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CHAPTER 4

Productivity and Economic Growth

THERE are a number of measures of economic growth, each with its own meaning and uses. In this chapter, the relationship of productivity change to three aggregate growth measures is quantified. So also are certain characteristic trends in the composition of both output and input which seem to be related to the dynamics of economic growth in general and productivity advance in particular.

The most direct measure of economic growth is the real net national product. Increments to real product can be directly partitioned between increases in inputs and in productivity. The productivity increment is, of course, the gain in real income accruing to the factors of production, and the distribution of that gain will be analyzed in the next chapter.

From a broader viewpoint, only if real net product grows proportionately more than the population does is there economic progress. As a second measure, therefore, real net product per capita is used. We also look at changes in the ratio of consumption to total net product to see to what extent output growth has been used to raise potential economic welfare directly as compared with its use for investment goods or national security. Since the rise in real net product per capita results, in part, from an increase in input per capita, changes in the structure of factor input, and changes in certain types of nonfactor input as well, will be examined from the view-point of their relation to productivity advance.

The third type of measure is one that breaks down the real gross national product of each period between that part required to support the population and capital of the prior year, and a "margin over maintenance." Some of the margin must go for national security, but the rest may be used to support population increases, or to increase consumption and investment per capita as compared with the previous period. This approach reveals the anatomy of progress better than the conventional classification of the net national product and permits an appraisal of the relative importance of productivity gains in economic progress as defined. Certain significant types of investment are not included or identified as such in the national product measures, however, and this omission is repaired in a final section of the chapter.

National Output, Input, and Productivity

In this chapter, the national security version of the Kuznets estimates of real net national product is employed. It will be remembered that his measure comprises private and public consumer outlays and net investment, to which we have added national security expenditures. Although the statistical basis of Kuznets' segregation of government output between final and intermediate products (and thus the implied productivity of factors commanded by governments) is tenuous, use of his estimates makes possible a comprehensive analysis of national economic growth in terms of major social purposes. His estimates include real net income from abroad that contributes to American planes of living, even though the associated net capital stock is located abroad.

PARTITIONING OF CHANGES IN TOTAL REAL PRODUCT

Between 1889 and 1953, the real net national product grew from less than $20 billion to $187 billion (in 1929 prices). This nearly tenfold increase over the sixty-four years represents an average annual compound rate of growth of better than 3.5 per cent. As indicated in Table 6, the rate of growth was highest in the early part of the period and was subject to

TABLE 6

National Economy: Growth Rates in Real Product, Factor Input, and Productivity, Subperiods, 1889–1957
(average annual percentage rates of change)

	Real Net National Product[a]	Total Factor Input	Total Factor Productivity
1889–1953	3.6	2.0	1.6
(1889–1957)	3.5	1.9	1.6
1889–1919	4.2	2.8	1.4
1919–53	3.1	1.3	1.7
1889–99	4.5	2.9	1.5
1899–1909	4.3	3.1	1.1
1909–19	3.8	2.3	1.5
1919–29	3.1	1.6	1.4
1929–37	0.2	−0.9	1.1
1937–48	4.4	2.2	2.2
1948–53	4.7	2.2	2.4
(1953–57)	2.2	0.7	1.5

SOURCE: Table A-XIX.
[a] Kuznets' concept, national security version.

progressive retardation right up through the prosperous 1920's. Following the stagnation of the 1930's, which saw little net gain in real output, the rate of growth picked up markedly and through 1953 was comparable with that of the pre-World War I decades (see Chart 6).

The rate of growth is slightly less when the long period is extended to 1957, as is shown in Table 6, for purposes of comparison with the data given in Chapter 3. This is due to the indicated retardation in the rate of growth between 1953 and 1957. At the time of writing, Kuznets' estimates were available only through 1953, and this terminal date is generally used in the rest of the chapter. For trend analysis, a few years more or less make little or no difference in the conclusions.

Over the period 1889–1953, national productivity increased at an average annual rate of 1.6 per cent a year, accounting for somewhat under half of the total growth of output. The rest of the expansion is attributable to the growth of input, which averaged 2.0 per cent a year. Up until 1919, however, productivity accounted for only one-third of the output increase, whereas since 1919 productivity has become, on balance, as important an element as input. This is partly the result of retardation in the rate of output growth and partly the result of an acceleration in the rate of increase in productivity. Based on the Kuznets estimates underlying this analysis, the productivity acceleration shows up after 1937; the growth rate averaged 1.3 per cent prior to 1937 and around 2.3 per cent thereafter. Judging from the real private domestic product estimates, however, the higher rate of growth began at about the end of the World War I.

Table 7 gives the results of a more elaborate attempt to partition the increments in real product between the factor input and productivity components. Since we are dealing with increments, averages were taken of annual changes over the several periods and subperiods. As first approximations to the input and productivity increments, the percentage changes in these variables were applied to the real net product of the previous year; the difference between the sum of these two increments and the total annual change in real net product (the "joint product" of the two components) was split equally between the variables in accordance with the procedure developed by Frederick C. Mills.[1] The general picture is similar to that obtained by comparing the relative rates of change in Table 6. Over the period as a whole, productivity is computed to have accounted for 48.5 per cent, as compared with 44.4 per cent, of the real-product increments. In a couple of the subperiods, however, the relative importance of the productivity increase is quite different when based on results obtained from the more painstaking method underlying Table 7.

[1] *Productivity and Economic Progress*, Occasional Paper 38, New York (NBER), 1952, p.31, n. 3. The equal division of the joint product has been criticized as being arbitrary.

CHART 6

National Economy: Real Net Product, Factor Input, and per Capita Measures, 1889–1957

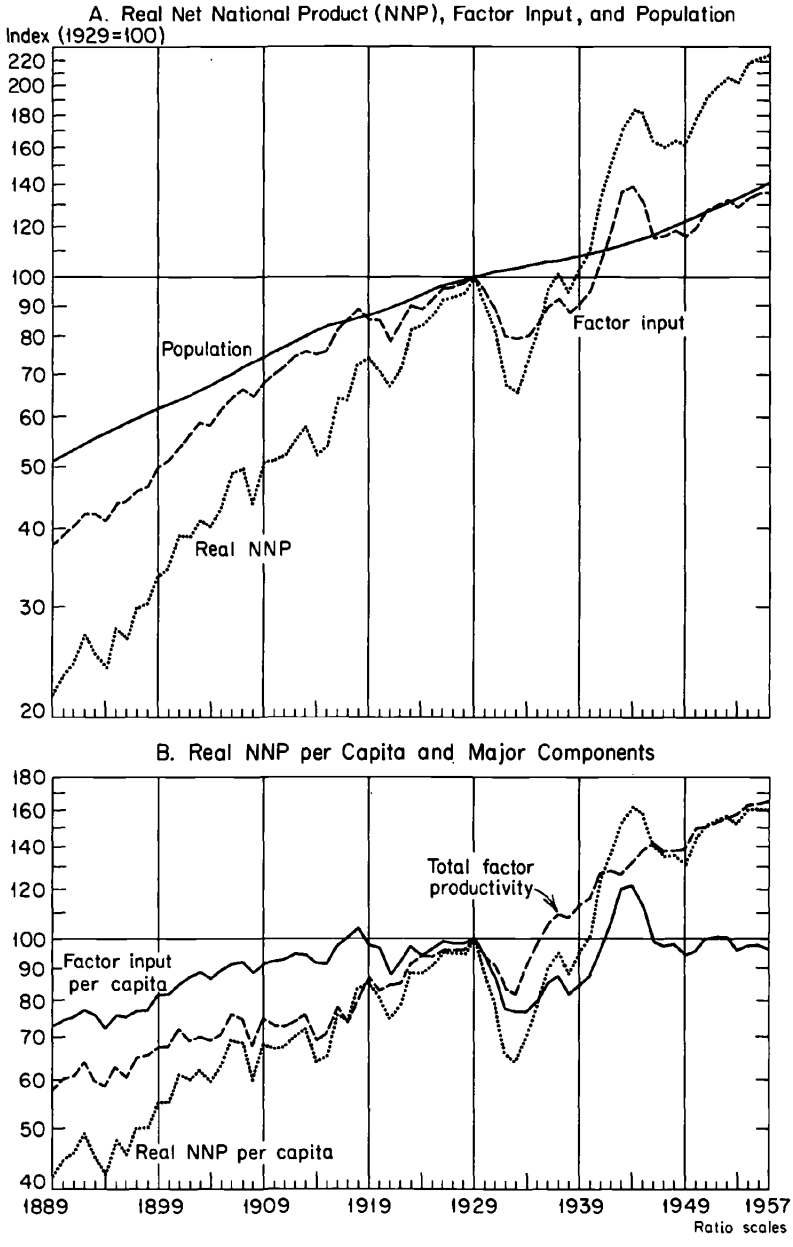


TABLE 7

Partitioning of Increments in Real Net National Product between Factor Input and Productivity, Subperiods, 1889–1953

PERIOD OF ANNUAL AVERAGE	REAL NNP[a]	INCREMENTS OF REAL NNP	ALLOCATION OF PRODUCT INCREMENTS[b]			
			Real Factor Input		*Productivity*	
	Millions of 1929 Dollars		Millions of 1929 Dollars	Per Cent of Total	Millions of 1929 Dollars	Per Cent of Total
1889–1953	75,141	2,579	1,329	51.5	1,250	48.5
1889–1918	37,783	1,546	1,133	73.3	413	26.7
1919–53	107,163	3,464	1,497	43.2	1,967	56.8
1889–98	23,651	867	596	68.7	271	31.3
1899–1908	37,554	1,238	1,142	92.2	96	7.8
1909–18	52,142	2,534	1,661	65.5	873	34.5
1919–28	73,974	2,011	769	38.2	1,242	61.8
1929–36	74,390	150	−698	−465.3	848	565.3
1937–47	128,829	5,390	2,454	45.5	2,936	54.5
1948–53	166,454	6,774	3,874	57.2	2,900	42.8

[a] NNP = net national product. From Table A-XIX (Kuznets' concept, national security version); absolute figures estimated from 1929 value and weighted index of output.

[b] Estimated by procedure of F. C. Mills, *Productivity and Economic Progress*, Occasional Paper 38, New York (NBER), 1952, p. 31, n. 3.

PRODUCTIVITY AND CHANGES IN REAL PRODUCT

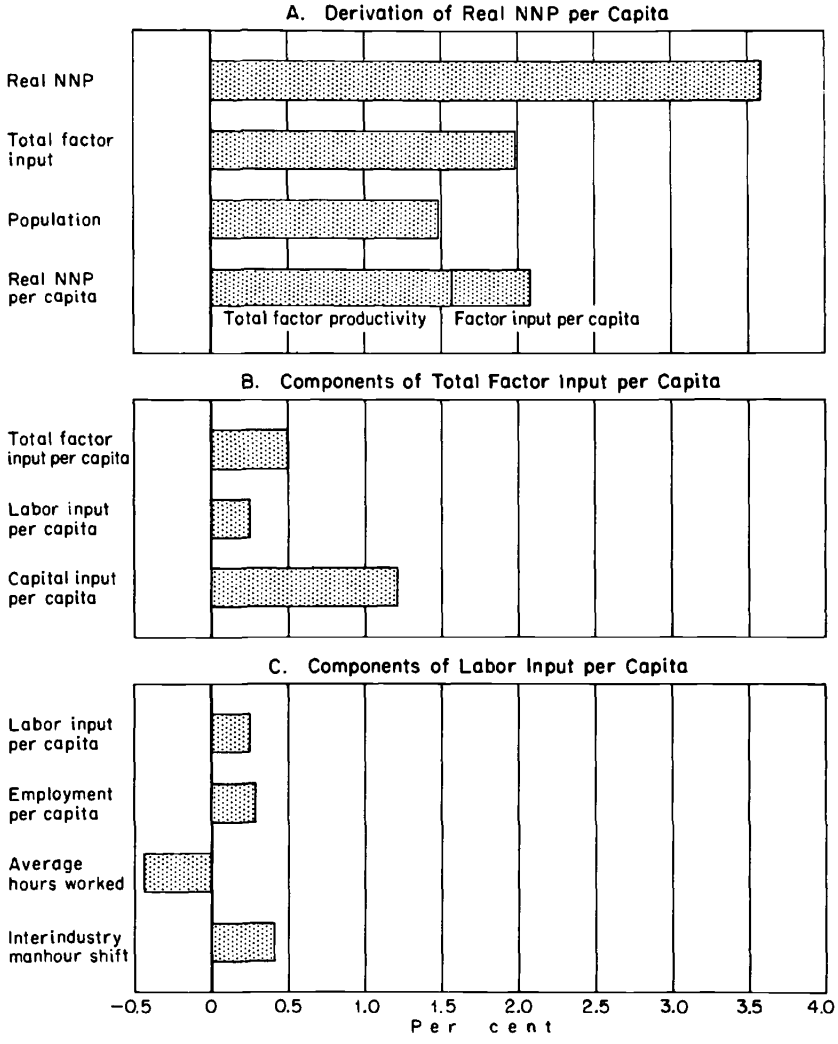
Between 1889 and 1953, while output was increasing between nine- and tenfold, the population of the nation grew from 62.5 million persons to over 160 million—roughly two and one-half times. Thus, output per capita grew by somewhat less than 300 per cent, which averages out at 2.1 per cent a year. On this basis, the gain of 1.6 per cent in the average annual rate of productivity accounts for about three-fourths of the increase in output per capita. The growth of input per capita accounts for the other fourth (see Chart 7, Panel A).[2]

Over the seven subperiods shown in Table 8, the rates of growth of real product per capita varied considerably; the weighted average deviation of the subperiod rates from the long-period rate of 2.1 per cent was 0.8 per cent. The larger part of the variation is traceable to variations in factor

[2] Solomon Fabricant has compared productivity changes in the private domestic economy with changes in real private domestic product per capita in *Basic Facts on Productivity Change*, Occasional Paper 63, New York (NBER), 1959, pp. 18–22. Since productivity rose more and real product less in the private domestic sector than in the total economy, the relative importance of productivity is greater by Fabricant's measure and differs somewhat over the subperiods in comparison with our measure.

CHART 7

Components of Real Net National Product per Capita, Average Annual Rates of Change, 1889–1953



input per capita. Productivity gains showed less variation; the average subperiod deviation from the 1.6 per cent productivity growth rate over the long period was 0.3 per cent. The several variables are plotted annually in Chart 6. It will be noted from the chart and table that between 1919

and 1953 (or 1957) there has been virtually no net change in input per capita. Thus, productivity increase has accounted for the entire growth of real product per capita since 1919, on net balance.

TABLE 8

Productivity in Relation to Levels of Living, Subperiods, 1889–1957
(average annual percentage rates of change)

	Real NNP per Capita[a] (1)	Ratio of Consumer Outlays to NNP (2)	Real Consumer Outlays per Capita[a] (3)	Total Factor Productivity (4)	Factor Input per Capita (5)	Addendum: Population (6)
1889–1953	2.1	−0.1	1.9	1.6	0.5	1.5
(1889–1957)	2.0	−0.1	1.8	1.6	0.4	1.5
1889–1919	2.4	−0.4	2.0	1.4	1.0	1.8
1919–53	1.8	0.1	1.7	1.7	0.1	1.2
1889–99	2.6	−0.4	2.2	1.5	1.1	1.8
1899–1909	2.3	0.1	2.4	1.1	1.2	1.9
1909–19	2.3	−1.0	1.3	1.5	0.8	1.5
1919–29	1.6	1.3	2.9	1.4	0.1	1.5
1929–37	−0.5	0.5	−0.1	1.1	−1.6	0.7
1937–48	3.2	−0.5	2.7	2.2	1.0	1.2
1948–53	3.0	−1.4	1.6	2.4	0.6	1.6
(1953–57)	0.4	0.1	0.5	1.5	−1.1	1.8

NNP = net national product.

SOURCE: Real net national product and real consumer outlays: Kuznets' concepts, Table A-1, adjusted to conform with internal weighting method. Population: *Current Population Reports*, Dept. of Commerce, Series P-25, No. 114; population prior to 1900 extrapolated by Kuznets' estimates.

[a] When 100 is added to the average percentage rates, col. (1) = col. (4) × col. (5); and col. (3) = col. (1) × col. (2).

Real consumption expenditures per capita increased by slightly less than 2 per cent, since the ratio of consumer outlays to net national product was significantly lower in 1953 than in 1889 (see Table 8). This was a concomitant of the much higher proportion of resources devoted to national security purposes in the latter year. The somewhat erratic fluctuations in the consumption ratio were chiefly the result of changing requirements for national security. The main exception occurred during the 1929-37 period, when the proportion of resources devoted to investment declined substantially. As a result, real consumer outlays showed a negligible drop relative to population, although real net product per capita was 4.2 per cent lower in 1937 than in 1929.

The Changing Structure of Inputs

Although the increase in productivity has been much larger than the growth of inputs relative to population, it is instructive to look at the structure of inputs per capita. Total factor input is a composite measure, and its growth relative to population is the net result of differential rates of change in the components. Examination of the changing composition of input not only fills in the arithmetic of economic growth, but also furnishes some clues as to the sources of productivity advance.

GROWTH OF CAPITAL RELATIVE TO LABOR INPUT

The average annual rates of change in labor and capital inputs per capita over the long period and the subperiods are shown in Table 9, together with their relative percentage weights. Total factor input is equal to the

TABLE 9

Labor and Capital Components of Input per Capita, with Measures of Factor Substitution, Subperiods, 1889–1957 (average annual percentage rates of change and percentage weights)

	Total Factor Input per Capita[a]	*Labor Input*		*Capital Input*		*Input Ratios*	
		Per Capita	Weight	Per Capita	Weight	Capital per Labor Unit	Total per Labor Unit[a]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1889–1953	0.5	0.2	70	1.2	30	1.0	0.3
(1889–1957)	0.4	0.1	70	1.2	30	1.1	0.3
1889–1919	1.0	0.6	65	1.9	35	1.3	0.4
1919–53	0.1	−0.1	75	0.6	25	0.7	0.2
1889–99	1.1	0.6	64	2.4	36	1.7	0.5
1899–1909	1.2	0.9	64	1.7	36	0.8	0.3
1909–19	0.8	0.4	67	1.7	33	1.3	0.4
1919–29	0.1	−0.3	70	1.2	30	1.5	0.4
1929–37	−1.6	−1.7	75	−1.3	25	0.4	0.1
1937–48	1.0	1.2	77	0.5	23	−0.6	−0.1
1948–53	0.6	0.1	79	2.5	21	2.4	0.5
(1953–57)	−1.1	−1.8	79	1.4	21	3.3	0.8

SOURCE: Table A-XIX and population series from Table 8.

[a] When 100 is added to the average percentage rates col. (1) is approximately equal to cols. (2) plus (4) times their respective weights shown in cols. (3) and (5). Col. (7) equals col. (6) times col. (5), with allowance for the effects of rounding.

weighted sum of labor plus capital inputs. As between the two broad factor classes, the growth of capital has been much greater than the growth of labor input. Even after allowance for the smaller weight

accorded capital, it accounts for the larger part of the 0.54 per cent a year average increase in total input per capita (0.36 compared with 0.18).

Changes in inputs on a per capita basis have a somewhat different relative importance than straight changes. Thus, capital input increased at an average rate of 2.7 per cent a year, about 60 per cent more than the 1.7 per cent rate of increase in labor input. However, the 1.2 per cent rise in capital per head is four times the 0.3 per cent rise in labor input per head (see Chart 6, Panel B).

The relative importance of the factors in total input growth varied considerably over the subperiods. Whereas capital per unit of labor input increased by 1.0 per cent a year on the average over the period, the average deviation of subperiod rates was 0.7 per cent. The highest average rates of increase in capital per unit of labor input were in the first decade, 1889–99 (at 1.7 per cent a year), and the recent subperiod, 1948–57 (at 2.8 per cent). The postwar acceleration followed a low rate of advance between 1929 and 1937 and an actual decline in the 1937–48 period as a result of wartime restrictions on private investment and of early postwar capital shortages.

The last column of Table 9 shows the rates of substitution of capital for labor; the substitution rates are equivalent to average annual percentage changes in the index of capital per unit of labor input weighted by the relative shares of capital in the national income in the several subperiods. On the average, the share of capital was about 30 per cent, but it declined over the period, as indicated in column (5) (see Chapter 5 for a discussion of the relative prices of the factors).

TRENDS IN THE COMPONENTS OF LABOR INPUT

Our estimates of labor input (L) in relation to population (P) can be derived as the product of the ratio of the labor force (LF) to population, the ratio of employment (E) to the labor force, average hours worked per year (MH/E), and the ratio of labor input to manhours worked. In algebraic terms:

$$\frac{L}{P} = \frac{LF}{P} \times \frac{E}{LF} \times \frac{MH}{E} \times \frac{L}{MH}$$

To derive labor input as such, it is merely necessary to multiply both sides of the equation by population, which means substituting the labor force itself for the ratio of labor force to population on the right-hand side.

The various elements into which the labor input estimates may be divided are shown in Table 10 in terms of average annual percentage rates of change. In general, it is evident that the average increase of 0.2 per cent a year in labor input per capita is fully accounted for by the relative shift of workers and manhours into higher-paying industries

(column 5). Unweighted manhours showed a slight downward tendency relative to population, as the increase in the ratios of labor force and employment to population was somewhat more than offset by the decline in average hours worked per year (see Chart 6, Panel C).

TABLE 10

Components of Labor Input per Capita, Subperiods, 1889–1957
(average annual percentage rates of change)

	Labor Input per Capita[a] (1)	Ratio of Labor Force to Population (2)	Ratio of Employment to Labor Force[b] (3)	Average Hours Worked per Year[c] (4)	Labor Input per Manhour[d] (5)
1889–1953	0.2	0.1	0.2	−0.4	0.4
(1889–1957)	0.1	0.1	0.1	−0.4	0.4
1889–1919	0.6	0.2	0.3	−0.3	0.4
1919–53	−0.1	0.0	0.1	−0.6	0.4
1889–99	0.6	0.4	0.0	0.0	0.3
1899–1909	0.9	0.4	0.3	−0.3	0.5
1909–19	0.4	0.0	0.5	−0.6	0.5
1919–29	−0.3	0.1	−0.4	−0.1	0.1
1929–37	−1.7	0.2	−0.8	−1.1	−0.1
1937–48	1.2	−0.1	0.9	−0.5	0.9
1948–53	0.1	−0.3	0.5	−0.7	0.6
(1953–57)	−1.8	−0.5	−0.8	−0.5	−0.1

[a] When 100 is added to the average annual percentage rates throughout, col. (1) = cols. (2) × (3) × (4) × (5).

[b] This ratio is influenced by the fact that our employment estimates were derived independently of the labor-force estimates. The rise in a ratio of consistent employment-to-labor-force figures is less (see Appendix A).

[c] The ratio of total manhours to the average annual employment estimates.

[d] The ratio of manhours weighted by average hourly earnings, by industry groups, to unweighted manhours.

Labor force and employment ratios. The increase in the proportion of the population participating in the labor force over the period was chiefly the result of a relative increase in the population of labor-force age. But even in relation to the population 14 years of age and over, there has been a slight increase in the labor-force ratio, as the rising participation ratios of women, especially in the 35–65 age bracket, have more than offset declines in some of the other brackets. The increasing labor-force participation of women may be traced in part to increasing productivity in household operation and to the shift of functions from the household to the business sector.

The ratio of employment to the labor force shows a small increase in our table due to the presumedly lower percentage of employment in 1889 than in 1953. It should not be inferred, however, that there has been an upward secular trend in the employment ratio. There is considerable variation from one key year to another. The most marked case is 1937 relative to 1929; the unemployment ratio was still relatively high in 1937, a year which saw a cycle peak, but not full recovery.

Average hours worked. Manhours worked have increased less than aggregate employment because of the secular trend toward a shorter workweek and work-year. From close to 54 hours in 1889 (60 in the nonfarm sector), the average annual workweek fell to 40 hours in 1953—an average annual decline of 0.4 per cent a year. The decline was by no means regular, however. Especially rapid reductions in average hours took place in the latter part of the 1909-19 decade, reflecting increased union strength in World War I and the effects of the Adamson Act, which established the eight-hour day for railroads; reductions took place again during the early 1930's, when shorter working hours were introduced over much of the economy as a means of sharing the work.[3]

It can be argued that reduction in the workweek helps promote productivity advance. There is some evidence to suggest that labor efficiency per hour increases as average weekly hours drop, but this force tends to wane with successive reductions in hours.[4] Of possibly greater importance is that insofar as shortening of standard hours comes at different times in different industries and establishments without corresponding reductions in the weekly wage, management is put under pressure to increase the degree of mechanization and the efficiency of operations generally.[5] The same reasoning would apply to increases in wage rates, hours remaining the same. The effect would vary depending upon such forces as the degree of price elasticity of demand for the products of the firms or industries affected.

The upgrading of labor. Since the effect of the declining length of the workweek on manhours offsets the increasing ratio of employment to population, the rise in labor input per capita may be ascribed to the impact on labor input of the relative shift of workers and manhours from lower- to higher-paying industries. It has been our contention that industry differentials in wage rates reflect, primarily, persistent differences

[3] Cf. Leo Wolman, *Hours of Work in American Industry*, Bulletin 71, New York (NBER), 1938.

[4] See Solomon Fabricant, *Employment in Manufacturing, 1899–1939: An Analysis of Its Relation to the Volume of Production*, New York (NBER), 1942, p. 13.

[5] This argument is developed by Edward F. Denison in "Measurement of Labor Input: Some Questions of Definition and the Adequacy of Data," *Output, Input, and Productivity Measurement*, Studies in Income and Wealth, Volume 25, Princeton University Press (for NBER), 1961.

in occupational structures and that wage rates in different occupations tend to reflect the differential contributions to product of different classes of workers. Thus, relative shifts of workers to higher-paying occupations and industries result in a greater "quantity" of labor input, reflecting the use of more valuable talents of individuals or a greater investment in training and development of innate skills. Interindustry shifts have gone on rather persistently throughout the whole period. The view that these movements have been associated with increased education per person is borne out by figures presented in Table 22. Table 11 makes clear that the

TABLE 11

Social-Economic Distribution of the Civilian Labor Force, 1890–1950
(per cent)

Group	1890	1910	1930	1950
Nonfarm	57.4	69.0	79.0	88.1
Proprietors, managers, etc.		6.6	7.5	8.8
Professional persons	3.7	4.4	6.1	8.6
Clerks and kindred workers	6.0	10.2	16.3	19.3
Skilled workers and foremen		11.7	12.9	14.2
Semiskilled workers		14.7	16.4	20.3
Unskilled workers		21.4	19.8	16.9
Farm	42.6	31.0	21.0	11.9
Proprietors, managers	23.1	16.5	12.4	7.5
Laborers	19.5	14.5	8.6	4.4

SOURCE: Estimates for 1910 and 1930 as compiled by Alba M. Edwards, *Census of Population, 1940, Comparative Occupation Statistics for the United States, 1870 to 1940,* Table XXVII, p. 187; estimates for 1890 based on occupational detail from the same source. Subgroups of nonfarm workers could not easily be identified except for professionals (*ibid.*, p. 111) and clerks (Edwards, "The White-Collar Workers," *Monthly Labor Review,* March 1934, p. 504). Estimates for 1950 from *Census of Population, 1950,* Vol. II, Part I.

shift toward higher-paying industries was indeed associated with relative shifts of the labor force towards more highly skilled or professional occupations, and from farms to generally more highly remunerated nonfarm pursuits.[6]

Within the professional category of the labor force, there is one group that is of particular importance in germinating new ideas and incorporating them in improved technology—the scientists and engineers. Estimates are

[6] Another investigator, weighting the numbers of persons in the various socio-economic groupings by appropriate average earnings, found much the same difference between the movement of weighted and unweighted gainful workers from 1870 to 1950 that we found between manhours weighted and unweighted from 1889 to 1953 (see George Tolley, North Carolina State University, unpublished worksheets; see also his discussion of Denison's paper, *op. cit.*).

presented in Table 12 of the numbers of engineers and chemists, 1890–1950, and their ratio to the labor force. In 1950, chemists accounted for only about one-eighth of the total but were still a slightly larger group than the total of other natural scientists, such as physicists, mathematicians, biologists, and geologists (but excluding the medical professions), for whom data are not available prior to 1950. With around 90 per cent coverage, the estimates give a good general picture of the growth of the technological professions as a whole.[7]

TABLE 12

Distribution of Engineers and Chemists[a] in the Labor Force, Decennial, 1890–1950

	Number of Thousands	Per Cent of Labor Force
1890	33	0.14
1900	52	0.18
1910	105	0.28
1920	169	0.40
1930	273	0.56
1930	277	0.58
1940	338	0.63
1940	363	0.68
1950	636	1.08

SOURCE: David M. Blank and George J. Stigler, *The Demand and Supply of Scientific Personnel*, New York (NBER), 1957, Tables B-1 and B-2, pp. 144–47. The overlap in 1930 represents an adjustment of 1930 "gainful workers" to the labor force concept. The overlap in 1940 represents reconciliation of 1940 and 1950 Census counts of engineers. For full description and derivation see *ibid.*, notes to Table B-1 and Appendix E.

[a] Chemists include metallurgists, and engineers include surveyors. Surveyors cannot be segregated prior to 1930; they accounted for 0.024 per cent of the labor force in 1930, 0.031 per cent in 1940, and 0.044 per cent in 1950.

Over the sixty-year period, total numbers of engineers and chemists increased eighteenfold, after adjustment for discontinuities in the estimates for 1930 and 1940. As a percentage of the labor force, the increase was about sevenfold. This averages out as a 3.3 per cent a year relative increase, about double the rate of productivity advance. There is no retardation as yet apparent in the relative growth of the technological professions. The marked slowdown in the 1930's as a result of depressed economic conditions was virtually made good in the subsequent decade. It is obvious, however, that this relative growth rate cannot continue indefinitely.

[7] See David M. Blank and George J. Stigler, *The Demand and Supply of Scientific Personnel*, New York (NBER), 1957, p. 3.

Median age of labor force. The median age of labor-force participants increased by more than one-fifth between 1890 and 1955 (see Table 13). Some observers think that aging of the labor force results in decreased average personal efficiency, other things being equal, which would tend to restrain productivity advance. Certainly, people pass the peak of their physical strength and vigor at relatively early ages. This effect should tend to be mitigated, if not offset, however, by the shift in skill and occupational requirements that increases the average age at which individuals attain top proficiency. Peak earnings of professional people, for example, are not reached until the middle years or beyond. It would be

TABLE 13

Median Age of the Population and the Labor Force, Selected Years, 1890–1955
(years)

	Total Population	Labor Force
1890	22.0	32.2
1920	25.3	34.3
1930	26.5	35.5
1940	29.0	36.0
1950	30.2	38.1
1955	30.0	39.1

SOURCE: *Economic Report of the President*, January 1957, Table C-4, p. 92.

hazardous to make any dogmatic statement about the relationship of average age to efficiency and to productivity advance in the face of technological changes that gradually alter the occupational composition of the labor force. In any case, the marked increase in the birth rate since 1940 has caused the median age of the population as a whole to decline in recent years, a development that will show up later as a drop in the median age of the labor force.

TRENDS IN THE COMPOSITION OF CAPITAL

Real capital stocks were weighted by rates of return in a number of sectors and industry groups to obtain an aggregate measure of real capital input. As was true of labor, although to a lesser degree, there was a relative shift of capital over the long period from industries with lower rates of return to those with higher rates of return on invested capital (see Table A-9). To the extent that higher rates of return are a result of greater intangible investment by the firms in an industry (for example the cumulation of technical knowledge from outlays on research and training), the weighted series reflects more fully the qualitative aspect of capital services.

Some of the major changes in the sectoral composition of capital stocks are shown in Table 14. The relative trends revealed clearly in this table seem to be typical concomitants of the process of economic development. Net investment abroad rose from negative figures prior to World War I to positive amounts in recent decades. The relative importance of the "social overhead" represented by publicly owned capital more than doubled between 1889 and 1953. Within the private domestic sector, the percentage of farm to total capital declined by almost two-thirds. Residential structures maintained a relatively constant ratio to total capital throughout, but showed a mild tendency to decline. Nonfarm, nonresidential plant, inventories, and equipment underwent a persistent and substantial relative increase.

TABLE 14

Distribution of Real Capital Stocks by Sector, Key Years, 1889–1953
(per cent)

	NATIONAL ECONOMY	REST-OF-THE-WORLD[a]	GOVERNMENT	PRIVATE DOMESTIC			
				Total	*Farm*	*Nonfarm* Residential	*Nonfarm* Nonresidential
1889	100.0	−4.1	5.5	98.6	38.9	27.6	32.1
1899	100.0	−3.0	5.4	97.6	30.6	30.1	36.9
1909	100.0	−1.6	6.7	94.9	25.3	28.7	40.9
1919	100.0	1.4	7.6	91.0	22.2	26.3	42.5
1929	100.0	3.2	9.0	87.8	16.3	28.5	43.0
1937	100.0	1.4	13.2	85.4	15.9	28.3	41.2
1948	100.0	1.9	13.7	84.4	15.6	25.9	42.9
1953	100.0	1.8	13.1	85.1	14.4	25.5	45.2

SOURCE: Table A-XV.
[a] Net foreign assets.

An analysis (based on Table 15) of real capital stocks by major type is possible for the domestic economy. Structures and equipment, the two most important types of capital, each grew almost as much as real net product until 1929. There were some subperiod variations between the two output-capital ratios, but the trends were virtually parallel. The 1929-37 change was somewhat atypical, since real product and the stock of structures showed little change, while the stock of equipment fell relatively.

It is the trend since the late 1930's that diverges sharply from previous experience. Between 1937 and 1953 the stock of equipment showed a greater increase than real product. But the stock of structures showed little growth, and the output-structures ratio increased by almost 70 per cent. Various reasons can be adduced to explain this discrepant behavior;

for example, the greater relative increase in the cost of buildings than in the price of machinery and equipment, the development of space-saving innovations, and greater technological improvements in equipment than in structures. In some important industries, such as the utilities, fixed facilities are built up well ahead of demand, so beyond a point output increases faster than plant as the latter is utilized with increasing intensity.

TABLE 15

Domestic Economy: Major Types of Real Capital Stocks and Relation to Real Net Product, Key Years, 1889–1953
(1929 = 100)

	Land, Farm and Forest	Structures	Equipment	Inventories
	REAL CAPITAL STOCK BY MAJOR TYPE			
1889	73	23	25	34
1899	86	40	33	42
1909	92	59	56	48
1919	98	72	80	73
1929	100	100	100	100
1937	101	101	89	101
1948	100	104	142	157
1953	104	120	203	188
	RATIOS OF REAL NET DOMESTIC PRODUCT TO REAL CAPITAL STOCK			
1889	32	103	95	68
1899	41	89	107	86
1909	58	91	95	110
1919	75	101	91	100
1929	100	100	100	100
1937	102	102	116	103
1948	165	158	116	105
1953	197	170	101	109

SOURCE: Capital: Table A-XVI; real net domestic product (national security version): Table A-I, col. (7) minus Table A-III, col. (4).

To the extent that construction-cost deflators do not fully allow for productivity gains, the real-plant estimates obtained by deflation may have a downward bias. But the possible bias is unlikely to be so large as to account for a significant part of the divergent movement of the ratios of output to fixed capital by type.

The ratio of output to inventories has tended upward through most of the period. Between 1919 and 1953, the increase was about 10 per cent. The increase between 1889 and 1919 shown by our estimates was considerably greater—but it will be remembered that the private nonfarm portion of inventories prior to 1919 was not estimated independently of output. Yet it seems reasonable to suppose that there was a trend toward

greater economy in the use of inventory stocks throughout the period as a result of steadily improving transportation and communication facilities and more efficient stock-control and merchandising methods generally.

The most striking increase was in the ratio of domestic output to land (farm and forest), which went up more than sixfold over the sixty-four years. Part of the rise is attributable to the less-than-proportionate increase in the demand for agricultural products as total real product rose. But gross farm output itself rose 30 per cent more than the acreage of farm land employed as crop yields per acre and production per animal unit were increased.

NONFACTOR INPUT TRENDS

Since the national product is measured net of intermediate products, a reduction in materials consumed per unit of output is reflected in a higher rate of increase in national product than would be shown if there were no economies in materials use. Transactions in semiprocessed goods or components are only of indirect significance in this connection, since changes in such transactions relative to the volume of final products reflect changes in raw materials use plus changes in the number of times materials change hands prior to final processing. Since the latter factor is largely a function of changes in the structure of business organization, we can see the basic phenomena better by looking directly at the consumption of raw materials relative to the national product rather than at the ratio of total intermediate-product purchases to product.

Productivity and raw material economies. Economies in consumption of materials per unit of output may result from fuller use of materials, a higher degree of processing, or a decline in the ratio of commodities to the national product.

Reliable estimates of domestic consumption of raw materials begin in 1900.[8] Over the half century 1900–52, total apparent consumption almost tripled, while real net national product increased close to sixfold. Thus, the ratio of output to raw materials input has more than doubled (Table 16), which means an average annual rate of increase of 1.4 per cent.

The foregoing comparison of real product with raw materials input, however, considerably overstates the contribution of materials economies to productivity gains since the value of raw materials obviously is much less than the value of final products. Approximations to the percentage-point increase in real national product and productivity attributable to the decrease in raw materials consumption per unit can be calculated in the following way: By adding the value of raw materials consumed to the net national product, both in 1929 dollars, we obtain a measure duplicative

[8] See *Raw Materials in the United States Economy, 1900–52*, Bureau of the Census Working Paper No. 1, 1954.

of raw materials input; if we then estimate a hypothetical real net national product by applying the 1929 ratio of the net measure to the measure gross of materials, we obtain estimates of what the net national product would have been had the requirements for raw materials remained constant at the 1929 proportion. The ratio of the actual to the hypothetical measure tells us by how much real product increased as a result of more economical

TABLE 16

Consumption of Raw Materials in Relation to Real Net National Product, Key Years, 1900–52
(1929 = 100)

	Real NNP[a]	*Apparent Consumption of Raw Materials*[b]				*Real NNP per Unit of Raw Materials Input*
		Total excl. Gold	Foods	Energy Materials	Physical-structure Materials	
1900	36.0	56.5	61.2	43.4	57.3	63.7
1909	52.8	72.2	76.5	56.6	75.9	73.1
1919	73.3	80.0	84.1	72.3	77.5	91.6
1929	100.0	100.0	100.0	100.0	100.0	100.0
1937	102.9	106.2	105.4	97.4	115.3	96.9
1948	163.7	140.3	131.0	141.7	159.4	116.7
1952	197.2	151.7	142.7	151.0	171.7	130.0

[a] NNP = net national product; Kuznets' concept, national security version (Table A-I).

[b] As estimated in *Raw Materials in the United States Economy, 1900–52*, Bureau of the Census Working Paper No. 1, 1954.

use of materials—assuming that resources are interchangeable between raw materials production and other uses without significant effect on over-all productivity. This computation is carried out in Table 17.

Over the period 1900–1952 as a whole, materials saving and greater processing accounted for a 0.25 per cent average annual increase in real net national product—or about one-sixth of the average percentage rate of increase in total factor productivity. The relative contribution from this source was more important in the early part of the period—from 1900 to 1919, the relative importance of materials economy was about one-third. Only in the period 1929–37 was there an increased use of materials per unit of output and a small negative influence on net product and productivity advance. Since 1948, the rate of saving in materials has been somewhat greater than the average over the half century.

Reductions in raw materials consumption per unit of output have also had an indirect influence on productivity change. If the hypothesis of a tendency towards diminishing returns in extractive industries is correct, then productivity advance in these industries and in the economy has been

greater than would have been the case had raw materials production risen more nearly in proportion to national output. That is, a sixfold increase in raw materials production between 1900 and 1952, instead of the less than threefold increase that actually occurred, would have placed a greater strain on domestic natural resources and might possibly have resulted in lower rates of productivity advance than were realized.

TABLE 17

Estimated Effect of Raw Materials Savings on Growth of Real Net National Product, Key Years, 1900–52

	Real NNP[a]	*Consumption of Raw Materials*[b]	*Real Product Gross of Materials*[c]	*Hypothetical Real NNP at 1929 Materials Usage*[d]	*Effect of Materials Savings on Real NNP*	
					Index[e] (1929 = 100)	Average Annual Rates of Change[f] (per cent)
	(millions of 1929 dollars)					
	(1)	(2)	(3)	(4)	(5)	(6)
1900	32.8	10.3	43.1	35.9	91.3	
1909	48.1	13.2	61.3	51.0	94.2	0.35
1919	66.7	14.6	81.3	67.7	98.5	0.45
1929	91.1	18.3	109.4	91.1	100.0	0.15
1937	93.7	19.4	113.1	94.2	99.5	−0.06
1948	149.2	25.6	174.8	145.6	102.4	0.26
1952	179.7	27.7	207.4	172.8	104.0	0.40

[a] NNP = net national product, Kuznets' concept, national security version (Table A-I).

[b] *Raw Materials in the United States Economy, 1900–52*, Bureau of the Census Working Paper No. 1, 1954.

[c] Col. (1) plus col. (2).

[d] Product of col. (3) and 1929 of col. (1) divided by 1929 of col. (3).

[e] Col. (1) divided by col. (4).

[f] Rates of change computed from col. (5) between terminal years of subperiods, ending with year shown in stub. The average annual percentage rate of change between 1900 and 1952 is 0.25.

Unit consumption by type of materials. The consumption of raw materials for food rose less in relation to real product than did the consumption of raw materials for other uses. This is due in part to a smaller increase in consumer outlays for food than in total real net product, especially prior to 1929. But there is also evidence that the real value of food production increased significantly in relation to raw materials input due primarily to greater processing but also to more complete use of the raw materials.

Economies in the use of physical-structure materials are partly a function of the increasing proportion of national product going into services rather than goods. Based on Kuznets' estimates, consumer services rose from 28 per cent of real net national product (national security variant) in 1900 to 37 per cent in 1929. The trend does not appear to have continued

since 1929. Based on a careful study by the Commerce Department, the proportion of real gross national product accounted for by services, as distinguished from commodities and construction, increased only from 30 per cent in 1929 to 31 per cent in 1953.[9]

A more important factor in the declining raw materials proportion of the national product is the increase in the durable goods proportion—for the ratio of raw materials purchases to total value added is smaller in durable goods manufacture than in nondurable goods. The Commerce Department study indicates that durable goods increased from 18 per cent of the real GNP in 1929 to 22 per cent in 1953.[10] Based on the Kuznets estimates, consumer durables plus producer durable equipment increased from 13 per cent of real gross national product (national security version) in 1900 to 16 per cent in 1929. But in addition to the greater processing of goods resulting from technological advance and shifts in the composition of demand, there was also undoubtedly some saving of materials in the making of identical goods through reduction of waste, redesign, better quality controls, and so on.

It is apparent from Table 16 that real product went up considerably less in relation to energy materials than to physical-structure materials. A more illuminating picture is obtained by relating the consumption of energy materials to their direct output, and energy, in turn, to the factor inputs and real product.

Energy consumption, inputs, and output. While real product went up by less than two-thirds in relation to energy materials consumed between 1900 and 1952, the efficiency of conversion of the energy potential of inanimate energy resources into work output increased more than fourfold between 1900 and 1950.[11] In relating energy consumption to input and product, we employ a measure of energy used for work output that includes only operations which have been or could be performed by muscle power, and excludes energy used for space heating, lighting, or refrigeration. One such measure, in terms of horsepower-hours, is shown in Table 18.

In the 1870-80 decade, each manhour was provided with 0.55 horsepower-hours of animal or inanimate energy; by 1950, over 5 horsepower-hours were associated with each manhour—almost a tenfold increase over the seventy-five-year period. The average annual rate of increase in the ratio was 3.0 per cent, although after a period of accelerating advance the increase in horsepower-hours per manhour slowed to an average annual rate of 1.5 per cent in the 1930-50 period.

[9] "New Distribution of National Output by Goods, Services, and Construction, 1929–56," *Survey of Current Business*, June 1957, p. 9.

[10] *Ibid.*, p. 9.

[11] J. F. Dewhurst, *America's Needs and Resources, A New Survey*, New York, Twentieth Century Fund, 1955, Table I, p. 1,113.

TABLE 18

Energy Consumption for Work Performance in Relation to Output and Inputs, Decennial, 1870–1950

	ENERGY CONSUMPTION FOR WORK PERFORMANCE *Horsepower-Hours*		RATIO OF ENERGY CONSUMPTION TO					
			Horsepower-Hours per Manhour		*Real Capital*		*Total Factor Input*	*Real Net National Product*
	Billions	Index	Hours	Index	Total	Equipment		
1870–80	22.0	5.1	0.55	14.3	34.5	41.5	21.1	35.7
1890	44.7	10.3	0.72	18.6	39.6	41.4	25.2	39.6
1900	74.3	17.1	0.98	25.5	43.4	50.3	31.8	44.5
1910	160.8	37.0	1.66	43.1	65.8	65.0	50.1	64.9
1920	283.3	65.1	2.64	68.4	85.0	81.7	72.8	82.6
1930	434.9	100.0	3.86	100.0	100.0	100.0	100.0	100.0
1940	491.9	113.1	4.35	112.7	119.3	124.4	113.2	92.0
1950	668.5	153.7	5.19	134.3	126.0	93.3	122.4	77.1

SOURCE: Energy consumption: J. F. Dewhurst, *America's Needs and Resources, A New Survey*, New York, Twentieth Century Fund, 1955, Table L, p. 1,116; manhours: Table A-X; equipment: Table A-XVI; net national product, total capital, and total factor input: Table A-XIX.

In relation to the real stock of capital, energy consumption more than tripled over the seventy-five years. Between 1930 and 1950, however, there was relatively little net increase. In relation to producer durable equipment the increase was less marked, with a net decline occurring between 1940 and 1950. Energy consumption per unit of real net product more than doubled over the entire period, but since 1930 the deceleration in its rate of increase relative to factor input was reflected in an actual decline relative to output.

There can be little doubt that the substantial increases in output per unit of input over the period were due in part to the striking increases in nonhuman energy relative to input. This trend was promoted by a decline in the relative price of energy as a result of marked increases in productivity in the energy-producing industries (see Chapter 6). Certainly, the increase in energy production was a necessary concomitant of the increase in equipment per worker and of faster and more powerful equipment. But the relation of energy to productivity is not a simple one, as evidenced by the deceleration in recent decades in the rate of increase in energy consumption per unit of input and a decline in relation to output at the same time that productivity advanced at a faster rate than it did in earlier decades.

The Changing Structure of Output

To complement the analysis of inputs as a means of gaining insight into the dynamics of productivity advance, one can also analyze the composition of output. Parts of output are devoted to increasing the quantity and quality of resources. Not all of these outlays are included or identified in the national product estimates.

MARGINS OVER MAINTENANCE OF PRODUCT

One helpful way of analyzing the composition of national product is in terms of the margin that remains after providing for the maintenance of the population of each previous year at the previous year's level of consumption and of net capital stock. This margin over maintenance, in turn, may be broken down into the portions required for national security, for growth of population, and a final "margin for economic progress" that may be invested in increasing the tangible or intangible capital per person. This margin gives us an alternative approach to the measurement of economic growth or progress. It was suggested, in somewhat different form, in an earlier National Bureau study by Mills.[12]

The real product necessary for maintenance of population is shown in Table 19 (column 2). It is computed annually as the real consumption of the previous year plus capital consumption allowances of the current year

[12] *Op. cit.*

TABLE 19

Margins over Maintenance of Real Gross National Product, Subperiods, 1889–1959
(annual averages)

PERIOD OF AVERAGE	REAL GROSS NATIONAL PRODUCT	MAINTENANCE OF POPULATION (CONSUMER AND CAPITAL GOODS)	MARGIN OVER MAINTENANCE OF POPULATION						
			Total	*Maintenance of National Security*	*Margin over Maintenance of Population and Security* *Total*	Provision for Growth of Population (Consumption and Capital)	Margin for Economic Progress Total	Consumption	Capital
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				MILLIONS OF 1929 DOLLARS					
1889–1953	84,291	70,641	13,650	6,488	7,162	3,817	3,345	1,215	2,130
1889–1918	42,610	35,857	6,753	813	5,940	2,745	3,195	580	2,615
1919–53	120,017	100,455	19,562	11,352	8,210	4,736	3,474	1,759	1,715
1889–98	26,781	22,264	4,517	143	4,374	1,785	2,589	314	2,275
1899–1908	42,111	35,180	6,931	334	6,597	2,906	3,691	648	3,043
1909–18	58,937	50,128	8,809	1,961	6,848	3,544	3,304	776	2,528
1919–28	83,181	71,058	12,123	1,380	10,743	4,284	6,459	1,690	4,769
1929–36	84,854	82,862	1,992	773	1,219	3,002	−1,783	71	−1,854
1937–47	142,417	109,583	32,834	24,944	7,890	4,388	3,502	3,077	425
1948–53	187,230	156,174	31,056	17,160	13,896	8,438	5,458	1,706	3,752
(1954–59)	226,324	190,389	35,935	21,914	14,021	9,732	4,289	2,745	1,544
				PERCENTAGE OF GROSS NATIONAL PRODUCT					
1889–1953	100.0	83.8	16.2	7.7	8.5	4.5	4.0	1.5	2.5
1889–1918	100.0	84.2	15.8	1.9	13.9	6.4	7.5	1.4	6.1
1919–53	100.0	83.7	16.3	9.5	6.8	3.9	2.9	1.5	1.4
1889–98	100.0	83.1	16.9	0.5	16.4	6.7	9.7	1.2	8.5
1899–1908	100.0	83.5	16.5	0.8	15.7	6.9	8.8	1.6	7.2
1909–18	100.0	85.1	14.9	3.3	11.6	6.0	5.6	1.3	4.3
1919–28	100.0	85.4	14.6	1.7	12.9	5.2	7.7	2.0	5.7
1929–36	100.0	97.7	2.3	0.9	1.4	3.5	−2.1	0.1	−2.2
1937–47	100.0	76.9	23.1	17.5	5.6	3.1	2.5	2.2	0.3
1948–53	100.0	83.4	16.6	9.2	7.4	4.5	2.9	0.9	2.0
(1954–59)	100.0	84.1	15.9	9.7	6.2	4.3	1.9	1.2	0.7

SOURCE: Gross national product, national security variant, Table A-XIX, allocated as described in text.

(averaged over the periods shown). The rest of the current-year real gross national product (column 3) is a margin over and above the requirements for maintenance of a given population with a constant level of capital and consumption goods per capita. This margin may be theoretically disposed of for purposes of growth—growth of population or of output per capita.

Some of the margin, however, is required for national security purposes —the amount depending on the interaction of international conditions and national foreign policy. Resources devoted to security purposes are *potentially* available to support economic growth (and a small portion of national security outlays does represent investment). But to calculate the *actual* margin available for economic growth (column 5), national security outlays must be deducted from the margin over maintenance of population.

The margin available for economic growth proper may be divided into two components—that necessary to support the growth of population, and that available for increased consumption or investment per capita. The former (column 6) is obtained by multiplying the net population increment of each year by the average per capita consumption and reproducible capital stock of the previous year. By subtracting the real consumption expenditures needed to support the population increment at the previous year's level from the total increment to consumption, that part of consumption outlay which serves to raise per capita consumption is obtained (column 8); an analagous procedure yields that portion of real investment which serves to increase capital stock per head (column 9). These last two components constitute what may be called a margin for economic progress, if the term is defined as the increase in real net economic output (excluding munitions) per capita.

Quite consistently for most of the subperiods, approximately 84 per cent of the real gross product has been required, on the average, to maintain the real personal consumption level of the previous year and to offset capital consumption. Of the remaining 16 per cent, national security required about 2 per cent of GNP, on the average, through 1929, and almost 14 per cent was available for population growth and economic progress. A little less than half of this margin over maintenance of population and security was needed to support the increase in population; the rest was devoted to raising real consumption and capital stocks per capita.

The 1930's were atypical in that there was little margin over maintenance of population and capital. Even with very low national security outlays, only 1.4 per cent of GNP was available for growth and progress between 1929 and 1937. More than this was required for consumption purposes by a growing population, and capital stocks per capita fell.

Since the 1930's, national security outlays have absorbed more than half the margin over maintenance. If we skip over the war years, and consider simply the period 1948–53, national security took 9 per cent of gross

expenditures. Growth of population, while less than in the early decades, was up from the 1930's and required 4.5 per cent of GNP. Only 3 per cent of GNP has been available for economic progress—as compared with almost 8 per cent before 1929. It is interesting that provision for increased real consumption per capita has consistently absorbed between 1 and 2 per cent of GNP over the decades (except in the 1930's); therefore, the large increase in national security outlays since World War II compared with earlier periods has been mainly at the expense of the proportion of product devoted to increasing the capital stock per capita. In fact, there was no net increase in this component from 1929 until after World War II; since 1948, about 2 per cent of GNP has augmented capital per head.

This bears out the implications of the total and partial productivity ratios—rates of increase in capital per head or per manhour have little relation to rates of increase in total productivity. Productivity growth accelerated after World War I (after 1937, using the national measures) while capital per person showed smaller increases than before. A marked increase in the efficiency of given quantities of capital has been associated with the acceleration of productivity advance, and significant savings in capital as well as in labor per unit of output have been realized.

PRODUCTIVITY AND THE MARGIN FOR ECONOMIC PROGRESS

Over the sixty-four-year period, the productivity increment has been just slightly larger than necessary to provide for increases in real consumption per capita. As Table 20 indicates, prior to 1919 the productivity increment

TABLE 20

Productivity Increment
in Relation to Consumption Margin, 1889–1953
(annual averages)

Period of Average	*Real GNP* Millions of 1929 Dollars	*Consumption Margin* Millions of 1929 Dollars	*Consumption Margin* Per Cent of GNP	*Productivity Increment* Millions of 1929 Dollars	*Productivity Increment* Per Cent of GNP	*Productivity Increment* Per Cent of Consumption Margin
1889–1953	84,291	1,215	1.5	1,250	1.5	103
1889–1919	42,610	580	1.4	413	1.0	71
1919–53	120,017	1,759	1.5	1,967	1.6	112
1948–53	187,230	1,706	0.9	2,900	1.5	170

SOURCE: Table 19.

was smaller, and after 1919 somewhat larger, than the margin for increased per capita consumption. The more ample relative dimensions of the productivity increment after 1919 are due to acceleration in its rate of

growth, since the consumption margin averaged about 1.5 per cent of GNP in both periods. The much larger relative size of the 1948–53 productivity increment was due both to a greater-than-average rate of productivity growth and to a consumption margin that was squeezed to smaller-than-average proportions by high national security outlays and an expansion of net investment over that of the preceding two decades. During this period the productivity increment provided almost one-third of the capital margin in addition to the entire consumption margin.

On the surface, it might seem that there is some contradiction between Tables 8 and 20. That is, the preceding section indicated that the rate of productivity gain was less than the rate of increase in real consumption expenditures per capita—1.6 versus 1.9 per cent a year, on the average. But this is consistent with the analysis just presented, since the 1.6 per cent is reckoned on the net national product (NNP) base, which is about one-sixth higher than the consumption outlay base to which the 1.9 per cent applies.

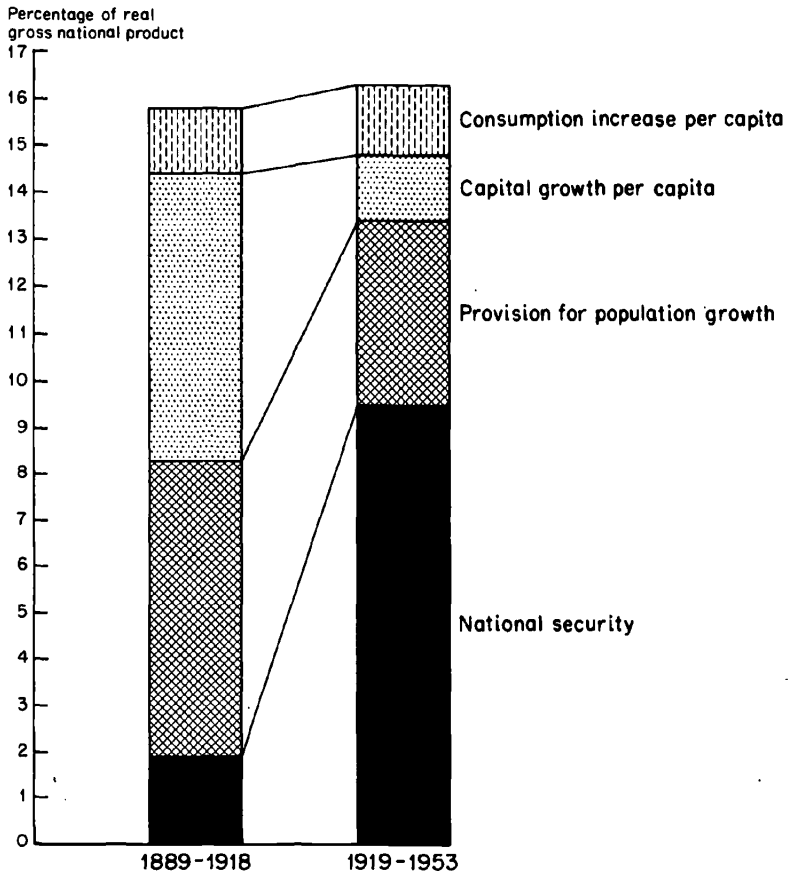
If the increase in planes of living largely absorbed most of the productivity increment, the question may be asked as to the source of the rest of the margin over maintenance of population. First, it should be clear that the margin over maintenance, which averaged 16 per cent, is much larger than the average increment to the real national product, which has averaged 3.6 per cent. Productivity and input increments contribute less than one-quarter to the total margin; the remainder results from the spending-saving pattern of the community as influenced by the tax and expenditure policy of governments.

The most striking tendency revealed in Table 19 is the relatively small proportion of product since 1929 that has gone to increase the stock of capital per head. Even the 2.0 per cent contribution in 1948–53 is only one-third of the proportion in 1889–1919. The low ratio has been associated with a relatively high level of national security outlays (especially since 1939), as is shown in Table 19 and in Chart 8. The method of financing those outlays has obviously tended to reduce investment relatively more than consumption. During the war, capital goods were allocated directly; but since the war, the upward trend of the interest rate has been indicative of the tight capital supply situation.

It is true that even with the small increases in capital per worker since the 1920's, productivity gains have been greater than in the pre-1919 period, when the relative growth of capital was much greater. Widespread introduction of capital-saving technology has made this possible, but it cannot be said that productivity gains would not have been greater in recent years had capital been more abundant. There is the additional circumstance that the national accounts as now constructed do not identify, nor even include, all types of investment. It is to this matter that we now turn.

CHART 8

National Product, Margins over Maintenance of the Population at Levels of Previous Year, 1889–1918 and 1919–53



HIDDEN INVESTMENT

Investment may be defined as the application of resources and the incurrence of costs in the current period with the objective of increasing productive capacity and income in future periods. By this definition, it is apparent that some items included in consumption outlays are really "investment in self," in personal productive capacity.[13] Looked at broadly, most personal consumption outlays and standards of living generally have some connection with productive efficiency, from the aspects both of

[13] An intensive analysis of this form of investment is being undertaken by Gary Becker of the National Bureau staff.

capacity and of incentive. Also, some items charged to current expense in business accounting, such as exploratory and research outlays, are not included in national product, although they are really a form of investment. Government outlays for the same purpose are partially included in national security outlays; by the Commerce Department concept, total intangible and tangible public investment are included in government purchases but are not separately identified.

Investment in persons. The two chief types of personal consumption expenditures that fit the definition of investment are expenditures for education and for health services. The Commerce Department estimates of personal consumption expenditures plus public educational outlays can be extended back to 1909 by major category to furnish a general picture of total educational and private health expenditures (Table 21).

TABLE 21

Consumption Expenditures by Major Type, Key Years, 1909–53

	Total[a]	Food, Clothing, and Housing[b]	Personal Business[b]	Leisure Pursuits[b]	Medical Care	Education
			CURRENT DOLLARS (BILLIONS)			
1909	27.3	21.9	1.9	2.2	0.8	0.5
1919	60.3	46.6	6.5	4.2	1.9	1.1
1929	80.5	54.6	13.3	7.4	2.9	2.3
1937	69.0	47.6	10.7	5.7	2.7	2.3
1948	181.4	128.5	25.0	15.1	7.4	5.4
1953	236.6	159.6	38.8	19.6	10.1	8.5
			PERCENTAGE DISTRIBUTION OF CURRENT-DOLLAR OUTLAYS			
1909	100.0	80.4	7.0	8.0	2.8	1.8
1919	100.0	77.3	10.7	7.0	3.2	1.8
1929	100.0	67.8	16.5	9.2	3.7	2.8
1937	100.0	69.1	15.5	8.2	3.9	3.3
1948	100.0	70.8	13.8	8.3	4.1	3.0
1953	100.0	67.4	16.4	8.3	4.3	3.6
			REAL OUTLAYS PER CAPITA (1929 DOLLARS)			
1909	446	369	11	40	13	13
1919	508	374	57	41	19	17
1929	670	454	111	62	24	19
1937	654	452	106	54	23	19
1948	880	608	136	78	36	22
1953	958	641	161	91	40	25

[a] Estimates are those of the Department of Commerce for 1929 and later years, extrapolated to 1909 by the estimates contained in William H. Shaw, *Value of Commodity Output since 1869*, New York (NBER), 1947; and J. F. Dewhurst, *America's Needs and Resources* New York, Twentieth Century Fund, 1947. Estimates of public educational outlay (see Appendix K) were added to personal consumption expenditures.

[b] Housing includes household operations; personal business includes transportation; leisure pursuits include recreation, personal care, religious and welfare expenditures, and foreign travel.

Expenditures for education increased from 1.8 per cent of total consumption expenditures in 1909 to 3.6 per cent in 1953. Real educational outlays per capita went up by 98 per cent over the forty-four-year period, or at an average rate of 1.6 per cent a year. This probably represents an understatement—since the price deflator is the average pay of teachers, deflated expenditures are, in effect, labor input without allowance for productivity change. Understatement is also suggested by the fact that deflated educational outlays per capita went up less than total real consumption expenditures per capita, although the opposite relative movement is indicated by the current-dollar estimates.

The increasing personal and public investment in education is reflected in the data relating to school enrollments and degrees earned (Table 22).

TABLE 22

Enrollments and Graduates in Secondary Schools and Institutions of Higher Education,[a] Decennial, 1890–1950
(per cent)

	Secondary Schools		*Institutions of Higher Education*	
	Enrollment per 100 Persons 14–17 Years Old	Graduates per 100 Persons 17 Years Old	Resident enrollment per 100 Persons 18–21 Years Old	Earned Degrees per 100 Persons 21 Years Old
1890	6.7	3.5	3.0	1.2
1900	11.4	6.4	4.0	1.9
1910	15.4	8.8	4.8	2.1
1920	32.3	16.8	8.1	2.7
1930	51.4	29.0	12.2	5.5
1940	73.3	50.8	15.3	7.9
1950	76.5	59.0	19.3	18.8

SOURCE: *Higher Education for American Deomocracy*, President's Commission on Higher Education, 1947, Vol. VI; and the *Statistical Abstract of the United States, 1956*, Dept. of Commerce.

[a] Public and private.

Over the sixty-year period 1890–1950, enrollments in institutions of higher education as a percentage of the relevant age class increased more than sixfold, while secondary school enrollments per 100 in the 14–17 age class increased more than tenfold. Numbers of graduates showed much greater relative increases.

It seems inevitable that this striking advance in the educational attainments of the American people should have increased the skills, efficiency, and inventive potential of the labor force. It correlates with the picture, shown earlier, of the relative increase in the skilled and professional groups in the labor force, and with the relative shift of workers to higher-paying occupations and industries. To this extent, investment in self is reflected

in our labor input measure. Within the same occupational groupings there must have been a trend towards higher educational attainment that should have increased the efficiency of labor within the various industries, but this part of the investment in persons does not affect labor input as measured.

Relative increases in private health outlays have also been striking (see Table 21). If public health expenditures were included, total levels, and possibly the increases as well, would be greater. The increasing outlays for health and related items were not without effect, if life expectancy may be taken as a criterion. As indicated in Table 23, the average life expectancy at birth in the United States increased from 47.3 years in 1900 to

TABLE 23

Average Length of Life and Survival Rates, by Sex and Color, Death-Registration States, Selected Years, 1900–55

	Total	*White*		*Nonwhite*	
		Male	Female	Male	Female
	ESTIMATED AVERAGE LENGTH OF LIFE (YEARS)				
1900	47.3	46.6	48.7	32.5	33.5
1909	52.1	50.9	54.2	34.2	37.3
1919	54.7	54.5	57.4	44.5	44.4
1929	57.1	57.2	60.3	45.7	47.8
1937	60.0	59.3	63.8	48.3	52.5
1948	67.2	65.5	71.0	58.1	62.5
1953	68.8	66.8	72.9	59.7	64.4
1955	69.5	67.3	73.6	61.2	65.9
	PROBABILITY OF SURVIVAL TO AGE 65 PER 100 PERSONS ATTAINING AGE 15				
1900–02		50.3	54.3	31.9	35.3
1919–21		58.5	61.2	41.3	37.0
1939–41		62.6	72.7	40.6	45.1
1953		66.9	80.9	50.0	59.6

SOURCE: *Abridged Life Tables: United States, 1954*, Vital Statistics—Special Reports: National Summaries, Vol. 44, No. 2, Department of Health, Education, and Welfare, May 15, 1956, Table 5 and derivation from Table 3.

69.5 years in 1955. The health and efficiency of labor-force members also probably improved over the period. More important, increasing survival rates mean that the investment in the birth, upbringing, and education of individuals yielded higher total returns.

There is a problem of distinguishing between gross and net investment in personal productive capacity. That part of investment-type outlays required to maintain the productivity of a given population at its previous level is akin to tangible investment designed to offset capital consumption.

The part of real outlays associated with increased population and increased outlays per person is a rough approximation of the net investment involved.

Although we have singled out two types of consumption expenditures for special comment, the rise in per capita consumption expenditures generally must have had a stimulating effect on personal efficiency and on productivity. Certainly, increasing per capita outlays for food, clothing, and shelter, for example, must have had some effect on health in addition to the effect of higher direct health outlays. More generally, the experience of rising planes of living, both for oneself and for those around one, must have raised standards and aspirations and so exerted a strong incentive effect on individuals to strive for further material progress.[14]

Intangible investment by business and government. There are several types of tangible and intangible investment that are charged by business firms to current expense. The Commerce Department attempts to estimate the volume of producers' durable equipment so charged and includes it in gross private domestic investment. Expenses of oil companies in drilling oil and gas wells are treated likewise. But several types of intangible investment, and certain mineral exploratory expenses, are not included in the national product or, in the case of public investment, are not segregated from other outlays.

Of the intangible investments, probably the most important types are expenditures for training and other ways of improving the efficiency of employees, and research and development outlays for the purpose of devising new equipment, processes, and procedures for increasing efficiency generally.

Unfortunately, data are not available to show the trend of training and educational costs incurred by industry. The total is undoubtedly large. In-plant training and various forms of apprenticeship have been practiced since time immemorial. If estimates were available for recent times, however, the general trend shown above by the estimates of public and private personal educational outlays would probably not be greatly modified by inclusion of business outlays for the same purpose.

Estimates are available for research and development outlays since 1920. The figures shown in Table 24 include publicly financed as well as business outlays. The estimates since 1941 are more reliable and more comprehensive than the earlier estimates. Although the two sets of estimates are not continuous, it is apparent that research and development expenditures

[14] This theme has been elaborated by Ruth Mack, "Trends in American Consumption and the Aspiration to Consume," *American Economic Review, Papers and Proceedings*, May 1956, pp. 55–68. She writes: "I hold that one cannot adequately explain . . . the growth in real consumption . . . without recognizing the unusual force of the drive to consume and its effect in activating productive effort" (p. 58).

have increased at a significantly higher rate than the net national product. The ratio of research and development outlays to national product has, however, not increased at an accelerating rate. The ratio more than doubled during the 1920's, doubled in the 1930's, and increased by one-half in the 1940's. On the basis of a McGraw-Hill survey of business

TABLE 24

Research and Development Expenditures in Relation to Net National Product, Selected Years, 1920–55

		RESEARCH AND DEVELOPMENT OUTLAYS			
		Old Series[b]		*New Series*[c]	
	NNP[a] Millions	Millions	Per cent of NNP	Millions	Per cent of NNP
1920	$78,100	$59	0.08		
1930	77,660	166	0.21		
1940	83,915	345	0.41		
1941	109,911			$ 900	0.82
1950	239,408			2,870	1.20
1955[p]	326,023			5,400	1.66

[p] = preliminary.

[a] NNP = net national product, Kuznets' concept, national security version, in current dollars.

[b] Estimated from figures shown in Vannevar Bush, *Science, the Endless Frontier*, A Report to the President, July 1945, p. 80.

[c] *The Growth of Scientific Research and Development*, Dept. of Defense, 1953, p. 10, and preliminary reports of United States National Science Foundation. The estimates comprise expenditures by government, industry, and nonprofit institutions for basic and applied research in the sciences (including medicine) and engineering and for the design and development of prototypes and processes. Excluded are quality control, routine product testing, sales promotion or services, and research in the social sciences and psychology.

intentions to spend for research and development,[15] it appears that the ratio will again increase by more than one-half in the 1950's.

Before World War I, organized industrial research laboratories were much more the exception than the rule.[16] Invention and development had, of course, been going on in a more or less informal manner for a very long time. But it was the work of technically minded, and sometimes trained, individuals working chiefly as individuals—as proprietors or works managers in larger firms, as professional scientists, inventors, or both,

[15] McGraw-Hill Publishing Co., Dept. of Economics, *Business' Plans for New Plants and Equipment, 1958–1961, 11th Annual Survey*, New York, undated.

[16] The first directory of industrial laboratories appeared in 1920 (*Research Laboratories in Industrial Establishments of the United States*, National Academy of Sciences).

or as production workers. In recent decades, invention and the development of innovations have become systematized and routinized, involving teams of scientists and engineers working in complex laboratories. The more informal type of innovation continues to be significant, but it is certainly of declining relative importance. Taking both informal and organized research and development together, its growth has extended over a much longer period of time and been more gradual than the growth of organized research and development alone—as witness the figures presented earlier on scientists and engineers in relation to the labor force. Even the latter comparisons probably overstate the growth of innovational activity, since untrained persons were relatively more important in earlier days.

Although we cannot measure it precisely, research and development activity is our best indication of the investment in scientific and technological advance that sooner or later results in productivity growth. We should not forget, however, that the volume and relative trend of this type of intangible investment depends on fundamental social values and institutions. The effect on productivity also depends partly on the rate at which cost-reducing innovations spread. This again is a function of social and institutional factors, such as the degree of competition, the availability and cost of financing, the availability of properly trained workers, and the state of long-run expectations.