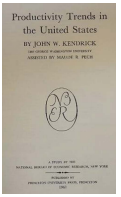
Introduction to:
John W. Kendrick,
Productivity Trends in the United States, NBER, 1961



Basic Facts on Productivity Change

AN INTRODUCTION BY SOLOMON FABRICANT

Importance of the Facts

PRODUCTIVITY has been much discussed in recent years, and too frequently misunderstood.

Productivity deserves the attention that it has received, for it is a measure of the efficiency with which resources are converted into the commodities and services that men want. Higher productivity is a means to better levels of economic well-being and greater national strength. Higher productivity is a major source of the increment in income over which men bargain and sometimes quarrel. And higher—or lower—productivity affects costs, prices, profits, output, employment, and investment, and thus plays a part in business fluctuations, in inflation, and in the rise and decline of industries.

Indeed, in one way or another, productivity enters virtually every broad economic problem, whatever current form or new name the problem takes—industrialization, or research and development, or automation, or tax reform, or cost-price squeeze, or improvement factor, or wage inflation, or foreign dollar shortage.

Despite its importance and the wide attention paid it, productivity is a subject surrounded by considerable confusion. For this there are a number of reasons. First, people employ the same term but mean different things. As a consequence, various figures on productivity change come into use, and these often differ in significant degree. Further, the rate of productivity change is not a fixed quantity. Professor Kendrick's figures show that it varies from one period to another. What the past or current rate of productivity change is depends on the particular period for which the calculation is made. If no reference is made to the period, and if the period varies considerably from one context to another, confusion results. In addition, the statistical information available for calculating productivity

NOTE. A longer version of this summary was published by the National Bureau in 1959 as Occasional Paper 63. Included here are also some paragraphs from a statement presented before the Joint Economic Committee of the United States Congress in April 1959.

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indexes is deficient in various respects. Better or worse—or merely different—methods of meeting these deficiencies, enumerated below, often yield results that differ appreciably. Failure to specify the methods and the assumptions involved in the process of estimation, or failure to understand them, adds to the confusion.

As has been said, the questions into which productivity enters are important. They are also difficult. We all have far to go before any of us can claim to understand fully the process of productivity change, its causes, or its consequences, or to see clearly the way to deal with the issues involved. But surely the way to more effective policy would be clearer if the basic facts of productivity change were established and widely known.

Establishing important economic facts is an objective of the National Bureau. Because the facts bearing on productivity are important, the Bureau has for a long time devoted a portion of its efforts to their determination and analysis. Its completed studies of national income, capital formation, production trends, mechanization, employment, and productivity have contributed essential pieces of information.

Currently, the task of cultivating this significant area of economic knowledge is being undertaken at the National Bureau in a number of separate, though related, projects: a study of trends in wages and productivity; a study of trends in national product, capital formation, and the relation between capital and product; and a study of cycles in productivity, costs, and profits. Some of the results of these current investigations have already been published (the present report by Professor Kendrick is the latest to be issued); some are in press; others are in various stages of preparation.[1]

Like the other studies, Professor Kendrick's must be rather technical in character, devoted as it is to the examination of concepts, the sifting of evidence, the preparation of estimates, and the analysis of complex results.

[1] The reports already published and those soon forthcoming are as follows: John W. Kendrick, *Productivity Trends: Capital and Labor*, Occasional Paper 53, New York (NBER), 1956; Solomon Fabricant, *Basic Facts on Productivity Change*, Occasional Paper 63, New York (NBER), 1959; John W. Kendrick, *Productivity Trends in the United States* (the present volume); Clarence D. Long, *Wages and Earnings in the United States: 1860–1890*, Princeton University Press (for NBER), 1960; Albert Rees, *Real Wages in Manufacturing, 1890–1914*, Princeton University Press (for NBER), 1961; and Albert Rees, *New Measures of Wage-Earner Compensation in Manufacturing, 1914–57*, O.P. 75, New York (NBER), 1960.

Also, Simon Kuznets, *Capital in the American Economy: Its Formation and Financing*, Princeton University Press (for NBER), in press; Leo Grebler, David M. Blank, and Louis Winnick, *Capital Formation in Residential Real Estate: Trends and Prospects*, Princeton University Press (for NBER), 1956; Alvin S. Tostlebe, *Capital in Agriculture: Its Formation and Financing since 1870*, Princeton University Press (for NBER), 1957; Melville J. Ulmer, *Capital in Transportation, Communications, and Public Utilities: Its Formation and Financing*, Princeton University Press (for NBER), 1960; Daniel Creamer, Sergei P. Dobrovolsky, and Israel Borenstein, *Capital in Manufacturing and Mining: Its Formation and Financing*, Princeton University Press (for NBER), 1960 and Thor Hultgren, *Changes in Labor Cost During Cycles in Production and Business*, Occasional Paper 74, New York (NBER), 1960.

Readers who put Professor Kendrick's important findings to practical use will appreciate the care he has taken to expose to their scrutiny the evidence on which the findings are based.

The more general reader may wish to have a less technical summary of the main results of this substantial research effort. This introduction is for him.

Even a summary of facts will have to cover a good deal of territory. Something needs to be said about each of the following matters: the long-term average rate of growth of national productivity; the degree to which growth of productivity has experienced change in pace; productivity increase in relation to the rise in the nation's real output; and the extent to which increase of productivity has been the general experience of the various industries of the economy. To each of these subjects, therefore, a brief section is devoted, which lists the main facts and provides such discussion of concepts, data, alternative measurements and findings as is necessary to make the results intelligible. We begin with a capsule statement of the highlights.

The Facts in a Nutshell

The essential facts on productivity and economic growth in the United States can be put most briefly and simply as follows:

1. During the past three generations, the nation's real output per manhour of work done has been rising at a substantial average rate—between 2 and 2.5 per cent per annum, or about 25 per cent per decade. This upward movement shows no signs of slowing down. On the contrary, the trend witnessed by this generation has been higher than the trend witnessed by earlier generations. Indeed, during the most recent period—after World War II—national output per manhour rose at a rate of 3 to 3.5 per cent per annum, or 35 to 40 per cent per decade. This means, in absolute terms, that in ten years there has seen *added* to an already large output per hour of American labor an amount that is well in excess of the *total* output obtained per hour of work in most regions of the earth.

2. The increase in national output per manhour is the outcome, first, of a heavy investment in business and farm plant and equipment, in public improvements, and in other tangible capital goods. The volume of tangible capital per head of the population has increased at an average rate of over 1 per cent per annum, or 10 per cent per decade. A contribution has come, second, from investment in education and on-the-job training and from expenditures on research and development and other forms of intangible capital. No really adequate figures can yet be offered here, but the contribution has undoubtedly been significant. Third has been greatly improved efficiency in the use of the country's labor and tangible and intangible capital resources.

3. A growing fraction of the potential product offered by a higher and higher output per manhour has been given up by our people in order to enjoy more leisure. Normal weekly hours of work per employed person, for example, have been cut by 20 to 30 per cent, on the average, since the turn of the century; and the practice of paid vacations, and of longer vacations has beome more widespread. Another fraction of the rising output per manhour has been used to finance investment in private and public capital. This fraction, however, has not had to rise to bring the great expansion in capital per head of the population to which reference was made a moment ago. In fact, it may even have fallen a bit. Still another and growing fraction has been used to meet the increased needs of national security. Along with this, a much smaller fraction has gone into technical and military assistance and aid to other countries. The rest, the great bulk of the rise in output per manhour, has been used by our people to get the goods and services for which they have worked and saved —a larger volume and better quality of goods and services, and many new goods and services. National consumption per capita has grown at a rate somewhat lower than the rate of increase in output per manhour; but the rate has nevertheless been very substantial—something like 1.8 per cent per annum, or 20 per cent per decade, on the average.

4. The gains of productivity have been widely diffused among our people. Real hourly earnings, including fringe benefits of several sorts, have grown about as rapidly, on the average, as has output per manhour. Further, a roughly similar upward trend is visible in the real hourly earnings of each of the industries for which figures are available. The rate of return on capital has tended to remain roughly constant, on the average, but even this horizontal trend reflects a gain from productivity in an important sense, since the great increase in capital per worker already mentioned would probably have reduced the rate of return on capital had not productivity risen.

5. Increased productivity inevitably involves the growth of new industries and the relative, or even absolute, decline of old ones. So, too, for different occupations and regions, which also have grown at widely different rates. In some cases this has meant the painful and difficult adjustments that constitute one of the costs of economic progress.

To spell out some of these points, and present some of the significant details, let us now draw on the remarkable record provided by Professor Kendrick.

The Long-Term Rate of Increase in National Productivity

Over the seventy-year period since 1889—the period which has been examined most closely and for which presently available statistics are most adequate—the rate of increase in productivity has been as follows:

Physical output per manhour in the private economy has grown at an average rate that appears to be about 2.4 per cent per annum.

Comparing output with a measure of labor input in which a highly paid manhour of work counts for proportionately more than a low-wage manhour yields a measure of productivity for the private economy that grew at a significantly smaller rate—about 2.0 per cent per annum.

A measure of productivity for the private economy that compares output not only with labor input (determined as before) but also with tangible capital, each weighted by the market value of its services, grew still less rapidly—about 1.7 per cent per annum.

All these indexes of productivity in the private economy rose somewhat more rapidly than the corresponding indexes for the economy as a whole, including government, when the usual measurements of government output and input are utilized. For the total including government, productivity rose about 1.5 per cent per annum.

This list presents the main broad measures of long-term productivity increase that Professor Kendrick has calculated for the American economy. It is by no means complete. Kendrick goes to some trouble to provide still other measures that differ in definition of output or input, in the degree to which they cover the economy, or in details of estimation. However, these alternative calculations yield results similar to those just given (compare, for example, Tables 1, 2, and 3), and we may, therefore, concentrate on the above measures. They differ enough among themselves to raise a serious question about the meaning and measurement of productivity.

Which measure of productivity is appropriate in any case depends, of course, on the question in mind. Change in output per manhour, for example, shows the combined effect on the product obtained from an hour of labor of two groups of factors: first, those causing increases in efficiency; and, second, those causing changes in the volume of tangible and intangible capital available per manhour. This measure answers an important question. But if what is wanted is a measure of increase in efficiency alone —and it is efficiency on which we are concentrating here—the index of output per manhour is deficient. A better measure, for our purpose, is one that compares output with the combined use of *all* resources.

Information on all resources is not available, however. Until rather recently, economists interested in measuring the rate of increase in national productivity had to make shift with labor input alone—first in terms of number of workers, then in terms of manhours. This is still true

for most individual industries, narrowly defined, even on a historical basis, and for both individual industries and the economy as a whole on a current basis.

For this reason, the most widely used index of productivity—the one cited first—is simply physical output per manhour. It is a useful index, if its limitations are recognized. Because in the economy at large and, as we shall see, in most—not all—individual industries, labor input is by far the most important type of input (measured by the fraction of income accruing to it), the index based on manhours alone is not often in serious error. It is a fair approximation to a more comprehensive index of efficiency. But as such it is usually subject to an upward bias, as the figures cited indicate.

The bias in output per manhour results not only from the omission of capital input. The usual index of output per manhour fails also to take into account change in the composition or quality of labor.[2] That is, manhours worked by persons of different skills, levels of education, and lengths of experience are treated as if equivalent, thus ignoring important forms of human capital that aid in production and contribute to wage and salary differentials. The index of output per weighted manhour—the second index cited—catches some of this intangible capital, for the labor in industries with high rates of pay is given a heavier weight than that in low-pay industries. However, the procedure of weighting is only a step in the right direction. All the labor within an industry is still assumed to be homogeneous. Perhaps more important, broad advances in education and the like, which improve the quality of labor in industries generally, are not taken into account. And differences in labor quality are imperfectly measured by pay differentials, since these are influenced by such other factors as the noneconomic advantages and disadvantages of particular occupations, differences in the cost of living, and uncompleted adjustments to changes in demand and supply. The figures previously given—the difference between the rate of increase in output per manhour and in output per unit of labor (weighted manhours), which is 0.4 per cent per annum—therefore indicate the direction, but not the degree of bias, arising from the neglect of changes in the quality of labor.

With respect to the volume of tangible capital, we are in a better position than with respect to the quality of labor. In recent years the available information on tangible capital has been broadened, worked

[2] If the index relates output to manhours of work done only by "production workers"—which is frequently the case for individual industries—there is a further source of error. In that case, the index will usually rise more rapidly than output per manhour of work done by all workers; for "nonproduction workers" have, over the years, generally increased in relative importance. Kendrick's indexes relate output to the work done by *all* workers, including proprietors, supervisory employees, and clerical workers, as well as wage earners.

over, pieced out, and put into usable form by Kuznets and his collaborators, and this has helped greatly to expand the coverage of inputs for productivity indexes. The data on tangible capital are still far from perfect. In calculating them, difficulties of all sorts are involved—the treatment of depreciation, the problem of allowing for changes in prices, and the proper valuation of land, among others. These problems have not been entirely solved, but we appear to be sufficiently close to a solution to warrant use of the data. With them, output per unit of tangible capital may be computed (as in Table 1). This is informative; but, like output per unit of labor, it is an incomplete index of productivity. It tells only part of the story.

Indexes of productivity based on the comparison of output with the input of both labor and tangible capital are better measures of efficiency than those based on labor input or capital input alone.

Indeed, the best currently available approximation to a measure of efficiency is such an index. As we have seen (it is the third index cited initially in the text), it indicates a rate of growth of productivity that is significantly below the rate for output in relation to labor input alone. That it is lower will not be a surprise, since it is well known that tangible capital has increased substantially more than the labor force: tangible capital per weighted manhour has risen at the average annual rate of 1.0 per cent. Because the services of labor have become more and more expensive relative to those of tangible capital, there has been a strong incentive for business firms and other producers to substitute capital for labor. Yet—and this may be surprising—capital increased less rapidly than did output. On net balance, output per unit of tangible capital rose by about 1 per cent per annum. Technological advance and the other means to improved efficiency have led to savings of capital as well as of labor.

Surprising, also, may be the fact that the difference between productivity measured in terms of labor and tangible capital combined and productivity measured in terms of labor alone is no more than the 0.4 per cent per annum that we have found. The reason is the relatively high weight given labor in combining it with tangible capital. Obviously, manhours cannot be combined with dollars of tangible capital without translating each of them into comparable units. The appropriate unit is a dollar's worth of services in a reference base period. If a manhour of labor commands $2 in the base period, and $100 of capital equipment commands $6 of net revenue per year (whether in rent, profits, or otherwise is immaterial), we count the $100 of equipment as equivalent to 3 manhours. Because, in production, use is made of many more manhours than of even hundreds of dollars of capital, labor as a whole gets a much greater weight than does capital. The weights for the private economy are currently as 8 to 2. The index of output per unit of labor and capital combined—

which rose at the rate of 1.7 per cent per annum in the private economy—is thus, in effect, a weighted average of the index of output per unit of labor—2.0 per cent per annum—and of the index of output per unit of capital—1.0 per cent.

This weighted index was called the best available approximation to the measure of efficiency that we seek. It is approximate for more reasons than those already given. One is the problem of measuring output, which involves combining into a meaningful aggregate a changing variety of old and new goods. A special difficulty arises in putting a figure on the quantity of services produced by government to meet collective wants. This accounts for the greater confidence most statisticians have in the estimate of productivity for the private economy, exclusive of government, and explains the plurality of estimates given in Table 2 for the economy inclusive of government.

A general deficiency of all the measures of output—and thus of productivity—is their failure to take adequate account of change in the quality of output. This, it is likely, subjects them to a downward bias. And to, repeat, the indexes of output per unit of labor and tangible capital combined, though broader than any other indexes now available, fail to cover adequately the investment in education, science, technology, and social organization that serves to increase production—a point to which we shall have to return.

The technical questions raised above (which have been selected from the host to which Kendrick pays attention) are, of course, matters primarily for the producer rather than the user of productivity statistics. But for the user it is important to be aware of the sharp differences made in the rate of growth of productivity by technical choices not always specified: whether output or input is defined in one way rather than another, or weights of components of output and input are determined by this rather than that method, or data are selected or estimated from one or another source.

Measured in any of the ways listed above, however, productivity in the United States has grown at a remarkable average rate over the past two-thirds of a century. The more comprehensive indexes, in which output is compared with both labor and capital input, indicate a doubling of efficiency every forty years. The index of output per unweighted manhour indicates a doubling even more frequently—every thirty years. Not many of the countries for which corresponding records might be constructed would show average rates as high or higher over so long a period. Over shorter periods, it is very likely, our long-term rate has been exceeded in various countries. This has happened here, as well as elsewhere, as we shall see in a moment. But it is safe to say that the United States long-term rate is not low in relation to the experience of other countries over comparable periods. It may appear low only in comparison

with aspirations—the long-term rates dreamed of by countries embarked on ambitious programs of economic development, or the rates some of our own citizens believe we need to reach and maintain if we are to meet some of the urgent problems that confront us.

Fluctuations in the Rate of Productivity Increase

Productivity did not grow at an even rate. Its rate of growth was subject to a variety of changes, which may be characterized as follows:

A distinct change in trend appeared sometime after World War I. By each of our measures, productivity rose, on the average, more rapidly after World War I than before.

Over the whole period since 1889, productivity fluctuated with the state of business. Year-to-year rises in productivity were greater than the long-term rate when business was generally expanding, and less (or often, falling), when business was generally contracting.

The slow rates of increase (or decline) in productivity appear to have been largely concentrated in the first stages of business contraction. Productivity rose most rapidly, as a rule, towards the end of contraction and during the early stages of expansion.

Year-to-year changes in productivity were appreciably influenced also by random factors.

The change in trend that came after World War I is one of the most interesting facts before us. There is little question about it. It is visible not only in the indexes that Kendrick has compiled for the private domestic economy, to which Charts 3 and 4 are confined. It can be found also in his figures for the whole economy, including government, as well as in his estimates for the group of industries for which individual productivity indexes are available. Some readers of the charts might prefer to see in them not a sharp alteration of trend, but rather a gradual speeding up of the rate of growth over the period as a whole. The latter reading is not entirely out of the question, but it seems to fit the facts less well than the former. By either reading, it is clear, the rate of growth in productivity witnessed by the present generation has been substantially higher than the rate experienced in the quarter-century before World War I.

The numerical rates of increase that Kendrick gives in Table 1 help to sharpen the differences. Alternative choices of the boundary year (which is rather arbitrarily set at 1919), and of the technical method of calculating the average rate,[3] would not eliminate the difference between the two periods.

[3] Because productivity fluctuates cyclically and otherwise, it is usually somewhat better to derive rates of increase from averages for several years, rather than from the figures for single years. For the long periods covered in Table 1, the differences would be negligible, however.

The change in trend came in each of the indexes shown, and at about the same time in each—in output per unit of labor (weighted or unweighted), in output per unit of tangible capital, and in output per unit of labor and capital combined. There is this difference, however: the quickening of pace was greater for capital productivity than for labor productivity, though it was by no means negligible for the latter. For output per unit of labor and capital combined, the rate of growth since World War I has been as much as 50 per cent higher than during the earlier period.

The charts show also the cyclical pattern of change in productivity, insofar as this is revealed by annual figures. As a rule, whenever national output rose—which is virtually whenever business was generally expanding—productivity grew more rapidly than its trend rate; whenever output fell, productivity grew less rapidly than its trend rate, or actually declined.

It is obvious why this is so when input is measured by the resources available for use, as it is in the case of tangible capital. The total volume of tangible capital in existence seldom declines even during business contractions, for net additions to capital have rarely become negative in this country; nor does the volume of tangible capital rise nearly as rapidly as output during business expansion, for additions to capital are small relative to the existing stock. For similar reasons, the labor force—and even more so, the population of persons of working age—also is very stable. Output per unit of available resources, whether of labor, capital, or labor and capital combined, will therefore show pronounced cyclical fluctuations—as Kendrick illustrates in Chart 5.

Much less obvious is the cyclical fluctuation of output per unit of resources actually put to use, which can be measured for labor.[4] There were 47 year-to-year rises and 21 falls in general business. Accompanying these rises and falls in output were the changes in labor productivity shown in Table 3. The average of the rates of growth in output per weighted manhour during the years of expansion in output equaled 2.4 per cent. During the years of contraction in output, the average annual rate of growth of output per weighted manhour equaled only 1.3 per cent.

[4] It is not possible to construct an adequate measure of capital input that takes account of the rise and fall in the intensity with which capital is used as business improves or worsens. There is, at present, insufficient information on the opening up or shutting down of plants or production lines, the movement of stand-by equipment into and out of use, and the change in number of shifts per day. Nor would using the rate of employment of the labor force and of hours of work per employee to approximate the rate of use of tangible capital add anything to what the index of output per manhour tells us.

Even for labor, the measure of actual use leaves something to be desired in the case of salaried workers. The measure of output, too, probably has some cyclical bias, for a variety of reasons; for example, it does not cover some types of maintenance and repair to which workers can be diverted when business is slack.

Because Kendrick's annual indexes involve a great deal of estimation and the piecing out of scanty data, it is encouraging to find some confirmation of the results in a sample of individual industries (largely manufacturing) that has been compiled by Thor Hultgren for the period since 1933. In gathering these statistics, Hultgren made a special effort to obtain adequate and comparable data on output and the manhours worked by wage earners. His sample has the further advantage of providing information on a monthly basis, far more satisfactory for the study of cyclical fluctuations than annual data.

Hultgren's data, set forth in his *Changes in Labor Cost During Cycles in Production and Business*, point to a most striking fact, something that we miss in the annual figures. As was shown by Kendrick's annual data, interruption of the rise in output per manhour came mainly during contractions. But the monthly data suggest, further, that most of the interruption may have usually been concentrated in the first half of contraction. After contraction had been under way for a while, and well before general business revival, output per manhour as a rule resumed its upward march, and increased at a rate even greater than the rate of increase during the latter part of expansion.

Hultgren's results are not altogether consistent, and his sample of industries and cycles is narrow and needs to be broadened. But if confirmed, his findings have interesting implications for the causes and consequences of productivity change. For example, they suggest that the most rapid rates of increase in output per manhour appear during that portion of the business cycle—the last stages of contraction and the early stages of expansion—when replacement and increase of plant and equipment are proceeding most slowly, and that during the initial stages of contraction, decline in output per manhour joins with increase in wage rates to push unit labor costs up.

Beyond the cyclical fluctuations in the rate of growth of productivity, other changes may be noticed in Kendrick's charts. These include occasional spurts and slowdowns that extend over a period of years. Kendrick's estimates, and similar data compiled earlier by Kuznets and Abramovitz for the full period following the Civil War, suggest the existence of a long cycle in the rate of change of productivity.[5] High rates of increase in net national product per unit of total input came, it seems, during periods of a decade or more centered in the late 1870's, the late 1890's, the early 1920's, the late 1930's, and the late 1940's or early 1950's.

[5] See Moses Abramovitz, *Resource and Output Trends in the United States since 1870*, Occasional Paper 52, New York (NBER), 1956. A section of Kuznets's forthcoming *Capital in the American Economy* is devoted to long waves in output, capital, and the ratio of capital to output. Abramovitz is currently studying this class of phenomena and related factors; for progress reports see the *Thirty-eighth Annual Report* of the National Bureau, 1958, pp. 47–56, and the *Thirty-ninth Annual Report*, 1959, pp. 23–27.

Low rates of increase came during periods centered in the late 1880's, the late 1910's, the early 1930's, and the 1940's.[6]

Some of the irregular changes shown in Charts 3 and 4 undoubtedly reflect inadequacies of the figures. Productivity change is measured by the ratio of two indexes, each subject to error; and even slight errors in these will sometimes combine to produce considerable error in the ratio, just as they will sometimes cancel one another. We cannot be sure whether or not the change between any particular pair of years is the result simply of statistical error. On the other hand, that the errors are, on the whole, not overwhelming is suggested by the fairly systematic business cycle behavior that we have noticed. We know, also, that some of the irregularities reflect not statistical error but the impact of weather, strikes, and the other real random factors to which life is subject.

The picture emerging from the information gathered by Kendrick and Hultgren is one of a persistent and powerful tendency towards improvement in efficiency. Sometimes the outcome was a rapid, sometimes a slow, rate of growth in productivity. Sometimes the tendency was entirely offset for a while by cyclical and random factors. But only twice was the interruption long enough to prevent productivity from reaching a new high within five years.

Because the rate of increase in productivity has been far from uniform, the user of productivity figures must know the period to which they relate. Rates of productivity increase derived from one period will differ, sometimes considerably, from those derived from a longer, or shorter, or altogether different period. The same caution may be noted with regard to extrapolations of past trends into the future. These, the record suggests, will always be rather risky.

Productivity and the Increase in National Product

The nation's product or real income—the terms are interchangeable—may be said to have grown through increases in the volume of resources available for use in production, and through increases in productivity, or the efficiency with which these resources are turned into product. Measurement of these two sources of increase in product suggests their relative importance over the past sixty-eight years:

> Each year's increase in productivity accounted, on the average, for almost half of the year's increase in product. The other half reflected, of course, an increase in resources—labor and tangible capital.
>
> Productivity increase accounted for a larger fraction—about eight-tenths—of each year's increase in per capita product, with

[6] A word of caution: The dating is very rough; and the levels of peaks in rate of increase vary greatly among themselves, as do the levels of troughs.

the rise in per capita resources contributing the other two-tenths.

Prior to World War I, both per capita resources and productivity grew significantly, and thus both contributed to the rise in per capita product. Since World War I, per capita resources have fallen slightly; but productivity has risen even more rapidly than before—rapidly enough, in fact, to keep per capita product growing at an average rate not far below the rate for the earlier period.

The full set of statistics for the national economy is set forth in Charts 6 and 7.

These results—and the results presented earlier—can be properly understood only if certain qualifications are kept in mind.

It is evident, to begin with, that the relative contributions to growth of product, of productivity on the one hand and of resources on the other, that emerge from these and similar calculations, depend on what is included in product and what is included in resources. More exactly, they depend on the importance and relative growth of the borderline items that are or are not included in each of these. What is in fact included is in part influenced by convention and in part by the availability of statistical data.

With respect to output, we have already noticed the question of government services. Similar questions arise with respect to certain expenditures by families—trade union fees and costs of getting to work are examples; and with respect to certain expenditures by business—for example, subsidies to factory cafeterias, "expense accounts," and medical services provided employees.[7] The main problem, however, appears to be with respect to defense expenditures by government (which has reached large proportions), and for this reason Kendrick has presented estimates that differ in the treatment of these expenditures (Table 2; and Appendix A, "National Product as Estimated by Kuznets").

More important seems to be the definition of resources. Kendrick has measured these by weighted manhours of work done and tangible capital available, and has thus largely excluded intangible capital. This results in some understatement of the contribution of resources, for it is likely that intangible capital has risen in relation to the resources he includes. There is a corresponding overstatement of the rise of productivity. It is possible that the upward shift in the rate of growth of productivity after World War I, and the downward shift in the rate of growth in per capita tangible

[7] For recent discussions, see *A Critique of the United States Income and Product Accounts*, Studies in Income and Wealth, Volume 22, and *The National Economic Accounts of the United States: Review, Appraisal, and Recommendations*, both issued by the National Bureau in 1958.

capital at about the same time, reflect some substitution of investment in intangible capital for investment in tangible capital.

In an important sense, society's intangible capital includes all the improvements in basic science, technology, business administration, and education and training that aid in production—whether these result from deliberate individual or collective investments for economic gain or are incidental by-products of efforts to reach other goals. If intangible capital were so defined, it would probably follow that much (not all) of the increase in product would reflect increase in resources. But so wide a definition of intangible capital would get us no closer to determining the causes of increase in product.

With the statistics presently available we have been able to measure the direct effects on output of the increases in labor time and in volume of tangible capital. We have been forced to lump together under the heading of productivity, and to measure as a whole, the indirect effects of the increases in these resources and the effects of all other causes. The residue includes the contributions of the several forms of intangible capital mentioned; the economies resulting from increased specialization within and between industries, made possible by growth in the nation's resources and in its scale of operations generally; the improvement (or falling off) of efficiency in the use of resources resulting from changes in the degree of competition, in the volume, direction and character of governmental subsidies, in the nature of the tax system, and in other government activities and regulations; and the greater (or smaller) benefits resulting from changes in the volume, character, and freedom of commerce among nations.

The simple calculation presented above does no more than suggest the high relative importance of the factors grouped under productivity. But that is significant. It is, as Abramovitz has pointed out, a "measure of our ignorance" concerning the causes of economic growth, and an "indication of where we need to concentrate our attention."[8] It is well to know how far short we are of determining the sources of increase in national product.

Productivity in Individual Industries

The rate of growth in the entire economy's productivity is the prime fact with which we are concerned. The facts on productivity in individual industries, to which Kendrick has devoted his last two chapters, are important, however, because they help us to understand the process by which national productivity has been raised:

> Rise in productivity has been a general industrial phenomenon. Virtually every individual industry for which a reasonably adequate index can be calculated shows an upward trend in

[8] *Op. cit.*, p. 11.

output per manhour, and this was almost as universally true of output per unit of tangible capital and of output per unit of labor and capital combined.

Among individual industries, as for the economy as a whole, the rise in output per manhour—the index most commonly available—nearly always exceeded the rise in productivity with capital as well as labor taken into account. For some industries the difference between the two measures was considerable.

Though almost all industries showed rises in productivity, there was great variation among them in the average rate of rise. Also, as might be expected, individual industries usually experienced greater temporal variation in the rate of productivity increase than did the economy as a whole.

The industries whose productivity advanced more rapidly than productivity in industries generally were more often than not also those that expanded their output and employment of labor and capital more than industry at large. Industries in which productivity lagged usually had a smaller growth in output and employment of labor and capital than industry at large—or even declined.

The generality of rise in productivity is the outstanding fact that emerges when individual industries are studied. It is illustrated by the detailed figures for major divisions given in Chart 12, and by the changes between 1899 and 1953 in thirty-three industries or divisions given in Table 35.

It is true that the statistics relate to a limited number of industries. The thirty-three industries for which individual productivity indexes are available make up less than half the entire economy, measured either by output or input. These industries, some narrowly and some broadly defined, are largely from the commodity-producing sectors of the economy, and observations are for the period beginning with 1899. Lack of data prevents giving similar information for earlier years and for other industries —the service industries, construction, trade, and government, and even some individual manufacturing, mining, and utility industries.[9]

However, it is very likely that productivity has increased not only in the industries for which separate productivity indexes could be calculated, but also in the others, including the service industries. This is indicated by Kendrick's comparison of the productivity rise in the "covered" industries (Table A-XXV) with the rise in the economy as a whole (Table A-XIX). The implied rate of increase of productivity in the industries not covered is of the same order of magnitude as the rate for the

[9] Kendrick's index for manufacturing as a whole, like all such indexes, is based on a sample of manufacturing industries. This is also true, in greater or lesser degree, of the other industries he could cover.

aggregate of those covered. Since this estimate is subject to considerable error, it cannot be conclusive in itself. But what we know of technological developments and the other immediate causes of productivity change in the service industries, for example, supports the impression of a rise.[10] We know, too, that the factors that make for increasing efficiency in the use of resources are general in character and are felt everywhere in the economy. Virtually all industries use mechanical power and have reaped some advantages from broadened national markets. More fundamentally, no industry has been free of the drives that improve efficiency.

Since the indexes for individual industries are often put to specific use, it is well to recognize that they are often less reliable than the indexes for the economy at large. In part, the deficiency arises from the diversity of sources from which the data on output and input come. This causes discrepancies in the matching of output and input. And other statistical errors are imbedded, which tend to cancel out in the indexes for the economy as a whole.

Probably more important is the difficulty created by interindustry flows of materials, fuel, services, and semifabricated components. For a single industry, output is generally measured on a gross basis: that is, output is not only the value (at base-period prices) of work done by labor and tangible capital on the goods and services supplied by other industries, but also the sum of the value of the work done and the value (also at base-period prices) of these supplies from other industries.[11] Subtraction of these supplies from gross output to yield an index of net output (as is in effect done to get the economy-wide index of output) would solve the problem. But only a few attempts to measure the net output of individual industries have been made, and these (except possibly for agriculture) must be viewed as still largely experimental and subject to considerable error.[12] With output measured gross, the supplies from other industries constitute an input on a par with the services of the labor the industry employs and the services of the tangible (and intangible) capital it uses. Labor and tangible capital alone thus fall short of measuring total input—much more so than in the case of the private economy as a whole. The usual productivity index for an individual industry, even if broad enough to include capital in the measure of resources used, is therefore

[10] See, for example, the interesting discussion of developments in trade in Harold Barger's *Distribution's Place in the American Economy since 1869*, Princeton University Press (for NBER), 1955.

[11] Gross output in this sense is "grosser" than gross national product, which differs from net product only by the amount of depreciation and other capital consumption.

[12] This and other problems of measurement were discussed in a meeting of the Conference on Research in Income and Wealth (October 1958). The proceedings have been published as Volume 25, *Output, Input, and Productivity Measurement*, Princeton University Press (for NBER), 1961.

correspondingly deficient. For many industries, perhaps, the resulting error is small. But this is by no means always the case, as is indicated by Kendrick's figures for agriculture (Tables B-I and B-II).

There is good evidence, further, that improved efficiency in the use of materials, fuel, and the like had been significant in certain industries—for example, electric power plants—and for these, the index of productivity based on gross output relative to input of labor and capital alone will understate the rise of efficiency. On the other hand, industries have generally become more specialized, and many now purchase materials and services formerly produced on their own premises—power used in manufacturing is an example. This works in the other direction.

Connections of these sorts between individual industries and other industries not only create difficulties of productivity measurement, but point also to the sources of productivity increase and diffusion. The connections provide channels along which new or improved or lower-cost materials, fuel, power, services, and equipment, as well as ideas, flow in to improve efficiency. What happens in an industry is influenced by the diligence, enterprise, and ability of its workers, management, and investors. It is influenced also by the quality and quantity of what the industry obtains from the rest of the world, domestic and foreign.

The fact that most of the individual-industry indexes are subject to greater error than the national indexes partly accounts for the differences among industries in average rate of productivity increase. It also contributes to the greater temporal variability of the industry indexes as compared with the fluctuations of the over-all indexes. But these deficiencies can hardly account for all the variation in average rate or for all the differences in degree of fluctuation. Technological development and the other immediate factors that impinge on labor, capital, or total productivity often affect different industries at different times and in different degrees. Some of the time and space variation in rate of productivity increase must be "real."

Industry differences in the behavior of output per unit of tangible capital, are especially striking and deserve comment. We noticed earlier that progress in the economy at large has led to reductions in the quantity of capital used per unit of product, despite substitutions of capital for labor. Over the period as a whole the phenomenon has been a general one, but the exceptions have been many. For example, output per unit of capital fell in agriculture over the twenty years 1899–1919, and, more recently, during 1948–53; rose during most of the other years of the period 1899–1953; and remained unchanged on net balance between 1899 and 1953. In manufacturing industries, also, output per unit of capital fell rather generally during 1899–1919; and in a fair number of them this was true also for 1948–53; but for the period as a whole, there was a net rise

in output per unit of capital in the great majority of manufacturing industries. In the case of the railroads and public utilities, the figures suggest rather clearly that increase in the scale of operations led to important economies in the use of fixed capital. The tendency may have been operating in other industries also, but if so, it was overshadowed by other developments.

Increased efficiency in the use of supplies, materials, fuel, or equipment, and substitution of one input for another, already mentioned, altered relations among industries and caused differences in rates of growth of output and input. Further, a better-than-average increase in an industry's productivity usually meant lower relative costs, lower relative prices (as we shall see later), and, therefore, a better-than-average increase in its output (Chart 22). Better-than-average increases in output were usually accompanied by better-than-average increases in employment of workers and tangible capital, despite the more rapid rise in productivity. Correspondingly, less-than-average increases in productivity were usually accompanied by less-than-average increases (or even decreases) in output and in the use of labor and capital resources.[13]

These relations do not exhaust the channels through which productivity and the forces back of it caused diversity in the growth of industries. The general increase in productivity and the increased income it brought per capita raised the demand for the output of industries that produce the goods and services on which people spend more freely as they grow richer, and thus helped push their output up more than that of other industries less favored—even when their productivity lagged behind that of other industries, and their costs and prices rose. The service industries are examples.

No one concerned with the rise and fall of industries, or—to single out a currently discussed problem—with the effects of "automation" on employment, may ignore these basic facts.

Although I have taken a good deal of space to introduce Professor Kendrick's study, I have not been able to include, or even refer to, many of his results that will interest even the general reader. For Professor Kendrick has provided us with what is, to the best of my knowledge, the most comprehensive survey of productivity trends in the United States ever made. It is a record that should find many uses.

[13] It should be noted that "better-than-average" in the text above refers to a comparison with the unweighted median of the thirty-three industry changes covered in the correlation, not to a comparison with the weighted average for the entire private domestic economy.