¹⁴ Tibor Scitovsky has contrasted economic efficiency with technological efficiency. He defines economic efficiency as production in "conformity with the community's wishes," while technological efficiency is "the achievement of the greatest possible output with given means or the achievement of a given output with the smallest means" (*Welfare and Competition*, Homewood, Ill., Irwin, 1951, p. 148).

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which have been elaborated by welfare economists. Over time, there are changes in the composition of population, in income distribution, in tastes, technology, and relative prices, which make it impossible precisely to quantify changes in the economic welfare of the community—even if it were legitimate to make interpersonal comparisons of satisfactions.

Even if we could precisely measure changes in the levels of material welfare of the community, this would illuminate only one aspect of the welfare or well-being of people considered more broadly. It is not necessary to embroider the theme that the good life is not an automatic consequence of a life replete with material goods. It is true that broadening the material base of life has provided the *potential* for a better life for an increasing number and proportion of individuals. The realization of that potential is a supreme challenge. In at least one important respect, however, productivity indexes are an indicator of the health of a community, since rising productivity reflects the expression on the material plane of the creative forces of individuals.

Finally, it must be remembered that the technological changes upon which productivity gains rest are bound to have a more or less disruptive influence on individuals and institutions. The strains on the social fabric that occur as the limits of adaptability to technological change are approached may be great and may offset the material advantage of the last fraction of productivity gain. On the other hand, people and institutions can be very flexible. One of the important problems involved in accelerating productivity advance (when this becomes a social objective), is to increase the range of adaptation. This is a problem that requires continuing research and inventiveness by those in the social and behavioral sciences.