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CHAPTER 7

Relative Changes in Productivity, Prices, and Resource Allocation

THUS far in Part III we have reviewed productivity movements in the various industries and industry groupings and have suggested some of the chief factors that may explain the different rates of change. It remains to explore the impact on economic structure of industry productivity changes.

Briefly, in this chapter it will be demonstrated that there is little connection between relative changes in productivity and factor prices in the several industries; there is, consequently, a significant negative correlation between relative changes in productivity and product prices. Through its effect on price, productivity is one of several factors affecting relative changes in quantities produced. On the average, the industry groupings of firms that increase their productive efficiency relative to the economy average are able to reduce the prices of their products relative to the general price level and thereby gain an increasing share of the market. Given relative changes in output, relative changes in productivity and factor substitutions provide a statistical explanation of relative changes in resource employment in the several industries. Firms in the technologically more progressive industries have tended to increase their employment of labor and use of capital somewhat more than industry as a whole—a fact which contradicts the notion of "technological unemployment" in any long-run sense.

Relative Changes in Productivity and in Prices

The interrelationship among productivity, product price, and factor price at the economy level was developed in Chapter 5. The interrelationships at the industry level are analogous, but more complex. Certain more or less realistic assumptions can be made, however, in order to simplify the relationship.

COMPONENTS OF INDUSTRY PRICE CHANGE

At the industry level, the basic identity of national product originating (at factor cost) with the quotient of factor price (product per unit of real input) and factor productivity holds, as at the economy level. To repeat the identity, but using *VA* (value added) as the symbol for national product originating in an industry:

$$VA/O = (VA/I) \div (O/I)$$

But this formulation does not tell us what we want to know about price. For the economy, the sum of the value added in each industry is equal to the value of all final products, to which a general price index for the economy applies. But in a component industry, value added is only a part of the value of production. The value of purchased intermediate products (materials and services) is the other part, to which value is added by processing within the given industry, i.e., by applying the services of labor and capital commanded by the given industry to the products purchased from other industries. So value added per unit of industry output is not the whole story of what happens to price, which also reflects prices of intermediate products. The value of production per unit of output (VP/O) is the relevant variable. Unit value of production would have the same movement as a variable-weighted price index if units of all types of output were separately weighted by base-period prices. In practice, there is generally some difference in movement between the unit value and the price of the output of an industry because, first, outputs are often measured in terms of somewhat heterogeneous units, so shifts in composition of output as well as changes in the price of identical units over time affect unit value; and, second, price and output indexes generally involve differing degrees of imputation, and weighting systems may not be fully consistent.

In the empirical investigation that follows, unit value indexes will be generally employed as price indicators since they are statistically consistent with the other variables of the system. Unit value indexes have another advantage over price indexes: They reflect changes in net realized price, which is desired, whereas price indexes are usually based on quoted prices, with more or less inadequate allowance for changes in discounts and other terms of sale. One drawback to their use is that errors in the output indexes and therefore in the productivity indexes affect the unit value indexes to the same degree in the opposite direction. Therefore, coefficients of correlation between relative changes in unit value and in productivity may contain a spurious element of uncertain magnitude. As a check on correlations involving unit value, therefore, we shall occasionally substitute price indexes since their derivation is wholly independent of the productivity variable.

Now, if we substitute unit value for unit value added in the left-hand side of the previous equation, we shall have to add the variables that explain changes in materials cost per unit of output (VM/O) to the right-hand side. Unit materials cost is the product of the price of materials and unit materials requirements. The price of materials may be expressed as

VM/M, where M is the physical volume of purchased materials (and services), obtained in practice by deflating the value of materials by the prices of the various intermediate products purchased by the given industry. Unit materials requirements (M/O) is the inverse of the "partial intermediate-product productivity ratio," if we wish to maintain parallelism with the partial factor productivity terminology. If consistent index numbers are used as the variables, the two terms on the right-hand side will have to be weighted by the base-period proportions of the value of product accounted for by value added and by value of purchased materials and services, designated by the subscripts *wa* and *wm*, respectively. Thus:

$$\frac{VP}{O} = \left(\frac{VA}{I} \div \frac{O}{I}\right)_{wa} + \left(\frac{VM}{M} \div \frac{O}{M}\right)_{wm}$$

An identity of this sort obviously does not explain the causal factors behind price change generally—the factors that cause changes in money demand to deviate from changes in the supply of goods. But the variables in the identity do enable us to analyze the components of a given relative price change. Also, given the rate of productivity advance in an industry and its unit materials cost, we can specify the change in factor price that is consistent with stable product prices.

PRODUCTIVITY-PRICE RELATIONS IN ILLUSTRATIVE INDUSTRY GROUPS

To indicate the type of price analysis that is possible when the several productivity and price variables identified in the equation above are known, we shall present the relevant index numbers for two important groups in the economy, farming and manufactured foods. These groups were chosen primarily because relatively good estimates could be prepared for all the variables. They are also suitable for illustrative purposes because of their different behavior.

The figures for the farm sector are shown in Table 52. Percentage changes in the variables over the entire period can be seen in the last line of the table. Between 1899 and 1953, composite factor price (wage rates and the unit compensation of capital), computed as the quotient of value added (national income) per unit of real factor input, rose over eightfold (column 3). But productivity (physical volume of gross output per unit of real factor input) more than doubled (column 4); so value added per unit of output increased by 233 per cent (column 2). The price of purchased materials and services consumed in the production process more than tripled over the period. This was far less of an increase than that in factor price; but materials consumption per unit of output, instead of declining, as did factor use per unit of output (the inverse of factor productivity), rose about two-and-one-half times (column 7). Thus,

TABLE 52

Farm Segment: Productivity and Prices of Outputs and Inputs, Key Years and Subperiods, 1899–1953

	Unit Value of Output[a] *(price)*	*Value Added Per Unit of*		*Productivity*	*Cost of Materials Per Unit of*		*Unit Materials Requirements*	*Relative Weight of Materials (per cent)*
		Output[b]	Input		Output[c]	Materials Input		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				INDEX (1929 = 100)				
1899	41.5	44.6	37.7	84.6	30.3	47.2	64.3	
1909	64.7	69.9	58.7	84.0	45.1	64.0	70.4	
1919	143.6	150.6	128.9	85.6	117.6	133.7	88.0	
1929	100.0	100.0	100.0	100.0	100.0	100.0	100.0	21.4
1937	81.2	79.5	85.1	107.1	87.8	86.1	102.0	
1948	187.5	171.6	283.8	165.4	246.2	162.0	152.0	
1953	170.8	148.5	307.2	206.8	252.9	154.6	163.6	
				LINK RELATIVES				
1899–1909	155.9	156.7	155.7	99.3	148.8	135.6	109.5	15.6
1909–19	221.9	215.5	219.6	101.9	260.8	208.9	125.0	14.8
1919–29	69.6	66.4	77.6	116.8	85.0	74.8	113.6	17.4
1929–37	81.2	79.5	85.1	107.1	87.8	86.1	102.0	21.4
1937–48	230.9	215.8	333.5	154.4	280.4	188.2	149.0	23.0
1948–53	91.1	86.5	108.2	125.0	102.7	95.4	107.6	28.0
1899–1953	411.6	333.0	814.9	244.4	834.7	327.5	254.4	15.6

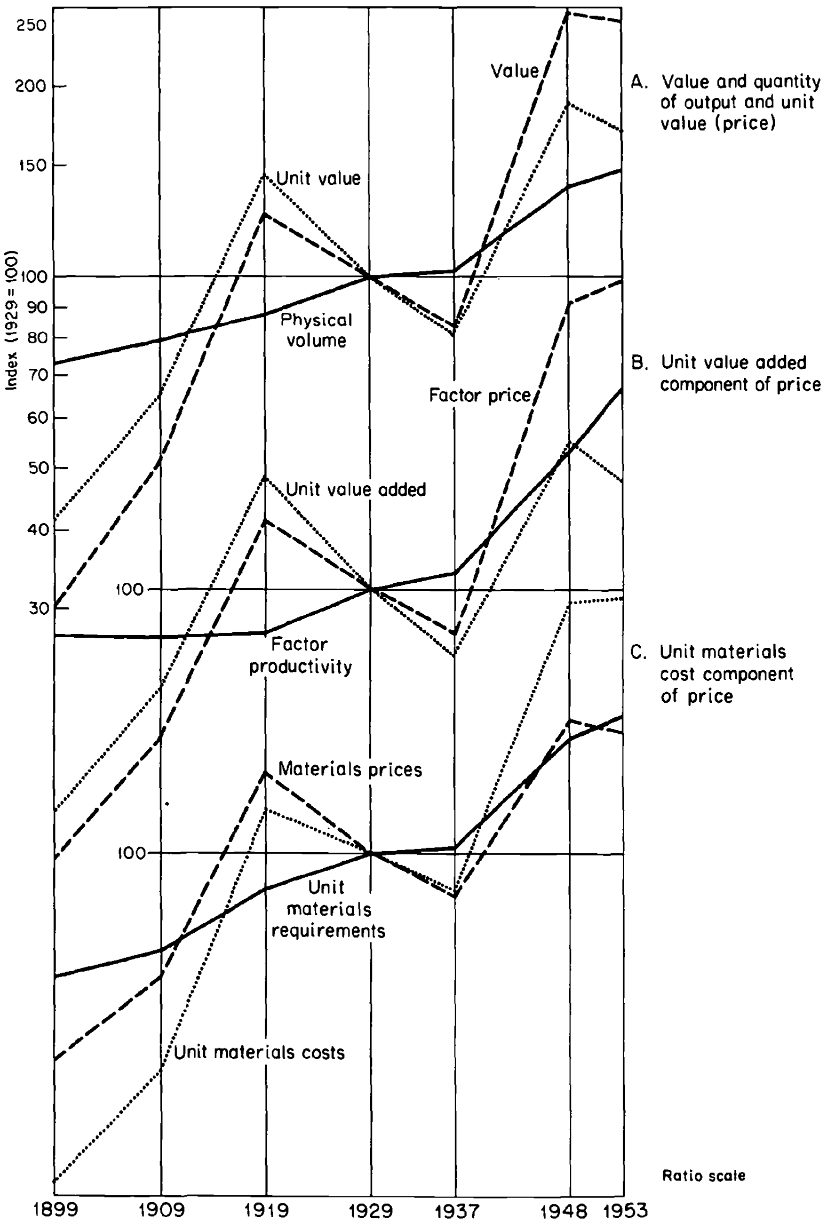
[a] Price is gross value of product divided by gross output. It may also be derived as the weighted average of value added per unit of output (col. 2) and cost of materials per unit of output (col. 5); weights for materials are given in col. 8; for value added, 100 – col. (8).

[b] Col. (3) divided by col. (4).

[c] Col. (6) times col. (7).

CHART 20

Farm Segment: Components of Price Movements, Key Years, 1899–1953



materials cost per unit of output (column 5) went up more than eightfold, compared with the tripling of factor cost per unit of output. But the effect of the very large increase in unit materials cost on final price was substantially mitigated by the relatively low proportion—16 per cent—of total cost accounted for by materials purchases in 1899, the base period for this comparison. The net effect of the several changes was a little more than fourfold increase in the average price (unit value) of output (Chart 20).

The manufactured-foods group (Table 53) differs in several respects from the farm sector. The average price (unit value) of output approximately tripled between 1899 and 1953. Value added per unit of output quadrupled, but the cost of materials per unit of output rose to only 263 per cent of the base value. In contrast to farming, materials accounted for a large proportion of total cost in the base period, and the change in unit materials cost dominated the movement of manufactured-foods prices.

The fourfold increase in unit value added was the resultant of a tenfold increase in factor price (value added per unit of input) reduced in its impact on value added per unit of output by an almost two-and-one-half-fold increase in total factor productivity, which amounts to a 60 per cent decline in real factor cost per unit of output.

Materials prices averaged better than a threefold increase over the fifty-four-year period, but the effect of this rise on materials costs per unit of output was cushioned by a reduction of one-fourth in materials requirements per unit of output. As a result, both unit materials costs and final prices of manufactured foods increased less than threefold over the period.

The reduction in unit materials requirements was largely the result of a shift in the product-mix of the industry toward more highly processed foods, but there was some saving of materials in the individual component industries. It will be noted that the reduction of materials requirements was accomplished in the 1899–1937 period; since 1937, unit materials requirements have increased somewhat. It is also striking that the very large productivity advance of the 1920's has not been closely approached either before or since that decade.

RELATIVE CHANGES IN PRODUCTIVITY, COSTS, AND PRICES

If one had consistent estimates for all industries of the four variables into which price changes can be decomposed, then relative price changes could be subject to full statistical description. It is interesting and useful, however, to see to what extent relative productivity changes alone can explain relative changes in prices or in unit values of output. An annex has been included at the end of this chapter, presenting most of the variables with which productivity has been correlated in the subsequent sections.

TABLE 53

Manufactured-Foods Industry:[a] Productivity and Prices of Outputs and Inputs, Key Years and Subperiods, 1899–1953

	Unit Value of Output[b] *(price)*	*Value Added Per Unit of*		*Productivity*	*Cost of Materials Per Unit of*		*Unit Materials Requirements*	*Relative Weight of Materials (per cent)*
		Output[c]	Input		Output[d]	Materials Input		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				INDEX (1929 = 100)				
1899	63.9	44.9	27.2	60.6	71.1	55.8	127.5	
1909	74.8	53.2	34.5	64.9	83.1	67.9	122.4	
1919	151.4	104.4	69.0	66.1	169.5	155.9	108.7	
1929	100.0	100.0	100.0	100.0	100.0	100.0	100.0	72.1
1937	85.1	83.1	93.5	112.5	85.9	89.7	95.8	
1948	186.2	170.4	225.3	132.2	192.4	204.0	94.3	
1953	185.2	180.8	266.4	147.3	186.9	187.3	99.8	
				LINK RELATIVES				
1899–1909	117.1	118.5	126.8	107.1	116.9	121.7	96.0	80.4
1909–19	202.4	196.2	200.0	101.8	204.0	229.6	88.8	80.1
1919–29	66.1	95.8	144.9	151.3	59.0	64.1	92.0	80.7
1929–37	85.1	83.1	93.5	112.5	85.9	89.7	95.8	72.1
1937–48	218.8	205.1	241.0	117.5	224.0	227.4	98.4	72.7
1948–53	99.5	106.1	118.2	111.4	97.1	91.8	105.8	74.4
1899–1953	289.8	402.7	979.4	243.1	262.9	335.7	78.3	80.4

[a] This table represents a special study of the foods group. The output index is based on complete coverage of food industries, using deflated value when no quantity data are available; in other tables the output index is based on quantity data, by industry, with an adequacy adjustment to estimate full coverage for the group. The index of materials prices is based on a Marshall-Edgeworth weighted average of deflated materials costs (computed for each industry in the foods group); in the other tables the materials price index was imputed from the ratio of the sum of materials costs in current and constant dollars. In other tables for other groups, the materials price index was computed for the group as a whole on the basis of weights obtained from the BLS Interindustry Relations Study, 1947, Division of Interindustry Economics, October 1952.

[b] Price is computed from value of product in index form divided by the output index. It may also be derived as the weighted average of value added per unit of output, col. (2), and cost of materials per unit of output, col. (5); weights are given for materials in col. (8), for value added, 100 – col. (8).

[c] Col. (3) divided by col. (4).

[d] Col. (6) times col. (7).

Before correlating these variables, it will be helpful to investigate the relationship between productivity changes and changes in each of the other three price-related variables. If, for example, there were highly positive correlations between changes in productivity and changes in factor prices, or in unit materials costs, or both, then relative changes in real factor costs per unit of output (the inverse of productivity) would be offset by relative changes in the opposite direction in the other cost elements, and the degree of correlation between relative changes in prices and in productivity would be low. That is, productivity gains in varying amounts would accrue to the factors or to suppliers of materials, and relative prices would not change.

Actually, we know that there are substantial relative changes in prices. Economic theory suggests that factor prices, rather than product prices, in the various industries tend to show the same proportionate changes under competitive conditions, given time for labor and capital to flow into the industries in which factor prices have risen relatively and out of those in which their unit compensation is temporarily depressed. Under these conditions, there should be little relationship between relative changes in productivity and factor prices, but a high degree of correlation between relative changes in productivity and in unit value added. It is more difficult to argue a priori with respect to the relative movements of productivity and unit materials costs. But if relative industry efficiency in the use of factors carried over to the use of materials, then there should be a negative rather than a positive relationship between relative changes in productivity and in unit materials cost.

Relative changes in factor prices. Analysis of the data bearing on the subject can be carried out by relating relative productivity changes to changes in average hourly earnings and in the price of capital separately, and then to total factor compensation per unit of input.

That changes in the average hourly earnings of labor are not closely related to productivity changes is indicated by our estimates of the former for the key years. The interindustry structure of average hourly earnings has not changed very much over the various subperiods of the fifty-four-year period, as shown by relative rankings of the thirty-three industry groups in this respect in Table 54. For percentage changes in average hourly earnings in the various groups relative to the mean change, the coefficient of variation is +.14 for the long period and averages +.09 for the six subperiods; this is considerably less than the coefficient of variation of percentage changes in productivity (cf. Table 36). Serial correlation of the group ranks with respect to average hourly earnings in each subperiod with ranks in the previous subperiod yields coefficients above +.9 in all subperiods except between the first two.

TABLE 54

Ranking of Average Hourly Earnings in Thirty-three Industry Groups, Subperiods, 1899–1953

	1899–1953[a]	1899–1909	1909–1919	1919–1929	1929–1937	1937–1948	1948–1953
Farming	1	1	1	1	1	1	1
Mining							
Metals	16	31	31	15	13	15	15
Anthracite coal	31	24	27	32	30	31	30
Bituminous coal	32	29	33	30	23	32	31
Oil and gas	24	14	29	25	20	21	21
Nonmetals	7	32	13	6	5	4	7
Manufacturing							
Foods	11	15	14	12	9	10	12
Beverages	27	33	32	31	28	18	18
Tobacco	2	7	2	2	2	3	3
Textiles	4	2	5	3	4	6	5
Apparel	12	9	19	20	14	11	8
Lumber products	3	3	3	4	3	2	2
Furniture	5	6	7	8	6	5	6
Paper	13	5	9	9	12	16	16
Printing, publishing	29	28	23	28	32	29	27
Chemicals	22	22	21	22	21	20	25
Petroleum, coal products	33	16	24	27	33	33	33
Rubber products	23	17	22	23	25	23	22
Leather products	8	8	12	11	8	7	4
Stone, clay, glass	15	18	16	17	16	14	14
Primary metals	28	26	30	29	27	27	28
Fabricated metals	18	20	18	21	18	17	17
Machinery, nonelectric	25	27	25	24	24	22	23
Electric machinery	19	25	20	19	22	19	19
Transportation equipment	30	10	28	33	31	30	29
Miscellaneous	14	19	15	18	17	13	13
Transportation							
Railroads	10	4	10	13	15	9	10
Local transit	9	12	8	10	10	12	9
Communications and public utilities							
Telephone	21	21	11	16	26	26	20
Telegraph	6	11	4	5	7	8	11
Electric utilities	26	30	26	26	29	28	26
Manufactured gas	17	13	6	7	11	25	32
Natural gas	20	23	17	14	19	24	24

[a] Rank of average of absolute hourly earnings in subperiods weighted by length of each subperiod. Hourly earnings for each subperiod represent an average of hourly earnings in the terminal years of the subperiod.

So it is not surprising that the coefficient of rank correlation between proportionate changes in productivity and in average hourly labor compensation, while positive, is barely significant, either over the long period or the subperiods, for the thirty-three groups or the eighty manufacturing industries (see Table 55). It will be noted that the highest coefficients are

TABLE 55

Coefficients of Rank Correlation[a] of Relative Changes in Productivity and in Factor Prices, Subperiods, 1899–1953

	1899–1953	1899–1909	1909–1919	1919–1929	1929–1937	1937–1948	1948–1953
33 industry groups							
Total productivity versus							
Average hourly labor compensation	0.24	−0.33	0.24	0.0	0.41	0.14	0.11
Capital compensation per unit	0.22[b]				0.20	−0.35	0.04
Factor compensation per unit	0.05	−0.22	0.03	0.19	0.62	−0.22	−0.01
Capital compensation per unit versus average hourly labor compensation	0.11[b]				0.13	0.19	0.19
80 manufacturing industries[c]							
Output per manhour versus average hourly labor compensation	0.26	0.39	0.27	0.21	0.44	0.42	0.20

[a] For $N = 33$, the value of the coefficient of rank correlation which is significant at the 0.05 level is 0.31; at the 0.01 level, 0.43. For $N = 80$, the comparable figures are 0.22 and 0.28.

[b] 1929–53.

[c] For the eighty manufacturing industries, the long period refers to 1899–1954, and the last two subperiods are 1937–47 and 1947–54.

for 1929–37. Apparently, relative changes in productivity are a more important determinant of changes in industry wage rates in a period of subnormal aggregate demand than at other times. Note that in the eighty manufacturing industries, in which average hourly earnings are probably less influenced by changing occupational structure, percentage changes in average hourly earnings are often more closely correlated with percentage changes in output per manhour in the subperiods than over the long period. It seems logical that the longer the period for adjustments, the more nearly alike will be the movements of wage rates. Over time, competition will tend to equalize changes in rates of compensation in the various industries—except insofar as these are a result of changing occupational structure or changes in basic supply and demand forces that alter the relation of wage rates among occupations.

Estimates of compensation per unit of real capital services are of poorer quality than the labor compensation estimates, particularly before 1929. But essentially the same result emerges from a correlation between proportionate changes in capital compensation per unit and in productivity. While the coefficient is positive in two out of three subperiods, it is not significantly high. The relatively high negative coefficient of rank correlation in the 1937–48 subperiod is interesting. With a high aggregate demand in the latter year, profitability was more affected by demand factors (such as war-born backlogs of requirements in certain areas) than by unit costs, although the firms of some industries set their own price ceilings.

Changes in total compensation per unit of composite factor input show a coefficient of rank correlation with productivity changes of less than +.1 for the long period; in three of the subperiods the coefficient was negative; and in all except that of 1929–37 it was low (see Table 55). This being so, one would expect a high negative correlation between relative industry changes in value added per unit of output and in productivity. The coefficient shown in Table 57 is —.74; while significant, it is not as high as might be expected, because the census value-added estimates used in getting most of the unit value-added figures for the correlation include certain intermediate services as well as factor compensation proper. Also, our capital compensation estimates are not necessarily consistent with the value-added figures.

But we are more interested in total unit values or prices of industry outputs than in unit values added since the former are the prices that influence sales. The extent to which relative industry price changes may be explained by relative productivity changes depends not only on factor prices but also on the patterns of change in the unit value of purchased materials and services, to which we now turn.

Relative changes in unit materials costs. The cost of purchased materials per unit of output is the product of the quantity of materials consumed per unit and the prices of the materials. Correlating the ranks of the percentage changes in each of these variables with percentage changes in productivity over the long period, we obtain a coefficient of almost —.4 in each case (see Table 56).

It is of interest that those industries with higher-than-average increases in factor productivity also tend to have larger-than-average savings in materials. This suggests that management efficiency in use of the factors carries over with respect to the use of intermediate products, and/or that the industries with relative increases in productivity tend also to be industries in which there are relative increases in the degree of processing of purchased materials. Perhaps an increasing degree of processing generally or a shift in the composition of output to types of products requiring greater processing offers improved opportunities for productivity advance. It is not as easy to suggest reasons why the prices of purchased materials should fall relatively in the industries experiencing relative productivity increases.

TABLE 56

Coefficients of Rank Correlation[a] of Relative Changes in Productivity and in Unit Cost of Materials, Thirty-three Industry Groups, Subperiods, 1899–1953

	1899–1953	1899–1909	1909–1919	1919–1929	1929–1937	1937–1948	1948–1953
Total factor productivity versus							
Materials cost per unit of output	−0.59	−0.55	−0.50	−0.58	−0.55	−0.36	−0.52
Real materials cost per unit	−0.39	−0.36	−0.38	−0.25	−0.22	−0.15	−0.10
Value (price) of materials per unit	−0.38	−0.37	−0.01	−0.51	−0.50	−0.28	−0.52
Real materials cost per unit versus materials price	−0.22	−0.16	−0.21	−0.22	−0.05	−0.04	−0.13

[a] For $N = 33$, the value of the coefficient of rank correlation which is significant at the 0.05 level is 0.31; at the 0.01 level, 0.43.

When relative productivity changes are correlated with the costs of purchased materials per unit of output, the coefficient (—.59) is substantially higher than is obtained using changes in either of the cost components. The result reflects a slight negative correlation between relative changes in unit consumption and prices of purchased materials (see Table 56). Apparently, industries facing relative increases in materials prices make more strenuous attempts to economize on materials or to substitute other inputs, but such possibilties are limited.

Relative changes in unit values of output. To the extent that there have been variations in the relative movements of factor prices and of materials costs per unit of output associated with relative changes in productivity, the degree of correlation between relative changes in productivity and prices will be reduced. Relative changes in factor prices have not been great, and neither has their degree of correlation with relative productivity changes. Relative changes in unit materials costs have been much greater than those in factor prices, and their degree of correlation with relative productivity changes has been substantially greater, although still not high. Therefore, it is not surprising that the coefficients of correlation between changes in productivity and in unit value or price are significant at the 1 per cent level (see Table 57 and Chart 21).

Although productivity is but one of four variables into which relative price change can be decomposed, the coefficient of rank correlation of —.72 between relative changes in productivity and in unit value means that approximately one-half of the variance in changes of unit values is explained by productivity changes. The coefficients of correlation are almost as high in relationships between relative changes in output per manhour and in unit values of output for the eighty manufacturing industries and the twelve farm groups.

TABLE 57

Coefficients of Rank Correlation[a] of Relative Changes in Unit Values or Prices and in Productivity or Related Variables, Subperiods, 1899–1953

	1899–1953	1899–1909	1909–1919	1919–1929	1929–1937	1937–1948	1948–1953
33 industry groups							
Total factor productivity versus							
Unit value added	−0.74	−0.79	−0.65	−0.46	−0.29	−0.64	−0.68
Unit value of output	−0.72	−0.74	−0.59	−0.61	−0.44	−0.60	−0.66
Price	−0.55	−0.62	−0.49	−0.60	−0.23	−0.41	−0.49
Unit labor cost versus							
Unit value of output	0.62	0.63	0.64	0.78	0.75	0.80	0.64
Price	0.55	0.47	0.50	0.69	0.41	0.68	0.64
80 manufacturing industries[b]							
Output per manhour versus unit value of output	−0.57	−0.76	−0.41	−0.54	−0.73	−0.33	−0.49
Unit labor cost versus unit value of output	0.69	0.76	0.61	0.70	0.74	0.72	0.49
12 farm groups[c]							
Output per manhour versus price	−0.55		−0.32	−0.43	0.03	0.31	−0.27

[a] Significance of rank correlation coefficients:

N	*0.05 Level*	*0.01 Level*
12	0.51	0.71
33	0.31	0.43
80	0.22	0.28

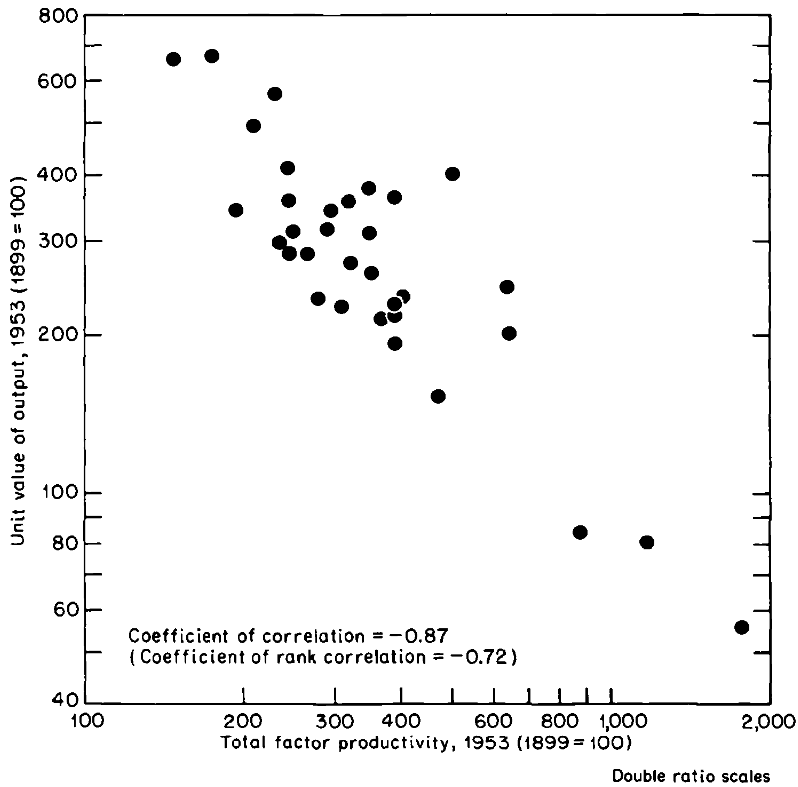
[b] For the eighty manufacturing industries, the long period refers to 1899–1954, and the last two subperiods are 1937–47 and 1947–54.

[c] For the twelve farm groups, the long period covers 1910–53, and the first available subperiod covers 1910–19.

It will be noted in Table 57 that the coefficient of correlation is not as high when changes in composite price indexes are used in the relationship instead of changes in unit values. As mentioned earlier, the unit value measures rest on the same output indexes that are used in the productivity calculations. Therefore, to the extent that there are errors in the output measures, the degree of correlation between changes in unit values and changes in productivity is overstated.

CHART 21

Thirty-three Industry Groups: Relation between Total Factor Productivity and Unit Value of Output, 1953 Relative to 1899



In the thirty-three groups, the degree of association between changes in productivity and changes in both unit values and prices has generally been lower in the subperiods since 1929 than earlier.

In Table 57, we have also shown coefficients of rank correlation between relative changes in prices and in unit labor costs (labor cost per unit of output). Although unit labor cost indexes are the quotient of average hourly earnings and output per manhour and thus measure but partially two of the four component variables of price change, the coefficients are almost as high as those obtained from relationships between productivity and prices (disregarding sign). This reflects the heavy weight of labor in both the productivity and the factor price measures.

A comparison of total factor productivity and prices reveals that relative changes in prices are less than proportionate to relative changes in productivity. A regression equation fitted to the percentage changes in the two sets of estimates for the thirty-three groups indicates that a 10 per cent change in productivity is associated with an 8 per cent change in price, on the average.[1] It is consistent with this relation that the dispersion of relative price changes is less than the dispersion of relative productivity changes: the coefficient of variation for proportionate changes in productivity in the thirty-three groups, 1899–1953, is +.46, whereas for unit value it is +.34. This is consistent with the fact that high-productivity industries tend also to reduce their unit materials cost more than average.

Relative Changes in Output, Productivity, and the Employment of Resources by Industry

Relative changes in output of the various industries of the economy are the result of three major sets of forces: (1) the income elasticities of demand for the various groups of products by which the industries are distinguished; (2) the price elasticities of demand for the various groups of products; and (3) shifts in demand as tastes of consumers change and new or modified products are introduced.

It is not our purpose here to present a full statistical explanation of changes in relative demand; instead, we shall focus on the relative changes in the distribution of resources among industries that result from relative changes in productivity. The main question to be answered is whether or not the interaction of relative changes in output and in productivity, acting through relative price changes and the other demand variables, has operated to produce a positive association with relative changes in productivity and in resource employment. If not, then the industries with greater-than-average productivity gains would be characterized by a declining proportion of the resources employed in the economy. Our analysis will show that the reverse tendency has prevailed over the longer periods.

RELATIVE CHANGES IN OUTPUT, PRICES, AND PRODUCTIVITY

Output and prices. There is a significant negative correlation between relative changes in productivity and prices; if there is likewise a negative association between relative changes in prices and in output, as would be expected, then it follows that productivity and output will be positively associated. Table 58, showing average annual percentage changes in

[1] The regression equation fitted to the logarithms of index numbers of unit values (y) and logs of index numbers of productivity (x) for 1953 (1899 = 100) is:

$$y = 4.7267 - 0.9013x$$
$$r = -.87$$

output by segment and by group for the long period, 1899–1953, and the subperiods, is provided for reference purposes. It will be noted that the dispersion of relative output changes is considerably greater than the dispersion of relative changes in productivity—more so for the long period

TABLE 58

Private Domestic Economy: Average Annual Rates of Change in Physical Volume of Output, by Segment and by Group, with Measures of Dispersion, Subperiods, 1899–1953 (per cent)

	Pre-1899	1899–1909	1909–1919	1919–1929	1929–1937	1937–1948	1948–1953	1899–1953	Mean Deviation of Subperiod Rates from Secular Rate
Farming	2.6	0.7	0.6	1.0	0.2	1.4	0.4	0.8	0.4
Mining	5.9	5.9	2.2	3.8	−0.5	3.1	0.7	2.8	1.6
Metals		5.5	0.9	3.2	−0.2	0.1	1.8	1.9	1.8
Anthracite coal		3.0	0.8	−1.8	−4.3	0.9	−11.6	−1.2	3.1
Bituminous coal		7.0	2.1	1.4	−2.3	2.7	−5.3	1.6	2.6
Oil and gas		7.3	7.3	9.1	2.6	4.2	4.8	6.1	2.0
Nonmetals		7.9	−0.5	7.5	−4.4	5.4	5.2	3.6	3.9
Manufacturing	4.8	4.7	3.5	5.1	0.4	5.4	5.7	4.1	1.4
Foods		4.0	3.8	4.4	0.5	3.6	2.0	3.3	1.0
Beverages		3.9	−9.6	−4.5	27.2	6.3	0.7	2.9	8.3
Tobacco		3.8	5.0	3.7	2.0	4.3	1.8	3.6	0.8
Textiles		4.1	1.6	3.5	1.0	3.7	0.8	2.7	1.2
Apparel		5.3	2.4	4.5	0.5	3.6	2.1	3.3	1.4
Lumber products		2.5	−2.7	1.3	−3.6	3.0	2.0	0.4	2.4
Furniture		2.9	0.3	7.0	−3.3	6.9	2.8	3.0	3.0
Paper		7.2	3.7	6.6	2.5	4.5	4.8	5.0	1.4
Printing, publishing		7.6	4.3	6.4	0.2	3.4	2.8	4.3	1.9
Chemicals		5.4	5.1	6.9	2.7	8.7	8.7	6.2	1.7
Petroleum, coal products		6.4	9.3	9.9	1.6	5.3	4.8	6.5	2.3
Rubber products		6.0	21.4	6.4	−1.2	5.9	4.6	7.5	5.1
Leather products		2.6	0.8	1.0	1.0	0.9	−0.1	1.1	0.5
Stone, clay, glass		6.5	−0.1	6.0	−0.1	5.4	3.9	3.7	2.5
Primary metals		7.2	3.6	4.9	−1.4	5.5	3.8	4.1	1.9
Fabricated metals		7.2	3.8	5.2	−0.8	6.2	11.5	5.2	2.3
Machinery, nonelectric		4.7	5.2	3.1	0.1	7.3	5.6	4.4	1.8
Electric machinery		9.2	9.4	8.0	−0.8	9.4	12.7	7.9	2.6
Transportation equipment		3.9	19.0	5.1	−1.2	5.5	13.7	7.2	5.5
Miscellaneous		6.4	2.4	3.7	0.8	7.1	5.9	4.4	2.1
Transportation	7.4	4.6	3.9	2.0	0.4	6.8	1.6	3.5	1.9
Railroads		6.1	4.4	0.8	−2.6	5.2	−1.5	2.6	3.0
Local transit		7.4	3.9	2.6	−2.5	3.6	−8.7	2.0	3.4
Residual transport		−0.7	1.8	6.7	7.5	7.5	8.0	4.7	3.2

(continued)

TABLE 58 (concluded)

Private Domestic Economy: Average Annual Rates of Change in Physical Volume of Output, by Segment and by Group, with Measures of Dispersion, Subperiods, 1899–1953
(per cent)

	Pre-1899	1899–1909	1909–1919	1919–1929	1929–1937	1937–1948	1948–1953	1899–1953	Mean Deviation of Subperiod Rates from Secular Rate
Communications and public utilities	6.8	12.9	7.3	8.1	1.8	7.3	6.1	7.5	2.2
Telephone		18.2	4.9	7.5	−0.9	7.2	2.6	7.1	4.1
Telegraph		3.7	2.6	8.0	−2.0	0.2	−2.4	2.1	2.9
Electric utilities		17.1	14.0	10.8	4.1	7.8	9.3	10.7	3.5
Manufactured gas		9.3	6.5	3.5	−1.3	4.5	−2.0	4.0	3.0
Natural gas		8.4	4.8	5.1	3.5	8.4	11.9	6.7	2.3
Residual sector	4.1	4.2	3.0	3.7	−0.2	4.3	5.3	3.3	1.2
Construction	4.3	5.7	−2.9	5.9	−5.9	7.2	5.6	2.6	4.7
Trade	4.6	3.9	2.2	4.2	0.5	4.4	2.6	3.1	1.2
Finance and services	5.4	5.2	2.5	3.4	−1.4	3.6	4.3	3.0	1.5
Private domestic economy	4.5	4.2	3.0	3.7	0.1	4.5	4.4	3.3	1.1
Mean deviation of 8 segment rates from economy rate	0.8	1.2	1.2	1.3	1.2	1.3	1.8	0.8	
Aggregate of 5 covered segments	4.8	4.1	3.0	3.7	0.4	4.6	3.7	3.3	1.0
Mean deviation from sector rates:									
5 segments	1.1	1.7	1.3	1.8	0.2	1.7	2.4	1.3	
33 groups		2.6	2.8	2.1	1.4	2.0	3.4	1.9	

than for the subperiods. Since there is greater dispersion in group rates of change in productivity than in prices, it is clear that relative changes in output are much more widely dispersed than relative changes in prices by industry group. Variability in group rates of output change over the subperiods is likewise considerably greater than that of productivity changes in the groups, although there is little difference in the variability of the two measures at the segment and economy levels.

The coefficient of correlation between relative changes in output and in price (unit value) for the thirty-three groups is —.48 for the long period. It averages somewhat less in the subperiods, as is shown in Table 59. This means that about one-fourth of the variance in relative output changes may be explained by relative changes in the prices (unit values) of the products of the thirty-three groups over the long period. We have noted that about one-half of the variance in relative price changes may be explained by relative changes in productivity. Yet the degree of association between relative changes in output and in productivity is greater than might be inferred from these correlations.

TABLE 59

Coefficients of Rank Correlation[a] of Relative Changes in Unit Values or Prices and in Output, Subperiods, 1899–1953

	1899–1953	1899–1909	1909–1919	1919–1929	1929–1937	1937–1948	1948–1953
33 industry groups							
Price versus output	−0.34	−0.54	−0.50	−0.26	−0.18	−0.49	0.07
Unit value versus output	−0.48	−0.64	−0.56	−0.16	−0.35	−0.57	−0.11
Manufacturing							
20 groups							
Price versus output	−0.45	−0.66	−0.78	−0.18	−0.39	−0.50	0.33
Unit value versus output	−0.54	−0.69	−0.69	−0.22	−0.65	−0.64	0.02
80 industries[b]							
Unit value versus output	−0.52	−0.51	−0.29	−0.19	−0.64	−0.42	−0.13
12 farm groups[c]							
Price versus output	0.22		0.07	0.47	−0.20	0.09	0.33

[a] Significance of rank correlation coefficients:

N	*0.05 Level*	*0.01 Level*
12	0.51	0.71
20	0.38	0.53
33	0.31	0.43
80	0.22	0.28

[b] For the eighty manufacturing industries, the long period refers to 1899–1954, and the last two subperiods are 1937–47 and 1947–54.

[c] For the twelve farm groups, the long period covers 1910–53, and the first available subperiod covers 1910–19.

Output and productivity. The coefficients obtained from correlating relative rates of change in productivity and output are shown in Table 60. The correlations were carried out separately for the thirty-three industry groups and the twenty manufacturing groups, using both total factor productivity and output per unit of labor input as the dependent variables. For the eighty manufacturing industries and the twelve farm groups, output per unit of labor input (manhours) alone could be used. The results are shown graphically by the scatter diagrams in Charts 22 and 23.

The degree of correlation is significantly positive in all cases except that of farming. The coefficient using the twenty manufacturing groups (+.66) is somewhat higher than that (+.64) obtained using all groups.

It makes little difference in the correlation whether rates of change in total factor productivity or in output per manhour are used for the twenty groups. In the case of the eighty manufacturing industries, the coefficient of rank correlation between rates of change in output and in output per manhour is +.67, almost as high as for the groups. In all cases, the degree of correlation is somewhat higher over the long period than in the subperiods, on the average.

TABLE 60

Coefficients of Rank Correlation[a] of Relative Changes in Productivity and in Output, Subperiods, 1899–1953

	1899–1953	1899–1909	1909–1919	1919–1929	1929–1937	1937–1948	1948–1953
33 industry groups							
O/I versus O	0.64	0.64	0.48	0.56	0.67	0.29	0.37
O/L versus O	0.68	0.69	0.53	0.49	0.61	0.25	0.30
Manufacturing							
20 groups							
O/I versus O	0.66	0.61	0.44	0.63	0.73	0.41	0.69
O/L versus O	0.69	0.72	0.55	0.55	0.79	0.36	0.60
80 industries[b]							
O/L versus O	0.67	0.57	0.22	0.49	0.69	0.31	0.67
12 farm groups[c]							
O/L versus O	−0.10		−0.17	−0.07	0.52	0.25	−0.02

NOTE: O = output; I = total input; L = labor input.

[a] Significance of rank correlation coefficients:

N	*0.05 Level*	*0.01 Level*
12	0.51	0.71
20	0.38	0.53
33	0.31	0.43
80	0.22	0.28

[b] For the eighty manufacturing industries, the long period refers to 1899–1954, and the last two subperiods are 1937–47 and 1947–54.

[c] For the twelve farm groups, the long period covers 1910–53, and the first available subperiod covers 1910–19.

Again, the possibility of a spurious element in the correlations due to errors in the output indexes should be kept in mind. For the twelve farm groups, relative changes in output and in output per manhour are not closely correlated; the coefficient is —.10 for the long period, which is not significant at the 5 per cent level. The result for farming is not surprising in view of the generally low price elasticity of demand for farm products. Also, the reciprocal influence of scale on productivity could hardly be expected to operate in extractive industry.

CHART 22
Thirty-three Industry Groups: Relation between Output and Total Factor Productivity, 1953 Relative to 1899

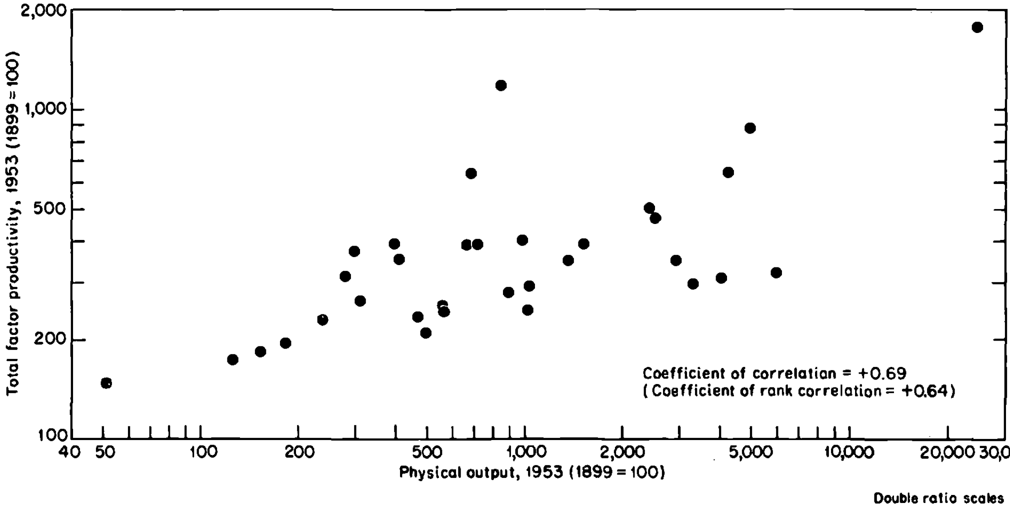
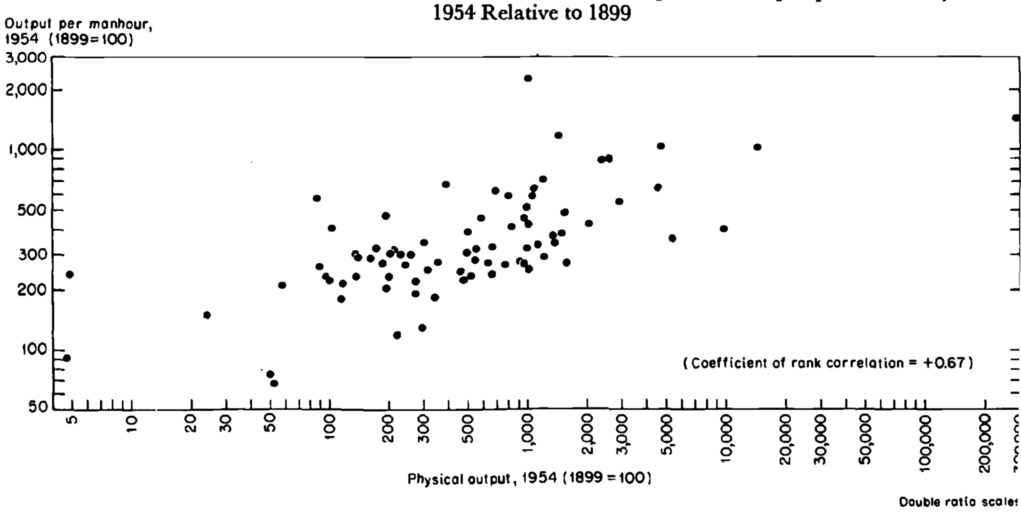


CHART 23
Eighty Manufacturing Industries: Relation between Output and Output per Manhour, 1954 Relative to 1899



The significant association between relative changes in productivity and in output is not due just to the influence of productivity on price and therefore on sales. As it has already been emphasized, increases in output make possible economies of scale that augment autonomous innovation in producing productivity advance. In fact, our analysis suggests that the influence of relative changes in scale on relative productivity changes may be more important than the reverse influence working through relative price changes. The problem is complicated by the possibility that other demand forces may tend to reinforce the productivity-price effect on output. For example, shifts in demand due to changing consumer preferences and increases in income probably favor new products, and productivity in industries producing new items generally rises faster than in industries producing older products.[2]

We cannot attempt a full analysis of relative output changes; this in itself would be a major research undertaking. From here on, we take the relative changes in output by industry as given and analyze the effect of relative productivity changes on the employment of labor and of capital in the various industries. The question is whether relative increases in output have been large enough to more than offset relative decreases in unit factor requirements and to result in rising resource employment in the technologically progressive industries.

VARIABLES EXPLAINING RELATIVE CHANGES IN THE EMPLOYMENT OF LABOR

In Table 61, index numbers of total factor productivity and other variables required to reconcile relatives of output and of employment (total persons engaged) are shown for major segments for 1953 on an 1899 base. By dividing output (O) by total factor productivity (O/I), total input (I) is obtained, and the quotient of total input and total input per unit of labor input (a measure of the substitution of capital for labor) is labor input (L). But labor input is manhours in component groups weighted by average hourly compensation, whereas our major interest is in employment of persons (E). The latter can be obtained as the quotient of labor input and labor input per person, which reflects the net effect of changes in average hours worked and interindustry shifts of manhours among groups with varying hourly compensation. To summarize:

$$E = O \div \frac{O}{I} \div \frac{I}{L} \div \frac{L}{E}$$

To illustrate by the manufacturing segment, output increased almost ninefold over the fifty-four years, while productivity and total factor input both approximately tripled. Since capital input increased somewhat more

[2] Solomon Fabricant, *Employment in Manufacturing, 1899–1939: An Analysis of Its Relation to the Volume of Production*, New York (NBER), 1942, p. 64.

than labor input, labor input increased to 270 per cent of the base. Labor input per person employed declined over the period, as the reduction in the workweek more than offset the upward influence of shifts of manhours from lower- to higher-paying groups; so employment rose to 325 per cent of the base figure. It is clear that productivity change is the chief variable relating output to employment changes, but other adjustments are also necessary to get a precise reconciliation.

TABLE 61

Private Domestic Economy: Output, Productivity, Persons Engaged, and Related Variables, by Major Segment, 1953 Relative to 1899

	Output (1)	Total Factor Productivity (2)	Factor Substitution[a] (3)	Labor Input (4)	Labor Input per Person (6)	Persons Engaged (6)
Private domestic economy	586	254	112	207	94	221
Farming	153	184	135	62	88	70
Mining	442	316	120	117	88	133
Manufacturing	885	291	113	270	83	325
Transportation	641	545	109	108	69	156
Communications and public utilities	5,015	680	113	655	78	839
Construction	400	184[b]		217	77	282
Trade	525	213[b]		246	58	424
Finance and services	484	193[b]		251	85	296

[a] Substitution of capital for labor as measured by the ratio of total factor input to labor input.

[b] Rough estimates of output per manhour for construction and trade, and of output per unit of labor input for finance and services.

To explain *relative* changes in employment by industry group—that is, changes in the proportions of total employment absorbed by each group—it is necessary to express the index numbers for each variable as percentages of the corresponding index numbers for the private domestic economy as a whole. This is done in Table 62. To illustrate again by the manufacturing segment, the ninefold increase in output was 150 per cent greater than the sixfold increase in real private domestic product. Total factor productivity went up 14 per cent more in manufacturing than in the economy, but factor substitution was about the same. Consequently, manufacturing labor input increased by about 30 per cent more than total labor input; but since labor input per person declined more in manufacturing than in the economy, the relative increase in persons employed was almost 50 per cent. This reconciles precisely with the increase in the manufacturing proportion of total persons employed in the private domestic economy, from 21 per cent in 1899 to 31 per cent in 1953.

How typical is the manufacturing segment in exhibiting relative increases in *both* productivity and employment? Of the twenty-four groups showing greater-than-average productivity gains over the period, fourteen showed relative increases in employment and one showed no change. One of the most amazing cases is the electric light and power industry, in which the productivity advance was seven times greater than the economy average; and yet relative employment increased sixfold as a result of a forty-twofold relative output gain! The nine groups experiencing relative productivity increases but declines in relative employment comprised two manufacturing groups (tobacco products and textile mill products), the metal and nonmetal mining groups, all three transportation groups, and the telegraph and manufactured gas utilities.

In the aggregate, employment in the twenty-four industries with relative productivity gains rose from 20 per cent of total employment in private domestic industries in 1899 to 28 per cent in 1953. This 40 per cent gain in relative employment is convincing evidence that relative productivity increase in the long run is not associated with relative declines in employment.

It will be observed, however, that of the thirteen industry groups or segments experiencing relative declines in productivity or in output per manhour, only five likewise showed drops in relative employment. But the large relative decline in farm employment was more than enough to offset relative employment increases in other technologically less progressive areas, of which trade and services were the largest. In these areas, whereas relative output fell somewhat, the productivity decline was relatively greater and was associated with substantial gains in the proportion of total employment absorbed by the trade and service industries.

RELATIVE CHANGES IN PRODUCTIVITY AND IN FACTOR INPUTS

Another way to measure the association between relative changes in productivity and in factor input is through correlation analysis. The coefficients of correlation obtained by using ranks of proportionate changes in productivity and in each of the factor inputs and the total are summarized in Table 63. Here, errors in the input estimates would tend to bias the correlations negatively.

All the correlations show a mildly positive association between relative changes in productivity and relative input changes over the long period. The association is somewhat stronger in the case of capital input than in the case of either manhours or persons employed, and the coefficient of rank correlation using total factor input lies between the coefficients obtained using the capital and labor variables. In the eighty manufacturing industries, the association between relative changes in output per

TABLE 62

Private Domestic Economy, by Segment and by Group: Factors Influencing Relative Changes in Employment, 1953 Relative to 1899;[a] and Distribution of Persons Engaged, 1899 and 1953
(per cent)

	Output	Total Factor Productivity	Factor Substitution[b]	Labor Input[c]	Labor Input per Person	Persons Engaged[d]	Distribution of Persons Engaged 1899	Distribution of Persons Engaged 1953
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Farming	26	72	121	30	94	32	37.8	12.0
Mining	75	124	107	57	94	60	2.5	1.5
Metal	48	125	110	35	99	35	0.5	0.2
Anthracite coal	9	58	90	17	94	18	0.5	0.1
Bituminous coal	40	91	97	46	89	52	1.0	0.5
Oil and gas	415	197	109	194	62	312	0.2	0.5
Nonmetals	114	153	108	69	115	60	0.3	0.2
Manufacturing	151	114	101	131	89	147	20.8	30.5
Foods	96	96	94	107	78	137	1.6	2.2
Beverages	80	93	91	95	80	118	0.3	0.3
Tobacco	116	252	208	22	83	27	0.6	0.2
Textiles	71	138	98	53	75	70	3.0	2.1
Apparel	96	99	98	99	73	135	1.6	2.2
Lumber products	21	68	97	32	80	41	2.8	1.1
Furniture	84	83	87	116	81	143	0.4	0.6
Paper	233	137	102	166	79	210	0.4	0.9
Printing, publishing	168	158	92	115	80	144	1.1	1.6
Chemicals	432	185	120	194	80	243	0.6	1.4

(continued)

TABLE 62 (concluded)

Petroleum, coal products	498	138	193	187	65	288	0.1	0.4
Rubber products	844	345	100	245	83	295	0.2	0.5
Leather products	31	77	93	44	72	61	1.1	0.7
Stone, clay, glass	123	154	96	83	83	100	1.1	1.1
Primary metals	152	109	108	129	79	164	1.3	2.2
Fabricated metals	259	153	98	173	82	211	1.3	2.7
Machinery, nonelectric	175	96	98	186	84	221	1.7	3.9
Electric machinery	1,014	126	98	820	78	1,053	0.2	2.1
Transportation equipment	726	251	97	297	81	365	0.9	3.3
Miscellaneous	176	114	96	161	84	192	0.5	1.0
Transportation	109	214	98	52	74	71	7.4	5.2
Railroads	68	153	101	44	71	62	3.9	2.4
Local transit	50	146	85	41	82	51	0.5	0.2
Residual transport	209	323	97	67	78	85	3.0	2.6
Communications and public utilities	855	267	101	317	83	380	0.7	2.5
Telephone	690	121	85	673	76	881	0.1	1.2
Telegraph	53	103	82	63	75	84	0.1	0.1
Electric utilities	4,186	693	130	464	78	597	0.1	0.6
Manufactured gas	144	462	93	34	72	47	0.2	0.1
Natural gas	565	116	149	326	73	446	0.1	0.3
Construction	68	65[e]		105	82	128	5.0	6.5
Trade	90	75[e]		119	62	192	11.2	21.5
Finance and services	83	68[e]		121	90	134	13.6	18.3

[a] Index numbers, for 1953 on an 1899 base, for the several segments and groups, are expressed as percentages of corresponding index numbers for the private domestic economy as a whole.

[b] Capital for labor.

[c] Col. (1) divided by col. (2) divided by col. (3).

[d] Col. (4) divided by col. (5) or col. (8) divided by col. (7).

[e] Output per manhour (for construction and trade) or per unit of labor input (for finance and services) relative to labor productivity in the private domestic economy as a whole.

CHART 24

Thirty-three Industry Groups: Relation between Total Factor Productivity and Persons Engaged, 1953 Relative to 1899

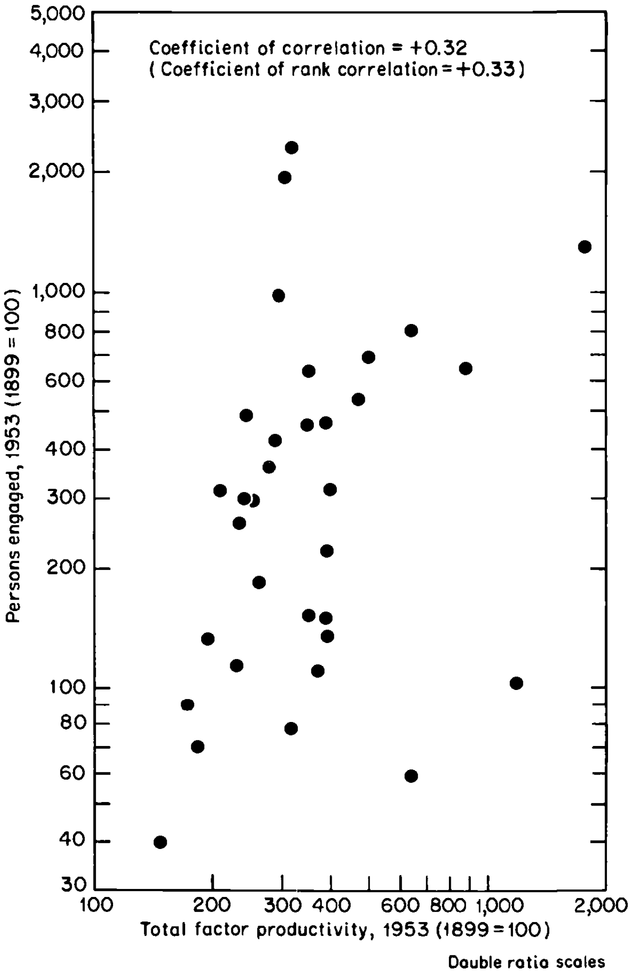


CHART 25

Thirty-three Industry Groups: Relation between Total Factor Productivity and Capital Input, 1953 Relative to 1899

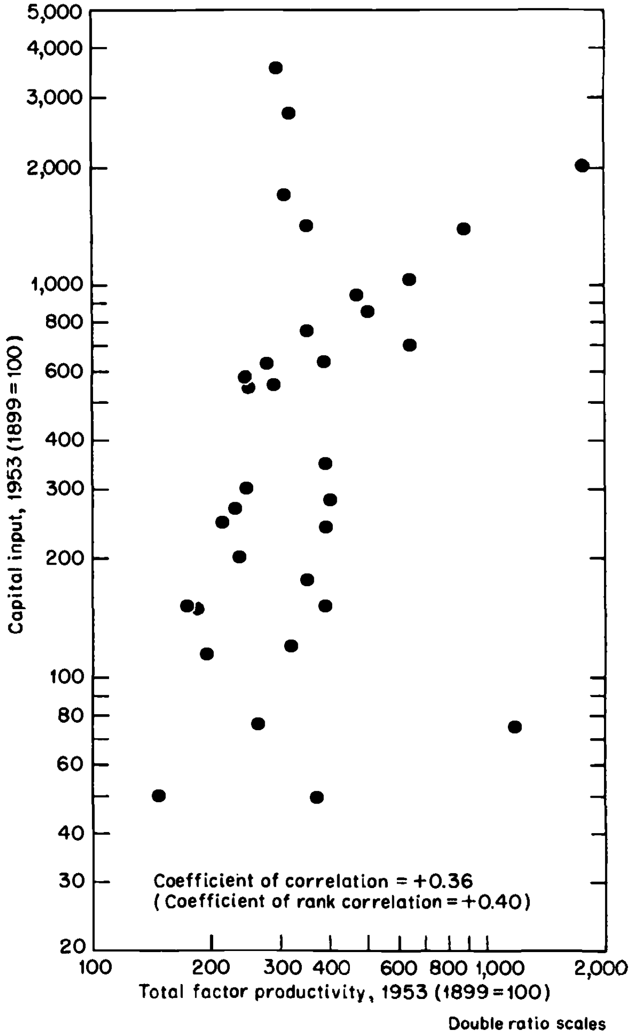


TABLE 63

Coefficients of Rank Correlation[a] of Relative Changes in Productivity and in Factor Inputs, Subperiods, 1899–1953

	1899–1953	1899–1909	1909–1919	1919–1929	1929–1937	1937–1948	1948–1953
33 industry groups							
Total factor productivity versus							
Persons engaged	0.33	0.35	0.11	−0.04	0.05	−0.19	0.19
Manhours	0.33	0.31	0.05	−0.08	−0.10	−0.34	0.15
Capital input	0.40	0.24	0.20	0.15	0.00	−0.40	0.03
Total factor input	0.35	0.29	0.06	0.03	−0.10	−0.37	0.10
80 manufacturing industries[b]							
Output per manhour versus							
Persons engaged	0.33	−0.01	−0.28	−0.05	0.09	−0.19	−0.12

[a] For $N = 33$, the value of the coefficient of rank correlation which is significant at the 0.05 level is 0.31; at the 0.01 level, 0.43. For $N = 80$, the comparable figures are 0.22 and 0.28.

[b] For the eighty manufacturing industries, the long period refers to 1899–1954, and the last two subperiods are 1937–47 and 1947–54.

manhour and in persons employed is somewhat lower than that obtained for the thirty-three groups. The results are pictured in Charts 24 and 25.

Table 63 indicates clearly that the correlations between relative changes in productivity and factor inputs are generally lower in the subperiods than over the long period. This is particularly marked in the eighty manufacturing industries. The associations are all negative in the 1937–48 subperiod, and occasionally so in other periods. The phenomenon of higher correlations over the long period than in the subperiods is consistent with the like results obtained in correlations between relative changes in productivity, prices, and output. Apparently, the theoretical propositions that prices tend to equal unit costs and that industries with declining relative unit costs tend to enjoy increases in relative demand and output describe the operations of the real economy more aptly if a rather long period is allowed for the adjustments to take place.

Annex: Variables Used in the Industry Analysis

For the convenience of other analysts, we present here tables showing for the thirty-three groups in key years the variables with which the productivity indexes were correlated. As described in the following notes, the index numbers of values per unit of output for mining and manufacturing should be relatively good, based as they are on consistent census data, but they are rougher for some of the other segments. Data on average hourly labor earnings are based on consistent earnings and employment estimates, but would be influenced by possible errors in our estimates of average hours worked per year. The estimates of capital compensation per unit of real capital are subject to a wider margin of error than the other series. Our industry price indexes have not been included because of their incomplete coverage for certain industries. However, the description and sources of price indexes used for the manufacturing industries are given in the Technical Note to Appendix D.

	1929=100					
	1899	1909	1919	1937	1948	1953
			FARMING			
Unit value of product	41.5	64.7	143.6	81.2	187.5	170.8
Unit value added	44.6	69.9	150.6	79.5	171.6	148.6
Unit materials cost	30.3	45.1	117.6	87.8	246.2	252.9
Average hourly earnings	34.9	50.8	110.2	71.1	238.0	276.5
Capital compensation per unit of real capital	30.3	66.0	160.2	92.7	196.8	116.3
			MINING: METALS			
Unit value of product	83.6	76.6	126.5	101.0	222.0	298.3
Unit value added	85.7	72.8	120.1	102.2	223.1	298.6
Unit materials cost	75.2	91.7	152.0	96.0	217.5	296.7
Average hourly earnings	46.6	56.0	107.4	122.6	251.1	357.3
Capital compensation per unit of real capital			119.6	151.2	230.8	96.9
			MINING: ANTHRACITE COAL			
Unit value of product	28.0	35.2	79.3	73.1	156.3	185.0
Unit value added	27.3	33.9	74.6	69.5	132.3	147.0
Unit materials cost	31.5	42.4	105.5	93.3	291.9	399.0
Average hourly earnings	25.6	31.1	76.8	104.8	217.2	297.7
Capital compensation per unit of real capital			89.5	−31.6	573.7	115.8
			MINING: BITUMINOUS COAL			
Unit value of product	48.8	59.9	139.8	108.9	280.2	276.2
Unit value added	52.4	62.8	138.6	107.3	264.9	255.7
Unit materials cost	28.5	43.7	147.3	117.5	364.9	390.0
Average hourly earnings	30.0	47.4	111.5	125.7	278.7	364.2
Capital compensation per unit of real capital			103.8	115.4	2023.1	253.3
			MINING: OIL AND GAS			
Unit value of product	49.5	48.3	142.4	96.3	208.4	199.3
Unit value added	45.1	43.5	129.0	105.3	232.0	223.8
Unit materials cost	76.5	72.9	212.9	48.9	84.6	70.9
Average hourly earnings	25.5	35.5	103.3	125.3	252.6	334.8
Capital compensation per unit of real capital			95.2	256.5	514.7	661.3
			MINING: NONMETALS			
Unit value of product	63.6	62.0	127.2	91.1	125.4	145.6
Unit value added	68.2	64.6	119.1	91.1	120.9	137.7
Unit materials cost	45.6	52.8	157.6	91.1	142.5	175.2
Average hourly earnings	67.6	59.4	91.3	107.2	250.0	342.1
Capital compensation per unit of real capital			104.1	82.4	312.2	275.7
			MANUFACTURING: FOODS			
Unit value of product	64.4	78.0	167.9	85.1	186.9	188.2
Unit value added	45.2	55.5	115.8	83.1	171.1	183.8
Unit materials cost	71.6	86.6	188.0	85.9	193.1	189.9
Average hourly earnings	29.0	38.0	82.9	101.4	213.3	286.6
Capital compensation per unit of real capital				126.6	301.8	277.7

(continued)

	1929=100					
	1899	1909	1919	1937	1948	1953
	MANUFACTURING: BEVERAGES					
Unit value of product	36.8	44.2	107.5	59.0	96.7	108.6
Unit value added	50.4	58.2	123.3	65.4	93.7	101.9
Unit materials cost	20.1	27.1	88.0	50.9	100.5	116.7
Average hourly earnings	37.9	49.6	86.2	114.1	194.2	272.2
Capital compensation per unit of real capital				233.3	550.0	447.2
	MANUFACTURING: TOBACCO PRODUCTS					
Unit value of product	70.5	76.3	115.9	87.1	131.8	147.4
Unit value added	69.5	66.6	92.1	92.7	131.3	175.1
Unit materials cost	71.8	94.5	161.2	76.5	132.6	91.2
Average hourly earnings	38.3	47.0	91.3	108.7	250.6	339.3
Capital compensation per unit of real capital				106.3	119.8	189.2
	MANUFACTURING: TEXTILES					
Unit value of product	47.1	57.2	151.6	72.2	148.0	158.9
Unit value added	47.5	53.9	140.2	74.0	169.4	156.3
Unit materials cost	46.6	59.5	160.2	70.7	132.0	160.8
Average hourly earnings	27.5	34.9	94.4	116.0	276.9	333.5
Capital compensation per unit of real capital				126.5	577.4	195.1
	MANUFACTURING: APPAREL					
Unit value of product	51.0	62.6	138.3	70.4	153.1	162.7
Unit value added	51.6	62.2	129.4	72.2	173.4	188.4
Unit materials cost	50.7	63.0	144.7	69.0	138.6	144.4
Average hourly earnings	24.4	33.4	91.0	96.3	207.5	245.0
Capital compensation per unit of real capital				70.3	183.7	104.1
	MANUFACTURING: LUMBER PRODUCTS					
Unit value of product	37.6	45.5	109.8	88.6	233.6	246.3
Unit value added	33.8	44.2	109.7	83.5	224.9	244.6
Unit materials cost	42.4	47.1	110.0	95.0	244.4	248.2
Average hourly earnings	27.1	35.8	83.4	88.6	214.2	290.8
Capital compensation per unit of real capital				149.1	785.3	376.9
	MANUFACTURING: FURNITURE					
Unit value of product	37.3	51.5	120.6	90.5	138.0	186.9
Unit value added	38.4	50.7	118.6	87.6	137.2	175.0
Unit materials cost	36.2	52.4	122.9	93.9	139.0	205.6
Average hourly earnings	27.6	36.3	77.4	95.2	217.5	288.6
Capital compensation per unit of real capital				120.0	770.0	690.3
	MANUFACTURING: PAPER					
Unit value of product	56.8	59.4	125.6	87.2	183.4	208.0
Unit value added	60.7	58.0	125.6	84.8	176.0	200.7
Unit materials cost	54.1	60.8	125.6	88.9	188.9	213.4
Average hourly earnings	26.9	36.0	83.8	119.3	259.7	349.8
Capital compensation per unit of real capital				76.8	497.6	492.0

(continued)

	1929=100					
	1899	1909	1919	1937	1948	1953
	MANUFACTURING: PRINTING AND PUBLISHING					
Unit value of product	74.3	67.0	101.3	80.5	140.9	161.9
Unit value added	73.1	64.5	88.7	79.2	132.6	147.3
Unit materials cost	80.1	75.5	139.4	80.8	144.3	180.1
Average hourly earnings	26.3	35.8	67.1	105.9	209.0	271.5
Capital compensation per unit of real capital				55.3	171.8	174.1
	MANUFACTURING: CHEMICALS					
Unit value of product	73.1	86.6	171.1	81.3	129.2	121.3
Unit value added	60.8	70.4	130.9	82.4	117.7	126.8
Unit materials cost	84.4	101.9	208.3	80.3	139.9	116.3
Average hourly earnings	27.3	37.0	79.1	107.6	232.4	331.0
Capital compensation per unit of real capital				104.7	233.3	224.1
	MANUFACTURING: PETROLEUM AND COAL PRODUCTS					
Unit value of product	64.8	71.4	170.3	83.6	189.8	174.1
Unit value added	66.2	63.4	169.1	67.8	158.5	134.1
Unit materials cost	64.3	73.9	170.6	88.8	200.0	187.1
Average hourly earnings	24.6	33.7	85.8	145.8	310.2	456.3
Capital compensation per unit of real capital				40.1	215.1	148.4
	MANUFACTURING: RUBBER PRODUCTS					
Unit value of product	209.3	229.9	189.9	87.2	138.7	177.3
Unit value added	172.1	180.5	187.9	75.7	140.7	176.4
Unit materials cost	241.9	275.3	191.6	98.0	136.7	178.2
Average hourly earnings	27.3	34.3	88.2	124.2	237.4	325.4
Capital compensation per unit of real capital				123.6	315.3	530.6
	MANUFACTURING: LEATHER AND PRODUCTS					
Unit value of product	47.7	62.8	151.7	72.1	172.0	161.2
Unit value added	37.3	50.2	128.4	71.1	180.8	191.0
Unit materials cost	54.5	71.4	167.4	72.9	166.2	141.1
Average hourly earnings	28.2	36.8	90.8	102.2	224.0	277.3
Capital compensation per unit of real capital				49.5	323.8	234.3
	MANUFACTURING: STONE, CLAY, AND GLASS PRODUCTS					
Unit value of product	54.2	56.5	125.2	90.9	159.7	186.7
Unit value added	56.9	56.0	115.7	86.2	148.7	170.4
Unit materials cost	49.5	57.4	142.0	98.8	180.6	215.6
Average hourly earnings	26.4	34.6	73.1	95.8	202.3	283.1
Capital compensation per unit of real capital				124.1	385.2	423.5
	MANUFACTURING: PRIMARY METAL PRODUCTS					
Unit value of product	84.9	74.3	128.8	101.1	150.6	194.7
Unit value added	78.0	55.2	124.8	107.7	161.1	215.4
Unit materials cost	88.1	83.9	130.8	97.9	145.3	184.3
Average hourly earnings	27.7	34.2	85.0	113.8	224.7	326.0
Capital compensation per unit of real capital				53.2	230.5	258.2

(continued)

	1929=100					
	1899	1909	1919	1937	1948	1953
	MANUFACTURING: FABRICATED METAL PRODUCTS					
Unit value of product	70.9	69.7	122.6	95.7	159.4	207.2
Unit value added	64.6	63.4	111.1	87.9	151.4	196.8
Unit materials cost	80.1	78.0	138.1	106.1	170.1	221.0
Average hourly earnings	27.2	35.4	76.4	100.1	220.9	303.4
Capital compensation per unit of real capital				80.6	190.7	154.4
	MANUFACTURING: MACHINERY, NONELECTRIC					
Unit value of product	52.3	53.7	108.4	94.1	163.7	182.9
Unit value added	45.9	49.0	101.4	88.7	142.4	162.4
Unit materials cost	64.1	61.6	120.8	103.6	200.6	218.2
Average hourly earnings	29.8	38.4	83.7	113.9	232.3	318.8
Capital compensation per unit of real capital				98.9	191.3	222.1
	MANUFACTURING: ELECTRIC MACHINERY					
Unit value of product	50.6	52.4	104.1	85.2	136.6	132.6
Unit value added	41.2	47.0	104.1	85.7	125.7	123.7
Unit materials cost	64.4	60.0	103.9	84.8	151.5	144.6
Average hourly earnings	30.0	39.8	81.8	121.4	238.2	319.6
Capital compensation per unit of real capital				118.6	253.7	331.6
	MANUFACTURING: TRANSPORTATION EQUIPMENT					
Unit value of product	81.9	98.1	152.3	109.5	178.7	211.7
Unit value added	94.5	116.8	167.4	77.7	162.5	195.3
Unit materials cost	74.0	86.9	142.4	122.8	189.1	222.3
Average hourly earnings	24.0	24.2	88.0	111.7	219.5	306.6
Capital compensation per unit of real capital				77.0	229.2	356.2
	MANUFACTURING: MISCELLANEOUS					
Unit value of product	51.2	62.5	122.2	77.5	142.7	160.9
Unit value added	44.7	53.7	109.1	73.6	138.7	156.3
Unit materials cost	60.4	75.9	141.9	83.3	148.6	167.6
Average hourly earnings	27.1	34.4	73.0	95.4	201.3	275.1
Capital compensation per unit of real capital				106.6	122.8	155.5
	TRANSPORTATION: RAILROADS					
Unit value of product	66.3	68.9	88.8	82.0	108.3	128.6
Unit value added	69.6	67.6	75.9	81.0	107.3	130.1
Unit materials cost	54.5	73.3	133.3	85.5	111.6	123.5
Average hourly earnings	25.6	30.5	85.1	106.3	200.1	289.2
Capital compensation per unit of real capital			57.3	34.6	109.2	98.3
	TRANSPORTATION: LOCAL TRANSIT (ELECTRIC RAILWAYS AND BUSES)					
Unit value of product	87.2	97.5	116.0	85.4	117.3	188.1
Unit value added	87.6	97.5	116.1	85.4	117.5	188.4
Unit materials cost	86.8	97.7	115.7	85.3	117.3	188.1
Average hourly earnings	30.4	36.3	80.9	114.4	225.5	289.5
Capital compensation per unit of real capital			80.2	27.9	41.4	157.7

(continued)

	1929=100					
	1899	1909	1919	1937	1948	1953
			COMMUNICATIONS: TELEGRAPH			
Unit value of product	54.0	69.3	105.4	81.9	125.7	154.1
Unit value added	44.6	65.2	99.1	77.4	135.5	170.5
Unit materials cost	107.8	95.1	145.3	109.3	63.5	50.9
Average hourly earnings	33.2	37.7	72.5	106.7	242.5	326.4
Capital compensation per unit of real capital				26.6	25.9	148.0
			COMMUNICATIONS: TELEPHONE			
Unit value of product	77.5	58.5	72.7	105.4	120.8	176.4
Unit value added	79.3	54.2	60.5	101.4	132.8	179.2
Unit materials cost	72.5	70.9	108.3	116.9	86.2	168.2
Average hourly earnings	32.7	33.9	73.6	139.2	233.5	323.3
Capital compensation per unit of real capital				67.6	57.6	116.8
			PUBLIC UTILITIES: ELECTRIC UTILITIES			
Unit value of product	112.0	117.5	123.3	76.9	64.0	62.6
Unit value added	106.5	112.4	110.3	75.9	50.4	51.2
Unit materials cost	161.5	160.8	238.6	86.0	184.6	164.0
Average hourly earnings	34.4	37.7	81.5	126.6	228.7	319.5
Capital compensation per unit of real capital	24.6	25.3	38.4	89.5	112.3	164.0
			PUBLIC UTILITIES: MANUFACTURED GAS			
Unit value of product	101.3	83.9	86.0	96.4	91.7	81.6
Unit value added	116.0	90.5	70.8	111.2	84.2	65.7
Unit materials cost	76.3	72.4	112.4	71.0	104.6	109.0
Average hourly earnings	34.0	37.0	80.5	126.8	323.4	470.2
Capital compensation per unit of real capital	23.3	66.7	24.2	142.9	111.1	312.0
			PUBLIC UTILITIES: NATURAL GAS			
Unit value of product	34.2	48.0	69.1	94.0	90.7	117.1
Unit value added	30.6	43.8	58.4	103.0	100.8	131.4
Unit materials cost	51.2	71.7	95.7	46.9	36.8	41.3
Average hourly earnings	33.9	37.2	80.6	126.6	254.9	362.2
Capital compensation per unit of real capital	43.0	46.1	113.8	132.1	300.8	391.3

SOURCES

Farming: For the output index see Appendix B, section on "Gross Farm Output." Gross value of farm production and value of materials and other intermediate products are estimates of Department of Commerce, the former extrapolated by Strauss and Bean (see Appendix B, Note 2). Value added is the difference between value of product and cost of materials. Average hourly earnings of labor is the Department of Agriculture series, farm wages without room and board. Capital compensation per unit of real capital is described in Appendix B, section on "Factor Weights in Farming."

Mining: For output measures see Appendix C, section on "Output." Value of production is taken from *Minerals Yearbook*, Bureau of Mines. Value of materials is estimated from the ratio of value of materials to value of product (Israel Borenstein, *Capital and Output Trends in Mining Industries, 1870–1948*, Occasional Paper 45, New York (NBER), 1954, Table 5). Value added is computed as the difference between value of product and cost of materials. Hourly earnings in mining are obtained from Leo Wolman's unpublished data. Capital compensation per unit is described in Appendix C, end of section on "Capital."

Manufacturing: For output indexes see Appendix D, section on "Output Estimates." Value of product, value added, and cost of materials are based on data from *Census of Manufactures* adjusted for census-to-census consistency. Hourly earnings are computed from wages and salaries of production workers and salaried employees divided by hours worked per week; these are from the *Census of Manufactures*, 1899–1929, and from the Office of Business Economics, Department of Commerce, 1929–53; Census data on hours were supplemented by BLS studies. Capital compensation per unit is described in Appendix D, section on "Capital Stocks and Input."

Transportation, Railroads: For output index see Appendix G, section on "Output." Value of product is represented by passenger and freight revenues (*Statistics of Railways in the United States*, Interstate Commerce Commission, annual). Cost of materials for Class I steam railroads (fuels, stationery and printing, advertising, and other miscellaneous materials and supplies) is available in *Statistics of Railways*. The ratio of cost of materials to operating revenues of Class I roads was applied to revenues of all roads to obtain cost of materials for all roads. Value added is computed as the difference between value of product and cost of materials. An index of hourly earnings was built up by linking monthly earnings in Class I steam railroads as estimated by the Bureau of Labor Statistics, 1929–53; unpublished series of Leo Troy, 1918–29; Paul Douglas's series, 1899–1919 (in his *Real Wages in the United States*, Boston, Houghton Mifflin, 1930). Capital compensation per unit is derived as the quotient of nonlabor compensation (the difference between Commerce's income originating in railroads and total labor compensation) and the index of real capital input.

Local Transit: For output index see Appendix G, sections on "Electric Railroads" and on "The Local-Transit Group." Value of product is the sum of operating revenue of electric railways (*Census of Electrical Industries*) and trolley, coach, and motor-bus operating revenues (*Transit Fact Book*, American Transit Association, New York). Value added is assumed to be a constant 75 per cent of value of product, the average ratio of income originating in railways (Department of Commerce) and operating revenues in 1929 and 1937. Cost of materials is therefore assumed to be 25 per cent of value of product. The hourly earnings index is a link of Bureau of Labor Statistics data (1932–53) and Douglas's average yearly wage adjusted by an hours series (1899–1932). Capital compensation per unit is derived as the quotient of nonlabor compensation (Commerce income originating in local transit less total labor compensation) and the index of real capital input.

Communications and Public Utilities: For output indexes see relevant sections of Appendix H. Values of product are represented by revenue: for the communications groups, from Census and Federal Communications Commission data; for electric utilities, from Census and Edison Electric Institute data; for the gas utilities from Census and American Gas Association data and from Jacob M. Gould, *Output and Productivity in the Electric and Gas Utilities, 1899–1942*, New York (NBER), 1946. For the communications groups, value added is national income, and material costs, the difference between value of product and value added. For electric utilities, the value of fuel consumption in bituminous coal equivalents (Gould and Edison Electric Institute) represents materials costs; and value added, the difference between value of product and materials cost. For manufactured gas, value added and cost of materials are given in *Census of Manufactures*. For natural gas, cost of materials is estimated by applying to value of product the ratios of materials cost to value of product for the oil and gas mining industry. Value added is the difference between value of product and estimated materials cost. Average hourly earnings of labor are computed from indexes of labor compensation and manhours. Estimates in absolute terms are derived by dividing 1929 labor compensation by the product of 1929 employment and average hours per man-year and applying to these 1929 estimates the indexes of hourly earnings. Capital compensation per unit is described, under the subsection "Total Input" in Appendix H, in the relevant section for each industry.

DIRECTOR'S COMMENT

by Stanley H. Ruttenberg

John Kendrick's text and monumental array of data, and Solomon Fabricant's Introduction as well, represent a considerable effort that will be useful to economists who specialize in the field of productivity. Much of this work is of a provisional nature, however, and its conclusions, in my opinion, are frequently less than definite or firm.

While Kendrick has performed a worthy pioneering task, the essential value of this work is experimental. Unfortunately, its exploratory nature is often covered by overstated conclusions that are based on provisional and inadequate analysis.

A new measure of productivity is introduced, for example, but its conceptual framework and proper use or uses are not clearly developed. The absence of a conceptual framework may add to existing difficulties in the application of productivity measures as tools for economic analysis and policy development. It has already added some confusion in the area of the greatest practical application of productivity—the area of collective bargaining and labor-management relationships.

There are many unanswered, basic questions concerning total factor productivity, as the new measure is called. Furthermore, this exploratory volume raises many additional problems, which are dismissed or only inadequately examined. Among these various issues are the following:

1. Should a productivity measure be called total factor productivity, when it excludes measurement of many intangible factors other than labor and capital?

The new productivity measure is an attempt to measure output per combined labor and capital inputs. It does not measure numerous other inputs, such as education, science, technology, social organization, cultural heritage, and the quality of human skills and ingenuity which are essential to rising productivity.

I am not advocating a combined measure of all the various tangible and intangible inputs. It seems to me, however, that the all-encompassing terms "total factor productivity" and "total productivity" are misleading when they are applied to a limited measure of two inputs.

2. What is the conceptual basis for the new productivity measure, which is output per unit of combined actual manhours and available capital?

This question is unanswered, except for the brief implication that the new productivity measure is a measure of efficiency, which is never defined. Does total factor productivity purport to measure efficiency, in terms of dollar costs to business, alone? Or does total factor productivity attempt to measure efficiency in terms of costs to the economy and society as a whole?

As developed in this volume, it would seem that total factor productivity attempts to measure the dollar costs to business of entrepreneurial decisions concerning investment, capital stock, and employment, including the costs of the entire capital stock, whether or not it is utilized, and the actual manhours that are worked. There are additional costs, however, which are not measured—such as the unemployment compensation and public assistance costs of underutilization of the potential labor force, the social waste of unused or underutilized manpower and labor skills, the social cost of business investment decisions which may involve the elimination of some existing departments or plants and investment in new locations.

It would appear that it is a limited type of efficiency that total factor productivity attempts to measure. The brief implication of a conceptual basis for the newly introduced measure, therefore, is most inadequate.

3. Although total factor productivity is a new measure, and it is referred to as a superior measure, its proper uses and applications are not developed.

In the absence of an adequate conceptual framework and a clear statement of purposes, uses, and appropriate applications, it is difficult to comprehend Kendrick's and Fabricant's views of the newly introduced productivity measure.

Total factor productivity is described as better than other measures, but why and how it is superior are not adequately explained. Since each productivity measure is good in itself for its own specific and limited purposes, if it is conceptually and mathematically valid, it is conceivable that the new measure may be superior to other measures for some purposes, inferior for other purposes, and inappropriate for still other purposes. The uses and appropriate applications of total factor productivity, however, are not developed and the supposed superiority of this measure is declared, but not explained.

4. Is there any relevance to be drawn from direct or implied comparisons of changes in real average hourly employee compensation and total factor productivity over periods of time? Kendrick and Fabricant assure me that they do not mean that total factor productivity is the appropriate yardstick for wage and salary policy decisions, but some readers may be misled.

This issue is important since it deals with the distribution of income and, in effect, with part of the basic structure of our economy and society.

Since total factor productivity rises at a slower rate than output per manhour, is it meant that real average hourly employee compensation should properly rise at a rate that is equal to the rate of total factor productivity and less than the rate of output per manhour? A practical application of this policy would result in a decline of the wage and salary share of national income and a rise in the national income share that goes to the return to capital.

If, in the view of Kendrick and Fabricant, real average hourly employee compensation should properly rise somewhat faster than total factor productivity, then the question is, how much faster—more rapidly than total factor productivity and less than output per manhour, proportionate to the rise of output per manhour, or more rapidly than output per manhour?

These questions are raised by the comparisons that are made. The relevance of the comparisons and answers to these questions, however, is not presented.

In other publications, Kendrick has indicated the impropriety of using total factor productivity as a yardstick for wage-productivity comparisons. Since the new productivity measure is admittedly not an appropriate yardstick, why are the comparisons made at all? Furthermore, what is the basis for apparently abandoning the usual comparison of real average hourly employee compensation with output per manhour?

These questions concern the use of productivity measures in collective bargaining, which is, at present, the area of its greatest application. There is, however, no direct discussion of this subject. The effect, therefore, is to add confusion in a difficult area of social and economic policy that involves the distribution of income.

5. Is total factor productivity a valid productivity measure, since it combines two conceptually different measures—output per unit of *actual* manhours and output per unit of *available* capital?

Output per manhour is a measure that is based on actual manhours, excluding the unemployed, the underemployed, and those who are out of the labor force because appropriate work is not available. This measure, therefore, is one of output per unit of *actual* inputs.

Output per unit of capital, on the other hand, is a measure that is based on available capital, including the total capital stock after depreciation, regardless of whether or not it is utilized. This measure, therefore, is one of output per unit of *available* inputs.

Is it appropriate to combine two such different measures into one new productivity measure? If there is some conceptual basis for combining these two differing measures, is the resultant factor productivity a measure of efficiency, as claimed? Would it not be more appropriate to leave these conceptually different measures as two distinctly separate measures of output per units of differing qualities and quantities of inputs? If any combination is presented as a measure of total factor productivity, it should be only one of the "variants" that Kendrick includes in his third chapter. In that combination, total labor supply—whether employed or unemployed—is counted as an input, just as is total capital—whether employed or unemployed.

These basic issues concerning the newly introduced productivity measure are not examined in any clear manner.

In addition, there are a number of difficult problems concerning capital productivity that are not adequately discussed. In measuring the available capital stock, there are problems of actual depreciation as contrasted with book depreciation and serious difficulties of price deflation. Any discussion of output per unit of capital should include a careful exposition of these difficulties, which are considerably greater than measuring employee manhours, with which there are many years of experience.

6. Is there validity to Kendrick's claim that the wage and salary share of national income has risen sharply?

The evidence of experts who have studied national income shares for many years casts serious doubt on Kendrick's claim of a sharp increase of the labor share of national income. Most students have concluded that the wage and salary share of national income has increased slowly over the past several decades or has remained relatively stable. They point, for example, to the necessity of accounting for the effects of labor force shifts before reaching any conclusions about the trend of the wage and salary share of national income. Kendrick mentions the effect of labor force shifts in one part of his book, but fails to give the matter the emphasis it deserves.

Although Kendrick declares that the wage and salary share of national income has risen sharply, the considerable body of literature of a contrary nature is not discussed adequately or refuted.

These comments indicate, in my opinion, the need for a considerable amount of continuing work in the area of productivity measurement and analysis. Kendrick's massive effort is just a beginning. It permits one to draw very tentative conclusions, but certainly no firm conclusions. His work does raise many issues, however, for much further research.

AUTHOR'S NOTE

Since most of the issues raised by Mr. Ruttenberg are discussed in some detail in the text, an additional "reply" is unnecessary. The reader may judge for himself the validity of Mr. Ruttenberg's comments. I should, however, like to reaffirm my conviction concerning the analytical usefulness of having measures of input, price, and productivity of tangible capital separately and in combination with labor, in addition to the labor measures alone. In Chapter 5, for example, far from "adding confusion," the full set of estimates makes possible a more complete statistical analysis of relative changes in factor incomes in the United States than any previously attempted.

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