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NATIONAL PRODUCTIVITY TRENDS

This chapter is concerned with productivity trends in the economy as a whole, with particular reference to the post-World War II period 1948 to 1966. For selected measures preliminary extensions of the estimates have been made through 1969. Actually, much of our analysis relates to productivity in the private domestic economy, or the business economy, since adequate output and productivity measures cannot be made yet for general governments, households, nonprofit institutions, and the rest-of-the-world sector. However, with the domestic business sector contributing about 85 per cent of the national product as measured by the U.S. Department of Commerce, business sector productivity is of paramount importance in the national economy as a whole.

National productivity movements are of particular significance. The economy-wide measures are, in effect, weighted averages of productivity in the various component sectors and industries (covered in Chapter 5). They thus provide an overall measure of average changes in productive efficiency, reflecting the net effect of cost-reducing innovations and other forces affecting productivity in all parts of the economy. As such, they afford one approach to the study of the causal factors by time-series analyses that relate aggregate measures of these forces to the overall productivity measures.

The total and partial productivity measures for the economy may also be used effectively in analyzing the macroeconomic impacts of changes in technology and the other forces affecting real unit costs of production. Thus, we can measure the contribution of productivity changes to economic growth and rising planes of living, the relationship between factor prices and product prices, and the stages of price level inflation. Further, the movements of the partial labor and capital productivity ratios, in conjunction with measures of the relative prices of labor and capital, are essential to an analysis of changes

in the functional distribution of national income. Finally, while we confine ourselves to an analysis of the U.S. economy here, it should be mentioned that productivity measures are also germane to the comparative study of economic growth among nations.

The Time Frame

Most of the analysis will relate to the period 1948-66, generally in terms of average annual percentage rates of change as computed by the compound-interest formula. Not only is this approach convenient but it permits precise reconciliations between rates of change in productivity and in the output and input components, which is not the case with trend rates computed by fitting time trends to the series by correlation techniques. Also, one can use the compound-interest formula to compute rates of change during subperiods covering complete cycles (measured here from peak to peak) during the period 1948-66, whereas fitted time trends would be inappropriate for the relatively short subperiods.

Yet it is well known that the choice of the first and last years between which the rates of change are computed will affect the result, although the effect will be diminished the more regular the series and the longer the time period. We shall supplement the rates computed under the compound-interest formula with rates obtained by fitting time trends to the logarithms of the series. The trend rates will also be affected by the period chosen, but the influence of the possible deviations from trend of the first and last year's values will be reduced.

Actually, the years 1948 and 1966 were chosen because it was felt that they were broadly comparable. 1948 was a cycle peak and the first full year following World War II without wage and price controls. Although 1966 has not been designated a peak, it was the last year in the long, strong expansion from the trough of 1961 and was followed by a marked retardation of growth, sometimes referred to as the "mini-recession" of 1967. Yet, as we shall see, total factor productivity was a bit below trend in 1948 and above it in 1966. So the rates of increase obtained by the compound-interest formula are slightly higher than the rates obtained from least-squares trend lines.

It may seem that we are unduly concerned with small differences in secular rates of change in productivity that result from a particular choice of methodology, concepts, and time periods. Yet it was not long ago that the secular growth rate in real private product per man-hour, then presumed to be 3.2 per cent per annum, was used by the Council of Economic Advisers as a

“guidepost” for noninflationary wage increases. Differences of tenths of a percentage point can be very important, particularly if compounded, when applied to a large base. At the same time, while we present various estimates of rates of change and try to appraise them, we must recognize, in the last analysis, that there is no unique estimate of *the* secular rates of change in an economic time series, though we can frequently obtain a good notion of the order of magnitude of the secular drift. Even the very concept of a secular trend has its limitations, of course, particularly if used as a basis for projection, since the underlying, unmeasured forces are subject to change.

Alternative Segmental Productivity Measures, 1948-66

Rates of change between 1948 and 1966 for three alternative measures of total factor productivity, by major economic segments, are shown in Table 3-1. We concentrate initially on the first column of the table, which relates to our basic productivity measure, in which capital stock is measured net of depreciation and weighted accordingly by various segments of the economy.

The average rate of growth in this basic measure of total factor productivity is 2.0 per cent a year for the total national economy, accounting for about half of overall economic growth. This rate of advance in the total

TABLE 3-1

Major Economic Segments: Alternative Total Factor Productivity Measures,
Average Annual Percentage Rates of Change, 1948-66

Economic Segment	Total Factor Productivity		
	Weighted Inputs		Unweighted Inputs ^a
	Net Capital	Gross Capital	
National economy	2.0	1.9	
Adjusted ^b	2.3	2.2	
Private domestic economy	2.5	2.3	2.8
Households and nonprofit institutions	1.0		
Private domestic business economy	2.5	2.3	
Nonfarm	2.4	2.3	

Source: Tables 5-1, A-17, A-19-21, A-17a, A-19a-A-21a, and A-19b.

^a The aggregate factor input index on which this variant is based does not incorporate industry compensation weights for labor and capital; that is, total man-hours are combined with total real capital, using 1958 shares of factor cost in the private domestic economy as a whole.

^b In this variant, real government product is obtained by applying a productivity increase of one per cent a year to real factor cost in the public sector.

economy is significantly below that shown for the private domestic economy. The reason for this, as pointed out in Chapter 1, is that OBE estimates real gross product originating in general government (and the small rest-of-the-world sector) without allowance for productivity advance. This downward bias is further accentuated in our estimates by the fact that our real labor input estimates for general government rise a bit more than the OBE real government product estimates, and that we add real capital costs of general governments to both real product and factor input, thereby increasing the relative importance of the public sector.

The treatment of real government product undoubtedly imparts a downward bias to real national product and productivity estimates—there is mounting evidence that productivity does indeed increase in the public sector. A pilot study of productivity in a number of federal government agencies indicated that during the post-World War II period productivity rose but little in three of the agencies, but rose markedly in the other two.¹ Estimates are not available for enough agencies to strike an average, but the implication of significant productivity advance in governments yielded by selected studies is hardly surprising. After all, government agencies have benefited from improved equipment, new management techniques, and other innovations that have raised productivity in the business economy, particularly the services sector. Improved office machines, especially electronic data processing equipment, are a case in point.

Given this evidence and reasoning, we have provided a variant of the national product and productivity estimates for the period 1948-66, in which we impute a productivity-growth factor to obtain an adjusted real product for general governments that raises the growth of overall real national product and productivity.² Specifically, we base the adjustment on the trend rate of increase in output per unit of labor input in the services sector, excluding households and nonprofit institutions but including government enterprises, which averaged 1.2 per cent a year during 1948-66 (see Table 5-5 in Chapter 5). We do not have capital and total factor productivity estimates for the services sector; but we assume the same relationship in that sector between growth rates in total factor productivity and labor productivity as in the private domestic economy as a whole. On this basis, the 1.2 per cent is

¹ See *Measuring Productivity of Federal Government Organizations*, U.S. Bureau of the Budget, 1965; see also the earlier work by Solomon Fabricant, assisted by Robert E. Lipsey, *The Trend of Government Activity in the United States Since 1900*, National Bureau of Economic Research, 1952.

² The need for this type of adjustment was indicated by Victor R. Fuchs, *The Service Economy*, New York, NBER, 1969, pp. 73-74.

reduced to a 1.0 per cent annual adjustment on total factor input. This is cumulated back and forward from the base period (1958) estimate of real factor cost in general government. The difference between adjusted and unadjusted real government product is added to real gross national product as a basis for computing adjusted total factor productivity in the national economy. The adjusted trend rate is 2.3 per cent a year. No adjustment is made for the small item of real product originating in the rest of the world, since this is almost entirely real property compensation, and there has been little net change in "capital productivity" in the postwar period.

The adjusted 2.3 average annual percentage rate is probably a better indication of past and prospective productivity trends in the national economy than the 2.0 per cent national rate. (We use the adjusted estimates for analysis in Chapter 4.) In projections, however, one is generally attempting to approximate changes in the official estimates, in which case the 2.0 per cent rate is more applicable—at least until OBE changes its method.³ It is even better to project real private product and add on real government product based on the anticipated growth of real factor costs in the public sector.

Table 3-1 distinguishes between the private domestic economy and the business (enterprise) economy, since, as noted earlier, the OBE estimates of real product originating in households and private nonprofit institutions may be subject to a downward bias through time. Actually, the average rates of productivity advance in the private domestic and business sectors during 1948-66 round off alike—2.5 per cent. First, even the OBE real product estimates do imply some increase in productivity in the household and institutions sector—1.0 per cent a year on the average between 1948 and 1966. Second, the sector is small; real product originating there comprised 2.8 per cent of real private product in 1958 and declined to 2.5 per cent in 1966.

In the rest of this chapter we focus on productivity in the private domestic economy, in part because we have a continuous record back to 1889 for historical perspective. The business sector estimates begin in 1929, and we compare the overall productivity estimates for this segment with the industry estimates for the postwar period in Chapters 5 and 6. As a practical matter, however, there is little difference between the productivity estimates for the two sectors.

³ For a suggested modification of the official methodology, see John A. Gorman, "Economic Change as Viewed Through the National Income and Product Accounts: The Implications of an Alternative Deflation Technique," *1969 Proceedings of the Business and Economic Statistics Section*, American Statistical Association, Washington, D.C., 1969, pp. 169-78; and John W. Kendrick, "Discussion," p. 192 of the same volume.

For some purposes, particularly wage analysis, economists are interested in productivity in the nonfarm business sector. As shown in Table 3-1, the rate of productivity advance in this sector averaged 2.4 per cent a year. This rate is slightly smaller than that in the business sector as a whole, reflecting a 3.3 per cent average annual increase in total factor productivity in the farm sector. Further segmentation of the nonfarm business economy by industry divisions and groups is deferred to Chapter 5.

Variant Total Factor Productivity Measures

One variant of total factor productivity referred to earlier is that in which real capital stocks and inputs are measured gross of real capital consumption, and weighted by base-period gross property income for combination with labor input. These variants show average annual growth rates 0.1 or 0.2 percentage points below the net productivity measures for the several segments. (See second column of Table 3-1.) This difference is due to the fact that capital input, which has grown faster than labor input, is accorded a significantly higher relative weight in gross productivity measures. The gross measure is more symmetrical in that the labor weight is also gross of depreciation on human capital. But since that portion of labor compensation promotes welfare whereas intangible capital consumption does not, we consider the net measure to be basic and center most of our analyses around it.

Another variant measure (shown in the third column of Table 3-1) for the private domestic economy is "unweighted productivity." The basic total factor productivity measure incorporates an aggregate of industry labor and capital inputs combined by industry compensation weights. Since there has been a relative shift of both labor and capital inputs towards industries providing higher rates of compensation per unit, weighted input rises by an average of about 0.3 percentage point more per annum than an unweighted input aggregate. Consequently, the unweighted total factor productivity index rises at an average annual rate of 2.8 per cent, compared with 2.5 per cent for the basic measure between 1948 and 1966 in the private domestic economy. We prefer the weighted measure, since in effect it is an internal mean of the component industry productivity measures and hence seems preferable for comparisons with industry measures. The internally weighted productivity index does not reflect the effects of interindustry resource shifts, since the shift effects are absorbed by the input measures. As indicated in the appendix (p. 157), between 1948 and 1966, labor input rose at an

average annual rate of 0.4 per cent more than unweighted man-hours, reflecting a relative shift of man-hours to higher-pay industries.

Total and Partial Productivity in the Private Domestic Economy

Now we turn to a more intensive examination of productivity trends in the private domestic economy, looking at the partial productivity ratios as well as total factor productivity. First we examine the compound rates of change between 1948 and 1966 and compare them with growth rates in the earlier periods 1889-1919 and 1919-1948. Then the growth rates for the postwar period based on the compound-interest formula are compared with rates based on fitting trend lines to the logarithms of the time series. (See Table 3-2.) In the case of total factor productivity, we shall later refer to trend lines fitted for segments of the entire period since 1889.

TABLE 3-2

Private Domestic Economy:
Average Annual Percentage Rates of Change
in Output, Inputs, and Productivity Ratios, 1889-1966, by Three Subperiods

	Compound Rates			Trend Rates
	1889 to 1919	1919 to 1948	1948 to 1966	1948 to 1966
<i>Real gross product</i>	3.9	2.8	4.0	3.6
<i>Inputs</i>				
Labor (weighted man-hours)	2.2	0.9	1.0	0.7
Man-hours	1.8	0.6	0.6	0.3
Capital (net)	3.3	1.2	3.5	3.3
Total	2.6	1.0	1.5	1.2
<i>Productivity ratios</i>				
Real product per unit of:				
Labor input	1.6	1.9	3.0	2.9
Man-hours	2.0	2.2	3.4	3.24
Capital	0.5	1.6	0.4	0.3
Total factor input	1.3	1.8	2.5	2.33
<i>Capital-labor input ratio</i>	1.1	0.3	2.5	2.6

Source: Computed from the estimates in Table A-19 and extrapolated from 1929 to 1889 by the series contained in John W. Kendrick, *Productivity Trends in the United States*, Princeton University Press for NBER, 1961, Table A-XXII.

Real gross product, the numerator of the productivity ratios, increased at an average compound rate of 4.0 per cent a year between 1948 and 1966. Total factor input rose at a rate of 1.5 per cent a year—a weighted average of a 1.0 per cent increase in labor input and a 3.5 per cent increase in (net) capital input. Thus, total factor productivity rose by 2.5 per cent a year over the period—a weighted average, in effect, of a 3.0 per cent increase in labor productivity and a 0.4 per cent rise in output per unit of capital input. Real product per man-hour rose at an average annual rate of 3.4 per cent. The 0.4 percentage point difference from output per unit of labor input represents the effect of relative shifts of man-hours from lower-pay to higher-pay industries, which causes labor input (man-hours by industry weighted by base-period average hourly compensation) to rise more than unweighted man-hours.

Looking over the decades before 1948 on Table 3-2, note that real GNP rose at an average annual rate of almost 4 per cent during the years from 1889 to 1919, and advanced at the much lower rate of 2.8 per cent in the 1919-48 period before resuming the 4 per cent trend. But the rates of increase in total factor input dropped even more between the first two periods, so that the growth rate in total factor productivity accelerated from 1.3 per cent a year in the period from 1889 to 1919 to 1.8 per cent during 1919-48, based on the compound-interest formula. From Table 3-2 it would appear that there was a further acceleration during 1948-66. Our subsequent trend analysis indicates, however, that there has been no further acceleration in the growth of total factor productivity since World War I if one abstracts from the effects of the Great Depression.

On the other hand, there has been a progressive acceleration in the rate of increase in output per unit of labor input—from 1.6 to 1.9 and to 3.0 per cent across the three periods shown in the table. The acceleration was reduced between the first two periods by a marked drop in the rate of substitution of capital for labor—from 1.1 to 0.3, as measured by the rate of increase in capital per unit of labor input. But the acceleration between 1919-48 and 1948-66 was accentuated by a pickup in the growth rate of the capital-labor ratio from 0.3 to 2.5 per cent a year, reflecting the high-investment aspect of the economy since World War II. Rates of increase in real product per man-hour showed a similar pattern of acceleration.

Rates of change in output per unit of capital mirror the movements in growth rates of capital. That is, increases of the output-capital ratio in periods before 1919 and after 1948 were around 0.5 per cent a year, reflecting the massive growth of capital. But during 1919-48, the increase averaged 1.6 per

cent as the growth rate of capital fell more than that of real product, reflecting lowered investment during the depressed 1930s and World War II.

For the period since 1948, we have also fitted least-squares trend lines to the logs of the output, input, and productivity indexes. For output and all the inputs, the trend rates of increase are somewhat less than the rates computed by the compound-interest formula applied to the first and last years. In other words, the values for output and inputs were below the estimated trend values in 1948 and above them in 1966. But the trend rate for output was farther below the compound rate for output than in the case of inputs, and the trend rates of growth in the productivity ratios were 0.1 or 0.2 less than the compound rates (see Table 3-2). Thus, the trend rate of increase in total factor productivity was 2.33 per cent a year, compared with the 2.5 compound rate. The trend rates for the two partial productivity ratios were 0.1 percentage point less each, while that for real product per man-hour was 3.24 per cent, compared with 3.4 on the compound-interest basis.

Subsequent preliminary estimates for the 1966-69 period suggest that the trend rates may provide a better indication of the secular drift of productivity in the post-World War II period than the 1948-66 compound rates. (See Table 3-3.) That is, an average annual growth rate of 0.9 per cent during 1966-69 in the private domestic economy was less than half the trend rate for 1948-66, and even farther below the compound rate. The mini-recession of 1967, which slowed growth of real product to 2.3 per cent, retarded productivity advance more than proportionately, to 0.8 per cent. The subsequent renewed growth of real product to 5 per cent in 1967-68 produced a respectable increase in total factor productivity of 2.1 per cent. But another significant slowdown in growth of real product in 1968-69 to less than 3 per cent caused a decline in productivity of 0.2 per cent.⁴

Compound rates for the period 1948-69 are thus closer to the trend rates than those for 1948-66 shown in Table 3-2. Also, if one calculated compound rates for the periods of 1946-66, or 1951-66, they would also be 2.3 with respect to total factor productivity—the same as the trend rate—since the values for the initial years 1946 and 1950 were above estimated value, as was true in the terminal year 1966. Rates of change between any pair of years during the period 1916-69 are shown in Table 3-3.

⁴ For a discussion of the 1966-70 productivity movements, see John W. Kendrick, "The Productivity Slow-down," *Business Economics*, September 1971. The author has calculated preliminary estimates of rates of change, 1969-72, in total factor productivity and real product per man-hour for industry groups in "U.S. Productivity Trends," *The Conference Board Record*, July 1973.

TABLE 3-3

Private Domestic Economy: Total Factor Productivity,
Average Annual Compound Rates of Growth Between Each Year
and All Succeeding Years, 1916-69

Final Date	Initial Date												
	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928
1917	-5.5												
1918	0.5	6.9											
1919	2.1	6.1	5.4										
1920	1.3	3.6	2.0	-1.2									
1921	2.0	4.0	3.0	1.8	5.0								
1922	1.7	3.2	2.2	1.2	2.5	0.1							
1923	2.3	3.6	3.0	2.4	3.6	3.0	5.9						
1924	2.5	3.7	3.1	2.7	3.7	3.3	4.9	3.9					
1925	2.2	3.2	2.7	2.2	2.9	2.5	3.3	2.0	0.1				
1926	2.2	3.1	2.6	2.2	2.8	2.4	3.0	2.1	1.2	2.3			
1927	2.0	2.8	2.4	2.0	2.5	2.1	2.5	1.6	0.9	1.3	0.4		
1928	1.9	2.6	2.1	1.8	2.2	1.8	2.1	1.3	0.7	0.9	0.2	0.1	
1929	2.0	2.7	2.3	2.0	2.4	2.1	2.4	1.8	1.4	1.7	1.5	2.1	4.2
1930	1.6	2.1	1.7	1.4	1.7	1.3	1.5	0.9	0.4	0.4	-0.0	-0.2	-0.3
1931	1.5	2.0	1.6	1.3	1.6	1.2	1.4	0.8	0.4	0.4	0.1	-0.0	-0.1
1932	1.1	1.6	1.2	0.9	1.1	0.7	0.8	0.2	-0.2	-0.2	-0.7	-0.9	-1.1
1933	1.0	1.4	1.0	0.7	0.9	0.6	0.6	0.1	-0.3	-0.4	-0.7	-0.9	-1.1
1934	1.4	1.8	1.5	1.2	1.4	1.1	1.2	0.8	0.5	0.6	0.4	0.4	0.4
1935	1.6	2.0	1.7	1.5	1.7	1.5	1.6	1.2	1.0	1.1	0.9	1.0	1.1
1936	1.8	2.2	1.9	1.7	1.9	1.7	1.8	1.5	1.3	1.4	1.3	1.4	1.6
1937	1.7	2.1	1.8	1.6	1.8	1.6	1.7	1.4	1.3	1.4	1.3	1.4	1.5
1938	1.7	2.1	1.8	1.6	1.8	1.6	1.7	1.4	1.3	1.4	1.3	1.4	1.5
1939	1.8	2.2	2.0	1.8	2.0	1.8	1.9	1.6	1.5	1.6	1.5	1.6	1.8
1940	1.9	2.2	2.0	1.9	2.0	1.9	2.0	1.7	1.6	1.7	1.7	1.8	1.9
1941	2.0	2.3	2.1	2.0	2.1	2.0	2.1	1.9	1.7	1.9	1.8	1.9	2.1
1942	1.9	2.2	2.0	1.9	2.0	1.9	2.0	1.8	1.7	1.8	1.7	1.8	2.0
1943	1.9	2.2	2.0	1.9	2.0	1.9	2.0	1.8	1.6	1.7	1.7	1.8	1.9
1944	2.0	2.3	2.2	2.0	2.2	2.1	2.2	2.0	1.9	2.0	2.0	2.1	2.2
1945	2.1	2.4	2.3	2.1	2.3	2.2	2.3	2.1	2.0	2.1	2.1	2.2	2.3
1946	1.9	2.2	2.0	1.9	2.0	1.9	2.0	1.8	1.8	1.8	1.8	1.9	2.0
1947	1.8	2.1	1.9	1.8	1.9	1.8	1.9	1.7	1.6	1.7	1.7	1.7	1.8
1948	1.9	2.1	2.0	1.8	2.0	1.8	1.9	1.8	1.7	1.7	1.7	1.8	1.9
1949	1.9	2.1	2.0	1.9	2.0	1.9	1.9	1.8	1.7	1.8	1.8	1.8	1.9
1950	2.0	2.3	2.1	2.0	2.1	2.0	2.1	2.0	1.9	2.0	2.0	2.0	2.1
1951	2.0	2.2	2.1	2.0	2.1	2.0	2.1	1.9	1.9	1.9	1.9	2.0	2.1
1952	1.9	2.2	2.0	1.9	2.0	1.9	2.0	1.9	1.8	1.9	1.8	1.9	2.0
1953	2.0	2.2	2.1	2.0	2.1	2.0	2.0	1.9	1.9	1.9	1.9	2.0	2.0
1954	2.0	2.2	2.1	2.0	2.1	2.0	2.1	1.9	1.9	1.9	1.9	2.0	2.0
1955	2.1	2.3	2.1	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.0	2.1	2.1
1956	2.0	2.2	2.1	2.0	2.1	2.0	2.1	1.9	1.9	1.9	1.9	2.0	2.0
1957	2.0	2.2	2.1	2.0	2.1	2.0	2.0	1.9	1.9	1.9	1.9	2.0	2.0
1958	2.0	2.2	2.1	2.0	2.1	2.0	2.0	1.9	1.9	1.9	1.9	2.0	2.0
1959	2.0	2.2	2.1	2.0	2.1	2.0	2.1	2.0	1.9	2.0	2.0	2.0	2.1
1960	2.0	2.2	2.1	2.0	2.1	2.0	2.0	1.9	1.9	1.9	1.9	2.0	2.0
1961	2.0	2.2	2.1	2.0	2.1	2.0	2.1	2.0	1.9	2.0	1.9	2.0	2.1
1962	2.1	2.2	2.1	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.0	2.1	2.1
1963	2.1	2.2	2.1	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.0	2.1	2.1
1964	2.1	2.3	2.2	2.1	2.2	2.1	2.1	2.1	2.0	2.1	2.1	2.1	2.2
1965	2.1	2.3	2.2	2.1	2.2	2.1	2.2	2.1	2.0	2.1	2.1	2.1	2.2
1966	2.1	2.3	2.2	2.1	2.2	2.1	2.2	2.1	2.0	2.1	2.1	2.1	2.2
1967	2.1	2.2	2.1	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.0	2.1	2.1
1968	2.1	2.2	2.1	2.1	2.1	2.1	2.1	2.0	2.0	2.1	2.0	2.1	2.1
1969	2.0	2.2	2.1	2.0	2.1	2.1	2.1	2.0	2.0	2.0	2.0	2.0	2.1

(continued)

TABLE 3-3 (continued)

Initial Date												
1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941
-4.6												
-2.1	0.4											
-2.8	-1.9	-4.1										
-2.4	-1.7	-2.7	-1.3									
-0.3	0.8	0.9	3.5	8.5								
0.6	1.7	2.0	4.2	7.0	5.5							
1.2	2.2	2.6	4.3	6.3	5.2	4.9						
1.2	2.0	2.3	3.6	4.9	3.7	2.9	0.8					
1.2	2.0	2.2	3.3	4.2	3.2	2.4	1.2	1.5				
1.6	2.3	2.5	3.5	4.3	3.5	3.0	2.3	3.1	4.7			
1.7	2.4	2.6	3.5	4.2	3.5	3.0	2.6	3.2	4.0	3.3		
1.9	2.5	2.7	3.5	4.1	3.5	3.2	2.9	3.4	4.0	3.6	3.9	
1.8	2.3	2.5	3.2	3.7	3.1	2.8	2.5	2.8	3.1	2.6	2.2	0.5
1.7	2.2	2.4	3.0	3.5	2.9	2.6	2.3	2.5	2.7	2.2	1.8	0.8
2.1	2.5	2.7	3.3	3.7	3.3	3.0	2.8	3.1	3.3	3.1	3.0	2.7
2.2	2.7	2.8	3.4	3.8	3.4	3.2	3.0	3.2	3.5	3.3	3.3	3.1
1.9	2.3	2.4	2.9	3.2	2.8	2.5	2.3	2.5	2.6	2.3	2.1	1.8
1.7	2.1	2.2	2.6	2.9	2.5	2.2	2.0	2.1	2.1	1.8	1.6	1.2
1.7	2.1	2.2	2.6	2.9	2.5	2.3	2.0	2.2	2.2	2.0	1.8	1.5
1.8	2.1	2.2	2.6	2.9	2.5	2.3	2.1	2.2	2.3	2.0	1.9	1.6
2.0	2.4	2.5	2.8	3.1	2.8	2.6	2.4	2.5	2.6	2.4	2.4	2.2
2.0	2.3	2.4	2.7	3.0	2.7	2.5	2.3	2.4	2.5	2.3	2.2	2.1
1.9	2.2	2.3	2.6	2.8	2.5	2.3	2.2	2.3	2.3	2.1	2.1	1.9
2.0	2.2	2.3	2.6	2.8	2.6	2.4	2.3	2.3	2.4	2.2	2.2	2.0
2.0	2.2	2.3	2.6	2.8	2.5	2.4	2.3	2.3	2.4	2.2	2.2	2.0
2.1	2.3	2.4	2.7	2.9	2.6	2.5	2.4	2.5	2.5	2.4	2.3	2.2
2.0	2.2	2.3	2.6	2.8	2.5	2.4	2.2	2.3	2.4	2.2	2.1	2.0
1.9	2.2	2.3	2.5	2.7	2.4	2.3	2.2	2.3	2.3	2.2	2.1	2.0
2.0	2.2	2.3	2.5	2.7	2.4	2.3	2.2	2.3	2.3	2.2	2.1	2.0
2.0	2.2	2.3	2.6	2.7	2.5	2.4	2.2	2.3	2.3	2.2	2.2	2.1
2.0	2.2	2.3	2.5	2.6	2.4	2.3	2.2	2.3	2.3	2.2	2.1	2.0
2.0	2.2	2.3	2.5	2.6	2.4	2.3	2.2	2.3	2.3	2.2	2.1	2.0
2.1	2.3	2.3	2.6	2.7	2.5	2.4	2.3	2.3	2.4	2.3	2.2	2.2
2.1	2.3	2.3	2.6	2.7	2.5	2.4	2.3	2.4	2.4	2.3	2.2	2.2
2.1	2.3	2.4	2.6	2.7	2.5	2.4	2.3	2.4	2.4	2.3	2.3	2.2
2.1	2.3	2.4	2.6	2.7	2.5	2.4	2.3	2.4	2.4	2.3	2.3	2.2
2.1	2.3	2.4	2.6	2.7	2.5	2.4	2.3	2.4	2.4	2.3	2.3	2.2
2.1	2.3	2.3	2.5	2.6	2.4	2.4	2.3	2.3	2.3	2.3	2.2	2.2
2.1	2.3	2.3	2.5	2.6	2.4	2.4	2.3	2.3	2.3	2.3	2.2	2.2
2.0	2.2	2.3	2.4	2.6	2.4	2.3	2.2	2.3	2.3	2.2	2.2	2.1

(continued)

TABLE 3-3 (continued)

Final Date	Initial Date													
	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	
1917														
1918														
1919														
1920														
1921														
1922														
1923														
1924														
1925														
1926														
1927														
1928														
1929														
1930														
1931														
1932														
1933														
1934														
1935														
1936														
1937														
1938														
1939														
1940														
1941														
1942														
1943	1.2													
1944	3.8	6.5												
1945	4.0	5.5	4.5											
1946	2.1	2.4	0.4	-3.5										
1947	1.4	1.4	-0.2	-2.5	-1.5									
1948	1.6	1.7	0.6	-0.7	0.7	3.0								
1949	1.8	1.9	1.0	0.1	1.4	2.8	2.6							
1950	2.4	2.6	2.0	1.4	2.7	4.2	4.7	6.9						
1951	2.2	2.4	1.8	1.3	2.3	3.3	3.4	3.8	0.9					
1952	2.0	2.1	1.6	1.2	2.0	2.7	2.6	2.6	0.5	0.2				
1953	2.1	2.2	1.8	1.4	2.2	2.8	2.7	2.8	1.4	1.7	3.3			
1954	2.2	2.2	1.8	1.5	2.2	2.7	2.7	2.7	1.6	1.9	2.8	2.3		
1955	2.3	2.4	2.1	1.8	2.4	2.9	2.9	3.0	2.2	2.6	3.4	3.4	4.6	
1956	2.1	2.2	1.9	1.6	2.2	2.6	2.5	2.5	1.8	2.0	2.4	2.1	2.1	
1957	2.1	2.2	1.8	1.6	2.1	2.4	2.4	2.4	1.7	1.9	2.2	1.9	1.8	
1958	2.1	2.2	1.9	1.7	2.1	2.4	2.4	2.3	1.8	1.9	2.2	2.0	1.9	
1959	2.2	2.2	2.0	1.8	2.2	2.5	2.5	2.4	2.0	2.1	2.4	2.2	2.2	
1960	2.1	2.2	1.9	1.7	2.1	2.4	2.3	2.3	1.9	2.0	2.2	2.1	2.0	
1961	2.1	2.2	1.9	1.8	2.1	2.4	2.3	2.3	1.9	2.0	2.2	2.1	2.1	
1962	2.2	2.3	2.1	1.9	2.3	2.5	2.5	2.5	2.1	2.2	2.4	2.3	2.4	
1963	2.3	2.3	2.1	2.0	2.3	2.5	2.5	2.5	2.2	2.3	2.5	2.4	2.4	
1964	2.3	2.3	2.1	2.0	2.3	2.6	2.5	2.5	2.2	2.3	2.5	2.4	2.5	
1965	2.3	2.4	2.2	2.0	2.3	2.6	2.6	2.6	2.3	2.4	2.5	2.5	2.5	
1966	2.3	2.3	2.2	2.0	2.3	2.5	2.5	2.5	2.2	2.3	2.5	2.4	2.4	
1967	2.2	2.3	2.1	2.0	2.2	2.4	2.4	2.4	2.1	2.2	2.4	2.3	2.3	
1968	2.2	2.3	2.1	2.0	2.3	2.4	2.4	2.4	2.2	2.2	2.4	2.3	2.3	
1969	2.2	2.2	2.0	1.9	2.2	2.3	2.3	2.3	2.1	2.1	2.3	2.2	2.2	

(continued)

TABLE 3-3 (concluded)

Initial Date													
1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
-0.4													
0.5	1.3												
1.1	1.8	2.3											
1.6	2.3	2.8	3.4										
1.5	2.0	2.3	2.2	1.1									
1.7	2.1	2.3	2.3	1.7	2.3								
2.0	2.5	2.7	2.8	2.6	3.3	4.4							
2.1	2.5	2.7	2.7	2.6	3.1	3.5	2.6						
2.2	2.6	2.7	2.8	2.7	3.1	3.3	2.8	3.1					
2.3	2.6	2.7	2.8	2.7	3.0	3.2	2.8	3.0	2.9				
2.2	2.5	2.6	2.7	2.6	2.8	2.9	2.6	2.6	2.4	1.9			
2.1	2.3	2.4	2.5	2.3	2.5	2.5	2.2	2.1	1.8	1.3	0.8		
2.1	2.4	2.4	2.5	2.4	2.5	2.5	2.2	2.2	1.9	1.6	1.5	2.1	
2.0	2.2	2.2	2.2	2.0	2.2	2.1	1.8	1.7	1.5	1.1	0.9	0.9	-0.2

Source: Table A-19 productivity index numbers extrapolated from 1929 to 1916 by series in *Productivity Trends*, Table A-XXII.

Chart 3-1: A Century of Economic Growth—U.S. Private Domestic Economy:
Output, Inputs, and Productivity Ratios, 1869–1969^a

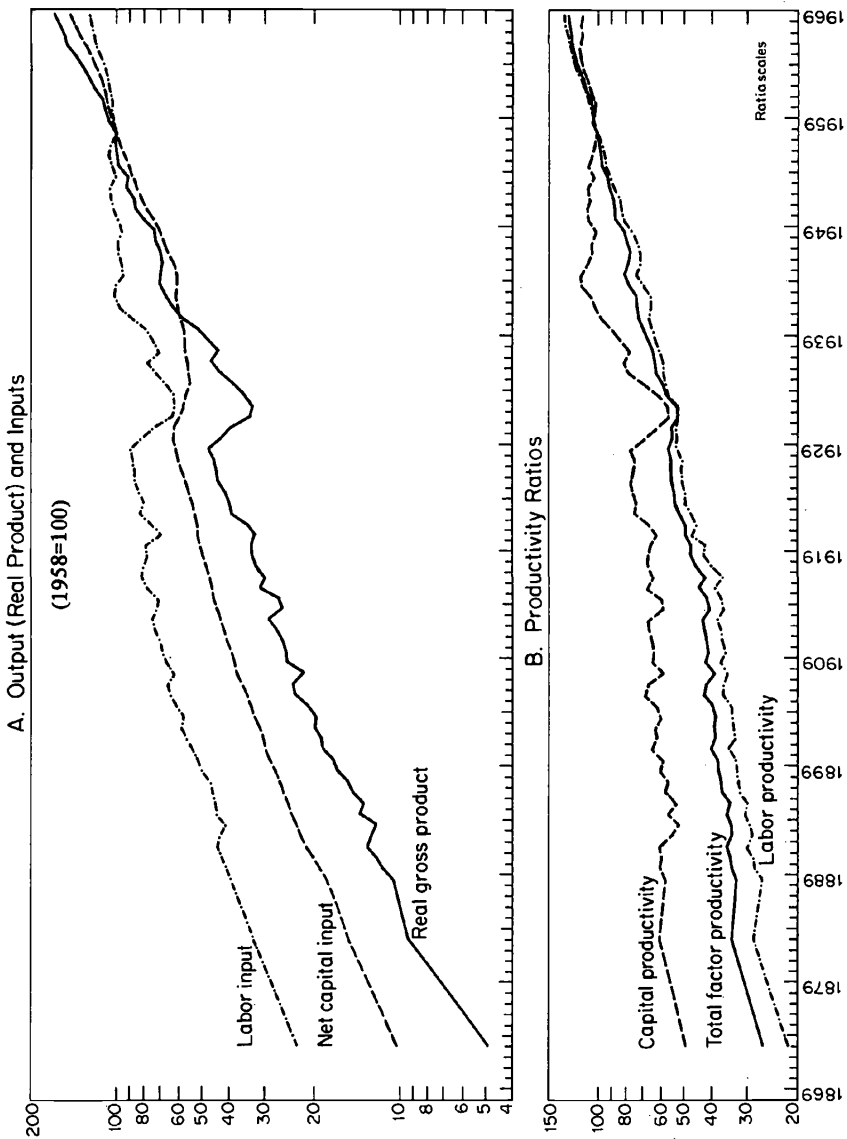


Chart 3-1 contains index numbers of total factor productivity and related series in the private domestic economy for the period 1869-1969 (the pre-1889 period is based on decade averages). Careful inspection of the time series on total factor productivity in panel B yields a number of interesting observations. First, there appears to have been an important change in trend during World War I, as noted in *Productivity Trends*. In that work, we fitted the new and steeper trend line to estimates beginning with 1919. But here we have chosen 1916 as the dividing year. Rates of advance between the peak years 1913 and 1916 are in line with those of the earlier period 1889-1916, while the rate between the peaks of 1916 and 1919 is in line with that of the subsequent period. The average rate of advance for the early period 1889-1916 is 1.0 per cent a year; the comparable rate for the subsequent period 1916-29 accelerates to 2.3 per cent (see Table 3-4).

It is possible to fit a trend line to the annual estimates for the entire half-century 1916-66.⁵ But close inspection of the data reveals that the trend was seriously interrupted by the major depression of the early 1930s. The productivity peak of 1929 was not exceeded until 1935. Beginning in 1936, the former trend rate of 1916-29 was resumed, although at a slightly lower level, and it continued without apparent change for the subsequent three decades through 1966. The downward shift of the trend line between 1929 and 1936 is not surprising in view of the severe drop in tangible and intangible investment, entailing a loss of productive capacity and efficiency that could never be fully made up.

The trend rate of advance for the period 1936-66 averaged 2.3 per cent a year—very close to that for the earlier period 1916-29, prior to the interruption of the Great Depression. If the trend line is fitted to the postwar period 1948-66, the slope is also 2.3 per cent, exactly the same as that for the thirty-year period 1936-66, and the coefficient of correlation is also very high—0.993 as compared with 0.994. The same rates of growth are obtained using productivity estimates for the business economy alone.

When estimates for total gross factor productivity are used, the trend rates are 0.24 per cent less, reflecting the use of gross capital inputs and correspondingly higher capital weights. When unweighted factor inputs are used, the trend rates for 1948-66 are about 0.3 per cent greater, since the shift effect shows up in the productivity rather than the input measures.

Whether the trend is fitted to the thirty-year period beginning in 1936 or the eighteen-year period beginning 1948, total factor productivity in 1948 is

⁵ The indicated average annual rate of increase is 2.1 per cent for 1916-66.

TABLE 3-4

Private Domestic Economy:
Trend Rates of Growth in Variant Measures
of Total Factor Productivity,
Selected Periods,^a 1889-1966

	Time Trend Only		Time Trend plus Ratio of Employment to Civilian Labor Force	
	Per Cent Growth Rate	Coefficient of Correlation	Growth Rate	Coefficient of Correlation
<i>Total net factor productivity</i>				
1889-1916	1.03	.935	0.98	.955
1916-1966	2.06	.990	2.02	.996
1916-1929	2.29	.966	2.29	.966
1936-1966	2.33	.994	2.18	.994
1948-1966	2.33	.993	2.36	.993
<i>Total net unweighted factor productivity</i>				
1916-1966	2.2	.969		
1936-1966	2.7	.994		
1948-1966	2.6	.992		
<i>Total gross factor productivity</i>				
1936-1966	2.09	.993		
1948-1966	2.09	.991		

Source: Table A-19, A-19a, and A-19b; extrapolations back to 1889 via Table A-XXII in *Productivity Trends*.

^a The straight-line time trends were fitted to the logarithms of the productivity measures for the years indicated.

below the trend value. This explains the fact that the average annual rate of productivity advance between 1948 and 1966 is 2.5 per cent, compared with the 2.33 per cent average rate based on the least-squares trend line. We believe that the latter gives the best measure of the long-run trend prevailing during the postwar period. But due to its convenience for comparisons with sub-period rates and with rates for outputs and inputs, we shall use the 2.5 per cent figure as the standard of comparison in subsequent sections.

An alternative method of trend fitting was also tried, with results quite similar to those already cited. In addition to using a time trend, we added a cyclical variable, the ratio of employment to civilian labor force, which would

tend to reduce the trend rate of growth. The indicated productivity growth rate for the half-century period 1916-66 was 2.02, compared with 2.06 yielded by use of time trend alone, and the coefficient of (multiple) correlation was higher, 0.996 compared with 0.990, reflecting the fact that productivity had a cyclical element, particularly during the Great Depression. The correlation coefficient differed insignificantly in the periods beginning 1936 and 1948, however.

But the indicated trend rates are somewhat different in the latter periods when multiple correlations are used in place of the simple time trend. For 1936-66 the growth rate obtained by the former approach is 2.18, compared with 2.33 by the latter, and for 1948-66 it is 2.36 as against 2.33. Thus, addition of a cyclical variable suggests a slight acceleration of productivity growth since 1948 compared with the results shown by the simple trend rate. But both approaches yield a lower trend rate for 1948-66 than that obtained by the compound-interest formula.

Variations in Growth Rates

The time path of growth seldom runs smoothly. To abstract from the effects of the business cycle, we have computed average annual percentage rates of change in real product and productivity ratios between annual cycle peaks, as designated by the National Bureau of Economic Research (see Table 3-5). Although 1966 is not officially a peak year, it did precede a marked slowdown of activity in 1967, so we feel it is not inappropriate to use the period 1960-66 for obtaining rates of change for comparison with earlier peak-to-peak changes.

Total factor productivity showed a high rate of growth in the first subperiod 1948-53, a marked slowdown in the subsequent two subperiods between 1953 and 1960, and a resumption of strong advance in 1960-66, followed by a marked retardation in the subperiod 1966-69 (not shown in the table). Output per unit of labor input (and per man-hour) exhibited much the same patterns of change, although the rate of increase in the last of the four subperiods was less than in the first. The pattern of peak-to-peak changes in output per unit of capital input was quite different. There was little change in this ratio from 1948 to 1960, as the real stock of tangible capital was expanded at much the same rate as output. Between 1960 and 1966, however, output went ahead significantly faster than the capital stock, and the ratio rose at an average annual rate of 1.7 per cent. This contributed

TABLE 3-5

Private Domestic Economy:
Average Annual Percentage Rates of Change in Real
Product and the Productivity Ratios, by Cycle Subperiods, 1946-67

<i>A. Peak to Peak</i>					
	1948-66	1948-53	1953-57	1957-60	1960-66
Real gross product	4.0	4.6	2.5	2.6	5.2
Total factor productivity	2.5	2.7	1.9	2.2	2.8
Real product per unit of					
Labor input	3.0	3.5	2.6	2.7	3.1
Man-hours (unweighted)	3.4	4.2	2.7	2.6	3.6
Capital input	0.4	0.2	-1.1	0.2	1.7
<i>B. Cycle Average to Cycle Average</i>					
	1946-49 to 1961-67	1946-49 to 1949-54	1949-54 to 1954-58	1954-58 to 1958-61	1958-61 to 1961-67
Real gross product	3.8	4.4	3.3	2.6	4.8
Total factor productivity	2.4	2.7	2.2	2.0	2.7
Real product per unit of					
Labor input	3.0	3.4	2.8	2.5	3.0
Capital input	0.3	0.1	-0.5	-0.3	1.6

Source: Tables A-19 and A-19b.

significantly to the resumption of a strong advance in total factor productivity. It should be noted that much of the advance in "capital productivity" was due to increasing utilization of capacity.⁶ If capital stock is adjusted for utilization rates, little movement is seen in the output-capital ratio over the entire period 1948-66.

This brings up the interrelationship between subperiod rates of change in output and in productivity, apart from cycle changes. As can be seen in Table 3-5, real product likewise showed a strong rate of advance in 1948-53, retardation in the two following subperiods, and the strongest growth rate of all after 1960—reflecting acceleration in underlying secular demographic forces, as well as increased rates of capacity utilization. We shall discuss the

⁶ According to estimates by the Federal Reserve Board, the rate of utilization of manufacturing capacity increased from 81 per cent in 1960 to 90 per cent in 1966. For earlier years, see *Federal Reserve Bulletin*, July 1967.

apparent correlation between rates of change in output and in productivity further when we look at a longer time span.

Another way of measuring subperiod changes, abstracting from the business cycle, is to average the various time series over completed cycles and compute rates of change from cycle average to cycle average. For present purposes, we average the annual observations from trough to trough of each cycle as a basis for calculating intercycle rates of change. The patterns are quite similar to those based on peak-to-peak rates of change. (See part B of Table 3-5.)

Variations in rates of change in output, input, and productivity have been a normal aspect of economic growth. This can be seen clearly in the following tables, which show rates of change from peak to peak since 1890 (Table 3-6) and from cycle average to cycle average since the 1888-91 cycle (Table 3-7). The sometimes wavelike movements in these rates of change have earned them the appellation of "trend cycles," or "long swings." The long swing is being studied intensively by Abramovitz, and we shall make only a few general observations here with particular reference to productivity.⁷

In the first place, it is clear that intercycle growth rates have been steadier since World War II than in earlier periods. (See Chart 3-2.) Both sets of measures for real product and total factor productivity show a significantly lower average deviation from the mean rates of growth in the period since 1948 (or 1946-49) than over the entire period since 1890 (or 1888-91). The average deviation in the postwar period is significantly lower, not only absolutely but also as a per cent of the mean growth rate. (See parts B of Tables 3-6 and 3-7.) In the case of real product, the mean deviation is significantly higher in the middle of the three subperiods delineated—1918-48 (in Table 3-6), and 1914-19 to 1946-49 (in Table 3-7)—reflecting the effects of major depression and war. In the case of total factor productivity, the average deviation falls progressively over the three periods when rates of change are calculated from peak to peak; it rises in the middle period when calculated on a cycle-average basis, although as a percentage of the mean growth rate it is about the same as in the early period. In general, rates of growth are somewhat more stable between cycle averages than between cycle peaks. On both bases, average deviations from mean growth rates for each partial productivity ratio are also lowest in the last period. There is greater variation throughout in rates of change in the output-capital ratio, reflecting the fixed nature of capital as we measure it.

⁷ See Moses Abramovitz, *Evidences of Long Swings in Aggregate Construction Since the Civil War*, Occasional Paper 90, New York, NBER, 1964.

TABLE 3-6
Private Domestic Economy:
Output, Inputs, and Productivity Ratios,
Average Annual Percentage Rates of Change Between Cycle Peaks

Cycle Peak Years	Real Product	Factor Inputs			Productivity Ratios		
		Total	Labor	Capital	Total	Labor	Capital
(1890)							
1892	7.0	4.2	3.5	5.8	2.7	3.4	1.1
1895	1.3	1.4	0.3	4.0	-0.1	1.0	-2.6
1899	4.7	3.2	3.2	3.2	1.5	1.4	1.5
1903	4.9	4.0	4.1	3.7	0.9	0.8	1.2
1907	4.8	2.9	2.8	3.4	1.8	2.0	1.4
1910	1.3	1.8	1.4	2.8	-0.5	-0.1	-1.5
1913	4.4	2.5	2.4	2.9	1.8	2.0	1.4
1918	2.5	1.8	1.6	2.5	0.6	0.9	0.0
1920	1.8	-0.2	-1.2	2.3	2.0	3.0	-0.4
1923	5.4	1.8	1.9	1.4	3.6	3.5	3.9
1926	3.9	1.9	1.6	2.7	2.0	2.3	1.1
1929	2.8	1.3	0.8	2.6	1.5	1.9	0.3
1937	-0.4	-1.5	-1.7	-1.0	1.1	1.3	0.6
1944	6.2	3.1	3.7	1.1	3.0	2.4	5.1
1948	1.1	0.6	-0.1	3.1	0.5	1.2	-2.0
1953	4.6	1.8	1.1	4.3	2.7	3.5	0.2
1957	2.5	0.6	-0.1	3.7	1.9	2.6	-1.1
1960	2.6	0.4	-0.1	2.4	2.2	2.7	0.2
1966	5.2	2.3	2.0	3.4	2.8	3.1	1.7

(continued)

TABLE 3-6 (concluded)
*B. Averages of Peak-to-Peak Rates of Change,^a
 with Mean Deviations,
 by Three Subperiods*

Period	Real Product	Factor Inputs			Productivity Ratios		
		Total	Labor	Capital	Total	Labor	Capital
1890-1966:							
Rate	3.5	1.8	1.4	2.9	1.7	2.0	0.6
Average deviation	1.7	1.0	1.3	0.9	0.8	0.8	1.3
1890-1918:							
Rate	3.9	2.7	2.4	3.5	1.1	1.4	0.3
Average deviation	1.6	0.9	1.0	0.7	0.9	0.8	1.3
1918-1948:							
Rate	3.0	1.0	0.7	1.7	2.0	2.2	1.2
Average deviation	1.9	1.2	1.5	1.1	0.8	0.7	1.9
1948-1966:							
Rate	3.7	1.3	0.7	3.4	2.4	3.0	0.2
Average deviation	1.2	0.8	0.8	0.6	0.4	0.3	0.7

Source: Table A-19; extrapolations back to 1890 via Table A-XXII in *Productivity Trends*.
^a Unweighted averages of rates of change shown in corresponding periods in part A.

TABLE 3-7
 Private Domestic Economy:
 Output, Inputs, and Productivity Ratios,
 Average Annual Percentage Rates of Change Between Cycle Averages, 1888-1967
 A. Change from Previous to Current Cycle Average

Cycle Years	Real Product	Factor Inputs			Productivity Ratios		
		Total	Labor	Capital	Total	Labor	Capital
(1888-91)							
1891-94	4.2	3.0	2.2	5.1	1.2	2.0	-0.9
1894-96	2.0	1.6	0.5	4.2	0.2	1.3	-2.2
1896-1900	5.4	3.2	3.3	3.3	2.1	2.1	2.0
1900-04	5.3	3.9	4.1	3.4	1.4	1.2	1.9
1904-08	4.0	3.0	2.8	3.4	1.0	1.2	0.6
1908-11	3.0	2.4	2.1	3.1	0.6	0.9	-0.2
1911-14	3.3	2.6	2.5	2.9	0.7	0.8	0.5
1914-19	2.6	1.8	1.4	2.5	0.8	1.1	0.0
1919-21	2.8	0.2	-0.7	2.3	2.7	3.6	0.5
1921-24	4.2	1.2	1.1	1.6	2.8	2.9	2.5
1924-27	5.2	2.9	3.1	2.4	2.3	2.1	2.8
1927-32	-0.1	-0.4	-1.3	2.1	0.3	1.2	-2.1
1932-38	-1.4	-2.5	-2.9	-1.3	1.1	1.5	-0.1
1938-46	6.4	3.1	3.9	0.7	3.1	2.4	5.5
1946-49	3.2	1.8	1.6	2.2	1.5	1.6	1.1
1949-54	4.4	1.7	0.9	4.3	2.7	3.4	0.1
1954-58	3.3	1.1	0.4	3.8	2.2	2.8	-0.5
1958-61	2.6	0.6	0.0	2.9	2.0	2.6	-0.3
1961-67	4.8	2.0	1.7	3.1	2.7	3.0	1.6

(continued)

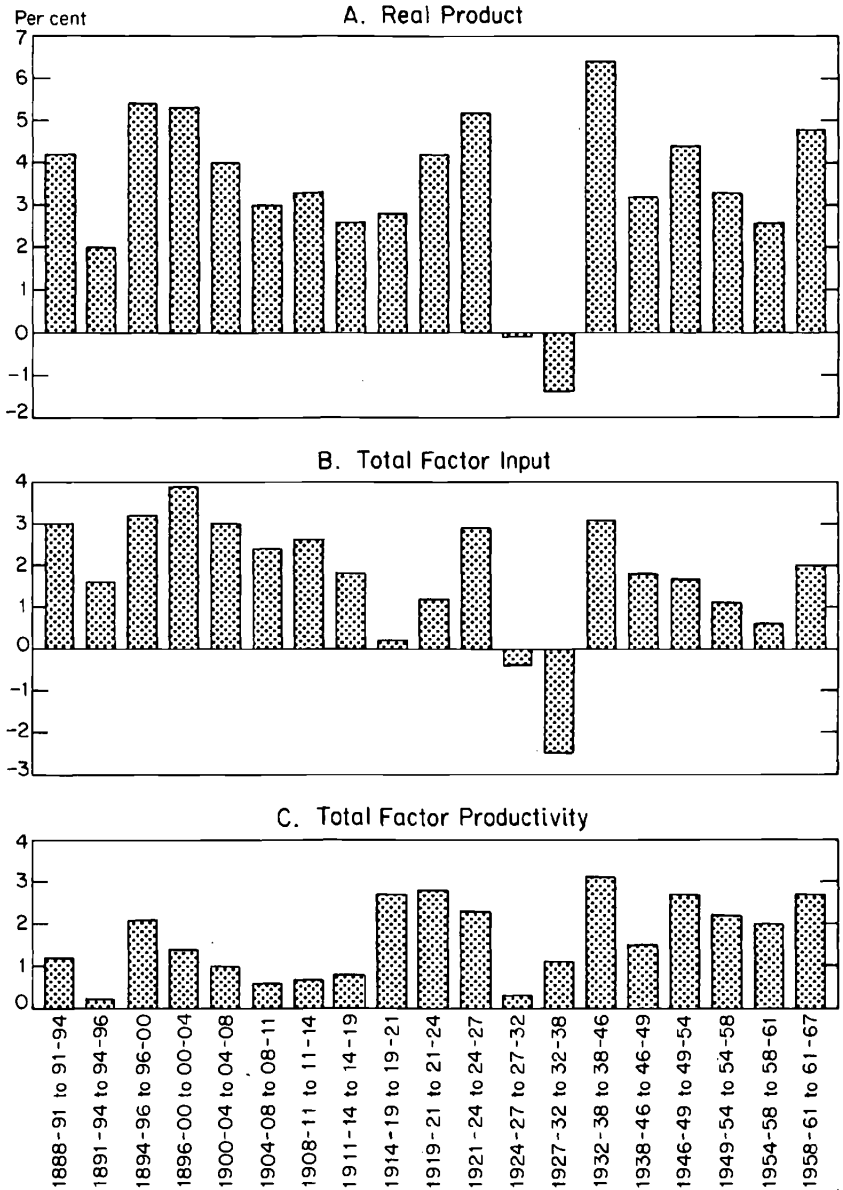
TABLE 3-7 (concluded)

*B. Averages of Rates of Change Between Cycle Averages,
with Mean Deviations 1888-91 to 1961-67,
by Three Subperiods*

Period	Real Product	Factor Inputs			Productivity Ratios		
		Total	Labor	Capital	Total	Labor	Capital
1888-91 to 1961-67:							
Rate	3.4	1.7	1.4	2.8	1.7	2.0	0.6
Average deviation	1.4	1.1	1.4	0.9	0.8	0.7	1.4
1888-91 to 1914-19:							
Rate	3.7	2.7	2.4	3.5	1.0	1.3	0.2
Average deviation	1.0	0.6	0.8	0.6	0.4	0.4	1.0
1914-19 to 1946-49:							
Rate	2.9	0.9	0.7	1.4	2.0	2.2	1.5
Average deviation	2.1	1.5	2.0	1.0	0.9	0.7	1.8
1946-49 to 1961-67:							
Rate	3.8	1.4	0.8	3.5	2.4	3.0	0.2
Average deviation	0.8	0.5	0.5	0.5	0.3	0.3	0.7

Source: Table A-19; extrapolations back to 1888 via Table A-XXII in *Productivity Trends*.

Chart 3-2: Long Swings in Economic Growth—U.S. Private Domestic Economy:
Average Annual Rates of Change in Real Product, Total Factor
Input, and Productivity Between Cycle Averages, 1881-91 to 1961-67



Source: Table 3-7.

The tables indicate a definite correlation between rates of change in real product (X) and in total factor productivity (Y) across cycles. In most (but not all) subperiods, the two variables move in the same direction. Using rates of change from peak to peak, the coefficient of correlation is 0.71, significant at the 0.05 level, and the estimating equation is $Y = 1.2610 + 1.3948 X$. Using rates of change based on cycle averages, the coefficient of correlation is 0.58, and the estimating equation is $Y = 1.4064 + 1.2082 X$.

The interaction between rates of change in real product and in productivity reflects a number of forces. To the extent that a larger than average growth in demand from one cycle to another raises utilization of productive capacity closer to an optimum rate, productivity advance would be favorably affected. Apart from the capacity utilization effect, greater increases in demand and output could lead to larger-scale economies than those accompanying smaller output increases. Conversely, greater productivity growth would contribute to larger output increases, assuming sufficient demand and the same rates of increase in real input. Some of the indicated correlations may be spurious, of course, to the extent that there are errors in the output measures. One could get away from the possibly spurious element in the output-productivity relation by narrowing the focus to correlations between rates of change in total factor productivity and rates of capacity utilization. Such correlations may be expected to have lower coefficients than those relating productivity to output, since changes in utilization rates are only one element in the latter relationship.

Variations in Annual Changes

The average deviations of annual percentage changes in productivity from trend rates are much bigger than average deviations of intercycle changes from their means. As shown in Table 3-8, the mean deviation of annual per cent changes in total factor productivity from the average per cent change of 1.8 over the entire period 1889-1966 is 2.7. This compares to an average deviation of 0.8 for intercycle average annual per cent changes from their means (see Table 3-6). The degree of variability in intercycle and annual changes in total factor productivity is quite similar to that in real product relative to its average rates of change.

The large variations in annual changes in real product and productivity reflect primarily the annual changes in demand and capacity utilization. They may also reflect some variations in the underlying forces of technological

TABLE 3-8
 Private Domestic Economy:
 Output, Inputs, and Productivity Ratios,
 Mean Average Annual Percentage Rates of Change, 1889-1966,
 by Subperiods and by Business Cycle Phase

Period	Real Product	Factor Inputs			Productivity Ratios		
		Total	Labor	Capital	Total	Labor	Capital
<i>A. All Years</i>							
1889-1966							
Rate	3.7	1.8	1.6	2.6	1.8	2.1	1.1
Average deviation	4.7	3.0	3.8	1.4	2.7	2.5	4.7
1889-1916							
Rate	4.2	2.8	2.6	3.5	1.3	1.5	0.8
Average deviation	5.2	2.3	3.2	0.8	3.3	2.7	5.1
1917-47							
Rate	3.1	0.9	0.9	1.2	2.1	2.2	2.0
Average deviation	5.4	4.2	5.4	1.9	2.9	2.8	5.5
1948-66							
Rate	4.0	1.5	1.0	3.6	2.5	3.0	0.5
Average deviation	2.8	2.0	2.4	0.9	1.2	1.2	2.6

B. Expansions

1889-1966 (54) ^a									
Rate	6.3	3.6	3.9	2.7	2.6	2.3	3.6		
Average deviation	3.3	1.8	2.5	1.4	2.5	2.4	3.7		
1889-1916 (18)									
Rate	7.4	4.2	4.6	3.3	3.0	2.7	3.9		
Average deviation	4.1	1.6	2.2	0.8	2.8	2.7	4.0		
1917-47 (20)									
Rate	6.6	3.7	4.6	1.3	2.7	1.9	5.4		
Average deviation	3.2	2.5	3.3	1.9	2.7	2.4	3.6		
1948-66 (14)									
Rate	5.3	2.7	2.4	3.8	2.5	2.8	1.5		
Average deviation	2.1	1.0	1.3	0.9	1.5	1.4	2.3		

C. Contractions

1889-1966 (23)									
Rate	-2.5	-2.4	-4.0	2.4	-0.1	1.6	-4.8		
Average deviation	3.9	2.9	3.5	1.4	3.0	3.0	3.2		
1889-1916 (9)									
Rate	-2.0	0.1	-1.3	3.7	-2.2	-0.8	-5.6		
Average deviation	3.9	1.9	2.6	0.8	2.9	2.6	3.6		
1917-47 (10)									
Rate	-3.8	-4.6	-6.5	1.1	0.8	2.9	-4.9		
Average deviation	4.6	3.4	4.1	1.7	3.2	3.4	3.6		
1948-66 (4)									
Rate	-0.3	-2.6	-3.9	2.9	2.3	3.7	-3.1		
Average deviation	1.0	1.0	1.3	0.7	0.1	0.4	1.2		

Source: Table A-19; extrapolations back to 1889 via Table A-XXII in *Productivity Trends*.

a Figures in parentheses indicate the number of per cent changes averaged for period. Two expansions (1916-17 and 1947-48) are included in the period 1889-1966 under A. and B., but not in subperiods.

progress, which are themselves influenced by variations in demand, particularly for investment goods and services. In addition, there are some erratic forces at work that have a different impact from year to year, as well as errors in the estimates, which, in all probability, also exert a significant influence.

When one correlates annual per cent changes in total factor productivity (Y) and in real product (X), the coefficient of correlation is 0.77, and the estimating equation is $Y = 1.2045 + 1.3460 X$. The fit is better than in the correlation between peak-to-peak rates of change, which is not surprising in view of the greater influence of changes in rates of capacity utilization on year-to-year changes in productivity. It is noteworthy that the regression coefficients are quite similar on both bases. The correlation between annual per cent changes in total factor productivity and in employment is not significant at the 0.05 level.

It is important to observe that average variations in annual productivity changes have become substantially narrower over the period studied. Thus, the average deviation dropped from 3.3 in the period 1889-1916 to 2.9 in 1917-47, and to 1.2 in 1948-66. The decline is much more pronounced when the average deviation is computed as a ratio to the mean per cent change in productivity, since the rate of productivity advance rose over the three periods. The average deviation in real product annual changes did not drop between the first two periods. Over 1948-66, however, it was substantially smaller, although larger relative to the mean per cent change than was true of productivity in the postwar period.

The relatively low variability of annual productivity changes in the period 1948-66 reflects in part the lessened variability in demand and real product. But it also reflects the gradual strengthening in the forces promoting technological advance. In the next chapter we shall see the substantial absolute and relative growth in research and development, as well as education and training, since the 1920s, indicating the growing institutionalization of cost-reducing innovation. Our interpretation is further supported by the fact that the average deviation of annual productivity changes from their mean fell between 1889-1916 and 1917-47 even in the face of an increase in the mean deviation of real product changes relative to their mean.

Annual variability of per cent changes in output per unit of labor input is somewhat less than that in total factor productivity, particularly in relation to mean changes. The variability of annual changes in output per unit of capital input is much larger than that in either one of the other two productivity measures. This reflects the relatively "fixed" nature of capital as

we measure it; abstracting from the secular trend in the output-capital ratios, annual changes in the ratio closely parallel changes in output itself.

During the years of business cycle expansion over the 1889-1966 period, percentage changes in total factor productivity averaged 2.6 per cent, but during the years of contraction, the average change was -0.1 per cent. (See parts B and C of Table 3-8.) In the early period 1889-1916, the average change during contractions was -2.2 per cent. During the middle period, 1917-47, the average change was a positive 0.8, and in the postwar period, it was 2.3 per cent, not far below the 2.5 per cent average increase of the expansion years, despite a small average decline in real product in the contractions. In the early period, the average increase during expansions was even sharper, 3.0 per cent, reflecting the rebounds following the declines during contractions.

The mean deviations from average annual per cent changes were slightly higher during contractions than during expansions, with the exception of the last period, 1948-66, when the average deviation from the mean increase during contractions was very small.

The average change in output per unit of labor input in contraction years was 1.6 per cent, compared with 2.3 per cent during expansions. The average changes in labor productivity in the contraction increased successively throughout the three periods.

As would be expected, output per unit of capital input showed large increases during expansions, averaging 3.6 for the seventy-seven-year period, and large decreases during contractions, averaging -4.8 per cent. The increases and decreases were smallest during the final period, 1948-66, reflecting the lessened variability in output itself.

In summary, it is clear that the degree of variability in productivity advance from year to year, as well as from cycle to cycle, has been significantly reduced since World War II. In part, it reflects a strengthening of the forces promoting cost-reducing innovations, and in part, the more stable rate of economic growth.