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NATIONAL PRODUCTIVITY AND ECONOMIC GROWTH

Here we focus our attention on the relative contribution of total factor input and productivity to economic growth in the national economy during the period 1948-66. To obtain growth rates, we use the real net national product (NNP), adjusted to allow for a 1 per cent per annum average increase of total factor productivity in general government. But since economic progress cannot occur unless real NNP grows faster than population, we shall also look at the relative contributions of total factor productivity and real total factor input, per capita, to rates of growth in real NNP, per capita.

There is also interest in the relative growth rates of labor and property income—in the changing functional distribution of income. We shall examine this aspect of growth in terms of relative changes in productivity and in real price of the two major classes, as well as more broadly in terms of the historical elasticity of substitution during the period covered. This analysis is confined to the business economy, for which independent measures of property and labor income are available.

In view of its major role in economic growth, perhaps the greatest interest centers on the causal factors behind productivity growth. In the final section, we shall discuss causes, with particular emphasis on the proximate determinants in the form of growth in real intangible capital stock resulting from investments in research and development, education and training, and other activities designed to increase the quality, or productive efficiency, of the tangible factor inputs, human and nonhuman.

The Role of Productivity in Economic Growth and Progress

Between 1948 and 1966, real NNP (adjusted for government productivity advance, as described in the previous chapter) increased at an average annual rate of 4.1 per cent. Total net factor productivity rose at an average annual

rate of 2.3 per cent, while real tangible factor inputs grew at a comparable rate of 1.8 per cent. (See Table 4-1). Thus, we may say that productivity advance accounted for roughly 56 per cent of total economic growth over the period. It will be recalled from *Productivity Trends* that prior to 1919 productivity accounted for well under half the overall growth rate. After 1919 it generally accounted for more than half. We recognize, of course, that productivity as "the residual" reflects various forces that affect the productive efficiency of the tangible factors. But we defer until the last section of the chapter an attempt to probe more deeply into underlying causes.

The relative impact of productivity advance differed considerably in the subperiods. In the first and last subperiods, 1948-53 and 1960-66, when the growth rate of real NNP exceeded 5 per cent, productivity grew only slightly faster than real tangible inputs. During the two middle subperiods, the rate of productivity advance decelerated, but the rate of increase in real factor input fell much more, so that productivity advance accounted for around three-quarters of the aggregate growth rate.

The role of productivity stands out much more prominently when we view it in relation to the rate of economic progress. Real NNP per capita rose at an average annual rate of 2.4 per cent. Real factor input per capita increased by only 0.1 per cent a year, so the 2.3 per cent annual rate of productivity advance accounted for almost all of the economic progress achieved between 1948 and 1966. (See Table 4-1 and Chart 4-1.) The figure 2.4 per cent may seem small, but given the power of compound interest, it means that real NNP per capita doubles every thirty years or so, thanks almost entirely to the forces that promote productivity advance. This is the same rate of progress experienced from 1889 to 1919,[1] but in the earlier period input per capita grew at a 1.0 per cent rate per annum. From 1919 to 1948, productivity advance accelerated, but input per capita fell somewhat, and the annual growth rate of real NNP was retarded to 1.5 per cent. Although the 2.4 per cent growth rate since 1948 is the same as in the period before 1919, the relative importance of productivity advance is much greater.

We recognize that real NNP per capita is scarcely an ideal welfare measure. National product, as currently estimated, excludes various kinds of nonmarket economic activity, the value of which would add more than 50 per cent to the present aggregates.[2] Also, deductions are not made for certain costs of producing final goods and services that are not included in NNP, or, more importantly, that might be imputed, such as the costs and disutilities

[1] See *Productivity Trends*, Table 8, p. 84.

[2] For rough estimates of the imputed values of major nonmarket economic activities, see the *Forty-seventh Annual Report* of NBER, June 1967, pp. 9-15.

TABLE 4-1

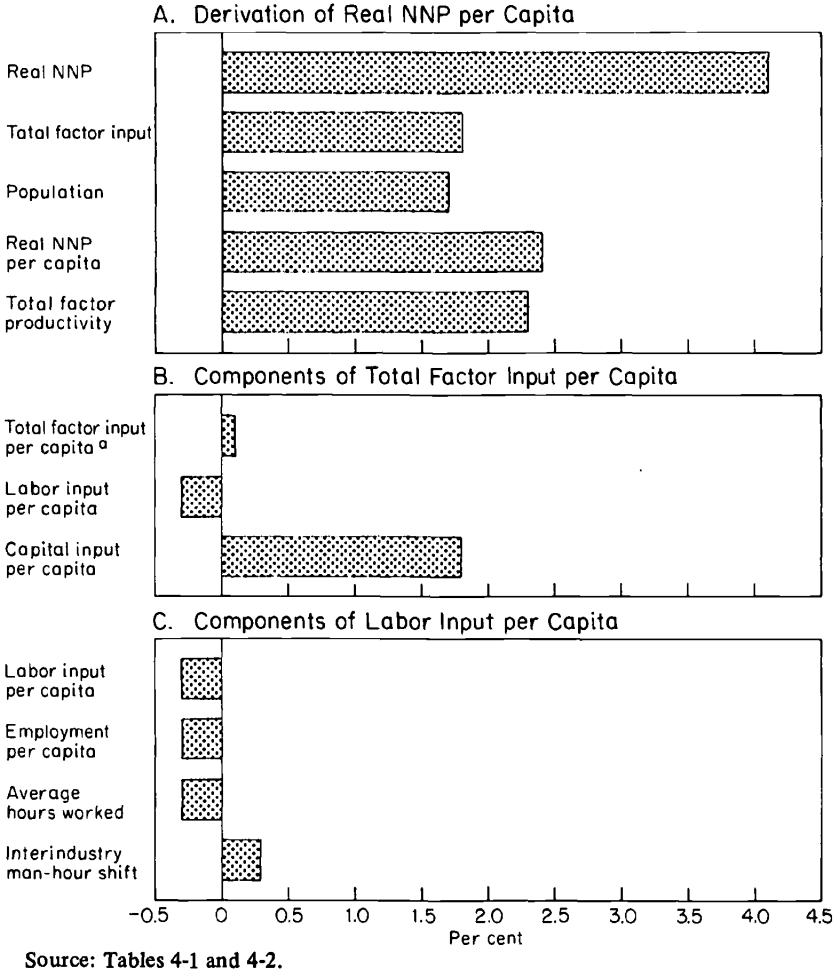
National Economy:
Components of Real Net National Product,
Total and per Capita,
Key Years, 1948-66

	Real NNP (Adjusted) (Col. 2 × Col. 3) (1)	Total Factor Input (2)	Total Net Factor Productivity (Col. 1 ÷ Col. 2) (3)	Population (4)	Total Factor Input per Capita (Col. 2 ÷ Col. 4) (5)	Real Adjusted NNP per Capita (Col. 3 × Col. 5 = Col. 1 ÷ Col. 4) (6)
			A. Index Numbers (1958 = 100)			
1948	72.1	89.2	80.9	83.9	106.4	86.0
1953	92.1	100.4	91.7	91.6	109.6	100.5
1957	101.2	102.9	98.3	98.3	104.6	102.9
1960	109.8	104.9	104.7	103.3	101.5	106.3
1966	148.9	122.1	122.0	112.6	108.5	132.3
			B. Average Annual Percentage Rates of Change			
1948-66	4.1	1.8	2.3	1.7	0.1	2.4
1948-53	5.0	2.4	2.6	1.8	0.6	3.2
1953-57	2.4	0.6	1.8	1.8	-1.2	0.6
1957-60	2.8	0.6	2.1	1.7	-1.0	1.1
1960-66	5.2	2.6	2.6	1.4	1.1	3.7

Note: For the average annual percentage rates of change, the relationships are approximately additive rather than multiplicative as in the case of index numbers.

Source: Col. 1: text; Col. 2: Table A-17; Col. 4: Bureau of the Census.

Chart 4-1: Components of Real Net National Product per Capita, Average Annual Rates of Change, 1948–66



Source: Tables 4-1 and 4-2.

[a] The difference between real NNP per capita and total factor productivity shown in panel A.

associated with environmental pollution. Even if NNP could be fully and accurately estimated, it would only furnish the basis for estimates of changes in *potential* welfare. Nevertheless, if its limitations are borne in mind, real NNP per capita provides a useful point of departure for assessing the rate of material progress.[3]

[3] See Moses Abramovitz's essay "The Welfare Interpretation of Secular Trends in National Income and Product" in *The Allocation of Economic Resources*, Stanford University Press, 1959.

As shown in Table 4-1, the rates and components of change differ significantly over the several subperiods. Real NNP per capita increased at an average annual rate of 3.2 per cent between 1948 and 1953, but decelerated during the subsequent two subperiods to 1960, reflecting not only some deceleration in the rate of productivity advance but, more importantly, a decline of around 1 per cent a year, on the average, in real total factor input per capita. In the final subperiod 1960-66, the rate of advance in real NNP per capita rose to a new high of 3.7 per cent a year. This reflected the return of the annual rate of productivity advance to the almost 2.6 per cent recorded in the first period, and an acceleration in the growth rate of real input per capita to 1.1 per cent a year.

In view of the importance of real input per capita, particularly for swings in the rates of change of real NNP per capita, it is worthwhile to examine its components (see Table 4-2). First of all, the 0.11 per cent average annual rate of increase in total factor input per capita during the period 1948-66 represents a weighted average of a 0.3 per cent drop in labor input per capita and a 1.8 per cent increase in capital input per capita. The decline in factor input in the two middle subperiods, 1953-57 and 1957-60, reflected a decelerating growth rate in real capital and substantial declines in labor input relative to population. The 1.1 per cent rate of growth in the 1960-66 subperiod mirrored a renewed surge in capital input per capita back to around 2 per cent a year and the highest growth rate in labor input per capita of the postwar period—almost 1 per cent a year, on the average.

The rates of change in labor input per capita may be, in turn, broken down into the three components shown in Table 4-2 and Chart 4-1. Thus, the 0.3 per cent annual rate of decline during 1948-66 reflects declines of 0.3 per cent each in the percentage of the population in work status (persons engaged per capita) and in average hours worked per year, counterbalanced in part by a rise of 0.3 per cent a year in the rate of increase in labor input per man-hour. The latter element measures the relative shift of workers and man-hours into high-pay industries, continuing a historical trend. The decline in the proportion of population working was due to a drop in the ratio of labor force to total population as the proportion of unproductive age groups rose during the period covered; the ratio of employment to labor force was the same in 1966 as in 1948. The decline in average hours worked also represents a continuation of a secular trend.

The drop in labor input per capita during the two middle subperiods reflects primarily a decline in the proportion of the population in work status, due largely to an upward creep in the ratio of unemployment to the

TABLE 4-2

National Economy:
Components of Total Factor Input per Capita,
Key Years, 1948-66

	Capital Input per Capita (1)	Labor Input per Capita (Col. 3 X Col. 4 X Col. 5) (2)	Persons Engaged per Capita (3)	Average Hours Worked per Year (4)	Labor Input per Man-Hour (5)
		A. Index Numbers (1958 = 100)			
1948	83.0	113.5	110.3	106.3	96.8
1953	92.5	114.2	111.1	102.7	100.1
1957	99.2	106.1	104.3	101.1	100.6
1960	101.8	101.4	99.9	101.1	100.4
1966	114.4	106.9	102.9	100.6	103.3
		B. Average Annual Percentage Rates of Change			
1948-66	1.8	-0.3	-0.3	-0.3	0.3
1948-53	2.2	0.1	0.1	-0.7	0.7
1953-57	1.8	-1.9	-1.6	-0.4	0.1
1957-60	0.9	-1.5	-1.5	0.0	-0.1
1960-66	2.0	0.9	0.5	-0.1	0.5

Note: For the average annual percentage rates of change, the relationships are approximately additive rather than multiplicative as in the case of the index numbers.

Source: Tables 4-1, A-6, A-10, A-13, and A-17.

civilian labor force, from 2.9 per cent in 1953 to 4.3 per cent in 1957 and on up to 5.5 per cent in 1960.

The significant rise in labor input per capita in the last subperiod reflects a renewed rise of an average 0.5 per cent a year in persons engaged per capita as unemployment fell back to 3.8 per cent of the civilian labor force in 1966; an increase of 0.5 per cent a year in labor input per man-hour; and a retarded decline in average hours worked of less than 0.1 per cent a year.

Factor Prices, Productivity, and Income Shares

It is a truism that the rate of change in productivity is equal to the rate of change in the ratio of average input prices to average output prices (at factor cost). Thus, between 1948 and 1966 the private domestic business economy showed average annual increases of 3.9 per cent in the average factor price, of 1.4 per cent in the average output price, and of 2.5 per cent in the ratio of the two price series—the same rate of increase as in total factor productivity (see Table 4-3). The rise in factor input prices relative to output prices, which is proportionate to the productivity increase, is the means whereby productivity gains are distributed to the owners of the factors of production. One can regard productivity gain as an increase in the "real price" of a unit of factor input, or as the increase in unit real factor income, since it is the same as factor income per unit deflated by the index of average prices of outputs (at factor cost).

These relationships do not tell us anything about inflationary processes. We cannot know whether factor price increases (less the productivity increase) pushed up product prices or product price increases (plus the productivity increase) pulled up factor prices, nor do we know the extent to which there was an interaction between the two. An analysis of inflation would have to include the study of disaggregated industry estimates, timing relationships, monetary factors, the profit-rate component of the price of capital, institutional factors, and so on. But we do know that the owners of the factors of production, in the aggregate, are unable to raise the real price per unit of combined factor input any faster than total factor productivity advances permit.

If the increase in average factor prices exactly equaled the increase in productivity, there would be no change in the product price index. The product price index would also remain stable if the average price of each factor rose exactly in proportion to the increase in the corresponding partial productivity ratio and the factor shares of national income remained constant. Or, given changes in the product price level, product shares would

TABLE 4-3

Private Domestic Business Economy:
Factor Incomes, Inputs, Prices, and Productivity, 1948-66,
Link Relatives and Rates of Change

	Link Relative, 1966 (1948 = 100)	Average Annual per Cent Rate of Change, 1948-66
Factor income		
Total	259.7	5.44
Labor	269.8	5.67
Property	236.1	4.89
Implicit price deflator	128.1	1.38
Real factor income		
Total	202.7	4.00
Labor	210.6	4.22
Property	184.3	3.46
Percentage shares of income		
Labor	104.0	0.22
Property	90.8	-0.54
Real factor input		
Total	129.6	1.45
Labor	117.4	0.89
Property	186.3	3.52
Factor productivity		
Total	156.6	2.52
Labor	172.9	3.09
Property	108.9	0.47
Factor price		
Total	200.4	3.94
Labor	229.8	4.73
Property	126.7	1.32
Real factor price		
Total	156.4	2.52
Labor	179.4	3.30
Property	98.9	-0.06

Note: Property refers to net capital.

Source: Factor income and percentage shares of income: Table 4-4; implicit price deflator: Department of Commerce; real factor input and factor productivity: Table A-20; real factor income, factor price, and real factor price: by computation.

remain constant if the real price of each factor rose in proportion to the increase in the corresponding partial productivity ratio.

But if the real price of one factor rises more than its productivity ratio

(made possible by a drop in the real price of the other factor relative to its productivity ratio), then the share of that factor in national income will increase. This is precisely what happened to labor income in the business economy from 1948 to 1966, on net balance. The real price of labor rose at an average rate of 3.3 per cent a year, representing a 4.7 per cent rate of increase in average hourly compensation deflated by the product price deflator, which rose at a 1.4 per cent annual rate. Average annual labor compensation was obtained by dividing total labor compensation by weighted man-hours, so that the 4.7 per cent rate of increase does not reflect inter-industry man-hour shifts, and thus the real-average-hourly-compensation series is consistent with the real-product-per-unit-of-labor-input series. The 3.3 per cent rise in real average hourly compensation exceeds by a bit more than 0.2 per cent the 3.1 per cent average annual rate of increase in real product per unit of labor input. This 0.2 per cent relative increase may also be called the increase in real unit labor costs, which is the quotient of real average hourly earnings and labor productivity.

As a result of this rise, the labor share of factor income originating in the domestic business economy expanded from 69.7 per cent in 1948 to 72.5 per cent in 1966—another average annual rate of increase of 0.2 per cent (see Table 4-4), and approximately the same rate of advance as that recorded between 1929 (when the labor share was 67.3 per cent) and 1948. It is also

TABLE 4-4

Factor Income Originating in the Private Domestic Business Economy, by Type, Selected Years, 1929-66

	Factor Income (Billions of Dollars)			Per Cent Distribution	
	Total	Labor	Property	Labor	Property
1929	78.8	53.0	25.8	67.3	32.7
1948	200.2	139.6	60.6	69.7	30.3
1953	263.7	194.8	68.9	73.9	26.1
1957	314.3	234.7	79.6	74.7	25.3
1960	351.4	264.8	86.7	75.3	24.7
1966	519.9	376.7	143.1	72.5	27.5

Note: Details may not add to total due to rounding.

Source: Department of Commerce estimates, with an allocation of proprietors' income as described in the appendix.

the same rate I obtained in a previous study for the expansion in the labor share of gross private domestic product (including households and private nonprofit institutions, excluded from the present analysis) between 1919 and 1960.[4] As shown in Table 4-4, however, there was a drop in the labor share between 1960 and 1966, but the increase was subsequently resumed.

The uptrend in the real price of labor and its share in national income was accompanied by an average decline in the real price of capital of 0.06 per cent a year, compared with a 0.47 per cent annual increase in capital productivity. The 0.5 per cent rate of decline in real capital cost annually per unit of output is consistent with the decline in its share of business factor income from 30.3 per cent in 1948 to 27.5 per cent in 1966. (See Tables 4-3 and 4-4.) Note also that the 0.5 per cent rate of decline in unit real capital cost per year, weighted by the 0.25 per cent share of capital, approximately equals the 0.2 per cent rate of increase in unit real labor cost, weighted by its percentage share in the base period.[5]

If the capital deflator shows the same movement as the overall product deflator, then the slight decline in the real price of capital may be interpreted as occurring in the rate of return on capital assets at market prices. We have not disentangled the rate-of-return and capital-asset price components of our capital price measure. But in view of the high rate of return prevailing in 1948 due to postwar capital shortages, it seems unlikely that the 1966 rate of return was higher, despite the significant increase from 1960. Unfortunately, time has not permitted us to pursue this aspect of postwar economic developments more fully.

Another way of explaining statistically the rise in the real price of labor and its income share is to view it as the product of changes in the relative quantities of factor inputs and in the relative prices of the factors. Thus, labor input relative to total factor input dropped by an average annual rate of 0.55, while the price of labor rose by an average 0.80 per cent a year relative to total factor price. The sum of these two rates is 0.25, which is approximately the rate of change in labor's share.

Since the rate of decline in relative labor input was more than offset by

[4] See John W. Kendrick and Ryuzo Sato, "Factor Prices, Productivity, and Economic Growth," *American Economic Review*, December 1963. The relationships among the variables discussed in this section are developed mathematically in Appendix A of that article, pp. 985-96.

[5] The implications of this relationship for "wage-price guideposts" are discussed in Kendrick and Sato (see footnote 4), p. 979; see also John W. Kendrick, "The Wage-Price-Productivity Issue," *California Management Review*, Spring 1962.

the rate of increase in the relative price of labor, it is apparent that the "historical" elasticity of substitution for the period was less than unity. In interpreting the coefficients presented below, it must be remembered that elasticities of substitution calculated from historical time series do not have the same meaning as the concept used in equilibrium theory. That is, in addition to indicating the relationship between relative changes in the prices and quantities of the factors, the coefficients may also reflect changes in the degree of disequilibrium in a dynamic economy, technological changes that are not neutral with respect to labor and capital requirements per unit of output, and so on. Nevertheless, the coefficients are useful summary measures of the historical relationship between relative changes in prices and quantities (we shall refer to them simply as "coefficients" in order to remind the reader of the several forces that may affect the relationship).

One way of estimating the coefficient of substitution is as the quotient of the two rates given above: 0.55/0.80 = 0.69. An alternative formula involves the difference between the growth rates of capital and labor inputs, divided by the difference between the growth rates of the real prices of labor and capital. Presumably, the small difference between the two estimates is due to rounding of the underlying index numbers and the derived rates of change. The coefficient of substitution estimated here compares to one of 0.58 I estimated for the period 1919-60 in the article cited earlier.[6] It is even closer to an estimate by Kravis of 0.64.[7]

The rates of change in factor shares can be related directly to the coefficient of substitution.[8] Thus, the growth rate of the labor share can be estimated as the difference between the rates of growth in real labor and capital inputs (0.89 - 3.52 = -2.63) times 1 minus the reciprocal of the coefficient of substitution (1 - 1/0.66 = -0.52), weighted by the share of capital in factor income, 0.25. The result is 0.3, which approximates the rate of growth of the labor share (with allowance for rounding errors). In other words, with a coefficient of substitution of less than unity, the factor with a relative decline of input obtains an increasing share of income. Given the relative growth of the factor inputs 1948-66, the coefficient of 0.66 is consistent with the increases in the real price of labor and its share of income as we have estimated them.

It has been argued that these relationships, and the market mechanisms

[6] Kendrick and Sato, p. 981.

[7] Irving B. Kravis, "Relative Income Shares in Fact and Theory," *American Economic Review*, December 1959, pp. 917-49.

[8] Kendrick and Sato, Appendix A, equations 14 and 15.

which facilitate them, augur well for the viability of the American economy.[9] That is, there appears to have been no pronounced long-run trend in the rate of return on capital, despite a significant fraction of income saved. Further, the rate of return has generally been adequate to induce a volume of tangible investment consistent with a high level of employment of resources. The rate of investment has provided a significant rate of increase in real capital stock and input per worker and per unit of labor input. As a result of the increasing relative abundance of capital and relative scarcity of labor, real income per unit of labor input has risen even faster than labor productivity. Given a historical coefficient of substitution of less than unity, as we have seen, this means that labor's share of factor income has risen.

Some economists argue that a rising labor share of income has made it easier to sustain adequate levels of aggregate demand. We would stress, rather, the development of built-in stabilizers and more informed macroeconomic stabilization policies as an explanation for the steadier rate of economic growth since World War II. Whatever its sources, the steadier growth of recent decades has been associated with a reduced variability in rates of productivity advance, as documented in Chapter 3.

Causal Factors Behind Productivity Advance

The analysis of the causal factors behind productivity advance is extremely complex. The purpose of this section is not to undertake such an analysis. Rather, my approach to the subject will be sketched briefly, with reference to a related study I am currently conducting for the National Bureau of Economic Research. In that study we present estimates of total investment and capital stocks, and analyze their relationship to economic growth.[10]

It is our basic hypothesis that the chief proximate determinant of productivity advance is the growth of the real stock of intangible capital resulting from investments designed to increase the quality, or productive efficiency, of the tangible human and nonhuman factors of production. In *Productivity Trends* (pp. 104-10), we alluded to outlays for research and development, education and training, and medical care as "hidden investments." They are

[9] Ibid.

[10] See *Forty-seventh Annual Report*, NBER, pp. 9-15. A preliminary summary of the findings is presented in John W. Kendrick, "The Treatment of Intangible Resources as Capital," *Review of Income and Wealth*, March 1972, and in Kendrick, "Economic Impacts of Scientific and Technological Progress," in Helen Perlman, ed., *The Research Revolution and the Outlook for R&D in the 1970's*, Menlo Park, Calif., Pacific Books, Inc., forthcoming.

indeed investments, in the same sense as tangible capital outlays, to the extent that they increase output- and income-producing capacity in future accounting periods. They are "hidden" in that they are not officially recognized as investments in the income and product accounts. Indeed, some of the intangible investments are not even included in the Commerce Department estimates, particularly those which are charged to current expenses by business, and those which involve imputations, such as the opportunity cost of students.

In the companion study, we have prepared comprehensive estimates of intangible investments, by type and by sector, in current and constant dollars for the period since 1929. Further, we have developed experimental estimates of the stocks of intangible capital, in current and constant dollars, for the same period, also by type and by sector of ownership and of use. Preliminary results indicate that there has been a substantial rise since the 1920s not only in intangible investment as a proportion of GNP but also in real stocks of intangibles in relation to real tangible capital stocks. However, presentation of our finished estimates, description of the sources and methods of estimation, and a summary of the findings will have to await completion of the study now in progress.

We recognize, of course, that there are factors other than the growth of intangible capital stocks which may have an important bearing on productivity changes. In the short run, productivity change appears to have a systematic relationship with the business cycle, as discussed in Chapter 3. Chief among the longer-term factors are: changes in the degree of economic efficiency as reflected in the allocation of resources, including the speed of adjustment to dynamic changes in the economy; the rate of diffusion of innovations; economies of scale, both internal and external, which are progressively affected by technological advance; and the average inherent quality of human and natural resources which reflect changes in the resource mix as well as possible trends within given resource categories. If analysis is confined to the private economy, there is also the additional factor of the changing volume of governmental inputs that affect productivity trends in the private sectors.

More fundamental are the basic values and socioeconomic institutions of society. Whereas these generally change slowly with regard to their net impact on productive efficiency and technological change, differences in values and institutions among regions and nations are presumably an important element in explaining differences in productivity levels and rates of change.