CHAPTER 3

Productivity Changes in the Economy

THIS chapter is devoted to a description of average changes in the private domestic economy since 1889. It provides the background for later analysis of the role of productivity in aggregate economic growth and a standard for comparison of productivity changes in the individual industries of the economy. The economy-wide estimates will also be useful for international comparison and analysis, but this use lies beyond the scope of the present volume.

Special interest attaches to over-all productivity indexes as the best available measures of net changes in the productive efficiency of the economy as a whole. In effect, the index of productivity in the private domestic economy is a weighted average of productivity indexes for the various industries. The component-industry measures show considerable dispersion and irregularity of movement. This is due partly to chance elements affecting invention, innovation, and the incidence of increasing returns, but it also reflects changing relative amounts of investment devoted to improvement of efficiency in the various industries. Only by study of the aggregate measure can we see the net effect of industry productivity changes and the degree of regularity of the forces promoting improved efficiency in the economy as a whole.

We shall examine both secular trends and shorter-period fluctuations in total factor productivity and the partial productivity ratios. The analysis is confined largely to the private domestic economy; the national product and productivity estimates are subject to some downward bias because of the method of estimating real product originating in the government and in the rest-of-the-world sectors. Since we later use the national productivity estimates for analysis of aggregate economic growth, however, we shall compare long-period productivity trends in the private domestic and total national economies. The differences are relatively minor, for the private domestic economy accounted for more than 90 per cent in all peacetime years.

Secular Trends

The long-term growth of total factor productivity and the partial productivity ratios will first be described in terms of average annual rates of change between 1889 and 1957. Inspection of the time series on an annual

basis reveals a distinct change in trend about 1919; so rates of growth over the two segments of the long period will also be computed. More complicated methods of trend fitting are employed, but these give virtually the same average rates of change as are obtained by use of the simpler compound interest formula.

THE LONG PERIOD, 1889–1957

Total factor productivity—variant measures. Between the terminal years of the period 1889–1957, productivity increased at an average annual rate of approximately 1.7 per cent in the private domestic economy (see Table 1 and Chart 1). Since the real private domestic product grew at

TABLE 1

Private Domestic Economy:
Growth Rates in Real Product and Productivity Ratios, 1889–1957
(average annual percentage rates of change)

	Real Gross Product	*Real Gross Product per Unit of*			*Real Gross Product per Manhour* (unweighted)
		Total Factor Input	Labor Input	Capital Input	
1889–1957	3.5	1.7	2.0	1.0	2.4
1889–1919	3.9	1.3	1.6	0.5	2.0
1919–57	3.1	2.1	2.3	1.3	2.6

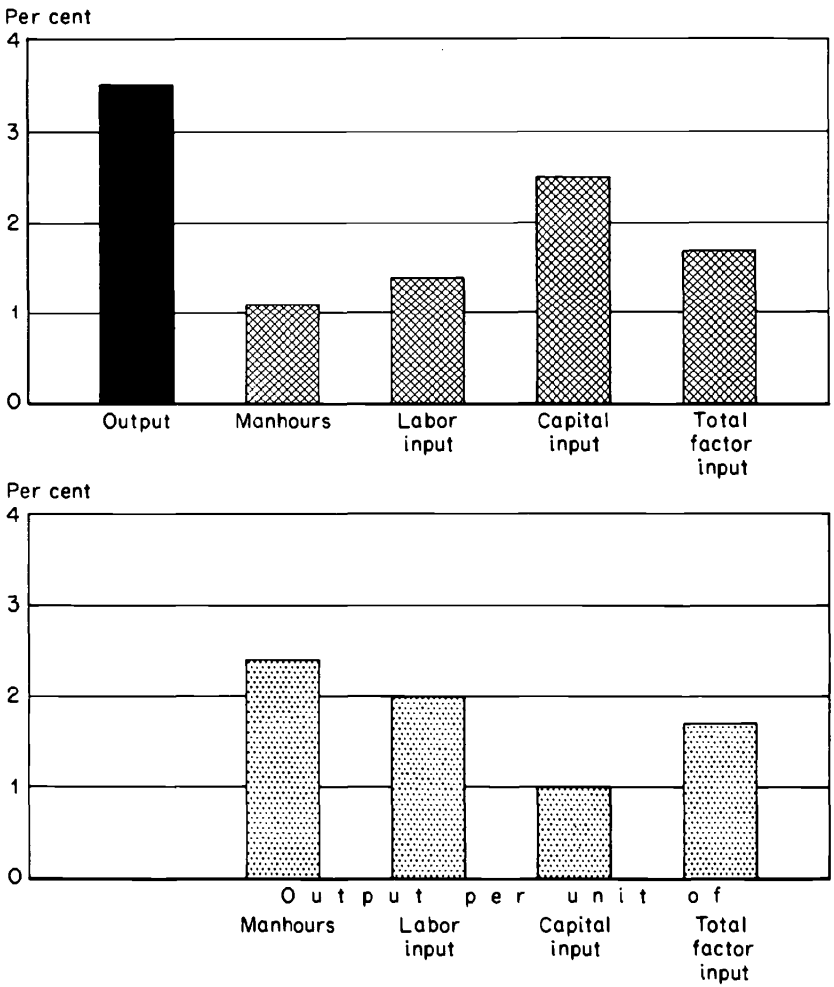
SOURCE: Table A-XXII.

an average annual rate of 3.5 per cent over the same sixty-eight year period, it is evident that about half of the growth in output was accounted for by additions to real labor and capital inputs, and half was contributed by increases in the efficiency with which the inputs were utilized, i.e., in productivity. The relative importance of productivity has been still greater in recent decades. But even the 1.7 per cent a year secular rate, when compounded, would result in a doubling of real private domestic product every forty years due to productivity growth alone; the 3.5 per cent annual rate of growth of real product as a whole results in a doubling every twenty years, on the average.

The rate of growth of productivity in the total national economy using the estimates of either the Commerce Department or Kuznets (national security version) is lower—1.6 per cent, as shown in Table 2. There is reason for thinking that these more comprehensive estimates understate actual productivity gains. The Commerce Department uses explicit conventions for estimating real product originating in the rest-of-the-world

CHART 1

Private Domestic Economy: Output, Inputs, and Productivity Ratios, Average Annual Rates of Change, 1889–1957



and general government that make no allowance for productivity change in these sectors (which comprise the difference between the private domestic and total national economies).

Measurement of the physical volume of gross and net government output is not generally practicable; but it seems obvious a priori that the

productivity of public resources must have increased over the period since many of the same technological improvements have been introduced in government as in private industry.[1] This must also have been true of real net capital stocks located abroad, but the estimates of real net factor income from abroad do not reflect it.

TABLE 2

Alternative Economic Sectors and Variant Concepts of National Product: Growth Rates in Real Product, Input, and Productivity, 1889–1957 (average annual percentage rates of change)

Economic Sector	Real Gross Product[a]	Total Real Factor Input	Total Factor Productivity
Private domestic	3.46	1.70	1.73
Private national	3.47	1.75	1.69
Total national:		1.92	
Commerce concept	3.50		1.55
Kuznets concepts:			
National security	3.50		1.55
Peacetime	3.39		1.44

SOURCE: Tables A-XIX through A-XXII.

[a] If real net product estimates are used, the growth rates are higher by 0.01 percentage point in the national security concept of the total economy; 0.02 percentage point higher in the private national economy; 0.03 percentage point higher in the Commerce national economy concept; and lower by 0.01 percentage point in the peacetime concept of the national economy.

Inclusion of the general-government and rest-of-the-world sectors raises real factor input proportionately more than real product in the total national economy as compared with the private domestic economy. The difference in average annual rates of change is 0.22 percentage point for input and 0.04 for real product.[2] Thus, the input of the two sectors rose even more than private domestic product. Reference to Table 2 indicates that the rest-of-the-world sector accounted for 0.04 percentage point of the difference between productivity growth in the private domestic and total national economies with the larger government sector accounting for the bulk of the total 0.18 percentage point difference. The proportionate difference between the two rates of growth differs somewhat by subperiod.

It is apparent that the differences shown are not major. Even if it were assumed that productivity in the total national economy rose at the 1.73

[1] See the experimental measures compiled by Henry Lytton, "Recent Productivity Trends in the Federal Government: An Exploratory Study," *The Review of Economic Statistics*, November 1959, p. 341.

[2] The greater relative discrepancy in the period since 1919 is traceable to our inclusion of the input of capital as well as of labor commanded by government, whereas the Commerce real government product estimates parallel the government labor input measure alone. Labor and capital inputs showed parallel movements between 1889 and 1919, but between 1919 and 1957 capital in this sector rose relative to labor input.

average annual percentage rate calculated for the private domestic economy instead of 1.55, then real national product would have risen at an average annual rate of 3.68 instead of at 3.50 as computed.

The Kuznets estimates (national security version) imply about the same rate of change in total factor productivity as the Commerce estimates, although there are several conceptual differences between the two series, as explained in Chapter 2. The chief difference is that Kuznets excludes estimated public services to business from final product while the Commerce Department includes all government purchases of goods and services. The amount involved is not large, and the conventions used by Kuznets to measure real government services to consumers and, by implication, real intermediate services to business result in a relatively stable ratio of the latter to real national product in the terminal years (see Appendix A, section on "Private purchases of goods and services"). Because the two sets of estimates yield much the same secular rate of productivity advance, it is plain that the Kuznets series also imply no advance in productivity of the factors employed in the public and foreign sectors. There is, however, some divergence in subperiod movements between the two series. Since the Kuznets conventions for excluding government real-cost services are quite arbitrary, the Commerce estimates are better suited to the study of productivity movements as such. Kuznets' estimates (national security version) will, nevertheless, be used for analysis of the interactions of productivity and economic growth because his national product estimates permit a complete breakdown by the broad purposes toward which economic activity is directed.

The rates of change in the Kuznets peacetime version of the national product are also shown in Table 2. In this version, Kuznets excludes national security outlays from final product on the grounds that they do not contribute directly to economic welfare but are merely a precondition for production and hence may be classed as intermediate. Since the proportion of total real gross national product devoted to national security purposes increased from 0.4 per cent in 1889 to 9.2 per cent in 1957, the average annual rate of growth of real product and productivity by the peacetime version was 0.11 percentage point lower over the sixty-eight-year period than by the national security version. Again, the differences vary by subperiod, depending on the changes in the distribution of the national product as between national security and civilian purposes.

We do not carry consideration of the peacetime version beyond this comparison and presentation of the basic estimates on which it is based (Tables A-I and A-II). It is only necessary to extend Kuznets' argument to read that national security is a goal equivalent to welfare in peacetime as well as in wartime to justify use of the more inclusive measures. In any case, from the standpoint of our interest in the productive capacity or

productivity of resources, it is desirable to use measures that do not fluctuate with changes in the degree of international tension, since the resources devoted to national security can be shifted to the production of consumer or capital goods without substantially affecting total product inclusive of national security outlays. Subsequent analysis of national productivity movements is therefore based on national product measures, including the output of security items in all years.

A final comparison relates to product estimates gross and net of capital consumption allowances. In the next chapter, we use real net national product and productivity measures. These are theoretically preferable since the production of capital goods required to offset that part of the stock consumed in the production process does not add to welfare any more than does the output of any other intermediate goods and services. Actually, the estimation of real capital consumption presents serious conceptual and statistical problems that make the net measures less accurate than the gross. Further, since estimates of real capital consumption are not available for most industry groups, our analysis of real private product (used later for comparison with industry real-product estimates) is based on the gross estimates. The figures in the footnote to Table 2 indicate that the broad real gross and net product estimates are virtually interchangeable if Kuznets' estimates of real capital consumption are accepted. Ideal measures of net product, were they available, might show greater divergence of movement from the gross measures.

The partial productivity ratios. The index of total factor input is a weighted average of the indexes of the two major inputs, labor and capital, each of which may also be related to output. Since capital per unit of labor input increased by about 1 per cent a year on balance between 1889 and 1957, output per unit of capital input shows a significantly smaller average annual increase than output per unit of labor input—1 per cent as compared with 2 per cent (see Table 1).

For reasons adduced in Chapter 2, aggregate labor and capital inputs were computed by weighting manhours and real capital stocks in the various industry groups by the compensation per unit of labor and capital in each. Since both labor and capital inputs have shown a persistent tendency to increase more rapidly in the higher-paying industries, the weighted input indexes have increased more than the unweighted. This is a rough measure of the increasing quality of resources resulting from interindustry transfers of resources to the extent that relative unit compensations indicate the relative marginal productivities of the resources in the various uses.

When output is related to unweighted indexes of the two factor inputs, the productivity ratios rise faster than in the measures we have used. Output per manhour increases at an average rate of 2.4 per cent a year

compared with the 2.0 per cent rise in output per unit of (weighted) labor input; and output per unit of capital (unweighted) increases by 1.1 per cent a year compared with 1.0 per cent for output per unit of (weighted) capital input. The ratio of output to a combination of both unweighted factor input indexes [3] increases at an average annual rate of 2.0 per cent compared with the 1.7 per cent shown by the preferred total factor productivity measure.

Our method of weighting inputs by industry has the distinct advantage that the productivity ratios are not affected merely by the relative shift of resources among industries[4]—the over-all productivity index is thus conceptually an internally weighted mean of the productivity indexes for the component industries. It can be compared with the industry indexes without the necessity of explaining that part of the change in the aggregate is due to interindustry shifts since these affect input rather than productivity by our procedure. The productivity indexes computed by using internal weights for the inputs are thus a purer measure of changes in technological efficiency as such. Another advantage is that they better indicate the extent to which rates of unit factor compensation in given employments can be raised consistent with stable average product prices. This is not true of productivity indexes using unweighted inputs since part of the "productivity" increase accrues to the factors as a result of upgrading.

THE BREAK IN TREND

Annual estimates of real private domestic product and associated factor inputs are plotted in Chart 2, and the derived estimates of total factor productivity, in Chart 3. Examination of the annual index numbers of total factor productivity reveals a distinctly higher trend since World War I than that which prevailed in the three prior decades. Rates of growth computed between the terminal years of the two periods are 1.3 per cent a year for 1889–1919 and 2.1 per cent for 1919–57. Actually, the change in trend could be interpreted as beginning in 1917, but it is more convenient for us to use the key year 1919 as the dividing point. The results are not substantially affected.

Trend lines fitted by the method of least squares to the two segments of the time series show the same rate of growth for the more recent period, but a somewhat lower rate for the early period—1.03 per cent. The difference arises because productivity in 1889 is below the trend line, whereas in 1919 it is above, as is apparent in Chart 3. Estimated productivity in both 1919 and 1953 is above the trend line; so the rate computed from terminal years is the same as that indicated by the method of least

[3] Manhours and unweighted capital input are combined by changing shares of national income in key years (see Table A-XXII).

[4] Effects of intra-industry shifts are not eliminated.

CHART 2

Private Domestic Economy: Real Gross Product and Factor Inputs, 1889–1957
(1929=100)

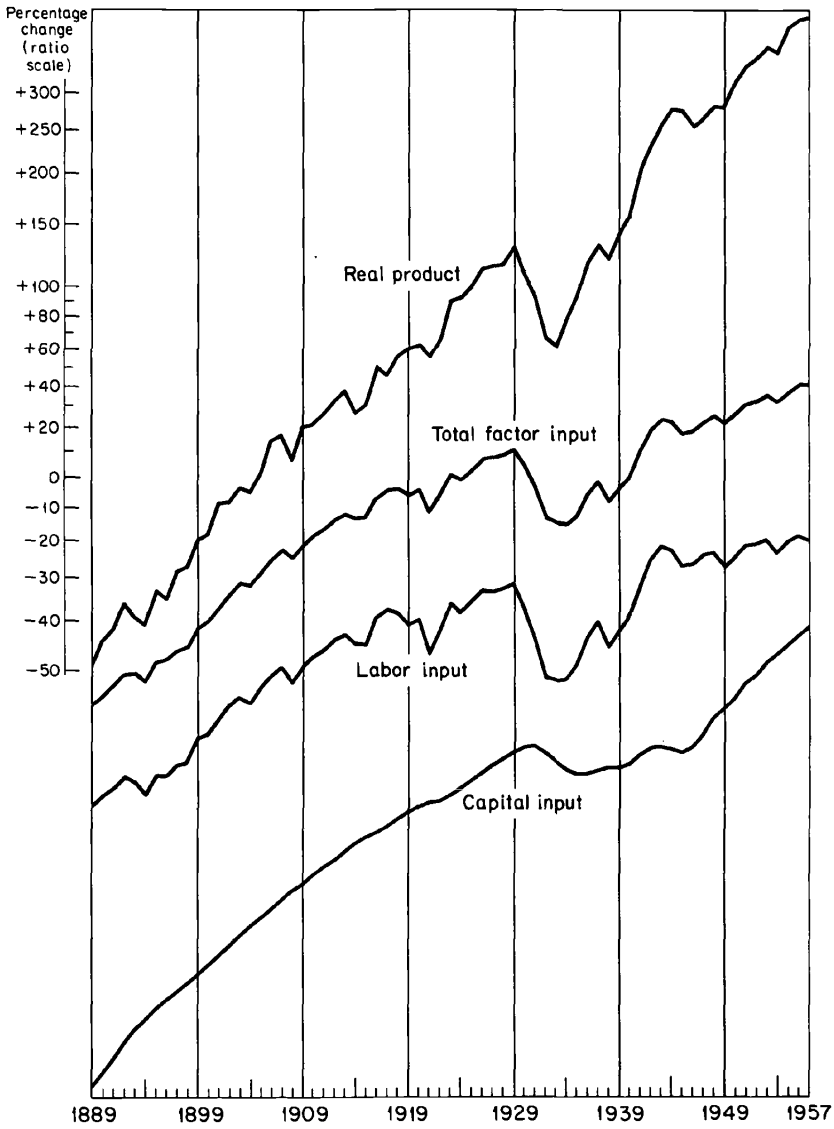
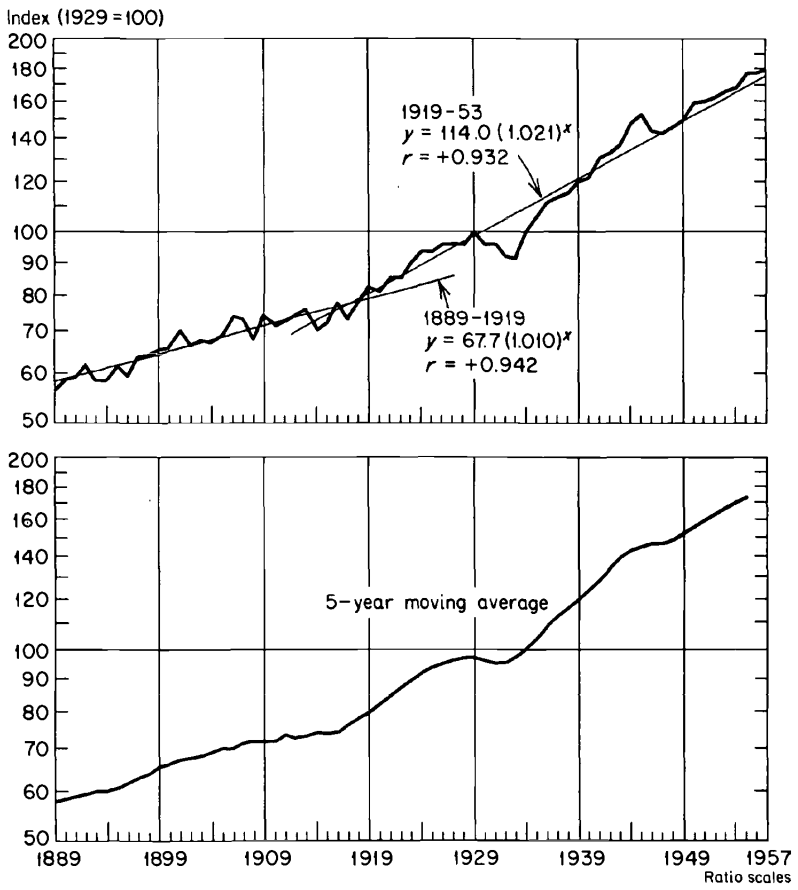


CHART 3

Private Domestic Economy: Trends in Total Factor Productivity, 1889–1957



squares.[5] Subsequent estimates for 1953–57 continue to fall around the trend line, although 1957 is a bit lower relative to the trend than is 1953.

An alternative method of fitting a trend is illustrated, for 1919–53, by the dashed line in Chart 5. Here, the logarithms of total factor productivity are related to time and to the ratio of civilian employment to the civilian labor force. By holding the employment ratio constant at a relatively full employment level (0.965) the calculated net trend tends to pass through

[5] Glover's method, which minimizes the sum of the squares of arithmetic deviations, yields the same growth rate for the early period as the usual least squares method, but a higher average rate for the recent period (2.23 per cent versus 2.10 per cent).

the productivity estimates for years of high employment. The indicated trend rate of increase is 2.0 per cent a year. This type of net trend is useful for the projection of productivity to years in which full employment is assumed. The estimating equation indicates that for each 1.0 per cent decline in the employment ratio, productivity deviates from its calculated trend value by approximately 0.6 per cent.

Although it is preferable to calculate trend rates of growth by a method of least squares, we shall generally use the simpler compound interest formula applied to terminal years of subperiods or long periods. The differences between the two methods are not great since the terminal years are years of relatively high economic activity and, in any case, productivity indexes fluctuate less than most economic variables. The compound interest calculation is also used because annual estimates are not available for many of the industry productivity series with which the estimates for the private domestic economy are compared later.

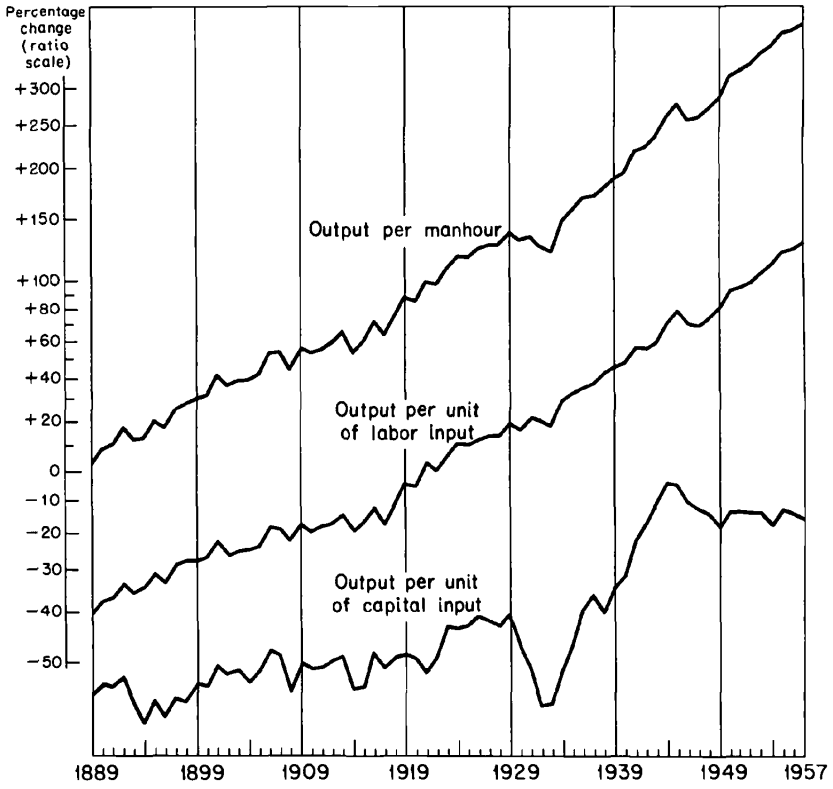
Less confidence can be placed in estimates for decades prior to 1889, but it is of interest that the average rate of increase in total factor productivity between the decade averages for 1869–78 and 1889–98 is 1.2 per cent a year, which is in line with the 1.3 per cent for the subsequent quarter century. The rate would be somewhat less if correction were made for the downward bias of the estimates for the first decade, resulting from the undercount of the Census of 1870. This defect in the national product estimates results in the appearance of an extraordinarily high rate of increase in real product and productivity between 1869 and 1879, which is reduced by the use of the decennial averages. Because of doubts as to the accuracy of the early estimates, however, we confine the analysis of productivity changes to the period since 1889.

Between 1889 and 1919, the rates of growth of both of the major partial productivity ratios were significantly less than in the more recent period (see Chart 4). Acceleration after 1919 is much more marked in the output-capital ratio, with the average rate of change in this ratio rising from 0.5 per cent to 1.3 per cent a year. The average annual rates of increase in output per unit of labor were 1.6 per cent and 2.3 per cent in the two periods. In the early period, capital stocks, on balance, were being built up more rapidly relative to the labor force than they were after 1919. In some industries prior to World War I, capital was growing even faster than output; since then the reverse tendency has prevailed in almost all industries (see Chapter 6).

A similar picture emerges from an aggregate of independently estimated output series, accounting for more than half of the national income originating in the private domestic economy, in relation to independently derived capital series and to manhour series which are part of the broader aggregate. The pertinent growth rates are shown in Table 3. The acceler-

CHART 4

Private Domestic Economy: Partial Productivity Ratios, 1889–1957 (1929=100)



ation since 1919 is even more pronounced than it is in the sector as a whole, which confirms the notion of a distinct break in trend.

Although there is little evidence of further acceleration in total factor productivity over the years since World War I, the rate of increase in real private product per manhour since World War II has been higher than in the interwar period. This is discussed by Fabricant in his introduction, and in a report by the Bureau of Labor Statistics released as this volume was being prepared for press.[6] Using essentially the same series on real private product per manhour as is presented here, the BLS report notes that for 1909–58 a curvilinear trend fits the data better than a straight-line trend. When, however, the period 1919–58 is used, and when a

[6] *Trends in Output per Manhour in the Private Economy, 1909–1958*, BLS Bulletin 1249, December 1959.

variable is introduced to represent the rate of utilization of capacity, the degree of acceleration is sharply reduced. It is further reduced if the data back to 1889 are used. For the private nonfarm sector separately, no acceleration of real product per manhour is apparent after 1919.[7]

TABLE 3

Private Domestic Economy, Covered-Industry Sector[a]
Growth Rates in Output and Productivity Ratios, 1889–1953
(average annual percentage rates of change)

	Output	*Output per Unit of*		
		Total Factor Input	Labor Input	Capital Input
1889–1953	3.2	1.7	1.9	1.0
1889–1919	3.1	0.6	0.8	0.1
1919–53	3.2	2.6	2.8	1.9

SOURCE: Table A-XXV.

[a] Aggregate of industry segments for which capital and labor input indexes as well as output indexes are available: farming, mining, manufacturing, transportation, and communications and public utilities; trade from 1929 forward.

Acceleration after 1947 in real product per manhour for the private economy can largely be explained in terms of a much higher rate of increase in real capital per manhour after World War II than in the interwar period. Acceleration is not significant in the total productivity measure since capital is included in the denominator of the ratio. Any projection of the postwar rate of increase in real private product per manhour would be predicated on a continuing high rate of increase in real capital stock per manhour, other things equal. But since this and the other causal forces are subject to change, any projection of a trend line beyond the historical period is hazardous.

It is not possible adequately to analyze the factors that may have been responsible for the change in productivity trend around the time of World War I, although it is a subject worthy of further investigation. A step in this direction can be taken by noting a few changes that occurred about the same time in associated variables. The scientific management movement, based on the ideas of Frederick W. Taylor, spread widely in the 1920's; college and graduate work in business administration expanded rapidly; and it was only after 1919 that organized research and development became a significant feature of the industrial landscape (see Chapter 4). It has also been suggested that the drastic change in national immigration policy promoted a more rapid increase in the average

[7] *Ibid.*, p. 27.

education of the labor force. That is, since the immigrants had less schooling, on the average, than the domestic labor force, the mass influx of workers from abroad prior to World War I had tended to retard the increase in average education.[8]

It is tempting to enumerate specific innovations that became important after 1919, such as mass or "flow" production techniques in manufacturing. Certainly, there was a remarkable acceleration in manufacturing productivity in the 1920's. But significant innovations were occurring throughout the whole period; short of a thorough study of their cost-reducing impact, it would not be possible to isolate those that contributed most to the speeding-up of productivity advance.

Temporal Variations in Growth Rates

SUBPERIOD CHANGES

In the private domestic economy as a whole, rates of growth over subperiods of approximately a decade in length have been relatively close to the longer-term trend rates. They are notably more stable than the subperiod rates in most of the industry groups surveyed later because the variations of the industry rates tend to be offsetting. The offsetting nature of divergent industry rates may be in part a result of random factors and in part a result of interindustry shifts of the resources devoted to technological progress.

Over the period 1889–1957, the average deviation of the subperiod rates of change in total factor productivity from the average rate for the period as a whole is 0.4 per cent—less than one-quarter of the average annual rate of growth. The average deviations are less, of course, for each of the two major time-segments into which the trend was broken—0.2 and 0.3 per cent for 1889–1919 and 1919–57, respectively (see Table 4).

Taking the period as a whole again, for the sake of convenience, the average deviation of subperiod rates of change in output per unit of labor input is the same as that for total factor productivity—0.4 per cent. The deviation for output per unit of capital input is absolutely greater, and relatively much greater—0.7 per cent. Apparently, the forces that determine the growth of investment and capital stock in relation to output are comparatively irregular in their operation.

Irregularity in the subperiod rates of change in input proportions—or, to put it differently, in the rate of substitution of capital for labor—may be due to changes in relative factor prices, in the propensity to save, or in the nature of technological advance, all of which are interrelated. But the effect on changes in productive efficiency does not seem to be marked.

[8] The author is indebted to Milton Friedman for this suggestion.

There is, however, a mild tendency for subperiod rates of change in capital per unit of labor input to be positively correlated with subperiod rates of change in output per unit of labor input.[9] This tendency is consistent with the fact that the average deviation of subperiod rates of change in total factor productivity from the long-period rate is somewhat less than the weighted mean of the average deviations of subperiod changes in each of the partial productivity ratios from their secular rates of change.

TABLE 4

Private Domestic Economy:
Subperiod Rates of Change in Real Product and Productivity Ratios, with Mean Deviations from Secular Rates, 1889–1957

	Real Product	*Real Product Per Unit of*		
		Total Factor Input	Labor Input	Capital Input
	AVERAGE ANNUAL PERCENTAGE RATES OF CHANGE			
1889–1899	4.5	1.6	2.0	0.4
1899–1909	4.2	1.2	1.3	0.8
1909–19	3.0	1.1	1.5	0.3
1919–29	3.7	2.0	2.2	1.4
1929–37	0.1	1.6	1.8	0.9
1937–48	4.5	2.3	2.2	2.7
1948–57	3.6	2.3	3.1	−0.2
	MEAN SUBPERIOD DEVIATIONS FROM LONG-PERIOD RATES			
1889–1957	0.9	0.4	0.4	0.7
1889–1919	0.6	0.2	0.3	0.2
1919–57	1.3	0.3	0.4	0.9

SOURCE: Table A-XXII.

ANNUAL CHANGES

Charts 3 and 4 show that annual variations relative to trends are much greater than the relative subperiod variations. The average deviation of the yearly percentage changes in productivity from the 1.8 per cent average annual rate, 1889–1957, is 2.9; the average deviation of the change in output per unit of labor input is somewhat less, while that for the change in the output-capital ratio is much greater. The average annual deviations of percentage changes in total factor productivity and labor productivity are somewhat smaller when computed from the trend rates for 1919–57, but they are still large.

In a few cases, the variations in annual productivity changes appear to be erratic, traceable to random factors or, possibly, to erratic errors in the

[9] The coefficient of rank correlation is +.29 (which is, however, not significant at the 5 per cent level).

estimates. The sharp rises in 1901 and 1906, followed by partially offsetting drops, appear to be of this character. The lower-than-trend values in 1914, 1915, and 1917 may reflect the repercussions of World War I, although it should be noted that productivity was well above trend in 1944 and 1945.

Productivity and the business cycle. The major cause of annual fluctuations in productivity change appears to be short-term changes in the scale of production. Over those forty-seven years of the period 1889–1957 that are characterized as reference cycle expansions, the average percentage change in productivity was 2.8, compared with a 1.8 per cent average of annual changes over the entire period. Over the twenty-one years characterized as contractions, productivity fell by 0.5 per cent on the average (see Table 5). The average deviations of the percentage changes

TABLE 5

Private Domestic Economy:
Change in Real Product and Productivity Ratios,
Years of Expansion and of Contraction, 1889–1957
(average annual percentage change)

	Years Covered (number)	*Real Product*	*Real Product per Unit of* Total Factor Input	Labor Input	Capital Input
Years of expansion					
1889–1957	47	6.7	2.8	2.4	4.0
1889–1919	20	2.8	2.8	2.5	3.5
1919–57	27	6.7	2.9	2.3	4.4
Years of contraction					
1889–1957	21	−2.9	−0.5	1.3	−5.2
1889–1919	10	−1.5	−1.5	0.0	−4.9
1919–57	11	−4.1	0.3	2.5	−5.5

SOURCE: Table A-XXII.

during expansions are absolutely smaller and relatively much smaller than are the average deviations during contractions. Productivity fell during half of the contractions, and the fall was particularly marked during major contractions. But in the other reference contractions, productivity rose. Productivity rose by more than the trend rates of increase in the postwar readjustment, 1918–19, and in three subsequent recessions, two of which were very mild.

With respect to partial productivity, output per unit of labor input rose only one-half as much in contractions as in expansions. Presumably, certain types of "overhead" employees are kept on payrolls when output falls, but are not so fully utilized as when production is expanding. Also,

when output falls below the point of the optimum combination of labor with fixed capital, it is to be expected that the productivity, or output per unit of each of the factors will decline. A partial offset might be provided by an increase in the efficiency of individual workers to the extent that less efficient workers are laid off first and those remaining exert more effort in view of growing unemployment. It is also probable that the pace of technological advance falls off a bit in recessions since investment in new plant and equipment tends to decline and research and development outlays to slacken despite the greater pressure towards cost reduction stemming from falling profit margins. On the other hand, some cost reductions can probably be achieved with little or no new capital and by concentrating production in more efficient plants.

Output per unit of capital input actually falls in contractions. This is, in part, a function of the technique of measuring capital input. We assume proportionality with real capital stocks, since from the standpoint of private ownership capital assets represent a real cost or charge regardless of the intensity with which they are employed. This is certainly the case when buildings or equipment are subject to long-term lease, or when they are financed by borrowed funds on which regular interest payments must be met. Even when equity capital is involved, presumably there must be some average rate of return over the lifetime of the underlying real assets, which is an implicit cost during recessions and must be incurred if capital is to remain in the industry.

Unlike labor, which can be laid off under conditions of declining activity (and subsequently does not represent a direct cost to private industry), capital stocks usually continue to increase in mild recessions—although the rate of increase declines as investment drops. Only in severe contractions does gross investment drop below capital consumption causing total capital stock to fall with output. Thus, when output falls, the output-capital ratio will drop even more, as a rule. This does not affect the subperiod or long-period changes since these are measured between years of high activity which give time for capital to be adjusted, more or less efficiently, to the volume of other inputs and to output.

Annual comparisons are, of course, a blunt instrument for cyclical analysis. Monthly estimates adjusted for seasonal variation permit a more refined analysis of changes in economic variables between turning points and during both expansion and contraction phases. This study has been confined to annual estimates, but a brief summary of the findings of Thor Hultgren with respect to movements of output per manhour over specific production cycles and the reference business cycle provides an illuminating supplement to our annual comparisons.[10]

[10] Thor Hultgren, *Changes in Labor Cost During Cycles in Production and Business*, Occasional Paper 74, New York (NBER), 1960.

Hultgren assembled monthly output per manhour estimates for 23 industries for one or more cycles between 1921 and 1956, giving him observations on 74 expansions and 83 contractions. In terms of the turning points identified in each industry output series (which mark production cycles), in 91 per cent of the expansions output per manhour increased, while in 72 per cent of the contractions output per manhour declined. There was, however, a declining proportion of increases in output per manhour during successive phases of expansion (from 88 to 68 per cent) and an increasing proportion of increases during successive phases of contraction (from 27 to 43 per cent).

At first glance, the positive relation between output and labor productivity movements seems to contradict our findings based on annual private domestic economy estimates, according to which output per manhour rises in contractions as well as in expansions, although in significantly lesser proportion. But it must be remembered that individual production cycles frequently do not coincide with the general reference cycle in timing. When they do not, the extent of the average industry expansion or contraction within the reference cycle dates is dampened. This influence is strong enough to reverse the picture of the relationship in contractions. In 76 per cent of Hultgren's 54 observations for reference expansions, output per manhour rose—a smaller percentage than prevailed during the production cycle expansions. But in 69 per cent of the 65 reference contractions, there was also a net increase in output per manhour as opposed to a majority of declines in production contractions. In other words, the adverse effect of declining volume is reduced, and the relative impact of technological advance is increased. The use of annual averages further accentuates the tendency towards rising output per manhour in contractions.

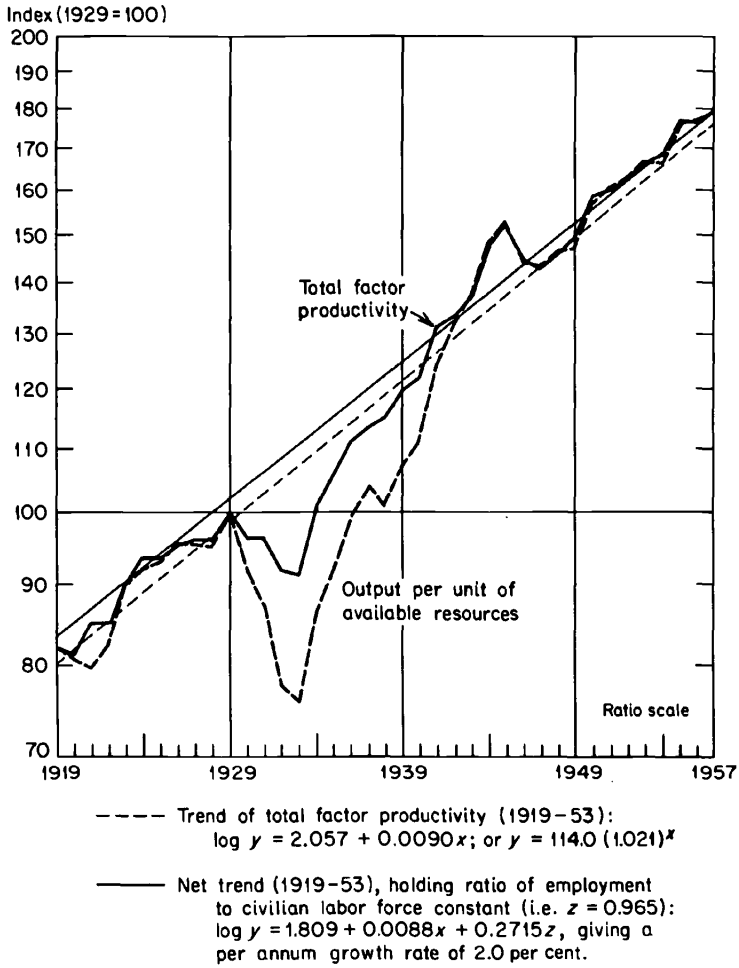
It is interesting to note also the relationships over the phases of the general business cycle. During expansions the percentage of observations in which output per manhour rose declined from 76 in the first phase to 63 in the last phase—a less pronounced decline than in individual production expansions. In the first phase of contraction, 48 per cent of the measures of industry output per manhour rose; in the last phase, 69 per cent were rising.

If monthly estimates of real capital stocks were available, it seems clear that the positive relation between output and the output-capital ratio would be more pronounced between turning points in the monthly reference cycle than between turning points on an annual basis. The positive relation would be still more pronounced over production cycles in which amplitudes of output fluctuation are greater than in the general business cycle.

Variant annual productivity measures. It would be possible crudely to adjust real capital stock estimates to make allowance for the hours of utilization

CHART 5

Private Domestic Economy: Trends in Alternative Productivity Measures, 1919–57



and thus achieve a formal consistency with the treatment of labor input. If this were done, capital and total factor productivity would probably not decline in most contractions, although the rate of increase would be retarded, as in the case of labor productivity, since there would be departures from optimum factor combinations. But such an adjustment to capital would have a most tenuous statistical basis, and even theoretically would be purely formal, since in a real sense productive efficiency does decline

when capacity is utilized at rates significantly below those for which it was created. In any case, the intermediate and long-term comparisons would not be affected because there is no clear-cut evidence of a marked trend in the degree of utilization of capital over time.[11]

A more interesting possible variant of the productivity series involves treating labor from the viewpoint of social cost, and counting unemployed members of the labor force over and above a normal "frictional" pool (say 3.5 per cent of the labor force) as part of labor cost. The further assumption is made that such persons—by definition willing and able to work—are desirous of working the same average hours as those put in by employed workers. This variant is shown for the period since 1919 in Chart 5. It is seen that productivity so calculated falls significantly more in years of marked depression than does our standard series—indicating that the efficiency with which society utilizes its potential resources drops more than does the productive efficiency of industry measured in terms of private-enterprise costs. The virtual identity in the movements of the alternative productivity series since World War II is a measure of the greater efficiency with which our social organization now provides for high levels of economic activity as compared with the 1930's and some earlier depressed periods.

[11] See Bert G. Hickman, "Capacity, Capacity Utilization, and the Acceleration Principle," *Problems of Capital Formation: Concepts, Measurement, and Controlling Factors*, Studies in Income and Wealth, Volume 19, Princeton University Press (for NBER), 1957, pp. 419–468.