Basic Facts on Productivity Change

SOLOMON FABRICANT

OCCASIONAL PAPER 63

NATIONAL BUREAU OF ECONOMIC RESEARCH, INC.

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(Resolution adopted October 25, 1926 and revised February 6, 1933 and February 24, 1941)

PREFACE

Among the facts on productivity presented here, some are new and some are old. For the old facts, I am obligated to many. For the new facts, and for confirmation of the old, my obligation is especially to the authors of several National Bureau studies, the main results of which I have attempted to weave together. Particular mention must be made of my debt to John W. Kendrick, upon whose work I have been able to draw very freely, and to Thor Hultgren for a similar favor.

Kendrick and Hultgren also made helpful comments on a first draft of this paper, as did Moses Abramovitz, Jack Alterman, Gary S. Becker, Leon Greenberg, Oswald W. Knauth, Geoffrey Moore, and Theodore W. Schultz. I am deeply grateful also to Maude E. Pech, who was in charge of the calculations. The charts were skillfully drawn by H. Irving Forman. Mary Phelps carefully edited the manuscript and saw it through press.

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November 14, 1958

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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. Our figures will show that it varies from one period to another. What the past or current rate of productivity change is will depend 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 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 I have 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; some are in press; others are in various stages of preparation.[1] The studies are rather technical in character, devoted as they are to the examination of concepts, the sifting of evidence, the preparation of estimates, and the analysis of complex results. All are, or will be, spread over

[1]The reports already published and those soon forthcoming are as follows:

John W. Kendrick, *Productivity Trends: Capital and Labor,* NBER, Occasional Paper 53, 1956

John W. Kendrick, "Productivity Trends in the United States" (typescript, 1958)

Clarence D. Long, "Wages and Earnings in the United States: 1860-1890" (mimeograph, 1958)

Albert Rees, "Real Wages in Manufacturing, 1890-1914" (typescript, 1958)

Simon Kuznets, "Capital in the American Economy: Its Formation and Financing" (mimeograph, 1958)

Leo Grebler, David M. Blank, and Louis Winnick, *Capital Formation in Residential Real Estate: Trends and Prospects,* Princeton University Press, 1956

Alvin S. Tostlebe, *Capital in Agriculture: Its Formation and Financing since 1870,* Princeton University Press, 1957

Melville J. Ulmer, *Capital in Transportation, Communications, and Public Utilities: Its Formation and Financing,* in press

Daniel Creamer, Sergei P. Dobrovolsky, and Israel Borenstein, "Capital in Manufacturing and Mining: Its Formation and Financing" (mimeograph, 1958)

Thor Hultgren, "Changes in Labor Cost during Cycles in Production and in Business" (typescript, 1958)

the many pages needed to expose to public scrutiny the evidence on which they are based – essential if they are to merit the confidence needed for wide acceptance.

It is useful, in these circumstances, to put together some of the main results of this substantial research effort, state the findings in a minimum of technical language, and make the results available promptly. This is the purpose of the present paper.

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; the extent to which increase of productivity has been the general experience of the various industries of the economy; and the relation between productivity increase and the increase in real wages. 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 conclude with a word on recent changes in productivity.

The Long-Term Rate of Increase in National Productivity

Over the sixty-four years between 1889 and 1953 – 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:[2]

Physical output per manhour in the private economy has grown at an average rate that appears to be about 2.3 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 (so determined) but also

[2]Average annual rates for the slightly longer period 1889-1957 (utilizing preliminary estimates for 1954-57) are not significantly different.

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 John 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, as Table 1 indicates, these alternative calculations yield results similar to those just given 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.

Productivity, I have mentioned, is a measure of the efficiency with which the nation's resources are transformed into the consumption, investment, and other goods that satisfy individual or collective wants. Now we can become more (or less) efficient in the use of a particular type of resource, say, plant and equipment, as well as of resources taken as a whole. A given volume of product might be obtained from a smaller amount of plant and equipment, used in conjunction with an unchanged amount of labor, land, inventory, and other resources. This would be a real gain. It would be proper to consider it the result of an increase in efficiency (if fluctuations due to weather and the like were not the cause); and we could measure the increase in efficiency by calculating the ratio of an index of physical output to an index of the volume of plant and equipment. We could also refer to this ratio as a productivity index, as is frequently done. It is necessary to note, however, that we would have to be sure that all resources other than plant and equipment had in fact remained constant (or equivalently, that we had been able to eliminate the effect of changes in them by appropriate statistical techniques), before we could interpret the index as reflecting change in efficiency.

We would also have to recognize that the importance of the change so calculated depended on the size of the particular input – in this case, the services of plant and equipment – relative to other

TABLE 1

Broad Measures of the Long-Term Rate of Increase in Productivity in the United States

Average annual percentage rates of change, 1889-1953

	Aggregate of Industries for which Individual Productivity Indexes Are Available	*Entire Private Domestic Economy*	*Entire Economy, including Government*		
			"National security" version of output	"Peace-time" version of output	Dept. of Commerce version of output
Gross physical output per unweighted manhour	2.3	2.3	2.2	2.0	2.2
Net physical output per unweighted manhour		2.3	2.2	2.0	2.2
Gross physical output per weighted manhour	1.9	2.0	1.8	1.6	1.8
Net physical output per weighted manhour		2.0	1.8	1.6	1.8
Gross physical output per unweighted unit of tangible capital	1.0	1.2	1.0	0.9	1.0
Net physical output per unweighted unit of tangible capital		1.2	1.0	0.9	1.1
Gross physical output per weighted unit of tangible capital	1.0	1.0	0.8	0.7	0.8
Net physical output per weighted unit of tangible capital		1.1	0.9	0.7	0.9
Gross physical output per weighted unit of labor and tangible capital combined	1.7	1.7	1.5	1.4	1.5
Net physical output per weighted unit of labor and tangible capital combined		1.7	1.6	1.4	1.6

Source: John W. Kendrick, "Productivity Trends in the United States" (a forthcoming report of the National Bureau of Economic Research), especially Chapter 3 and Appendix A. The underlying indexes, reproduced in part in Tables A and B, below, are subject to some revision. Use was made by Kendrick of estimates developed in other National Bureau studies by Kuznets, Goldsmith, Blank, Tostlebe, Ulmer, Creamer, Borenstein, and Barger, among others, as well as of data published by the Departments of Commerce and of Labor.

Gross output differs from net output by the amount of depreciation and other items of capital consumption, in the case of the national indexes; and also by the amount of materials, fuel, and supplies consumed, in the case of the industries covered in the first column of figures (except agriculture). See Kendrick for a fuller explanation of those differences; and also for a detailed explanation of the difference between the weighted and unweighted indexes.

Industries for which individual productivity indexes are available for 1889-1953 include farming, mining, manufacturing, transportation, and communications and public utilities. The detailed list is given in Table B.

The three sets of indexes for the entire economy differ mainly in the treatment of defense outlays in the calculation of national product and of inputs. The "national security" and "peace-time" versions of national product are based largely on concepts developed by Kuznets; the Department of Commerce version is that currently published by its Office of Business Economics.

inputs. If the services of plant and equipment constituted a small fraction of total input, doubling the ratio of product to plant and equipment would have much less significance than if these services constituted a large fraction. In other words, an adequate index of productivity for a single resource requires not only eliminating the effect of changes in other resources, but also somehow taking into account the relative importance of the resource.

When other resources are used in significant volume, and change occurs in the volume of such resources used (which is almost always the case), a measure of productivity based on a single resource might tell us little or nothing of change in the efficiency with which this resource was being utilized. It might not even point in the right direction. For example, output per unit of plant and equipment might have fallen because plant or equipment was being substituted for labor or other resources. Yet the efficiency with which plant and equipment was being used might have risen.

Nor would the index of output per unit of plant and equipment (or any other single resource) provide reliable information on the efficiency with which all resources were being used. Only if all other resources were of small importance, or moved in the same direction (indeed, in virtually identical proportion) as plant and equipment would an index of productivity based on plant and equipment alone provide a reasonably accurate answer to that question. Yet that is the question with which we are primarily concerned.

As a general rule, therefore, it is better not to limit productivity indexes that purport to measure change in efficiency to a comparison of output with a single resource. The broader the coverage of resources, generally, the better is the productivity measure. The best measure 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 man-hours. 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 I 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.[3] 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 non-economic 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 0.3 per cent per annum – therefore indicate the direction but not the degree of bias arising from the neglect of change in the quality of labor.

With respect to tangible capital, we are in a better position. In recent years the available information on tangible capital has been broadened, worked over, pieced out, and put into usable form, 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 treat-

[3]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. Our indexes relate output to the work done by all workers, including proprietors, supervisory employees, and clerical workers, as well as wage earners. The only exception is the index in Table 4, which gives output per production worker.

ment 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 (Table 1).[4] 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 0.9 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 three-tenths of one per cent per annum that we have found. The reason is the relatively high weight given labor in combining it with

[4]The index of output per weighted unit of tangible capital in Table 1 differs from the index of output per unweighted unit of tangible capital for reasons analogous to those accounting for the difference between output per unweighted manhour and output per weighted manhour. (However, the difference between the average annual rates for output per unit of capital – about 0.2 per cent – is somewhat smaller than the difference for output per manhour. In part at least, this is probably because the number of separate industries or divisions to which the weights can be applied is much smaller in the case of capital than in the case of manhours.) More specifically, the weighting allows for interindustry differences, over the base-period, in ratios of total capital (including intangibles) to tangible capital. The base-period weighting cannot take into account such changes in these ratios of total capital to tangible capital as may occur in years after the base-period; and it has other limitations in accounting for forms of capital other than tangible.

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 two dollars in the base period and a hundred dollars of capital equipment commands six dollars of net revenue per year (whether in rent, profits, or otherwise is immaterial), we count the hundred dollars of equipment as equivalent to three 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.[5]

I have called this weighted index 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 1 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 I have selected from

[5]Output may be compared also with a *weighted* combination of *unweighted* manhours and of *unweighted* tangible capital. This is one of the possible alternative calculations not given in Table 1. So measured (see Table A, in the appendix), the rate of increase in productivity turns out to be 2.0 per cent per annum between 1889 and 1953. This is, in effect, the weighted average of the 2.3 per cent for output per unweighted manhour and the 1.2 per cent for output per unweighted unit of capital shown in Table 1.

a host) 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 dreamt 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 Chart 1 is confined.[6] 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 chart might prefer to see in it 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 in Table 2 help to sharpen up the differences.

[6]Sources of the figures in this and later charts are Tables A, B, and C, in the appendix, unless otherwise noted. For recent years, estimates are preliminary.

TABLE 2

Average Rates of Increase in Productivity before and after 1919
Private Domestic Economy

	Average Annual Percentage Rate of Change		
	1889-1957	1889-1919	1919-1957
Physical output per unweighted manhour	2.4	2.0	2.6
Physical output per weighted manhour	2.0	1.6	2.3
Physical output per weighted unit of tangible capital	1.0	0.5	1.3
Physical output per unit of labor and capital combined (weighted)	1.7	1.3	2.1

Source: Table A.

Alternative choices of the boundary year (which is rather arbitrarily set at 1919), and of the technical method of calculating the average rate,[7] would not eliminate the difference between the two periods.

The change in trend came in each of the indexes shown, and 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 chart shows also the cyclical pattern of change in productivity, in so far 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 the 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. These will be more pronounced than the fluctuations in the chart, for only capital input is there measured by available resources.

[7]All average annual rates of increase given in this paper are in effect based on geometric means of the year-to-year relatives. They were calculated by the compound-interest method from the indexes for the first and last years of the period covered. For output per unit of labor and capital combined, in both subperiods, Kendrick calculated the average rates also by the method of least squares applied to logarithms. These are: 1889-1919, 1.0; 1919-57, 2.2.

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 2, the differences would be negligible, however. In the final section of this paper, which concentrates on the shorter postwar period, we do calculate average rates of change between averages for several years.

CHART 1

Indexes of Productivity in the United States, 1889-1957
Estimates for the Private Domestic Economy

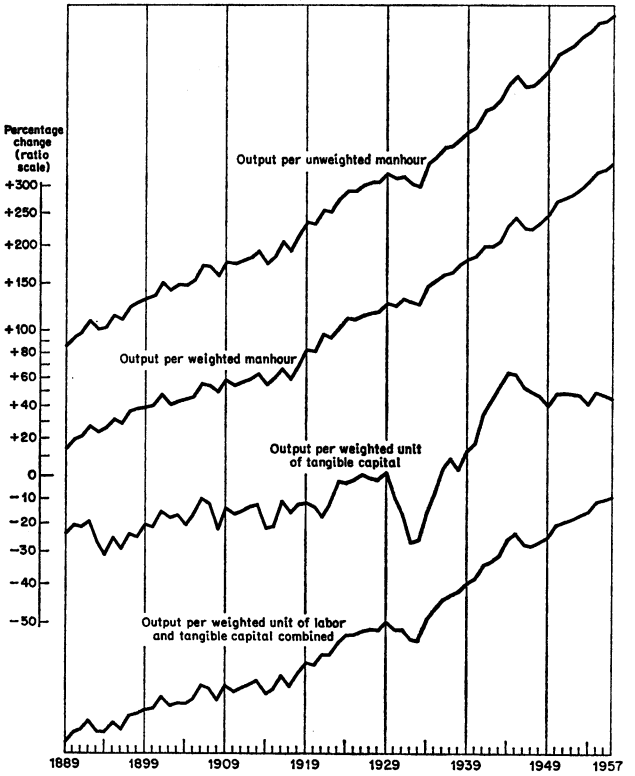


TABLE 3

Direction of Change in Output per Manhour during Years of Rising and of Falling Output, 1889-1957
Private Domestic Economy

	Number of Year-to-Year Changes	
	When output rose	When output fell
Output per unweighted manhour		
Rose	44	7
Remained unchanged	1	0
Fell	6	10
Output per weighted manhour		
Rose	42	8
Remained unchanged	1	0
Fell	8	9

Source: Table A.

Much less obvious is the cyclical fluctuation of output per unit of resources actually put to use, which we can measure for labor.[8] There were 51 year-to-year rises and 17 falls in the output of the private domestic economy. 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 2.7 per cent. During the years of contraction in output, the average annual rate of growth of output per weighted manhour equaled only 0.1 per cent.

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) compiled by Thor Hultgren for the period

[8]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.

TABLE 4

Percentage of Industries with Rising Output per Manhour[a] between Successive Stages of Business Cycles

	Business Cycles				
	Mar. 1933-May 1938	May 1938-Oct. 1945	Oct. 1945-Oct. 1949	Oct. 1949-Aug. 1954	All Four Cycles[c]
From Stage[b]					
I to II	67	100	42	89	77
II to III	67	91	46	67	67
III to IV	100	36	46	67	63
IV to V	67	36	54	83	63
V to VI	17	85	47	47	48
VI to VII	25	77	47	58	53
VII to VIII	71	58	66	83	68
VIII to IX	100	46	68	72	69

Source: Thor Hultgren, "Changes in Labor Cost during Cycles in Production and in Business" (proposed Occasional Paper). Covers up to fifteen industries in manufacturing, two in mining, and the railroads.

[a]One-half of the percentage of industries with unchanged output per manhour is included with the percentage that showed rises.

[b]Stages are defined as follows: I, average of three months centered at trough; II, average of first third of expansion; III, average of second third of expansion; IV, average of last third of expansion; V, average of three months centered at peak; and similarly for the contractions, VI-IX.

[c]Includes also three earlier cycles for the railroad industry.

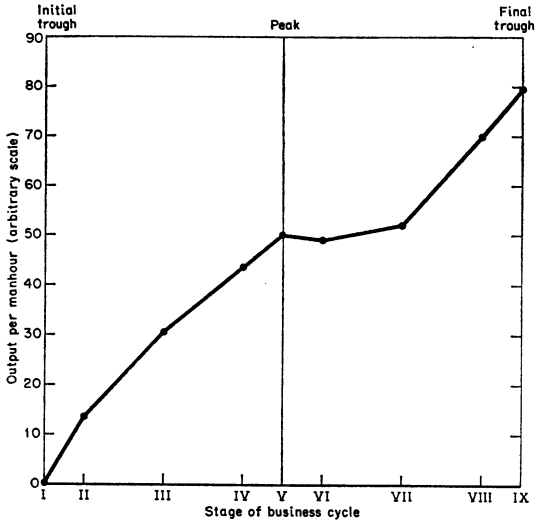
1933-54. In gathering these statistics, Hultgren made a special effort to obtain adequate and comparable data on output and the manhours worked by wage earners. His sample has the further advantage of providing information on a monthly basis, far more satisfactory for the study of cyclical fluctuations than annual data.

Hultgren's data, set forth in Table 4 and Chart 2,[9] 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 contraction. 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.

[9]Chart 2 is derived from Table 4, last column, by assuming that the percentage of industries with rising output per manhour (minus 50 per cent) is equal to the rate of increase in output per manhour.

CHART 2

Average Business Cycle Pattern of Output per Manhour



Hultgren's results are not altogether consistent, and his sample of industries and cycles is thin 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 Chart 1. These include occa-

sional spurts and slow-downs 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.[10] 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. 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.[11]

Some of the irregular changes in Chart 1 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 fast, 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.

[10]See Moses Abramovitz, *Resource and Output Trends in the United States since 1870,* National Bureau of Economic Research, Occasional Paper 52, 1956. A section of Kuznets' forthcoming report on *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 a progress report see the *38th Annual Report* of the National Bureau, 1958, pp. 47-56.

[11]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 nation's product or real income – the terms are interchangeable – may be said to have grown through increase in the volume of resources available for use in production, and through increase 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 about half of the year's increase in product. The other half reflected, of course, increase in resources – labor and tangible capital.

Productivity increase accounted for a larger fraction – about nine-tenths – of each year's increase in per capita product, with the rise in per capita resources contributing the other tenth.

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 private domestic economy is set forth in Chart 3, and the average annual rates are given in Table 5.[12]

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 governmental 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

[12]The decline in labor input per capita during the period 1919-57, which may appear puzzling, is due largely to a decline (0.6 per cent per annum) in hours per employed worker.

TABLE 5

Average Rates of Increase in Output, Input, and Productivity, 1889-1957
Private Domestic Economy

	Average Annual Percentage Rates of Change		
	1889-1957	1889-1919	1919-1957
Total Output and Input			
Physical output	3.5	3.9	3.1
Labor input (weighted manhours)	1.4	2.2	0.8
Capital input (weighted tangible capital)	2.5	3.4	1.8
Total input (weighted manhours and tangible capital)	1.7	2.6	1.0
Per Capita Output and Input			
Physical output	1.9	2.1	1.8
Labor input	−0.1	0.5	−0.5
Capital input	1.0	1.6	0.5
Total input	0.2	0.8	−0.3
Productivity			
Output per unit of total input	1.7	1.3	2.1

Source: Table A, and the census estimate of population growth as extrapolated to 1889 by Simon Kuznets.

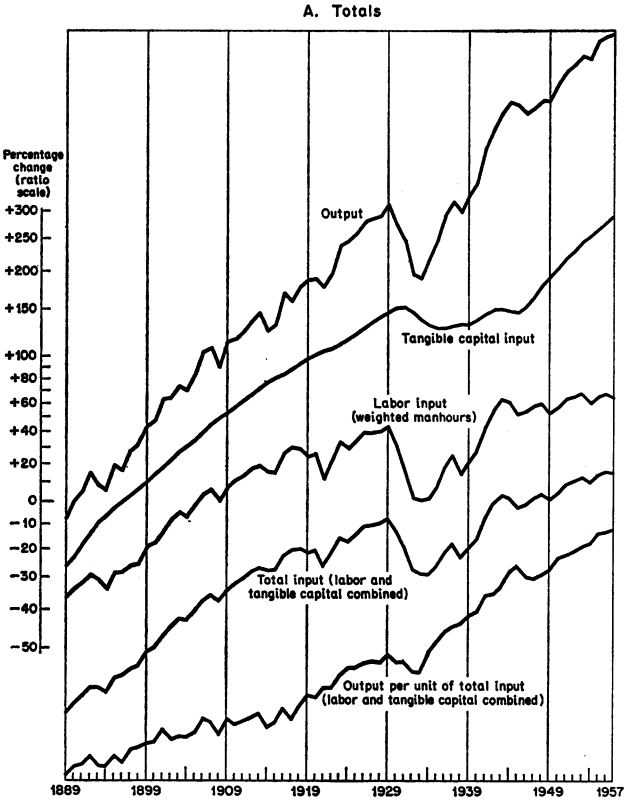
business – for example, subsidies to factory cafeterias, "expense accounts," and medical services provided employees.[18] The main problem, however, appears to be with respect to defense expenditures by government (which has reached large proportions), and for this reason we have presented estimates that differ in its treatment (Table 1). Because the results turn out to be fairly similar, however we measure output inclusive of governmental services (and input inclusive of the labor and capital employed by government), I have not taken the space to show the trends. They will be given in detail in Kendrick's report.

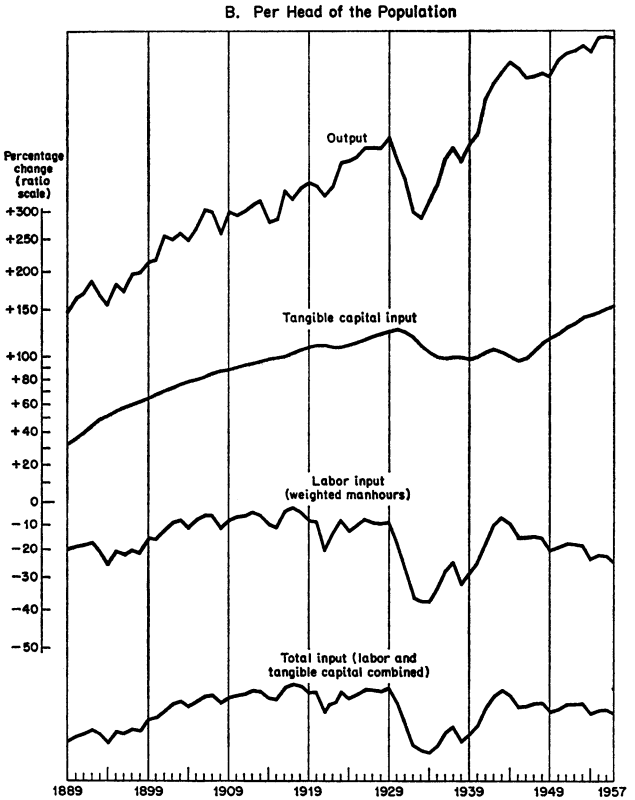
More important seems to be the definition of resources. We have measured these by weighted manhours of work done and tangible capital available, and have thus largely excluded intangible capital. This results in some understatement of the contribution of resources, for it is likely that intangible capital has risen in relation to the resources we include. There is a corresponding overstatement of the rise of productivity. It is possible that the upward shift in the

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

CHART 3

Output, Input, and Productivity, 1889-1957
Estimates for the Private Domestic Economy




B. Per Head of the Population
Percentage change (ratio scale)
+300
+250
+200
+150
+100
+80
+60
+40
+20
0
−10
−20
−30
−40
−50
Output
Tangible capital input
Labor input (weighted manhours)
Total input (labor and tangible capital combined)
1889
1899
1909
1919
1929
1939
1949
1957

rate of growth of productivity after World War I, and the downward shift in the rate of growth in per capita tangible 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 increase in labor time and increase in volume of tangible capital. The indirect effects of the increases in these resources, and the effects of all other causes, we have been forced to lump together under the heading of productivity and to measure as a whole. 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 its scale of operations generally; the improvement (or falling off) of efficiency in the use of resources resulting from change in degree of competition, in 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 change in the volume, character, and freedom of commerce among nations.

The simple calculation presented in this section 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."[14] It is well to know how far short we are of determining the sources of increase in national product.

[14]*Resource and Output Trends in the United States since 1870,* National Bureau of Economic Research, Occasional Paper 52 (1956), p. 11.

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 are worth presenting here, 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 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 virtually all industries showed rises in productivity, there was great variation among them in average rate of rise. Also, as might be expected, individual industries generally 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 a decline.

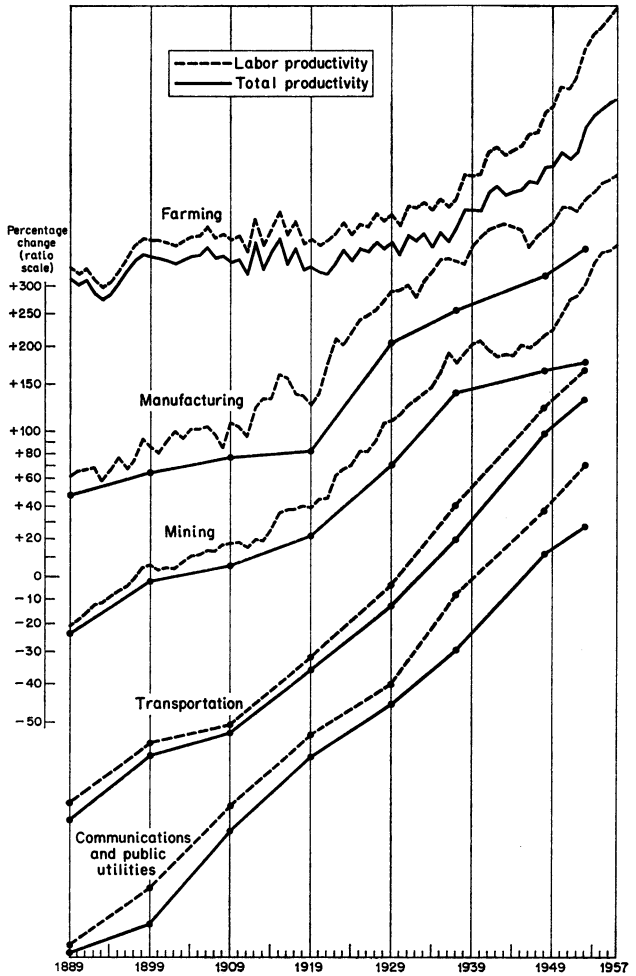
The generality of rise in productivity is the outstanding fact that emerges when individual industries are studied. It is illustrated by the detailed figures for five major divisions given in Chart 4, and by the changes between 1899 and 1953 in thirty-three industries or divisions.[15]

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 nar-

[15]The detailed data are given in Table B, in the appendix.

CHART 4

Indexes of Productivity in Five Major Industrial Divisions
Estimates for 1889-1957 or 1889-1953



rowly 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.[16]

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 with the rise in the economy as a whole (Table 1). The implied rate of increase of productivity in the industries not covered is of the same order of magnitude as the rate for the 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.[17] We know, too, that the factors that make for increasing efficiency in the use of resources are general in character, 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.

[16]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.

[17]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 the National Bureau of Economic Research, 1955.

NOTES TO CHART 4 ON FACING PAGE

Labor productivity: output per weighted manhour (in the case of farming, per unweighted manhour).

Total productivity: output per weighted unit of labor and tangible capital combined.

Output is measured gross, except for the farming index which is net.

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 the sum of the value of the work done and the value (also at base-period prices) of these supplies from other industries.[18] 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.[19] 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 correspondingly deficient. For many industries, perhaps, the resulting error is small. But this is by no means always the case, as is indicated by figures available for agriculture (Table B).

There is good evidence, further, that improved efficiency in the use of materials, fuel, and the like has 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

[18]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.

[19]This and other problems of measurement were discussed in the most recent meeting of the Conference on Research in Income and Wealth (October 1958). The proceedings will be published under the title, *Output, Input, and Productivity Measurement.*

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.

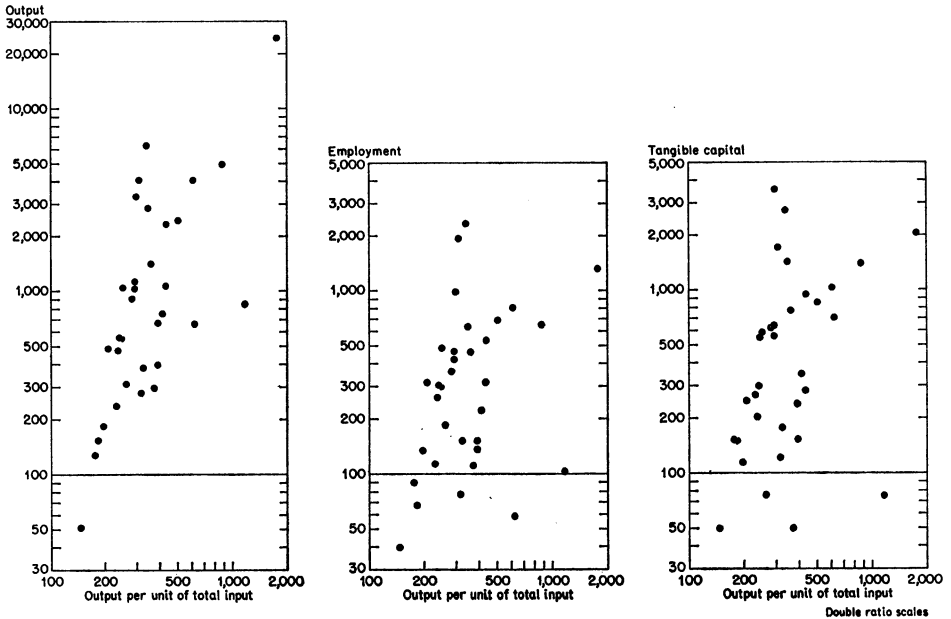
The fact that the individual industry indexes are subject to greater error than the national indexes partly accounts for the differences among industries in average rate of productivity increase. It also contributes to the greater temporal variability of the industry indexes as compared with the fluctuations 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."

Industrial differences in the behavior of output per unit of capital, especially striking, 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

CHART 5

Relation between Change in Productivity and Output, and Productivity and Input, 33 Industry Groups: Indexes for 1953 Relative to 1899



costs, lower relative prices (as we shall see later), and therefore a better than average increase in its output (Chart 5). 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.[20]

These relations do not exhaust the channels through which productivity and the forces back of it caused diversity in 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.

Productivity and the Rise in Real Hourly Earnings

Productivity increase means more goods and services – more real income – available for distribution per unit of resources. Has the rise in productivity been reflected in the hourly real earnings of workers, as would be expected?

Real earnings per hour of work in the private domestic economy rose over the period since 1889 at an average annual rate about equal to the rate of increase in product per manhour, and greater than the rate of increase in product per weighted unit of labor and capital combined.

During recent decades, real hourly earnings have increased more

[20]Coefficients of rank correlation between the changes compared in Chart 5 are as follows: between productivity (output per unit of total input) and output, 0.64; productivity and employment, 0.34; productivity and tangible capital, 0.40.

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.

rapidly, on the average, than during earlier decades. The change in the trend of real earnings thus matches the change in the trend of productivity noticed earlier, though the data do not permit a confident conclusion on their relative timing.

Long-term trends in hourly earnings in individual industries roughly paralleled the trend in the general average of hourly earnings. There was little systematic difference in rate of increase in hourly earnings between industries in which productivity rose very rapidly and those in which productivity rose slowly; or between those industries with high or low, or relatively rising or falling, capital per manhour.

These facts support the conclusion of generations of economists that over the long run the dominant factor in the general rise of real hourly earnings has been the increase in national productivity, and that the more rapid rise in earnings generally than in output per unit of labor and tangible capital combined has resulted largely from greater scarcity of labor relative to capital and from improved quality of labor.

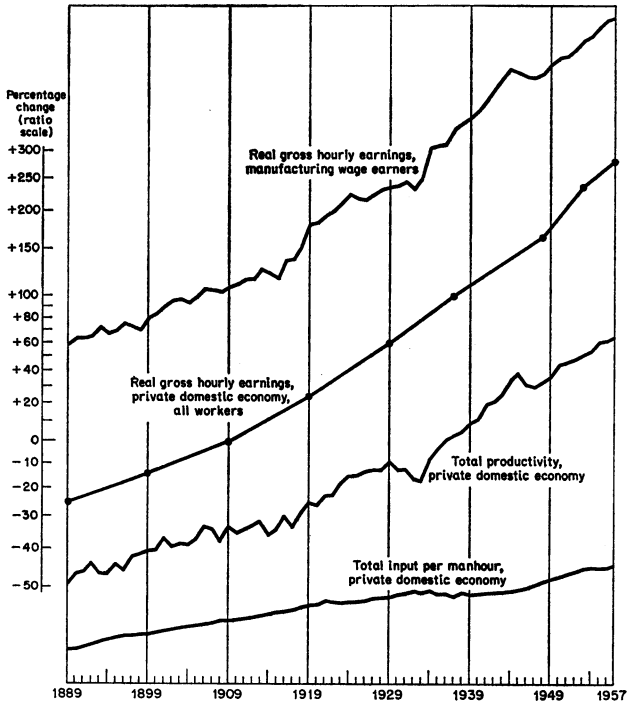
The facts on real earnings in the economy at large may be inferred from the information already presented, plus one other piece of evidence. This is an estimate of the percentage of national income received in the form of wages and salaries, including allowances for the labor of farmers and other proprietors. The percentage seems to have fallen somewhat between 1889 and 1899, moved along a horizontal trend over the period to 1929, and then returned to the 1889 level in recent decades.[21] The index of real earnings per hour of work is obtained simply by multiplying an index of this percentage by the index of real national product per manhour. The derived index of real hourly earnings is shown in Chart 6, and its rate of growth, in Table 6.

The same facts lead also, it should be noted, to the conclusion that the rate of return on capital – total non-labor income per dollar of tangible capital, both in constant prices – has fallen considerably in relation to the real hourly earnings of labor, but not absolutely. This is consistent with such other information as is available on trends in interest rates and in rates of return on property. Productivity increase thus offset the effects of the rise in capital per worker,

[21]See J. Burkhead, *Journal of the American Statistical Association,* June 1953; D. G. Johnson, *Review of Economics and Statistics,* May 1954; and Edward C. Budd, *Studies in Income and Wealth,* Volume 24, in preparation for press. The underlying data are those of W. I. King, Simon Kuznets, and the Department of Commerce.

CHART 6

Real Hourly Earnings Compared with Productivity and Total Input per Manhour, 1889-1957
Estimates for the Private Domestic Economy



and prevented the appearance of the absolute long-term decline in the rate of return on capital that might otherwise have been expected.

The upward drift of real earnings in relation to total productivity does not appear to be seriously in doubt, despite gaps in the under-

TABLE 6

Average Rates of Increase in Productivity, Total Input per Manhour, and Real Hourly Earnings, 1889-1957

	Average Annual Percentage Rate of Change		
	1889-1957	1889-1919	1919-1957
Output per unit of labor and capital combined, private domestic economy	1.7	1.3	2.1
Total input per manhour, private domestic economy	0.6	0.7	0.5
Real hourly earnings, private domestic economy, all workers (including proprietors and family workers)	2.4	1.7	3.0
Real hourly earnings, manufacturing, wage earners	2.3	1.9	2.6

Source: Tables A and C.

lying statistics, difficulties in distinguishing labor income from property income (as in agriculture), and differences of opinion on a variety of questions (such as whether income should be measured before or after income tax). But it is well to check the crudely derived data on earnings, available at best for occasional years only, with direct evidence on the annual movement of real hourly earnings.

For this purpose we make use of the index of real hourly earnings of manufacturing wage earners since 1889 shown in Chart 6 and summarized in terms of its average annual rate of increase in Table 6. The index, greatly improved over that previously available, we owe to Albert Rees and Clarence Long, who re-examined the available wage statistics for the period prior to World War I, reconsidered the methods and weights used in combining them into an index, and constructed a new cost of living index.

The agreement between the two indexes is surprisingly good. Of course, the index of real hourly earnings for the entire private economy covers also the real hourly earnings of manufacturing wage earners, and some degree of similarity must therefore be expected. However, wage earners in manufacturing have seldom numbered more than a fourth or fifth of all workers, and the parallelism is so close as to indicate virtual identity of the long-term percentage change in the real hourly earnings of manufacturing wage earners with the percentage change in the real hourly earnings of all other workers – that is, those in non-manufacturing and the salaried

workers and proprietors of manufacturing – except possibly in the recent period.[22]

The parallelism is all the more surprising because the economy-wide index reflects the increase in wages caused by the shift of workers from low-pay industries, such as agriculture, to high-pay industries, whereas the manufacturing index reflects such shifts only within the manufacturing sector. Further, the manufacturing index relates to wage earners alone, and thus cannot reflect adequately the rise in hourly earnings that might be expected to result from investment in education.[23] However, the index of hourly earnings of factory wage earners has undoubtedly been affected by factors peculiar to manufacturing, and these might have worked to push up relative earnings in factories. It is tempting to speculate further about the complex of factors that lies behind the similarities between the two indexes of hourly earnings, but this is hardly worth while before more work has been done to improve the estimates;[24] and in any case speculation can only prompt – not take the place of – the hard labor of unraveling and weighing the factors involved.

This much seems clear and is important: Both the manufacturing index and the index for the entire private economy show that real hourly earnings rose substantially more rapidly than productivity over the period 1889-1957.

[22]Even for the recent period the difference is less than appears in Chart 6 and the figures underlying it. The earnings index for the entire private economy includes certain supplementary wage benefits that the index for wage earners in manufacturing does not. (See the brief discussion in the last section of this paper.)

[23]On the other hand, it is possible that the portion of hourly earnings earned on investment in education has risen no more rapidly, on net balance, or perhaps even less rapidly, than the earnings of labor of a constant "quality" – just as the return to tangible capital has risen no more rapidly.

This possibility has been suggested by Gary Becker, who is in charge of the National Bureau's study of investment and the returns on investment in education. Becker will deal with many questions over which I must slur – the effect of education on length of working life, the fraction of earnings that represents amortization of invested capital, etc. Some of these questions have been discussed in the National Bureau's study of *Income from Independent Professional Practice* by Friedman and Kuznets (1945).

[24]The new index for manufacturing prior to 1914 is probably as good an estimate as we shall have. How much change will be made in the manufacturing index after 1914, which is being re-examined by Leo Wolman, remains to be seen.

The index for the private economy as a whole is quite rough, as has been indicated. One question not mentioned relates to the deflator, for which several alternatives are available. These move rather differently, as is shown in a note to Table C, although not so differently as to alter our main conclusions.

The new index of real hourly earnings in manufacturing, as well as the derived index of real hourly earnings for the entire private economy, leads to a substantial revision of prevailing impressions concerning the historical relation between productivity and real wages prior to World War I. It has long been thought, for example, that real hourly wages in manufacturing rose by only 8 per cent between 1890 and 1914, despite much greater concurrent increases in productivity. Rees's index for the twenty-four-year period shows a much larger gain in real wages, a rise that is much more in line with the productivity increase of the time.[25] The present data indicate that real hourly earnings have normally, not always, moved up more rapidly than national productivity – output per unit of labor and tangible capital – and that, as in the case of national productivity, the rate of increase in real hourly earnings was greater in recent decades than in earlier decades.

To help explain the greater rise in real hourly earnings than in productivity two factors were singled out at the beginning of this section: increasing scarcity of labor relative to capital, and improved quality of labor. The trend in both combined is suggested by the rise of total input (weighted manhours and tangible capital) per manhour, in Chart 6. On each of the two factors a comment is necessary.

First, the decline in labor input relative to capital (or to total input) is not unambiguous evidence of increasing labor scarcity. The technological and other changes that have played a part in raising efficiency might also have altered the relative usefulness of labor and capital – an essential ingredient in their scarcity – in favor of the one or the other. If the technological and other changes back of productivity increase were not neutral in this respect, they would have tended to push the rate of return for labor relative to that for capital in one or the other direction.

Second, the shift of labor from lower- to higher-pay industries is at best a very rough measure of the improvement in the quality of the labor force. If more adequate allowance could be made for quality improvement, our measure of labor input would probably rise more than is now indicated; labor input relative to tangible capital would decline less; and productivity would rise less. Our inability – as yet – to measure quality of labor adequately thus probably leads us to overemphasize in some degree the contribution of productivity and labor scarcity to the rising trend of real hourly

[25]See his comment in the National Bureau's *38th Annual Report*, p. 60.

earnings, and correspondingly to underemphasize the contribution of investment in education and other forms of personal capital.

The information we have on the economy as a whole provides strong evidence of the competition in the markets for goods, labor, and capital that causes real hourly earnings to rise with national productivity and the other factors mentioned. Additional important evidence is provided by the developments in individual industries (Chart 7).

As we should expect to find in a competitive economy, the trends in productivity in individual industries and the trends in their hourly earnings are only weakly correlated. That is, hourly earnings in different industries moved up at fairly similar rates. The parallelism we noticed between the trend of real hourly earnings in manufacturing and in the economy at large is a fairly general phenomenon.

We find also, as we should expect, that there is a stronger relation between an industry's trend in productivity and the trend in its product prices.[26] As a rule, in industries with high rates of productivity increase, product prices fell in relation to the prices of other goods, while in industries with low rates of productivity increase, relative prices of products usually increased.

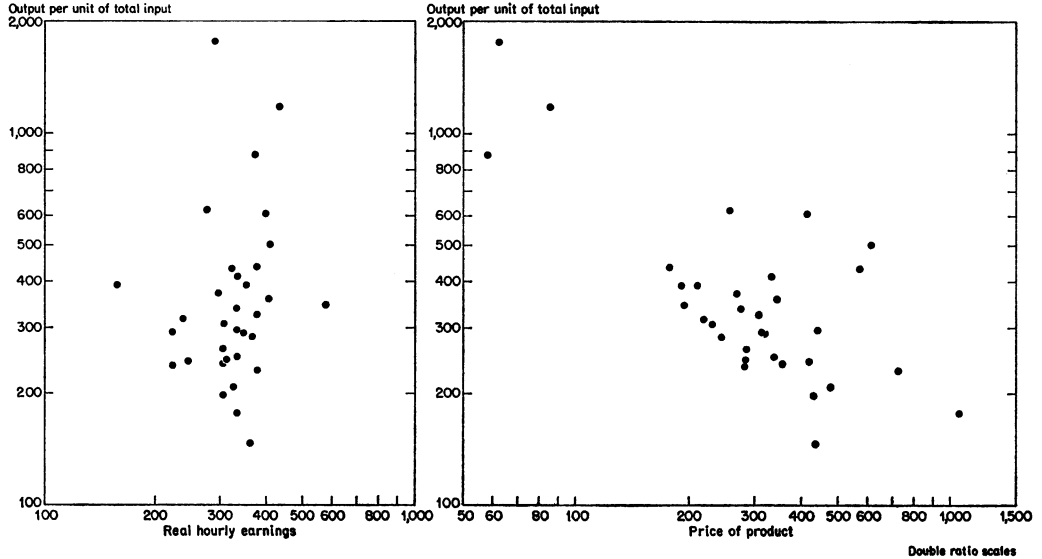
To find *closely* parallel changes in the average rates of wages and salaries paid by different industries would be surprising. The American economy is one in which economic advance has brought not only greater efficiency but also other changes – in the type of labor used by different industries, in the relative scarcity of the skills they employ, in the values placed on the various noneconomic advantages and disadvantages of working in them, and in other determinants of demand and supply. So continuous has the flow of changes been that adjustment to them has never stopped. The exceptions to the rule are therefore many in Chart 7, and they invite study.

As for the general level of real wages, a fuller explanation of its historical changes must take account also of the behavior of money wages, retail prices, and productivity during the business cycles and periods of inflation and deflation that are found in the record of the past seven decades. And it is hardly necessary to add that it must take account of still other factors peculiar to particular periods, as well as of the more or less gradual changes in the markets for labor, goods, and capital that have taken place over the years.

[26]The strength of each of the relations is measured by the coefficient of rank correlation. Between change in productivity and in hourly earnings, it is +0.23, according to Kendrick's calculations. Between change in productivity and in price, the coefficient of correlation is much higher, –0.56.

CHART 7

Relation between Change in Productivity and Real Hourly Earnings, and Productivity and Price of Product, 33 Industry Groups
Indexes for 1953 Relative to 1899



But the chief determinants of the longer-run trends in the general level of real wages and in the level of real wages in individual industries appear to be those with which we began our discussion.

Recent Productivity Trends in Perspective

Recent events are always of special interest. We therefore now take a closer look at productivity and a few related changes since World War II, viewing them in the perspective of the full record. For the private domestic economy we find that:

Output per manhour (and much the same may be said of output per weighted manhour) rose between 1945 and 1957 at an average rate that was high, though not unprecedently so, for a twelve-year period. The postwar rate was significantly higher than the average rate over the full period 1919-57, and still more so than the rate over 1889-1957.

Tangible capital was pushed up at an extraordinarily high rate — faster than in any preceding period of similar length. Since output rose at a rate only moderately better than average, output per unit of tangible capital fell.

Output per unit of labor and capital combined rose during 1945-57 at a rate slightly better than the long-run average and about the same as the average for 1919-57.

Real hourly earnings in manufacturing — not including certain types of supplementary employee remuneration — rose about as rapidly as over the full period 1919-57, and therefore less rapidly over the postwar period than output per manhour and more rapidly than total productivity. The postwar difference between the annual rates for real hourly earnings in manufacturing and total productivity appears to have been about the same as the difference over the longer period 1919-57 and between 1889 and 1919.

Most of these facts have already been presented in the charts above. The set of calculations provided in Table 7 may be helpful. It should be emphasized that because of cyclical and other fluctuations in the figures, the average rates of change over the postwar period were calculated by comparing the average level in 1945-48 with the average in 1953-57; and that we are focusing on output, input, and earnings expressed only in real terms (that is, adjusted

for price change), and are thus passing over aspects of recent developments that are crucial for the problem of inflation.

It may surprise those people who have heard of the "new" technological age that output per manhour (and also output per weighted manhour) rose during the period after the war at an average rate that, though high, was within the range of experience for earlier periods of similar length. Even if the average postwar rate is calculated for the period beginning with 1947 and ending with 1955, it is not without an earlier parallel.

The index of output per unit of labor and capital combined is, of course, a weighted average of the labor and capital productivity indexes. Since output per unit of tangible capital fell substantially between 1945 and 1949, and then fluctuated about a fairly constant level, output per unit of labor and capital combined rose much less rapidly than output per manhour. The considerable diversity of experience to which total productivity was subjected during the postwar period averaged out to an annual rate of 2.1 per cent for the period as a whole – the same, as has been mentioned, as the average for the longer period 1919-57.

The rise in real hourly earnings relative to total productivity came mainly in the second half of the period. In manufacturing, for example (which appears to have had a fairly typical experience),[27] real hourly earnings rose between 1948-53 and 1953-57 about five per cent more than total productivity. Over the full postwar period – comparing 1945-48 with 1953-57 – real hourly earnings in manufacturing rose at a rate approximately halfway between the

[27]Indexes of real average (gross) hourly earnings of production workers or nonsupervisory employees in the nonagricultural industries for which data are available are as follows for selected periods:

	1945-1948	1948-1953	1953-1957
Metal mining	100.0	112.7	137.9
Railroads (Class I)	100.0	119.3	137.7
Bituminous coal mining	100.0	115.7	134.0
Building construction	100.0	111.1	131.0
Electric light and power	100.0	107.7	126.7
Manufacturing	100.0	109.2	125.5
Retail trade	100.0	108.0	123.6
Hotels (year-round)	100.0	107.1	123.3
Wholesale trade	100.0	106.4	123.1
Telephone	100.0	105.9	122.5
Laundries	100.0	101.0	107.6

(The hourly earnings are those reported by the U.S. Bureau of Labor Statistics, deflated by the BLS consumer price index. The averages are calculated with the terminal years – for example, 1945 and 1948, in the case of 1945-1948 – given half weight.)

TABLE 7

Rates of Increase in Productivity in the Private Domestic Economy, and in Real Hourly Earnings in Manufacturing, 1945-1957

	PRIVATE DOMESTIC ECONOMY				
	Output per unweighted manhour	*Output per weighted manhour*	*Output per unit of tangible capital*	*Output per unit of labor and capital combined*	*Real Hourly Earnings in Manufacturing*
	Annual Percentage Rate of Change				
1945-46	−5.1	−5.2	−6.5	−5.5	−2.1
1946-47	0.4	−0.6	−2.4	−1.0	−0.5
1947-48	3.4	2.9	−1.4	2.0	1.4
1948-49	3.8	4.4	−4.6	2.3	4.8
1949-50	7.8	6.5	5.5	6.3	3.6
1950-51	2.5	1.5	0.3	1.3	0.5
1951-52	2.1	1.5	−0.3	1.1	2.7
1952-53	4.0	3.2	−0.2	2.4	5.1
1953-54	2.4	3.1	−4.4	1.2	1.9
1954-55	4.8	4.7	5.7	5.0	4.2
1955-56	0.8	0.6	−1.2	0.2	3.8
1956-57	2.5	2.4	−1.9	1.3	1.0
	Average Annual Percentage Rate of Change				
1945-48 to 1948-53	3.4	2.8	−1.0	2.0	2.2
1948-53 to 1953-57	3.2	2.9	0.0	2.2	3.1
1945-48 to 1953-57	3.3	2.9	−0.5	2.1	2.7

Source: Tables A and C. The estimates for the more recent years are preliminary. In calculating the averages for 1945-48, 1948-53, and 1953-57, terminal years were given a weight of one-half.

corresponding rates for output per manhour and output per unit of labor and capital. Real hourly earnings in the economy as a whole seem to have risen more rapidly than in manufacturing, however, and therefore more rapidly than both output per manhour and total productivity during the postwar period. Since the economy-wide index of earnings covers supplementary employee benefits, and the manufacturing index does not, some difference in this direction is to be expected.[28] But the estimate for all workers is probably too rough to be taken seriously as an accurate indication of the trend over so short a period.

Indeed, in any analysis of trends in the postwar period it is necessary to keep in mind not only that there have been considerable year-to-year variations in the rate of growth in real wages, in pro-

[28]See the discussion in the second paragraph following.

ductivity, and in the relation between the two, but also that the figures are subject to a considerable margin of error, especially large in proportion to the annual changes. Although the data for recent years are, as a rule, more complete and of better quality than those for the earlier decades, they suffer in some degree from the usual statistical deficiencies.

Further, the recent period has seen a number of developments that serve to feed doubts about the precision of the estimates. These include a growing disparity between hours worked and hours paid for, a matter stressed first by the presentation of two alternative estimates of output per manhour in the January 1958 Economic Report of the President and second by the prospective initiation by the Bureau of Labor Statistics of a periodic survey to measure the difference between hours paid for and hours worked in manufacturing industries.[29]

Also of growing importance have been items of supplementary employee remuneration – "fringe benefits" – that do not enter the usual calculations of hourly earnings. In 1953 manufacturing establishments reporting such items to the Bureau of Labor Statistics paid out 7 cents per payroll hour for private pensions credits, 3 cents for "insurance, health, and welfare," and 6.5 cents for such legally required payments as Old Age and Survivors insurance, unemployment and workmen's compensation, and state temporary disability insurance.[30] The total of these amounted to almost 9 per cent of the 1953 payroll of reporting establishments. The percentage was undoubtedly smaller in earlier years and larger in later. The rise

[29]The two Economic Report estimates of average annual percentage change in output per manhour in the private economy differ as follows with respect to growth between 1948-53 and 1953-57. (Year-to-year changes, of course, differ even more widely.) Based on manhours paid for (as estimated on the basis of Bureau of Labor Statistics data), output per manhour rose at an average annual rate of 3.0 per cent. Based on manhours worked (as estimated on the basis of Bureau of the Census data), the rate of increase was 3.5 per cent.

Kendrick's series falls about midway between the two, though his index, like the second one above, is based primarily on hours worked. But there are other sources of difference between his and the other indexes in the choice of the weight-base and of employment estimates, and in the treatment of income on foreign assets.

[30]*Problems in Measurement of Expenditures on Selected Items of Supplementary Employee Remuneration,* Bulletin No. 1186, Department of Labor, 1956. The study was undertaken by the Bureau of Labor Statistics with financial assistance from the National Bureau.

Kendrick's index of real hourly earnings in the economy at large includes an allowance for these items, as estimated by the Department of Commerce.

in the real hourly earnings of factory workers in recent years has thus been understated.

Less clear in their effect on the postwar statistics are difficulties in the estimation of tangible capital. These have been caused by inflation, coupled with the prevalence of original-cost depreciation accounting; and by a number of temporary and permanent revisions in the internal revenue code governing the calculation of depreciation changes.

Developments since the war have affected not only the statistics that one must use to describe the course of events. As is always the case, these developments have also generated new factors that played a part in recent events. Some are factors that will persist and influence the trends of the future. Others will turn out to be peculiar to the period. A detailed study of the period is essential if the nature and significance of these new factors are to be assessed. Essential also is a study of the longer record. For only in the light of the longer record can the new factors be recognized and weighed.

Even our brief survey of this record suggests, however, that the postwar period probably resembles past periods more than it departs from them. In the recent, as in the early decades of the period since 1889, the *main* source of the rise in real wages is to be found not in special factors but in the persistent features of our economic development – the upward trend in productivity and the upward trend in tangible and other capital per worker.

TABLE A

Annual Indexes of Output, Input, and Productivity, 1889-1957
Estimates for the Private Domestic Economy

		INPUT					
		Manhours		*Tangible Capital*		*Total Input, Weighted*[a]	
YEAR	GROSS PHYSICAL OUTPUT	Unweighted	Weighted	Unweighted	Weighted	Estimate A	Estimate B
1889	22.3	51.1	44.6	30.7	29.8	44.5	39.8
1890	24.2	53.0	46.2	32.2	31.1	46.3	41.3
1891	25.3	54.3	47.6	34.0	32.8	47.8	42.8
1892	27.7	56.1	49.5	36.0	34.8	49.6	44.8
1893	26.3	55.5	48.6	37.8	36.6	49.9	44.8
1894	25.5	53.5	46.1	39.1	37.7	49.0	43.6
1895	28.8	56.8	49.9	40.6	39.2	51.8	46.7
1896	28.1	56.8	49.9	42.1	40.6	52.3	47.2
1897	31.0	58.6	51.7	43.4	41.7	53.9	48.7
1898	31.6	58.9	51.9	44.8	43.1	54.6	49.3
1899	34.6	63.2	56.7	46.2	44.4	57.9	52.9
1900	35.5	63.9	57.5	47.7	46.1	58.9	54.0
1901	39.6	66.7	60.7	49.1	47.6	61.3	56.7
1902	39.8	69.6	64.3	50.6	49.3	63.7	59.7
1903	41.9	71.6	66.6	52.4	51.3	65.6	61.9
1904	41.2	70.6	64.9	53.7	52.8	65.4	61.3
1905	44.3	74.0	69.0	55.2	54.2	68.2	64.4
1906	49.6	77.0	72.4	57.4	56.3	71.0	67.5
1907	50.5	78.7	74.3	59.5	58.6	72.8	69.5
1908	46.0	75.3	70.1	61.2	60.4	71.2	67.4
1909	52.1	79.4	74.9	62.6	61.8	74.4	71.0
1910	52.5	81.5	77.5	64.4	63.7	76.4	73.3
1911	54.5	83.0	79.0	66.1	65.7	77.9	75.0
1912	57.3	85.6	82.2	67.5	67.3	80.2	77.7
1913	59.7	86.3	83.2	69.2	69.4	81.2	79.0
1914	54.8	84.7	80.7	71.0	71.5	80.7	78.0
1915	56.4	83.9	80.4	72.5	73.2	80.6	78.3
1916	65.1	90.0	88.3	73.6	74.4	85.1	84.1
1917	63.0	91.9	90.7	75.0	76.3	86.8	86.3
1918	67.5	91.1	90.0	76.3	78.4	86.7	86.5
1919	69.7	88.2	86.7	77.5	80.3	85.1	84.9
1920	70.0	89.4	87.9	78.9	82.0	86.4	86.2
1921	67.5	80.5	77.8	79.8	83.2	80.3	79.3
1922	71.8	86.5	84.6	80.8	83.8	84.9	84.4
1923	82.0	93.4	93.0	82.9	85.5	90.4	90.9
1924	83.6	91.2	90.0	85.5	87.7	89.6	89.3

Source: John Kendrick, "Productivity Trends in the United States" (in preparation), Appendix A.

[a]Estimate A is a weighted combination of unweighted manhours and unweighted tangible capital. Estimate B is a weighted combination of weighted manhours and weighted tangible capital.

PRODUCTIVITY: OUTPUT PER

Manhour		*Unit of Tangible Capital*		*Unit of Total Input (weighted)*		
Unweighted	Weighted	Unweighted	Weighted	Estimate A	Estimate B	YEAR
43.6	50.0	72.6	74.8	50.1	56.0	1889
45.7	52.4	75.2	77.8	52.3	58.6	1890
46.6	53.2	74.4	77.1	52.9	59.1	1891
49.4	56.0	76.9	79.6	55.8	61.8	1892
47.4	54.1	69.6	71.9	52.7	58.7	1893
47.7	55.3	65.2	67.6	52.0	58.5	1894
50.7	57.7	70.9	73.5	55.6	61.7	1895
49.5	56.3	66.7	69.2	53.7	59.5	1896
52.9	60.0	71.4	74.3	57.5	63.7	1897
53.7	60.9	70.5	73.3	57.9	64.1	1898
54.7	61.0	74.9	77.9	59.8	65.4	1899
55.6	61.7	74.4	77.0	60.3	65.7	1900
59.4	65.2	80.7	83.2	64.6	69.8	1901
57.2	61.9	78.7	80.7	62.5	66.7	1902
58.5	62.9	80.0	81.7	63.9	67.7	1903
58.4	63.5	76.7	78.0	63.0	67.2	1904
59.9	64.2	80.3	81.7	65.0	68.8	1905
64.4	68.5	86.4	88.1	69.9	73.5	1906
64.2	68.0	84.9	86.2	69.4	72.7	1907
61.1	65.6	75.2	76.2	64.6	68.2	1908
65.6	69.6	83.2	84.3	70.0	73.4	1909
64.4	67.7	81.5	82.4	68.7	71.6	1910
65.7	69.0	82.5	83.0	70.0	72.7	1911
66.9	69.7	84.9	85.1	71.4	73.7	1912
69.2	71.8	86.3	86.0	73.5	75.6	1913
64.7	67.9	77.2	76.6	67.9	70.3	1914
67.2	70.2	77.8	77.0	70.0	72.0	1915
72.3	73.7	88.5	87.5	76.5	77.4	1916
68.6	69.5	84.0	82.6	72.6	73.0	1917
74.1	75.0	88.5	86.1	77.9	78.0	1918
79.0	80.4	89.9	86.8	81.9	82.1	1919
78.3	79.6	88.7	85.4	81.0	81.2	1920
83.8	86.8	84.6	81.1	84.1	85.1	1921
83.0	84.9	88.9	85.7	84.6	85.1	1922
87.8	88.2	98.9	95.9	90.7	90.2	1923
91.7	92.9	97.8	95.3	93.3	93.6	1924

(table concludes on next pages)

TABLE A, *concluded*

YEAR	GROSS PHYSICAL OUTPUT	INPUT					
		Manhours		*Tangible Capital*		*Total Input, Weighted*[a]	
		Unweighted	Weighted	Unweighted	Weighted	Estimate A	Estimate B
1925	86.6	94.5	93.6	88.2	89.8	92.7	92.5
1926	92.0	97.8	97.5	91.6	92.7	96.0	96.1
1927	93.0	97.2	97.3	94.6	95.4	96.5	96.8
1928	93.9	98.1	97.9	97.5	97.7	97.9	97.8
1929	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1930	90.8	93.1	91.9	101.7	102.0	95.2	94.3
1931	84.0	85.4	82.3	101.9	102.1	89.4	87.1
1932	71.8	75.6	71.2	100.3	99.9	81.5	78.1
1933	70.0	74.9	70.5	97.6	96.5	80.3	76.7
1934	76.9	73.6	70.8	95.2	93.8	78.8	76.3
1935	83.8	77.6	74.9	94.2	92.5	81.6	79.1
1936	94.5	83.4	82.6	94.1	92.5	86.0	85.0
1937	101.0	88.6	87.4	95.3	93.8	90.2	88.9
1938	95.4	81.0	79.3	95.9	94.6	84.4	82.8
1939	104.1	85.2	84.2	96.0	94.3	87.7	86.6
1940	110.2	88.9	88.6	97.3	95.9	90.9	90.3
1941	130.4	96.9	99.3	99.7	99.0	97.6	99.3
1942	142.6	104.4	108.6	101.6	101.7	103.9	107.1
1943	153.1	108.2	114.2	101.6	101.8	106.8	111.5
1944	162.8	106.7	112.7	100.7	100.9	105.5	110.1
1945	160.4	100.9	106.3	99.7	99.8	100.7	104.9
1946	153.5	101.7	107.3	100.9	102.1	101.6	106.2
1947	157.4	103.9	110.6	104.0	107.3	104.0	110.0
1948	163.8	104.5	111.9	108.0	113.3	105.4	112.3
1949	162.9	100.1	106.6	112.2	118.1	102.8	109.1
1950	178.7	101.9	109.8	116.3	122.8	105.0	112.6
1951	188.5	105.1	114.4	121.5	129.1	108.6	117.5
1952	194.0	105.7	115.7	125.8	133.2	110.0	119.4
1953	202.9	106.3	117.2	129.6	139.6	111.3	121.9
1954	199.5	102.1	111.8	133.0	143.6	108.6	118.5
1955	217.3	106.1	116.3	137.1	148.0	112.6	122.9
1956	222.6	107.8	118.4	142.1	153.4	115.0	125.7
1957	225.2	106.4	116.9	146.5	158.2	114.8	125.5

PRODUCTIVITY: OUTPUT PER

Manhour		*Unit of Tangible Capital*		*Unit of Total Input (weighted)*		
Unweighted	Weighted	Unweighted	Weighted	Estimate A	Estimate B	YEAR
91.6	92.5	98.2	96.4	93.4	93.6	1925
94.1	94.4	100.4	99.2	95.8	95.7	1926
95.7	95.6	98.3	97.5	96.4	96.1	1927
95.7	95.9	96.3	96.1	95.9	96.0	1928
100.0	100.0	100.0	100.0	100.0	100.0	1929
97.5	98.8	89.3	89.0	95.4	96.3	1930
98.4	102.1	82.4	82.3	94.0	96.4	1931
95.0	100.8	71.6	71.9	88.1	91.9	1932
93.5	99.3	71.7	72.5	87.2	91.3	1933
104.5	108.6	80.8	82.0	97.6	100.8	1934
108.0	111.9	89.0	90.6	102.7	105.9	1935
113.3	114.4	100.4	102.2	109.9	111.2	1936
114.0	115.6	106.0	107.7	112.0	113.6	1937
117.8	120.3	99.5	100.8	113.0	115.2	1938
122.2	123.6	108.4	110.4	118.7	120.2	1939
124.0	124.4	113.3	114.9	121.2	122.0	1940
134.6	131.3	130.8	131.7	133.6	131.3	1941
136.6	131.3	140.4	140.2	137.2	133.1	1942
141.5	134.1	150.7	150.4	143.4	137.3	1943
152.6	144.5	161.7	161.3	154.3	147.9	1944
159.0	150.9	160.9	160.7	159.3	152.9	1945
150.9	143.1	152.1	150.3	151.1	144.5	1946
151.5	142.3	151.3	146.7	151.3	143.1	1947
156.7	146.4	151.7	144.6	155.4	145.9	1948
162.7	152.8	145.2	137.9	158.5	149.3	1949
175.4	162.8	153.7	145.5	170.2	158.7	1950
179.4	164.8	155.1	146.0	173.6	160.4	1951
183.5	167.7	154.2	145.6	176.4	162.5	1952
190.9	173.1	156.6	145.3	182.3	166.4	1953
195.4	178.4	150.0	138.9	183.7	168.4	1954
204.8	186.8	158.5	146.8	193.0	176.8	1955
206.5	188.0	156.7	145.1	193.6	177.1	1956
211.7	192.6	153.7	142.4	196.2	179.4	1957

TABLE B

Summary Statistics for Individual Industrial Groups and Divisions
Indexes for 1953 Relative to 1899

		INPUT			OUTPUT PER UNIT OF				
	Output	*Labor*	*Tangible Capital*	*Total*	*Labor*	*Tangible Capital*	*Total Input*	*Real Hourly Earnings*	*Price of Product*
Farming, based on gross output	203	62	151	83	330	134	244	247	420
Farming, based on net output	153				248	101	184		
Mining									
Metals	279	71	121	88	391	231	317	239	220
Anthracite coal	51	35	50	35	148	103	147	362	436
Bituminous coal	237	95	267	103	248	89	230	378	725
Oil and gas	2,434	401	855	486	607	285	501	409	613
Nonmetals	671	143	239	172	470	280	390	158	210
Manufacturing									
Foods	554	220	299	230	252	186	241	308	355
Beverages	475	196	202	200	242	235	238	224	283
Tobacco	661	46	700	106	1,442	94	620	276	257
Textiles	382	108	177	118	354	216	325	378	308
Apparel	552	205	550	224	269	100	246	313	283
Lumber products	128	67	152	72	192	84	177	334	1,061
Furniture	486	240	248	233[b]	202	196	208[b]	326	479
Paper	1,406	342	765	391	411	184	359	405	345
Printing, publishing	1,058	238	282	245	444	376	432	321	571
Chemicals	2,335	400	942	537	583	248	435	377	178
Petroleum, coal products	2,875	385	1,431	831	746	201	346	577	194
Rubber products	4,953	507	1,399	564	978	354	878	371	58
Leather products	185	90	115	94	206	161	198	306	432

TABLE B, *concluded*

		INPUT			OUTPUT PER UNIT OF				
	Output	*Labor*	*Tangible Capital*	*Total*	*Labor*	*Tangible Capital*	*Total Input*	*Real Hourly Earnings*	*Price of Product*
Manufacturing (cont.)									
Stone, clay, glass	757	171	348	184	443	217	412	334	334
Primary metals	910	267	629	321	341	145	284	366	245
Fabricated metals	1,133	358	638	389	316	178	291	347	319
Machinery, nonelectric	1,046	384	581	418	272	180	251	333	339
Electrical machinery	6,264	1,693	2,742	1,854	370	228	338	332	276
Transportation equipment	4,059	615	1,026	669	661	396	608	398	415
Miscellaneous mfg.	1,038	331	556	355	313	187	292	223	314
Transportation[a]									
Railroads	396	91	152	102	437	261	390	352	191
Local transit	296	84	50	80	351	595	372	296	270
Communications, public utilities									
Telephone	4,048	1,391	1,704	1,318[b]	291	238	307[b]	308	230
Telegraph	310	130	76	118	239	409	263	306	286
Electric light and power	24,550	964	2,035	1,390	2,560	1,207	1,764	289	62
Manufactured gas	846	69	75	72	1,219	1,129	1,176	431	86
Natural gas	3,311	673	3,551	1,118	492	93	296	333	442

Source: Kendrick, "Productivity Trends in the United States" (in preparation). Slight inconsistencies are due to rounding of figures.

[a]The index in Chart 4 covers also waterways, motor transport, pipelines, airlines, and services allied to transportation.

[b]Inconsistency due to chaining indexes calculated on several weight-bases. See Kendrick's forthcoming report for a full explanation.

TABLE C

Indexes of Real Hourly Earnings, 1889-1957

Year	*Manufacturing, Wage Earners*[a]	*Private Domestic Economy, All Workers*[b]	Year	*Manufacturing, Wage Earners*[a]	*Private Domestic Economy, All Workers*[b]
1889	47.3	47.0	1924	96.9	
1890	48.5		1925	94.4	
1891	48.5		1926	93.9	
1892	48.9		1927	96.0	
1893	51.3		1928	99.3	
1894	49.5		1929	100.0	100.0
1895	50.1		1930	100.1	
1896	52.1		1931	102.6	
1897	51.2		1932	98.9	
1898	50.2		1933	103.6	
1899	53.1	53.4	1934	120.5	
1900	54.4		1935	121.3	
1901	56.1		1936	121.4	
1902	58.1		1937	131.5	125.3
1903	58.3		1938	134.6	
1904	57.4		1939	138.0	
1905	59.0		1940	143.0	
1906	61.8		1941	150.1	
1907	61.3		1942	158.5	
1908	60.4		1943	168.1	
1909	61.8	62.3	1944	175.4	
1910	62.9		1945	172.3	
1911	64.2		1946	168.6	
1912	64.6		1947	167.8	
1913	67.4		1948	170.1	166.0
1914	66.5		1949	178.2	
1915	64.7		1950	184.6	
1916	70.3		1951	185.5	
1917	70.6		1952	190.6	
1918	74.6		1953	200.3	210.3
1919	83.5	77.5	1954	204.2	
1920	83.9		1955	212.7	
1921	87.3		1956	220.7	
1922	88.6		1957	223.0	237.6
1923	92.7				

[a]Source: Hourly earnings for 1919-57 are those of the Department of Labor; 1890-1914, Rees, "Real Wages in Manufacturing, 1890-1914" (typescript, 1958); 1914-19, interpolated by the index for payroll manufacturing industries given by Douglas, *Real Wages in the United States, 1890-1926* (Houghton-Mifflin, 1930); 1889, Rees's figure for 1890 extrapolated by data in Long, *Wages and Earnings in the United States: 1860-1890*, in press. The cost of living index for 1914-57 is that of the Department of Labor; 1890-1914, Rees; 1889-90, Long.

[b]Source: Kendrick, Chapter V. This index is derived by multiplying the index of real gross national product per unweighted manhour (in the private domestic economy) by an index of the estimated percentage of national income (also for the private domestic economy) received by wage earners, salaried workers and entrepreneurs. The deflator involved is the implicit index

of price of the national product at "factor cost." Alternative indexes of real hourly earnings, obtained by deflating by the implicit index of national product price at "market" (A, below) or by the BLS-Rees-Long index of the cost of living (B, below), are as follows:

	A	B
1889	52.1	54.0
1899	59.2	60.3
1909	64.9	74.3
1919	76.6	82.3
1929	100.0	100.0
1937	120.5	118.2
1948	171.8	176.7
1953	209.6	215.0
1957	236.8	249.0

Index A is given in the work by Kendrick cited. It should be noted that Kendrick's deflators, and the deflators in the sources he used, were calculated before the new indexes of Rees and Long were available.