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Relation between Labor and Capital per Unit of Output and Capital per Man-hour

The reversal in the trend in the capital-output ratios suggests that in the earlier decades technological innovations tended to replace other factor inputs by capital rather than to increase the efficiency of capital, while in more recent decades the reverse has been true. This generalization is consistent with the trends in capital (in 1929 prices) per man-hour worked and in manhours per unit of output.

Man-hours per unit of output — the reciprocal of “labor productivity” — are reduced whenever labor is replaced by other factor inputs or whenever other factor inputs operate more efficiently if the efficiency of labor itself remains unchanged. For this reason the index of man-hours per unit of output (in 1929 prices) declined by substantial amounts from one decade to another beginning with 1900; one or the other or both factors have been in continuous operation during this period (Table 15), in addition to the probable increase in the efficiency of labor itself due to public education, aging of the labor force, and a shorter workweek — to mention a few factors. Over the first three decades the reduction in man-hours per unit of output was principally associated with the continuous increase in the amount of capital per man-hour worked. The extraordinary reduction in man-hours per unit of output between 1919 and 1929 was associated with an unusually large increase in capital per man-hour, as well as with a modest increase in capital efficiency, as shown by the decline in the capital-output ratios between 1919 and 1929. During the last two decades the more moderate reductions in man-hours per unit of output are primarily correlated with the increased efficiency of capital, since the amount of capital per man-hour worked — whether we look at total capital or fixed capital — decreased slightly between 1929 and 1948.⁴³ That is, in “real” terms labor was equipped with slightly less capital in 1937 and 1948 than in

⁴³ This discussion assumes that the improved efficiency of labor input per se has been a minor factor in the reduction of man-hour requirements.

TABLE 15

Indexes of the Ratios of Man-hours Worked and Total Capital to Output and of Total and Fixed Capital to Man-hours Worked
All Manufacturing, Selected Years, 1880-1948
(all money values in ratios based on 1929 prices)

Benchmark Years	Man-hours Worked to Output (1)	INDEXES OF RATIOS (1929 = 100)		Total Capital to Output (4)
		Total Capital to Man-hours Worked (2)	Fixed Capital to Man-hours Worked (3)	
1900 ^a	191.7	46.4	48.0	90.7
1900 ^b	187.1	47.9		89.7
1909	173.4	63.5		109.8
1919	152.3	75.8		115.5
1929	100.0	100.0	100.0	100.0
1937	84.2	99.4	94.9	83.7
1948	74.0	98.9	96.1	73.2

^a Including custom and neighborhood shops.

^b Excluding custom and neighborhood shops.

Source: Output and capital estimates described in Section 1. Man-hours worked is the product of (a) average hours worked per week from *Historical Statistics of the United States, 1789-1945*, p. 67, Table 123, for 1900 and 1909 and Bureau of Labor Statistics *Handbook of Labor Statistics, 1950 Edition*, pp. 58-59, Table C-1, for 1919-1948 and (b) total employment (active proprietors, salaried personnel and wage earners) from the *Census of Manufactures* for 1900-1919 and the *Survey of Current Business*, National Income Supplement, 1951, pp. 182-83 and 186-87, Tables 25 and 27, for 1929-1948. Column 4 based on data in Appendix Table A-2.

1929; but because the capital is more efficient, man-hours per unit of output declined by 16 per cent between 1929 and 1937 and by 12 per cent between 1937 and 1948. These are matched by decreases of 16 and 13 per cent in the capital-output ratio, i.e. by increases in capital efficiency. While the virtual identity of the relative changes in man-hours per unit of output and in the capital-output ratio is probably accidental, it is no accident that man-hours used per unit of output diminish with a decline in capital used per unit of output.

The relationship between labor per unit of output, capital per employee, and capital per unit of output is more clearly revealed by examining the movements of these ratios by groups of manufacturing industries (Table 16).⁴⁴ For each of 20 industry groups it is possible

⁴⁴ Since we do not have separate indexes of man-hours worked for each industry group, we make no effort to convert number employed to a man-hour basis. Labor

TABLE 16

Indexes of Ratios of Number Employed* to Output, of Capital to Number Employed, and of Capital to Output
Twenty Major Manufacturing Industries, Selected Years, 1900-1948
(all money values in ratios based on 1929 prices)

Industry and Ratio	1900	INDEX OF RATIOS (1929 = 100)				1948
		1909	1919	1929	1937	
Food & kindred products						
1) Labor ^a /output	100.0	111.4	125.3	100.0	94.9	84.8
2) Capital/labor ^a	91.1	96.3	86.7	100.0	83.4	83.0
3) Capital/output	91.0	107.7	109.2	100.0	78.9	70.1
Tobacco products						
1	292.1	259.6	178.1	100.0	65.8	32.5
2	19.3	27.6	47.1	100.0	115.5	200.9
3	56.0	71.6	83.6	100.0	76.2	65.8
Textile mill products						
1	184.7	167.4	149.5	100.0	92.1	82.1
2	64.1	73.5	87.8	100.0	69.8	76.9
3	118.5	123.4	131.3	100.0	64.3	63.1
Apparel						
1	154.1	150.7	132.2	100.0	136.6	98.5
2	60.3	71.6	103.6	100.0	60.6	76.1
3	92.8	108.0	136.7	100.0	82.7	75.1
Leather & leather products						
1	96.7	78.9	100.9	100.0	117.4	94.8
2	83.8	121.2	108.4	100.0	65.7	64.8
3	81.3	95.8	109.7	100.0	77.1	61.4
Rubber products						
1	658.8	515.0	280.6	100.0	88.1	58.8
2	29.5	38.6	53.2	100.0	82.5	87.5
3	194.9	199.2	149.5	100.0	73.0	51.8
Lumber & basic timber products						
1	68.4	90.8	104.6	100.0	104.3	114.0
2	54.1	67.0	68.1	100.0	77.7	61.1
3	37.0	61.0	71.2	100.0	81.1	69.7
Furniture & finished lumber products						
1	84.3	89.9	106.3	100.0	100.6	67.3
2	93.6	110.3	105.7	100.0	78.1	72.6
3	79.0	99.4	112.6	100.0	78.8	48.9

per unit of output is measured by the ratio of number employed to output, and we substitute number employed for man-hours to relate labor to capital. Number

TABLE 16 (cont.)

Industry and Ratio	1900	INDEX OF RATIOS (1929 = 100)			1937	1948
		1909	1919	1929		
Paper & allied products						
1	189.5	147.5	150.0	100.0	109.9	89.5
2	56.5	80.2	82.5	100.0	80.5	73.4
3	107.3	118.4	124.2	100.0	88.4	65.9
Printing, publishing, & allied industries						
1	140.1	125.7	114.4	100.0	106.9	98.5
2	67.5	71.7	75.4	100.0	93.2	84.2
3	94.6	90.3	86.4	100.0	99.5	83.1
Petroleum refining						
1	277.8	225.9	300.0	100.0	77.8	74.1
2	31.5	40.4	39.2	100.0	103.5	102.3
3	87.6	91.8	117.9	100.0	82.2	76.0
Chemicals & allied products						
1	178.7	159.6	185.1	100.0	93.6	85.1
2	59.4	70.9	71.3	100.0	86.8	87.6
3	105.6	113.1	131.6	100.0	81.4	74.6
Stone, clay, & glass products						
1	210.3	149.0	144.9	100.0	90.9	75.7
2	42.6	70.3	75.1	100.0	85.3	67.4
3	89.7	104.9	109.0	100.0	77.8	51.0
Iron & steel & their products						
1	181.2	136.9	138.1	100.0	124.4	85.0
2	69.5	113.8	117.2	100.0	93.2	99.3
3	126.0	155.6	162.4	100.0	115.9	84.4
Nonferrous metals & their products						
1	206.4	145.0	145.9	100.0	89.0	120.2
2	50.1	80.9	78.1	100.0	103.3	76.2
3	102.8	117.0	113.6	100.0	91.3	91.3
Machinery, except electrical						
1	171.8	147.0	146.4	100.0	100.0	90.1
2	64.1	89.1	77.9	100.0	86.8	77.3
3	110.1	131.1	114.2	100.0	86.9	69.5
Electrical machinery						
1	86.3	81.6	93.0	100.0	85.6	50.5
2	119.1	160.4	121.5	100.0	83.7	131.3
3	102.7	130.9	112.8	100.0	71.6	66.3

employed is the total of active proprietors, salaried personnel, and wage earners (monthly average).

TABLE 16 (cont.)

Industry and Ratio	1900	INDEX OF RATIOS (1929 = 100)				1948
		1909	1919	1929	1937	
Transportation equipment, except motor vehicles						
1	130.9	144.7	111.2	100.0	103.3	139.5
2	59.0	54.7	71.0	100.0	109.1	63.6
3	77.3	79.1	79.1	100.0	113.3	89.0
Motor vehicles						
1	964.9	598.2	162.3	100.0	96.5	82.5
2	65.5	58.5	93.6	100.0	95.0	108.9
3	634.8	351.8	152.3	100.0	92.3	90.3
Miscellaneous manufactures						
1	262.9	233.1	291.9	100.0	137.9	108.1
2	31.7	39.3	34.5	100.0	58.2	58.9
3	83.1	91.3	100.5	100.0	79.9	63.6

* "Number employed" or "labor" refers to the total of active proprietors, salaried personnel, and wage earners (monthly average).

Source: Estimates of output and capital described in Section 1. For employment data see Table 15.

to prepare the following ratios for selected benchmark years: (a) number employed to output in 1929 prices, (b) capital in 1929 prices to number employed, and (c) capital to output, both in 1929 prices. Each ratio is expressed as an index with the 1929 ratio taken as 100. We use these data to answer two questions: (a) Is the decrease in the index of labor per unit of output between 1900 and 1929 related to the increase in the index of capital per employee during the same period? (b) Is the decrease in the index of labor per unit of output between 1929 and 1948 related to the decrease in the index of capital per unit of output (i.e. the increase in capital efficiency) during that period?

To answer the first question, we rank the 20 industries by the absolute amount of decline in the index of labor per unit of output between 1900 and 1929, starting with the largest decrease. This ranking is compared with the ranking of the same industries according to the size of the increase in the index of capital to number employed. The degree of association of the two rankings can be represented by the coefficient of rank correlation, which can vary from +1 to -1. For the 20 industries the coefficient of rank correlation is +0.67. If, however, two

industries are omitted — motor vehicles, with a phenomenal reduction in the index of labor per unit of output from 965 in 1900 to 100 in 1929, and lumber and basic timber products, with an actual increase in labor per unit of output — the coefficient is +0.91. Thus for most industries the reduction in labor per unit of output between 1900 and 1929 is closely associated with the extent of additional capital provided all employed personnel.

We use a similar procedure to answer the second question. The 20 industries are arrayed by order of the decrease in the index of labor per unit of output between 1929 and 1948, and this ranking of industries is compared with their ranking according to the decrease in the index of capital per unit of output. The coefficient of rank correlation is +0.47. That is, the continued decline in labor per unit of output after 1929 was associated, but only to a moderate degree, with the extent of the decline in capital per unit of output (increased efficiency of capital). If the 4 of the 20 industries with increasing labor per unit of output between 1929 and 1948 are omitted from the rankings, the degree of association between the reduction in labor and capital per unit of output is somewhat higher, +0.66. To demonstrate that these correlated movements are important links in a causal chain requires an entirely different set of data and analysis which must be deferred to another occasion.⁴⁵

⁴⁵ Some of these aspects of productivity are discussed by George J. Stigler, *Trends in Output and Employment* (National Bureau of Economic Research, 1947), and by Frederick C. Mills, *Productivity and Economic Progress*, Occasional Paper 38 (NBER, 1952).