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Chapter Title: Fluctuations in the Rate of Productivity Increase

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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.<sup>6</sup> 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.

<sup>6</sup>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

	<i>Average Annual Percentage Rate of Change</i>		
	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,<sup>7</sup> 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.

<sup>7</sup>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

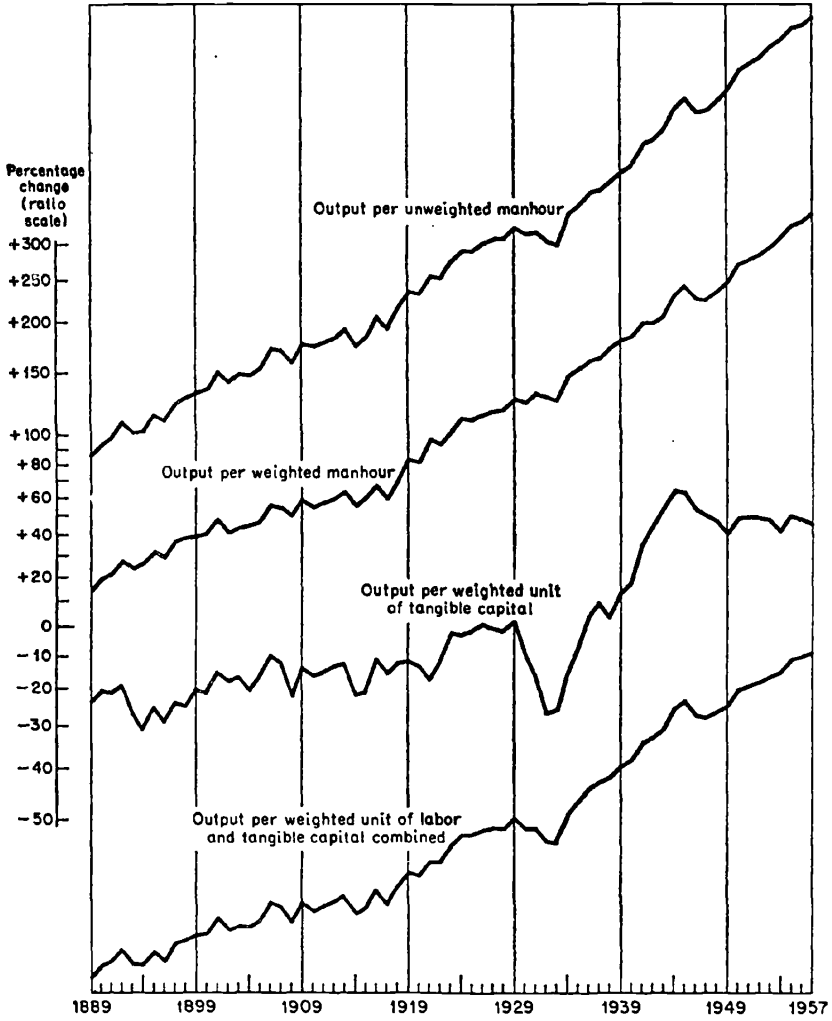


TABLE 3

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

	<i>Number of Year-to-Year Changes</i>	
	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.<sup>8</sup> 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

<sup>8</sup>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<sup>a</sup>  
between Successive Stages of Business Cycles

From Stage <sup>b</sup>	<i>Business Cycles</i>				
	Mar. 1933- May 1938	May 1938- Oct. 1945	Oct. 1945- Oct. 1949	Oct. 1949- Aug. 1954	All Four of the Cycles <sup>c</sup>
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.

<sup>a</sup>One-half of the percentage of industries with unchanged output per manhour is included with the percentage that showed rises.

<sup>b</sup>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.

<sup>c</sup>Includes also three earlier cycles for the railroad industry.

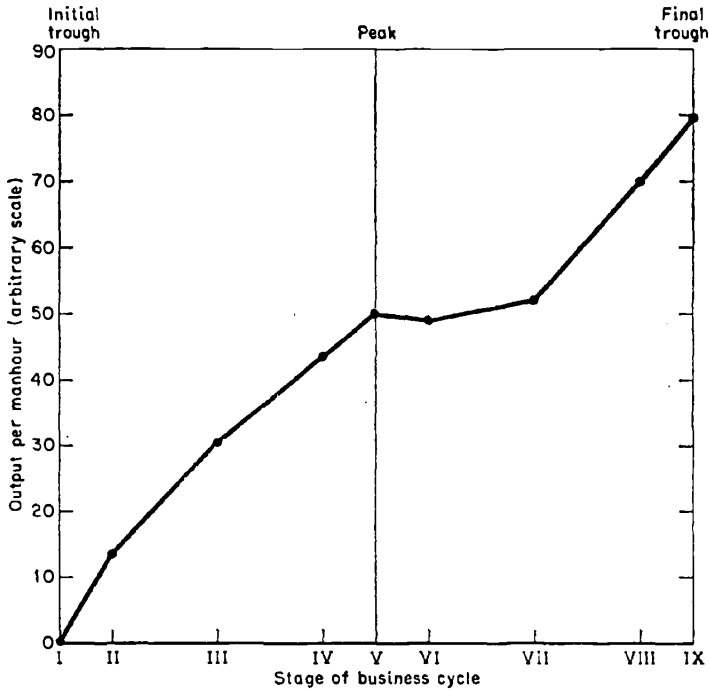
1933-54. In gathering these statistics, Hultgren made a special effort to obtain adequate and comparable data on output and the man-hours worked by wage earners. His sample has the further advantage of providing information on a monthly basis, far more satisfactory for the study of cyclical fluctuations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

Hultgren's data, set forth in Table 4 and Chart 2,<sup>9</sup> 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.

<sup>9</sup>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.<sup>10</sup> 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.<sup>11</sup>

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.

<sup>10</sup>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.

<sup>11</sup>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.