Industry Changes in Nonlabor Costs

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Changes in the forces of both demand and supply interact to produce changes in industry structure. This paper deals with one aspect of changing industrial structure—industry changes in nonlabor costs. I first look at these changes as the product of relative industry changes in outputs and in unit nonlabor costs—largely accepting the former as given, despite the obvious interactions. I then look behind the industry changes in unit property costs to note the relative changes in capital productivity and in the gross price of capital and analyze the relationships of these two variables to each other and to selected additional variables.

Since changes in industry shares of property costs are related to changes in the property share of gross national income by industry, these changes are also examined. Changes in factor shares are "explained" statistically in terms of relative changes in factor prices and in factor inputs. The general patterns of these changes and the associated coefficients of substitution are set forth and an effort is made to explain them in terms of general economic forces.

Although the emphasis of the paper is on property costs, I will also briefly treat changes in indirect business taxes by industry.

Most of the basic industry series were provided by the Office of Business Economics: gross national product and income by major types of income; real gross product (1958 dollars); persons engaged in production; and average compensation per full-time equivalent employee.[1]

[1] The estimates of the Office of Business Economics, U.S. Department of Commerce, are published in the national income statistical supplement to the *Survey of Current Business*, November 1966. The gross income and product

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Since the "profit-type income" category of OBE includes net proprietors' income, it was necessary to estimate the portion of this which is believed to represent compensation for the labor of proprietors in order to split gross national income into the labor and property shares. There are a number of alternative methods for doing this as noted by Greenberg and Mark; I chose the simplest method, which consists of imputing the average earnings per full-time equivalent employee in each industry to the numbers of proprietors in the industry. "Labor productivity" is estimated as the ratio of real product originating to numbers of persons engaged.

The Statistical Framework

The sector studied was limited to the private domestic business economy, for the simple reason that only in the industries comprising private business is there the full complement of nonlabor as well as labor income. In the government, household, and nonprofit institutions sectors a net property return is not even imputed in the Commerce Department accounts. Even if it were, an analysis of its share would reveal merely the assumptions of the estimators! In a few instances, the industry detail provided by OBE was combined for pragmatic reasons.[2]

Real capital stock estimates for twenty-eight of the fifty basic industries used in the study were kindly provided by Michael Gort and Rayford Boddy.[3] They have developed estimates of gross and net capital stock in current and constant prices, with a number of variants of the net stock estimates. I have chosen to work with the gross stock estimates, partly in order to simplify the analysis, and partly in order to avoid the problem of choosing among alternative depreciation patterns and the associated valuation adjustments on net profits. Thus, my capi-

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estimates are published only for major industry groups and subgroups. The two-digit industry detail was furnished by OBE to the authors of papers for the December 1966 sessions of the Conference on Research in Income and Wealth for their analytical use.

[2] Chiefly, I combined those service industries which comprised private-nonprofit institutions as well as private businesses, prior to eliminating the income originating in the former.

[3] These estimates will be published by Michael Gort and Raford Boddy in a forthcoming article. Their capital stock estimates cover the period 1948–63, but the estimates for the years 1961–63 were received too late for use in this study; I extrapolated their estimates for 1948–60 by similar sources and methods, but my estimates for 1961–63 are subject to revision.

tal productivity estimates are the ratios of real gross product to real gross capital stock (the inverted ratios representing capital coefficients); and the "price" of capital is a gross price, computed as the ratio of gross property compensation and the real gross capital stock. This unorthodox variable thus reflects changes in the rate of depreciation, as well as in the net rate of return, and in the average prices of the underlying stock of capital goods.[4] Using gross "cash flow" has the advantage of avoiding a separation of depreciation and profits before taxes, but if time had permitted, I would also have treated depreciation and profits separately.

The analysis is confined to trends of industry shares of nonlabor costs between the two three-year periods 1948–50 and 1961–63. Each of these periods includes one recession year, but the earlier period probably represents a somewhat higher average rate of capacity utilization. Nevertheless, apart from a few exceptional industry situations, the periods chosen for comparison would appear to reveal basic trends in the several variables rather well. The framework developed here could be used for analyses of cyclical movements and movements from one cycle-average to another, as well as the trend over the period as a whole.

The limited time since receipt of the basic industry product estimates has forced me to make this paper more of a preliminary survey of the field than a thorough analysis. I hope that the paper will stimulate further work on factor costs by industry. Certainly the estimates now available from OBE on industry product make possible quantitative analyses which go beyond any previously attempted.

Indirect Business Taxes

Before turning our attention to gross property compensation, I believe it is worthwhile to take at least a passing look at indirect business taxes by industry. In 1948–50, these taxes accounted for 9.4 per cent of gross private domestic business product, increasing to 11.2 per cent in 1961–

[4] This is demonstrated in the following equation, in which K is the real gross stock of capital, P the average prices of the underlying capital goods (so that PK is the current-dollar value of the gross stock), r the gross rate of return on PK, and C the current-dollar gross property compensation:

$$\frac{C}{K} = \frac{rPK}{K} = rP$$

63. According to the Commerce estimates, there is a wide variation among industries in the proportions of gross product accounted for by indirect business taxes, as well as in the changes in these proportions. Concomitantly, there have been substantial differences among industries in the proportions they contribute to the government's total indirect business tax take, as implied in Table 1. Relative percentage changes in industry proportions are spelled out in Table 2, column 5. (All tabular matter is grouped at the end of this article.)

Before discussing the changes, it should be pointed out that about two-thirds of indirect business taxes are levied directly on commodities in the form of sales taxes, excises, and customs duties. About one-third are represented by property taxes, which differ according to the volume of taxable property commanded by an industry. OBE must have experienced some difficulties in allocating indirect taxes by industry, especially in the case of property taxes; and an appraisal of OBE methodology is needed. But the divergences in trends are so marked in many instances that the probable margins of error in the estimating procedures could hardly be a significant element in the results.

The changing proportions of total indirect business taxes contributed by an industry can be factored into relative changes in output and in unit tax payments (see Table 2, columns 5, 1, and 3). Sharply increasing relative tax payments (over 25 per cent in the period from 1948–50 to 1961–63) were a result *both* of relative increases in output and in unit taxes in a few industries: real estate, brokerage, and selected services. In more cases of sharp industry increases, the relative increase in unit taxes much more than offset the effect of declining relative output, i.e., in the cases of the petroleum industry; stone, clay, and glass; contract construction; insurance agents; repair services; and nonfarm agriculture. In almost as many cases, the sharp relative increase in tax take was due entirely to sharp relative increases in output, with unit taxes falling relatively for chemicals, transportation equipment (excluding motor vehicles), air transportation, radio-TV, and banking.

Marked declines of industry shares in total indirect business taxes were generally due to relative declines in both output and in unit taxes (in about ten industries). Relative declines in output much more than offset relative increases in unit taxes in the coal industry and in leather and leather products. Conversely, relative declines in unit taxes much

more than offset relative increases in output in electrical machinery, instrument manufacture, and pipeline transportation.

The most important thing to notice is that there have been wide divergences among industries in the changes in indirect business taxes per unit of output over the period studied. These have obviously influenced relative prices, and thus relative changes in sales, output, and resource allocation. I do not attempt to trace the impacts—to do so would require data on gross industry prices and sales, as well as the industry product estimates and deflators, plus more time than was at my disposal. Yet it seems clear that the wide divergences noted must have distorted resource allocation considerably as compared with a competitive model in which prices reflect unit resource costs unaffected by indirect taxes.

The OBE has performed a service in allocating indirect business taxes on an industry basis: by spelling out the differential industry impact of changes in these taxes, it has made possible more rational action on the part of legislators. Possibly our legislators at the several levels have wished to raise indirect tax rates more than average in the petroleum industry, construction, and primary metals, to name a few, and to lower or raise them less than average on foods, apparel, electrical machinery, and pipelines. But they should know what they are doing, and in what degree, when they indirectly influence resource allocations. This objective would be further facilitated if the OBE estimates were provided in greater detail, possibly on a commodity-group as well as an industry basis, with the related gross sales and price information, and if the impact of indirect business taxes on prices were traced through to demand for goods and for the underlying factor services by industry.

Relative Changes in Gross Property Compensation

The industry shares of gross property compensation (GPC) have varied widely between 1948–50 and 1961–63, as shown in Table 1. The percentage changes in industry shares are indicated by the index numbers of relative GPC in Table 2, column 6. To take a few extreme examples from that table, gross property compensation in radio and TV broadcasting increased 3.6 times more than in the private domestic economy, while that of insurance carriers rose only 21.2 per cent as much (i.e., the industry percentage of GPC fell by over 78 per cent).

The relative industry changes in gross property compensation can be decomposed into relative changes in output and in GPC per unit of output (columns 1 and 4). Thus, in the case of radio-TV broadcasting, relative industry output rose by 80 per cent; the rest of the rise in the GPC percentage was due to a doubling of GPC per unit of output. With regard to insurance agents, relative output actually rose a bit—by 12 per cent; the decline in the industry share of total GPC was accounted for by an 81 per cent drop in GPC per unit of output.

There does not appear to be a significant correlation between relative industry changes in output and in unit GPC. In half the industries, both variables moved in the same direction, and in the other half of the industries, they moved in opposite directions. One might expect a significant negative correlation between relative industry changes in output and in unit *total* cost (the gross industry product price deflator): the correlation is negative, but not significant at the .05 level.[5] In any case, GPC on the average accounted for little more than one-third of total industry gross product in the private domestic business economy, and the relationship between relative changes in unit GPC and in total unit cost was not close between 1948–50 and 1961–63.[6]

In over half the industries—28—I was able to probe behind the relative changes in unit GPC. This variable may, of course, be viewed as the product of the gross capital coefficient and the gross "price of capital" (gross property compensation per unit of real gross capital stock). In the private domestic business economy, for example, the gross capital coefficient rose by 2 per cent over the period observed, while the gross price of capital rose by 19.3 per cent—accounting for the 21.7 per cent increase in unit property return. In looking at the component industries, however, I am concerned with the changes in these variables *relative* to the economy changes, as shown in the first two columns of Table 3. Thus, to take the first industry in the table, farming, a 13 per cent increase in the gross capital coefficient was more

[5] The coefficient of correlation is $-.175$. The estimating equation follows, with Y = relative unit total cost and X = relative output:

$$\log Y = 2.16219 - .0826 \log X$$

[6] The coefficient of correlation between these two variables was only 0.056. This implies a significant negative correlation between relative unit labor cost and output, which seems to have been the case, based on examination of a scatter diagram.

than offset by a 31 per cent decline in the gross price of capital—which "explains" the 22 per cent drop in unit property compensation shown in Table 2. The products of columns 1 and 2 in Table 3 should equal the link relatives shown in column 4 of Table 2 (unit gross property compensation), allowing for small discrepancies due to rounding.

When the two components of unit GPC are related to each other, a significant negative correlation emerges.[7] That is, a relative increase in the gross price of capital is associated with a relative drop in the real gross stock of capital per unit of output (capital coefficient), and the relative quantity change appears to be somewhat less than proportionate to the relative price change.

There may, of course, be a spurious element in this correlation (and subsequent ones) between variables containing a common component. Yet, from the theoretical viewpoint, one would expect this inverse relationship, especially if relative industry changes in the gross price of capital were closely related to those in the ratio of the gross price of capital to the gross compensation per employee (or per man-hour).

Since (as Greenberg and Mark point out) there was a rather narrow dispersion in rates of change in average labor compensation over the period, while at the same time there was a wide dispersion in rates of change in property return, relative industry changes in the latter were quite similar to changes in the ratios of the two factor prices. Thus, industry changes in the gross capital coefficients are also significantly related to industry changes in the ratio of the price of labor (measured as average annual compensation per full-time equivalent employee) to the gross price of capital.[8] A priori, one would expect a relatively more intensive use of capital if its relative price had fallen in relation to wage rates.

[7] The coefficient of correlation is −.796. The estimating equation follows, with X = the relative industry real gross stock of capital per unit of real gross product and Y = the relative gross price of industry capital (gross property compensation per unit of real gross capital stock):

$$\log Y = 4.5842 - 1.0286 \log X$$

[8] The coefficient of correlation is .621. The estimating equation follows, with X = the relative industry gross capital coefficient defined as in footnote 7, and Y = the relative ratio of the price of labor (average annual compensation per full-time equivalent employee) to the gross price of capital, as defined above (data presented in Table 3):

$$\log Y = .1343 + .9300 \log X$$

Since a thirteen-year period is being studied, I have been treating gross capital return per unit of real capital stock as a "price." Yet, it must be remembered that there is a residual, profit element in the "price," and that relative industry changes in the price of capital will be affected by the differential industry impact of dynamic change. This suggests that there is a reciprocal interaction in the relationship just discussed which may be more obvious if we speak of a *positive* relationship between relative industry changes in "capital productivity" and in the gross property return per unit of real capital. That is, in industries in which capital productivity is increasing fastest, one would expect a favorable impact on profit rates, as well as a continuing effort to economize on capital per unit of output.

Looking further at the output-capital ratio, it was interesting to discover a significant positive correlation between relative industry changes in capital productivity and in output.[9] This is also true of relative changes in labor productivity (measured as real product per person engaged) and in output.[10] The significantly positive correlations between relative industry changes in productivity of both factors and in output are behind the negative correlation between relative changes in total unit costs and in output.[11]

The positive correlation between relative industry changes in output and in capital productivity would have suggested a possible negative correlation between relative changes in output and in unit GPC, were it not for the fact I noted earlier: that is, the association between output and capital productivity is offset by the positive correlation between capital productivity and the gross price of capital, so that no significant correlation exists between output and unit GPC.

[9] The coefficient of correlation is .612. The estimating equation follows, with Y = relative industry capital productivity (real gross product per unit of real gross capital stock), and X = relative industry real gross product:

$$\log Y = 1.1039 + 0.4342 \log X$$

[10] The coefficient of correlation is 0.388, which is barely significant at the .05 level. The estimating equation follows, with Y = relative industry labor productivity (real gross product per person engaged in production) and X = relative real industry gross product:

$$\log Y = 1.5686 = .2126 \log X$$

[11] See John W. Kendrick, *Productivity Trends in the United States*, Princeton for NBER, 1961, Chapter 7.

The Property Share of Gross Factor Income

Changes in industry shares of gross factor income by type of compensation are related to changes in factor shares of gross income originating in each industry. For example, if an industry (such as manufactured food, as shown in Table 1) experiences a greater drop in its share of gross property compensation than in its share of gross factor income, this is associated with a fall in the property share of gross factor income. In the case of manufactured food, as shown in Table 4, the property share of gross income fell by 11 per cent between 1948–50 and 1961–63 —somewhat more than the 3 per cent drop in the private domestic business economy as a whole.

In this section, I will examine the changes in factor shares of gross income over the chosen period. One approach to this analysis is demonstrated for all industries in Table 4. The percentage shares of property are shown for the two periods in the first two columns, and the link relatives indicating the proportionate changes in shares are shown in column 3. It will be noted that in the majority of industries, the property share declined, although in several industries there were marked increases, notably in communications.

Columns 4 and 5 "explain" the changes in property shares in terms of changes in unit property cost relative to unit total factor cost. If GPC per unit of output rises less than total cost per unit, then obviously the property share declines. Looking behind this relationship, one might inquire as to the conditions under which unit labor cost, and thus unit total cost, rises more than unit property cost.

One way of describing these conditions would be in terms of the relative movements of productivity and price for each of the factors. A decline in the property share would indicate that an increase in the price of labor exceeded the increase in labor productivity by a wider margin than the increase in the price of capital exceeded the increase in average capital productivity.

Another way of putting it is that if the relative decrease in the price of a factor is proportionately greater than the relative increase in its quantity of input, that factor's share will decline. This approach has been implemented for the twenty-eight industries for which capital data are available in Table 5. The "coefficient of substitution" in column 4

shows the ratio of rates of change in relative quantities to rates of change in relative prices. This concept is familiar as the "elasticity of substitution"; but since I am applying it to historical time series affected by dynamic changes, I merely term it a "coefficient."

Looking now at Table 5, it will be noted that in all industries and industry groups but one (transportation equipment manufacturing, except motor vehicles), the real gross capital stock (or "input") rose in relation to persons engaged (labor input). Conversely, the gross price of capital fell in relation to the price of labor (average compensation per employee, or per person engaged) in all but four of the industries. One of the four is transportation equipment excluding motor vehicles, which preserves an inverse relationship. In the other three industries (and in the communications group), the direct relationship is indicated by the minus (−) sign before the substitution ratio.

Examining the coefficients of substitution in column 4 of Table 5, one sees that in ten out of the thirty-five industries and groups the coefficients are greater than unity. This means that if relative capital input increased (which it did in all of these industries), the capital share increased, since the relative capital price declined less (or rose less, in the case of negative coefficients) than the proportionate increase in the relative volume of capital. In the one industry in which the relative capital input fell, the property share of income also rose, which is consistent with a coefficient of substitution below 1.

In twenty-five of the thirty-five industries and groups, and in the private domestic business economy as a whole, the coefficients of substitution were less than unity—and in all but transportation equipment excluding motor vehicles (in which relative capital input fell), the gross property share of income fell. In all but four of the industries, the coefficients were well above 0.5, indicating that generally the rate of change in the relative price of capital was well under twice the rate of change in the relative quantity of capital input. In the private domestic business economy as a whole, the coefficient was 0.89—considerably higher than the 0.58 which R. Sato and I computed for the U.S. economy over the period 1919–60,[12]—but still below unity.

In speculating about the prevailing pattern of relative factor prices, inputs, and shares, I believe the following general points may be made

[12] See J. W. Kendrick and R. Sato, "Factor Prices, Productivity, and Economic Growth," *American Economic Review*, December 1963, p. 981.

with considerable confidence.[13] The relative growth of capital in relation to the work force in the private economy as a whole reflects the saving and investment propensities of the community. As a result largely of research and development outlays, resulting in new products and cost-reducing inventions, investment demand schedules have shifted upwards enough to offset the tendency towards diminishing returns to capital. Rates of return on new investment have fluctuated, but have shown no sustained trend in either direction, while the real stock of capital grew by at least one per cent a year faster than the labor force, on the average, over the past half-century—and relatively even faster since World War II.

In analyzing the downward tendency in the relative price of capital, it must be remembered that this consists of two elements: prices of the underlying capital goods, and the gross rate of return on the stock of capital. As far as the average prices of reproducible capital goods are concerned, it is clear that these have risen significantly less than wage rates generally, since labor productivity has risen significantly in the capital-goods industries while factor prices in these industries change more or less proportionately to factor prices in the economy as a whole. As noted above, the rate of return on capital shows no sharp trend, and over the period in question this rate probably declined somewhat in most private industries—thus reenforcing the tendency for capital prices to rise less than the price of labor. But as has been pointed out elsewhere,[14] a general trend in the profit rate tends to be self-limiting through its effect on saving and investment.

If I am correct in positing no substantial longer-run trends in interest-plus-profit rates in conjunction with significant upward trends in productivity in the private economy including capital goods industries, then a relative decline in the ratio of capital to labor prices follows. Indeed, this would seem to be the chief mechanism whereby the relative growth of the capital stock is absorbed by the various industries. The fact that the over-all coefficient of substitution is less than unity reflects the basic fact that the rate of growth of productivity has exceeded the rate of growth of the capital stock per worker.[15] So the general tendency has been for property shares of factor income to drop, and thus for industry

[13] *Ibid.*, p. 975.
[14] *Ibid.*, p. 982.
[15] See Kendrick, *Productivity Trends*, Chapters 3 and 4.

shares of gross property cost to fall more, or rise less, than industry shares of gross national income.

It has been noted that a substantial majority of the thirty-five industries studied here tend to follow the private business economy pattern—a rise in the capital-labor ratio (one exception), a drop in the gross price of capital relative to average labor compensation (four exceptions), and a coefficient of substitution less than unity (ten exceptions). The variations among industries in the coefficients are due to: (a) differences in rates of growth of the capital-labor ratio due to differences and changes in the relative unit factor requirements of innovations in the various industries, and differential rates of shift in investment demand schedules; (b) differential changes in the price of capital, particularly the rate-of-return component, and/or in average labor compensation.

Of these variables, my judgment is that differential changes in the rate of return is probably the most important factor over shorter- or intermediate-term periods. It was certainly a key element in the communications industry, for example, reflecting changes in regulatory agency policies over the period studied.

Hopefully, the analysis here points the way to the further research needed to provide full economic explanations for the changing factor shares of income by industry, and for changing industry shares of factor compensation.[16]

[16] After completion of this paper, my attention was called to a recent econometric study of changing factor shares, "The Share of Corporate Profits in the Postwar Period," by Murray Brown (U.S. Department of Commerce, Staff Working Paper in Economics and Statistics No. 11, April 1965). This paper provides excellent parallel reading for the discussion in this volume.

TABLE 1

Industry Proportions of Gross Private Domestic Business Product By Major Type of Cost (Income), 1948–50, and 1961–63

(per cent)

	Total Gross Product		Total Gross Income		Gross Property Compensation	
	1948–50 (1)	1961–63 (2)	1948–50 (3)	1961–63 (4)	1948–50 (5)	1961–63 (6)
Private domestic business economy	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture, forestry, and fisheries	9.0	4.7	9.6	5.0	15.5	9.2
Farms	8.7	4.5	9.2	4.7	15.4	9.1
Agricultural services, forestry, and fisheries	.32	.28	.36	.33	.07	.12
Mining	3.7	2.8	3.9	2.9	6.5	5.3
Metals	.38	.25	.39	.26	.62	.34
Coal	.97	.31	1.05	.34	.66	.24
Petroleum and natural gas	3.1	2.8	2.9	2.4	5.4	4.2
Nonmetallic mining	.26	.27	.27	.29	.33	.32
Contract construction	4.9	5.2	5.3	5.7	.78	1.07
Manufacturing	32.4	32.8	32.7	33.8	25.1	23.68
Nondurables	15.4	13.9	14.7	13.5	11.6	10.1
Food	4.4	3.6	3.7	3.3	3.1	2.6
Tobacco	.76	.68	.22	.28	.32	.50
Textile mills	2.0	1.01	2.1	1.1	1.5	.62
Apparel	1.5	1.2	1.7	1.3	.56	.44
Paper	1.1	1.3	1.2	1.4	1.4	1.3
Printing and publishing	1.6	1.6	1.7	1.8	.76	.82
Chemicals	2.0	2.5	2.2	2.8	3.0	3.5
Rubber and miscellaneous plastics	.61	.80	.59	.79	.31	.53
Leather	.51	.36	.55	.40	.21	.14

(continued)

TABLE 1 (continued)

	Total Gross Product		Total Gross Income		Gross Property Compensation	
	1948–50	1961–63	1948–50	1961–63	1948–50	1961–63
	(1)	(2)	(3)	(4)	(5)	(6)
Durables	17.0	18.9	18.0	20.3	13.8	13.6
Lumber and wood	1.2	.78	1.3	.86	.95	.49
Furniture	.55	.49	.60	.55	.30	.25
Stone, clay, and glass	1.09	1.2	1.2	1.3	.98	1.1
Primary metals	2.8	2.6	3.0	2.9	2.6	2.2
Fabricated metals	2.0	2.0	2.2	2.2	1.5	1.2
Machinery, except electrical	2.8	3.0	3.0	3.3	2.1	2.2
Electrical machinery	1.9	2.7	2.0	2.9	1.3	1.5
Transportation equipment, except motor vehicles and ordnance	.94	2.2	1.01	2.4	.36	.91
Motor vehicles	2.5	2.6	2.4	2.5	2.9	3.0
Instruments	.46	.74	.48	.81	.20	.61
Miscellaneous manufacturing	.70	.56	.75	.60	.44	.28
Transportation	6.4	5.0	6.4	5.2	3.9	3.0
Railroads	3.4	1.7	3.4	1.8	2.2	1.1
Nonrailway transportation	3.0	3.3	3.0	3.4	1.7	1.9
Local and highway passenger	.74	.47	.74	.45	.33	.22
Motor freight and warehouses	1.3	1.7	1.3	1.8	.65	.78
Water	.48	.38	.50	.42	.24	.13
Air	.23	.49	.23	.50	.16	.35
Pipeline	.12	.10	.12	.11	.17	.19
Transportation services	.15	.16	.16	.18	.12	.16
Communications	1.7	2.5	1.6	2.4	1.2	3.4
Telephone and telegraph	1.6	2.3	1.4	2.2	1.1	3.1
Radio and TV	.13	.24	.14	.27	.08	.28

(continued)

TABLE 1 (concluded)

	Total Gross Product		Total Gross Income		Gross Property Compensation	
	1948–50 (1)	1961–63 (2)	1948–50 (3)	1961–63 (4)	1948–50 (5)	1961–63 (6)
Electric, gas, and sanitary services	2.0	2.9	2.0	2.9	1.1	3.1
Wholesale and retail trade	20.7	19.3	19.9	17.9	14.7	9.1
Wholesale	7.4	7.7	6.6	6.6	6.4	5.5
Retail	13.3	11.6	13.3	11.3	9.1	4.6
Finance, insurance, and real estate	11.8	15.9	11.1	14.8	23.1	31.2
Finance and insurance	2.8	3.8	2.8	3.9	1.8	1.6
Banking	1.2	1.7	1.3	1.9	1.9	2.7
Brokerage	.17	.35	.16	.35	–	.10
Insurance carriers	1.0	1.2	1.02	1.2	.49	.10
Insurance agents, etc.	.34	.50	.35	.53	.22	.37
Real estate	9.0	12.2	8.3	10.9	21.3	30.0
Services	7.3	8.8	7.6	9.5	6.3	8.2
Hotels and lodging places	.71	.65	.74	.68	.34	.37
Personal services	1.4	1.2	1.5	1.3	.57	.23
Miscellaneous business services	.72	1.5	.77	1.6	.36	.84
Repair services	.72	.84	.78	.92	.08	.20
Amusement, except motion pictures	.53	.60	.43	.53	.23	.27
Motion pictures	.54	.26	.45	.26	.34	.14
Other services (private business)	2.7	3.8	2.9	4.2	4.3	6.1

TABLE 2

Relative Changes in Real Product and Selected Unit and Total Costs[a], *Private Domestic Business Economy by Industry, Based on Index Numbers, 1961–63*
(1948–50=100)

	Real Product (1)	Unit Costs (income)			Total Cost	
		Total (2)	Indirect Bus. Taxes (3)	Gross Property Compensation (4)	Indirect Bus. Taxes (5)	Gross Property Compensation (6)
Private domestic business economy (1948–50=100)	157.4	127.8	151.7	121.7	238.7	191.6
Private domestic business economy (1961–63 index Nos. = 100)						
Agriculture, forestry, and fisheries	75.3	70.0	102.2	78.7	77.2	59.2
Farms	75.1	68.0	100.9	78.2	75.8	58.7
Agricultural services, forestry, and fisheries	80.2	111.0	155.6	213.1	125.1	172.0
Mining	83.6	88.5	106.5	97.7	89.4	81.8
Metals	83.4	81.1	77.9	66.6	65.3	54.7
Coal	47.6	67.3	110.7	78.8	53.6	36.1
Petroleum and natural gas	95.0	97.8	151.7	81.8	144.2	77.6
Nonmetallic mining	116.8	88.5	61.9	83.2	74.9	97.2
Contract construction	91.7	115.5	149.6	149.9	137.0	137.5

(continued)

TABLE 2 (continued)

	Real Product	Unit Costs (income)			Total Cost	
		Total	Indirect Bus. Taxes	Gross Property Compensation	Indirect Bus. Taxes	Gross Property Compensation
Manufacturing	99.3	101.9	85.7	95.3	85.2	94.4
Nondurables	96.0	94.1	82.1	90.9	78.8	87.4
Food	85.0	98.2	69.8	96.1	59.4	81.9
Tobacco	94.4	94.9	69.0	168.9	65.2	156.5
Textile mills	75.9	67.6	67.6	53.7	51.4	40.7
Apparel	85.1	90.2	87.0	93.3	74.2	79.4
Paper	104.8	105.2	110.5	91.4	116.7	95.6
Printing and publishing	91.4	112.5	94.7	118.0	86.5	107.7
Chemicals	149.3	82.7	88.4	78.8	132.2	117.6
Rubber and misc. plastics	110.0	117.7	92.1	153.7	101.3	169.3
Leather	60.9	115.3	100.7	109.0	61.5	66.4
Durables	102.0	109.1	101.5	96.5	103.6	98.4
Lumber and wood	76.6	84.1	107.0	66.6	82.1	51.0
Furniture	81.3	110.6	112.0	105.3	91.3	85.6
Stone, clay, and glass	92.6	115.1	138.0	121.3	128.2	112.3
Primary metals	66.5	141.3	156.0	125.8	104.5	83.6
Fabricated metals	99.2	100.2	102.6	83.9	102.3	83.2
Machinery, except electrical	92.4	116.8	116.2	113.4	107.5	104.6
Electrical machinery	161.9	86.6	46.3	70.8	74.7	114.6
Transportation equipment, except motor vehicles and ordnance	194.7	117.9	69.4	129.0	134.8	251.1

(continued)

TABLE 2 (continued)

	Real Product	Unit Costs (income)			Total Cost	
		Total	Indirect Bus. Taxes	Gross Property Compensation	Indirect Bus. Taxes	Gross Property Compensation
Motor vehicles	104.6	101.3	114.8	96.4	120.4	100.8
Instruments	136.4	118.5	43.6	218.0	62.5	297.7
Miscellaneous manufacturing	87.0	90.0	78.2	74.5	68.0	64.8
Transportation	77.3	101.1	76.0	99.2	58.7	76.7
Railroads	60.8	82.2	53.4	84.8	32.6	51.5
Nonrailway transportation						
Local and highway	3.3	189.7	244.1	205.2	81.7	67.7
Motor freight and warehouse	135.8	96.9	79.8	87.2	107.6	118.6
Water	69.4	115.9	55.9	76.9	39.3	53.3
Air	274.7	75.7	51.5	80.9	140.5	222.2
Pipeline	126.2	64.7	34.0	89.0	43.0	112.2
Transportation services	58.0	188.9	185.8	229.9	108.1	133.3
Communications	147.2	97.6	58.6	190.2	86.0	280.0
Telephone and telegraph	144.7	96.8	59.2	190.4	85.5	275.4
Radio and TV	180.2	105.6	103.9	199.6	187.0	360.0
Electric, gas, and sanitary services	157.2	92.7	67.8	119.8	106.6	187.9
Wholesale and retail trade	99.2	93.8	109.8	62.4	108.8	62.2
Wholesale	111.8	92.9	96.4	77.1	107.7	86.1
Retail	91.7	94.8	120.0	55.2	110.1	50.7

(continued)

TABLE 2 (concluded)

	Real Product	Unit Costs (income)			Total Cost	
		Total	Indirect Bus. Taxes	Gross Property Compensation	Indirect Bus. Taxes	Gross Property Compensation
Finance, insurance, and real estate	117.0	115.7	116.0	115.7	135.7	135.2
Finance and insurance	97.0	140.6	127.2	96.5	123.2	93.3
Banking	81.9	170.6	152.1	175.7	125.0	143.8
Brokerage	128.0	174.7	105.3	209.2	134.4	
Insurance carriers	112.4	106.0	100.9	18.9	113.2	21.2
Insurance agents, etc.	100.1	147.9	133.6	166.1	133.4	166.3
Real estate	124.3	108.7	110.7	111.8	137.5	138.7
Services	99.0	122.6	74.3	131.6	73.6	130.5
Hotels and lodging places	88.2	103.9	110.4	123.8	97.6	109.2
Personal services	80.6	111.0	108.9	49.1	87.8	39.6
Miscellaneous business services	151.3	133.6	78.9	152.8	119.4	231.2
Repair services	199.2	116.9	156.5	244.1	155.6	242.2
Amusement, except motion pictures	98.5	115.5	77.9	118.6	76.8	118.6
Motion pictures	36.2	131.1	39.7	110.3	14.4	39.9
Other services (private business)	106.7	132.9	130.9	132.7	139.9	141.6

[a]The industry index numbers for 1961–63 in the table are obtained by dividing their values on a 1948–50 base by the index numbers for the total private domestic economy shown in the first line. Thus, we see for the several variables the industry movements between 1948–50 and 1961–63 *relative* to the movements for the private domestic economy.

TABLE 3

Relative Changes in the Capital Coefficient[a], Gross Price of Capital[b], and Associated Variables, Private Domestic Business Economy, by Selected Industries, 1961–63

(index numbers, 1948–50 = 100)

	Capital Coefficient[a] (1)	Gross Price of Capital[b] (2)	Output Per Worker (3)	Price of Labor[c] (4)	Ratio, Prices of Labor to Capital[d] (5)	Capital Per Worker[e] (6)
Farms	112.9	68.8	126.5	69.2	100.6	142.8
Mining	213.6	38.7	130.5	101.7	262.8	278.7
Petroleum	127.7	64.0	90.4	97.8	152.8	94.2
Contract construction	206.1	73.0	89.5	102.4	140.3	184.5
Manufacturing	103.8	91.5	97.2	102.9	112.5	100.9
Nondurables	103.5	87.7	101.3	97.4	111.1	104.8
Food	98.6	97.3	94.3	100.1	102.9	93.0
Tobacco	99.3	166.6	114.4	112.9	67.8	113.6
Textile mills	103.0	51.0	115.5	84.8	166.3	119.0
Apparel	96.0	96.6	89.2	81.5	84.4	85.6
Paper	123.0	73.4	87.4	102.4	139.5	107.5
Printing and publishing	104.1	113.2	80.7	91.7	81.0	84.0
Chemicals	81.0	96.9	121.3	107.5	110.9	98.3
Rubber	92.0	167.1	90.0	99.4	59.5	82.8
Leather	143.9	74.2	74.7	87.5	117.9	107.5
Durables	104.4	93.5	94.9	107.4	114.9	99.1
Furniture	96.1	110.6	81.8	91.3	82.5	78.6
Stone, clay, and glass	138.6	87.3	93.2	104.5	119.7	129.2
Primary metals	157.7	79.4	75.6	109.3	137.7	119.2
Fabricated metals	117.5	71.3	94.8	100.5	141.0	111.4
Machinery, except electrical	115.3	98.2	86.0	103.0	104.9	99.2
Electrical machinery	69.3	102.5	108.6	105.2	102.6	75.3
Transportation equipment, except motor vehicles	57.5	225.3	95.1	112.8	50.1	54.7
Motor vehicles	124.0	78.5	125.1	109.5	139.5	155.1

(continued)

TABLE 3 (concluded)

	Capital Coefficient[a] (1)	Gross Price of Capital[b] (2)	Output Per Worker (3)	Price of Labor[c] (4)	Ratio, Prices of Labor to Capital[d] (5)	Capital Per Worker[e] (6)
Transportation	89.1	111.4	99.4	104.6	93.9	88.6
Railroads	90.2	93.6	117.6	100.9	107.8	106.0
Water	113.0	67.3	88.2	111.8	166.1	99.7
Air	83.0	98.8	134.5	106.7	108.0	103.3
Communications	84.5	226.0	143.4	110.5	48.9	121.2
Telephone and telegraph	81.2	236.9	147.0	110.1	46.5	119.4
Radio and TV broadcast	100.1	197.7	73.7	99.0	50.1	73.8
Electric and gas, etc.	70.5	169.7	150.1	109.6	64.6	105.8
Wholesale and retail trade	121.3	51.5	94.4	94.8	184.1	114.5
Wholesale	125.7	60.9	101.4	99.3	163.1	127.5
Retail	121.2	45.2	88.7	92.1	203.8	107.5

[a]Real gross stock of capital per unit of output (real gross product).

[b]Gross capital compensation per unit of real gross capital stock.

[c]Average annual compensation per full-time equivalent employee.

[d]Column 3 divided by column 2.

[e]Real gross stock of capital per person engaged in production.

TABLE 4

The Changing Property Share of Gross Factor Income, Private Domestic Business Economy, by Industry
(percentages, and index numbers 1961–63 on a 1948–50 base)

	Property Shares of Gross Factor Income (per cent)		Link Relatives, 1961–63 (1948–50 = 100)		
	1948–50	1961–63	Property Share[a]	Unit Property Cost	Unit Total Cost
	(1)	(2)	(3)	(4)	(5)
Private domestic business economy	35.3	34.3	97.2	121.7	125.5
Agriculture, forestry, and fisheries	57.0	63.2	110.0	95.8	86.3
Farms	59.1	66.7	112.9	95.2	84.3
Agricultural services, forestries, and fisheries	7.44	12.63	192.3	259.4	134.9
Mining	58.1	62.5	107.7	119.1	110.6
Metals	55.90	43.81	79.4	81.0	102.0
Coal	22.16	24.44	109.9	95.9	83.7
Petroleum and natural gases	64.87	59.16	91.2	99.4	109.0
Nonmetallic mining	43.30	38.01	87.8	101.2	115.5
Contract construction	51.3	64.0	124.8	182.4	146.1
Manufacturing	27.1	24.0	88.9	116.0	130.5
Nondurables	21.1	19.5	92.4	110.6	119.9
Food	29.86	26.65	89.0	117.0	131.5
Tobacco	51.37	61.33	119.7	201.9	168.7
Textile mills	24.28	18.94	78.0	65.4	86.0
Apparel	11.82	11.64	98.5	113.5	115.5
Paper	38.53	31.96	83.0	112.2	133.9
Printing and publishing	16.00	15.94	99.9	143.6	143.8
Chemicals	47.73	43.46	91.1	95.9	105.3
Rubber and miscellaneous plastics	18.77	23.13	123.1	187.1	152.0
Leather	13.59	12.26	90.2	132.7	147.1

(continued)

TABLE 4 (continued)

	Property Shares of Gross Factor Income (per cent)		Link Relatives, 1961–63 (1948–50 = 100)		
	1948–50	1961–63	Property Share[a]	Unit Property Cost	Unit Total Cost
	(1)	(2)	(3)	(4)	(5)
Durables	27.0	22.9	84.7	117.5	138.7
Lumber and wood	25.18	19.40	77.0	81.0	105.2
Furniture	17.54	15.99	91.2	128.1	140.5
Stone, clay, and glass	29.25	29.64	101.3	147.6	145.7
Primary metals	30.04	25.62	85.3	153.1	179.4
Fabricated metals	23.98	19.15	79.8	102.1	127.9
Machinery, except electrical	24.27	22.31	91.9	138.0	150.1
Electrical machinery	22.63	17.16	75.8	86.2	113.7
Transportation equipment, except motor vehicles and ordnance	12.66	13.15	103.8	157.0	151.3
Motor vehicles	42.69	40.78	95.5	117.3	122.8
Instruments	15.15	25.73	169.8	265.3	156.2
Miscellaneous manufacturing	20.52	16.05	78.1	90.7	116.1
Transportation	21.1	19.5	92.4	120.7	130.6
Railroads	22.81	21.84	95.7	103.2	107.7
Nonrailroad transportation					
Local and highway passenger	15.64	16.84	107.7	249.7	231.9
Motor freight and warehouse	17.47	14.94	85.3	106.1	124.4
Water	17.13	10.56	61.6	93.5	151.7
Air	24.69	24.46	99.3	98.5	99.2
Pipeline	49.61	61.63	124.3	108.3	87.1
Transportation services	26.53	30.94	116.4	279.8	240.4
Communications	27.4	47.6	173.9	231.5	133.1
Telephone and telegraph	28.01	49.11	175.3	231.7	132.2
Radio and TV	19.64	35.36	180.1	242.9	134.9

(continued)

TABLE 4 (concluded)

	Property Shares of Gross Factor Income (per cent)		Link Relatives, 1961–63 (1948–50 = 100)		
	1948–50	1961–63	Property Share[a]	Unit Property Cost	Unit Total Cost
	(1)	(2)	(3)	(4)	(5)
Electric, gas, and sanitary services	52.3	63.0	120.8	145.8	120.7
Wholesale and retail trade	26.0	17.5	67.3	76.0	113.0
Wholesale	34.21	28.60	83.6	93.8	112.2
Retail	23.95	13.99	58.4	67.2	115.1
Finance, insurance, and real estate	73.5	72.4	98.6	140.8	142.8
Finance and insurance	22.2	14.6	65.8	117.4	178.4
Banking	49.33	48.50	98.3	213.8	217.5
Brokerage		10.28			211.4
Insurance carriers	16.82	2.90	17.3	23.0	133.1
Insurance agents, etc.	21.97	23.62	107.6	202.2	188.0
Real estate	90.8	92.9	102.5	136.1	132.8
Services	29.2	29.6	101.3	160.2	158.2
Hotels and lodging places	16.37	18.89	115.4	150.7	130.6
Personal services	13.90	5.89	42.4	59.8	141.1
Miscellaneous business services	16.68	17.91	107.5	185.9	172.9
Repair services	3.64	7.31	201.0	297.1	147.8
Amusements, except motion pictures	18.96	17.28	91.3	144.3	158.1
Motion pictures	26.72	17.78	66.5	134.2	201.8
Other services (private business)	52.28	50.56	96.7	161.5	167.0

[a]Columns 2 ÷ 1 equals columns 4 ÷ 5.

TABLE 5

Relative Capital Input, Relative Price of Capital, and Capital Share of Income Private Domestic Business Economy, by Selected Industries, 1961–63

(index numbers 1948–50=100)

	Relative Capital Input[a] (1)	Relative Price of Capital[b] (2)	Capital Share of Income[c] (1×2) (3)	Coefficient of Substitution[d] (4)
Private domestic business economy	126.4	76.9	97.2	.89
Farms	127.1	88.7	112.7	1.99
Mining	146.4	73.5	107.6	1.24
Petroleum	117.0	77.9	91.1	.62
Contract construction	250.2	49.9	124.8	.21
Manufacturing	132.2	67.1	88.7	.70
Nondurables	134.6	68.7	92.5	.79
Food	123.6	72.2	89.2	.65
Tobacco	120.0	99.4	119.3	28.2
Textile mills	149.3	52.2	77.9	.61
Apparel	122.6	80.2	98.3	.92
Paper	129.5	64.1	83.0	.58
Printing and publishing	119.5	85.6	99.9	.99
Chemicals	119.4	76.3	91.1	.65
Rubber	117.3	104.9	123.0	-3.36
Leather	147.0	61.3	90.1	.78
Durables	130.1	65.2	84.8	.61
Furniture	112.9	80.9	91.3	.57
Stone, clay, and glass	150.8	67.2	101.3	1.04
Primary metals	143.4	59.5	85.3	.69
Fabricated metals	142.5	56.1	79.9	.61
Machinery, except electrical	131.7	69.8	91.9	.76
Electrical machinery	108.4	69.9	75.8	.22
Transportation equipment, except motor vehicles	82.7	125.5	103.8	.84
Motor vehicles	147.7	64.6	95.4	.89

(continued)

TABLE 5 (concluded)

	Relative Capital Input[a] (1)	Relative Price of Capital[b] (2)	Capital Share of Income[c] (1×2) (3)	Coefficient of Substitution[d] (4)
Transportation	122.9	75.2	92.4	.72
Railroads	138.6	69.1	95.8	.88
Water	136.1	45.2	61.5	.38
Air	142.2	69.7	99.1	1.00
Communications	147.2	118.2	174.0	-2.33
Telephone and telegraph	145.2	120.8	175.4	-2.00
Radio and TV broadcast	148.6	121.8	181.0	-2.02
Electric and gas, etc.	120.9	99.6	120.4	49.00
Wholesale and retail trade	143.3	47.1	67.5	.47
Wholesale	144.5	57.8	83.5	.67
Retail	139.1	42.0	58.4	.32

[a]Index numbers of ratio of real gross capital stock to average of the real stock and persons engaged, each weighted by its share in gross factor income, 1948–50.

[b]Index numbers of the ratio of gross property compensation per unit of real gross capital stock to an average of this variable compensation per full-time equivalent employee, weighted by gross income shares, 1948–50.

[c]Columns (1)×(2) should equal column 3 of Table 4, except for errors due to rounding.

[d]Rate of change in relative capital input (Column 1) divided by rate of change in relative capital price (Column 2).

COMMENT

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INTRODUCTION

In this note I compare two alternative methods for measuring capital input: (1) the method developed by John W. Kendrick and employed in his paper, "Industry Changes in Nonlabor Costs"; (2) the method

developed by Zvi Griliches and myself, which was published in "Sources of Measured Productivity Change: Capital Input." [1] Both of these methods are consistent with an accounting framework for national product and national wealth. The problem of choosing between the methods amounts to answering the questions, what is capital input? what is the price of capital? Definite answers to these questions may be obtained by appealing to the economic theory of capital. This theory suggests measures of capital input that may be employed in studies of total factor productivity or in estimating production functions. Data on capital and labor input comprise an explicit set of real-factor accounts corresponding to the real-product accounts. These accounts may be constructed with available data; the measurement of real input could be considerably refined through the introduction of new data.

THE KENDRICK APPROACH

The basis of the Kendrick approach is a definition of capital input as real gross capital stock. In an earlier paper Kendrick gives the following justification for this definition:

> . . . the prices of the underlying capital goods, as established in markets or imputed by owners, can be appropriately combined (with variable quantity weights) to provide a deflator to convert capital values into physical volumes of the various types of underlying capital goods at base-period prices. Or, the result can be achieved directly by weighting quantities by constant prices.
>
> As I view it, this is the most meaningful way to measure "real capital stock," since the weighted aggregate measures the physical complex of capital goods in terms of its estimated ability to contribute to production as of the base period.[2]

The "ability to contribute to production" is, of course, measured by the price of capital services, just as the ability of labor input to contribute to production is measured by the price of labor services. The price of capital services is not the same as the price of investment goods, the "deflator" of Kendrick's definition of real capital stock.

Kendrick takes the price of capital to be the ratio of gross property compensation to real gross capital stock and capital productivity to be the ratio of real gross product to real gross capital stock. While these

[1] *American Economic Review,* May 1966, pp. 50–61.

[2] John W. Kendrick, "Some Theoretical Aspects of Capital Measurement," *American Economic Review,* May 1961, p. 106.

definitions are consistent with his definition of capital input, they suffer from the same deficiencies. When the resulting estimates of the price of capital and capital input are employed to estimate the elasticity of substitution between labor and capital, a number of anomalies result. For example, the elasticity of substitution for the rubber industry is estimated to be -3.36 while the elasticities for communications, telephone and telegraph, and radio and TV broadcasting are -2.33, -2.00, and -2.02, respectively. None of these estimates can be interpreted as elasticities of substitution. These anomalous results may reflect the fact that the price of capital services, as defined by Kendrick, does not provide a conceptually adequate measure of the ability of capital goods to contribute to production.

AN ALTERNATIVE APPROACH

To provide a measure of capital input that reflects the productivity of capital goods, it is necessary to answer the questions, what is capital input? what is the price of capital? The answers to these questions are intimately related since it is necessary to aggregate over different kinds of capital to obtain the quantity and price of capital input. To perform this aggregation correctly, prices and quantities of capital input for each kind of capital are required. The values of the capital services must be added together to obtain total capital input in current prices. A deflator constructed as an index of capital service prices must be applied to the capital input in current prices to obtain an index of real capital input. Conceptually, this problem is identical to that of measuring real labor input. Denison [3] and Kendrick [4] have made important contributions to the measurement of real labor input. The problem to be posed is the construction of an analogous measure of real capital input. The two measures of real-factor input may then be combined into a set of real factor accounts, corresponding to the familiar real-product accounts.[5]

If capital services were bought and sold by distinct economic units in the same way as labor services, there would be no conceptual or

[3] E. Denison, *The Sources of Economic Growth in the United States and the Alternatives Before Us,* Supplementary Paper No. 13, New York, Committee for Economic Development, 1962.

[4] John W. Kendrick, *Productivity Trends in the United States,* Princeton for NBER, 1961.

[5] Factor accounts are usually given only in current prices; implicit in any study of total factor productivity is a set of factor accounts in constant prices.

empirical difference between the construction of a quantity index of total capital input and the construction of the corresponding index of total labor input. Beginning with data on the value of transactions in each type of capital service, this value could be separated into a price of capital service or rental and a quantity of capital service in, say, machine-hours. These data would correspond to the value of transactions in each type of labor service, which could be separated into a price of labor service or wage and a quantity of labor service in, say, man-hours. A quantity index of total capital input would be constructed from the quantities of each type of capital service, using the relative shares of the rental value of each capital service in the rental value of all capital services as weights.

The measurement of capital services is less straightforward than the measurement of labor services because the consumer of a capital service is usually also the supplier of the service; the whole transaction is recorded only in the internal accounts of individual economic units. The obstacles to extracting this information for purposes of social accounting are almost insuperable; the information must be obtained by a relatively lengthy chain of indirect inference. The data with which the calculation begins are the values of transactions in new investment goods, just as in Kendrick's construction of an index of real capital stock. These values must be separated into a price and quantity of investment goods. Second, the quantity of new investment goods reduced by the quantity of old investment goods replaced must be added to the accumulated stocks. The third step in this procedure is to calculate the quantity of capital services corresponding to each stock. In the measurement of capital it is conventional to assume that capital services are proportional to capital stock. Where independent data on the rates of utilization of capital are available, this assumption may be dispensed with.

Paralleling the calculation of quantities of capital services beginning with the quantities of new investment goods, the prices of capital services must be calculated beginning with the prices of new investment goods. Finally, a quantity index of total capital input must be constructed from the quantities of each type of capital service, using the relative shares of the implicit rental value of each capital service in the implicit rental value of all capital services as weights. The implicit rental value of each capital service is obtained by simply multiplying the quan-

tity of that service by the corresponding price. At this stage the construction of a quantity index of total capital input is formally identical with the construction of a quantity index of total labor input or total output. The chief difference between the construction of price and quantity indexes of total capital input and any other aggregation problem is in the circuitous route by which the necessary data are obtained.

In effect, Kendrick assumes that the price of capital services is proportional to the price of the corresponding investment good for all types of stock—land, buildings, equipment, and inventories. This assumption is invalid so long as different depreciation rates and rates of capital gain or loss prevail for different classes of assets. As we shall see, the calculation of a conceptually correct index of capital input requires precisely the same data as those employed by Kendrick so that the assumption of proportionality between capital service prices and investment goods prices may be dispensed with.

The following notation is used to represent the capital accounts which provide the basis for measuring total capital input:

I_k—quantity of output of the k^{th} investment good,
K_k—quantity of input of the k^{th} capital service,
q_k—price of the k^{th} investment good,
p_k—price of the k^{th} capital service.

Under the assumption that the proportion of an investment replaced in a given interval of time declines exponentially, the cumulated stock of past investments in the k^{th} capital good, net of replacements, satisfies the well-known relationship:

$$I_k = \dot{K}_k + \delta_k K_k, \tag{1}$$

where δ_k is the instantaneous rate of replacement of the k^{th} investment good. Similarly, in the absence of direct taxation the price of the k^{th} capital service satisfies the relationship:

$$p_k = q_k\left[r + \delta_k - \frac{\dot{q}_k}{q_k}\right], \tag{2}$$

where r is the rate of return on all capital, δ_k is the rate of replacement of the k^{th} investment good, and $\dot{q}_k/q_k$ is the rate of capital gain on that good. Given these relationships between the price and quantity of investment goods and the price and quantity of the corresponding capital

services, the only data beyond values of transactions in new investment goods required for the construction of price and quantity indexes of total capital input are rates of replacement for each distinct investment good and the rate of return on all capital. We turn now to the problem of measuring the rate of return.

First, to measure the values of output and input it is customary to exclude the value of capital gains from the value of input rather than to include the value of such gains in the value of output. This convention has the virtue that the value of output may be calculated directly from the values of transactions. Second, to measure total factor productivity, depreciation is frequently excluded from both input and output; this convention is adopted, for example, by Kendrick.[6] Exclusion of depreciation on capital introduces an entirely arbitrary distinction between labor input and capital input, since the corresponding exclusion of depreciation of the stock of labor services is not carried out.[7] To calculate the rate of return on all capital, I subtract from the value of output plus capital gains the value of labor input and of replacement. This results in the rate of return multiplied by the value of accumulated stocks. The rate of return is calculated by dividing this quantity by the value of the stock.[8] The implicit rental value of the k^{th} capital good is:

$$p_k K_k = q_k \left[r + \delta_k - \frac{\dot{q}_k}{q_k} \right] K_k.$$

To calculate price and quantity indexes for total capital input, the prices and quantities of each type of capital service are aggregated, using the relative shares of the implicit rental value of each capital service in the implicit rental value of all capital services as weights.

I have outlined a method for computing the price of capital services in the absence of direct taxation of business income. In the presence of direct taxes we may distinguish between the price of capital services before and after taxes. The expression given above for the price of capital services is the price after taxes. The price of capital services before taxes is:

[6] Kendrick, *Productivity Trends.*

[7] This point is made by Evsey Domar, "On the Measurement of Technological Change," *Economic Journal,* December 1961, pp. 709–729.

[8] The procedure proposed by Domar, *ibid.,* p. 717, n. 3, fails to correct for capital gains. Implicitly, Domar is assuming either no capital gains or that all capital gains are included in the value of output, whether realized or not.

$$p_k = q_k\left[\frac{1-uv}{1-u}r + \frac{1-uw}{1-u}\delta_k - \frac{1-ux}{1-u}\frac{\dot{q}_k}{q_k}\right],$$

where u is the rate of direct taxation, v the proportion of return to capital allowable as a charge against income for tax purposes, w the proportion of replacement allowable for tax purposes, and x the proportion of capital gains included in income for tax purposes.

I estimate the variables describing the tax structure as follows: The rate of direct taxation is the ratio of profits tax liability to profits before taxes. The proportion of the return to capital allowable for tax purposes is the ratio of net interest to the total return to capital. Total return to capital is the after tax rate of return, r, multiplied by the current value of capital stock. The proportion of replacement allowable for tax purposes is the ratio of capital consumption allowances to the current value of replacement. The proportion of capital gains included in income is zero by the conventions of the U.S. national accounts. Given the value of direct taxes, the after tax rate of return is estimated by subtracting from the value of output plus capital gains the value of labor input, replacement, and direct taxes. This results in the total return to capital. The rate of return is calculated by dividing this quantity by the current value of the stock of capital. Given data on the rate of return and the variables describing the tax structure, the price of capital services before taxes is calculated for each investment good.[9] These prices of capital services may be used in calculating indexes of capital input, total input, and total factor productivity.

DOES IT MATTER?

We have presented two alternative approaches to the measurement of capital input. In both approaches the value of gross property compensation is taken as given. Both approaches employ data on investment in each type of capital good and deflators for each good together with data on gross property compensation to obtain a measure of capital input. Given data on taxation of income from capital, the measurement of capital service prices before taxes is feasible. The sum of the products of these service prices and the corresponding quantities of capital services must add up to gross property compensation. The economic theory of capital suggests a price for capital services that is a weighted

[9] Further details are given in Zvi Griliches and D. Jorgenson, "The Explanation of Productivity Change," *Review of Economic Studies*, July 1967, pp. 249–283; see especially the Statistical Appendix.

TABLE 1

Index of Total Factor Productivity, 1945–65
(1958 =1.000)

Year	Kendrick Measure of Capital Input and Analogous Measure of Labor Input (1)	Column 1 Adjusted for Utilization Rates (2)	Griliches–Jorgenson Measure of Capital Input (3)
1945	.913	.968	1.030
1950	.922	.963	.992
1955	1.016	1.023	1.032
1960	1.061	1.046	1.040
1965	1.209	1.172	1.157

sum of the cost of capital, the rate of replacement, and capital losses. This price will be proportional to the price of investment goods only if rates of replacement and capital gain or loss are the same for all capital goods. Kendrick's method for measuring capital input is based on the assumption that service prices and investment goods prices are proportional. The method which Griliches and I developed dispenses with this invalid assumption.

Now that I have compared the two alternative approaches to the measurement of capital input from the theoretical point of view, one may ask, does the difference between the two approaches matter empirically? To answer this question I offer some results from a recent study of growth in total factor productivity in the United States, beginning in 1945.[10] In the accompanying table three alternative indexes of total factor productivity are presented. The first index employs a Kendrick-type measure of capital input and the corresponding index of labor input. The second adjusts both labor and capital for rates of utilization; employment is converted to man-hours while numbers of machines are converted to machine-hours. Finally, the third index replaces capital goods prices by capital service prices in the measurement of capital input. This index employs measures of both capital input and labor input that conform to the principles outlined

[10] *Ibid.*

above. The growth in real product unexplained by growth in real input is reduced from 1.41 per cent per year in the first index to .96 per cent per year in the second index and, finally, to .58 per cent per year in the third index. I conclude that errors in the measurement of capital input are extremely important in the measurement of real input and, hence, in the measurement of real factor productivity. The correct measurement of capital input does matter empirically for real factor accounting, for studies of total factor productivity, and for studies of production functions. For all these reasons the conceptually correct method of measuring capital input, based on capital service prices rather than capital goods prices, is to be preferred.