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The Growth Record of the United States Mining Industries, 1870–1948

This brief discussion of the growth of the mining industries in terms of output, capital, employment, horsepower, and supplies is intended to disclose changes that may help to explain the movement of the capital-product ratios in those industries. We shall also examine the output trends for relationships that may be of use in projecting future output.[1]

Output

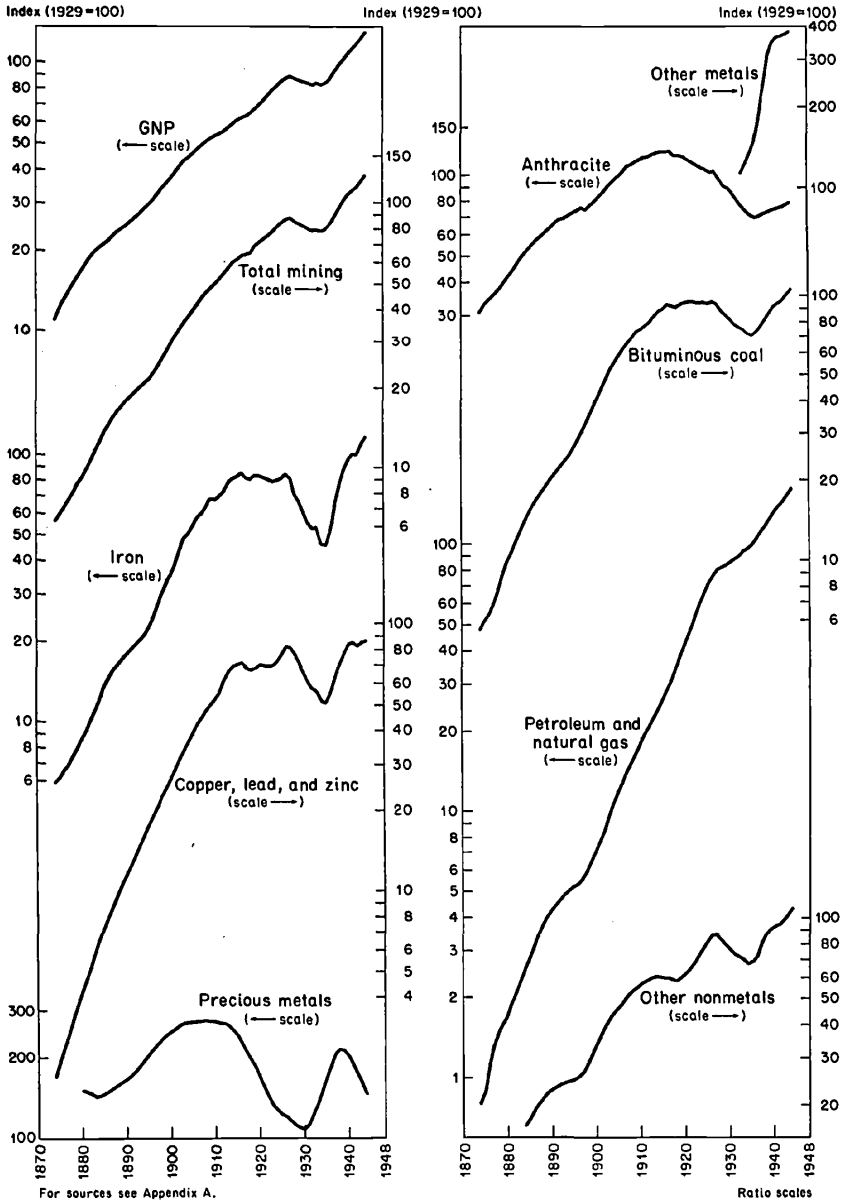
The trends in mineral output are presented in Chart 1. The chart reveals a characteristic common to many of the mining series and one that seems to have an important bearing on the movement of the capital-output ratios. This common feature is the sharp retardation in the secular growth of output that occurred in the second decade of this century. As we shall find in the next section, the turning points in the movement of the capital-output ratios occurred at about the same time. Hence, except for the petroleum and natural gas industry and possibly "other nonmetals,"[2] high rates of growth in output have tended to

[1] The reader interested in a more detailed treatment of output and employment trends in mining will find it in Harold Barger and Sam H. Schurr, *The Mining Industries, 1889–1939: A Study of Output, Employment and Productivity* (National Bureau of Economic Research, 1944).

[2] While growth in output of other nonmetals was close to, if not below, zero between 1909 and 1919, it is difficult to judge whether this was the effect of slackening in the primary secular movement of this series accompanied by a downswing in the secondary secular movement, or the result of the latter only. The other nonmetals series is heavily weighted by construction materials and shows swings in the rate of growth similar to those of construction. The swings in the secular growth of gross construction are dated by Simon Kuznets as follows: troughs — 1897, 1917, and 1935; peaks — 1909, 1926, and 1945 ["Swings in the Rate of Secular Growth," Work Memorandum 37, Capital Requirement Study (mimeographed, National Bureau of Economic Research, 1952)]. A similar timing of swings in the other nonmetal series can be determined by inspection of Chart 1.

CHART 1

INDEXES OF OUTPUT, BY MAJOR AND MINOR MINING INDUSTRIES, AND INDEX OF GROSS NATIONAL PRODUCT, BASED ON VALUES IN 1929 PRICES, 1870–1948 NINE-YEAR MOVING AVERAGES



For sources see Appendix A.

coincide with increases in the capital-product ratio, and comparatively low rates of growth (or declines) with declines in the ratio.

We can see the growth of mineral output in better perspective by comparing output with consumption and relating mineral consumption to gross or net national product (constant prices) — a ratio which may be described as a "mineral coefficient." This ratio is interesting as a measure of the nation's mineral consumption in relation to its product. Because of a high degree of substitutability among minerals, mineral coefficients can be based only on broad groups of minerals. For this purpose, we divide mineral output into three groups — metals except gold,[3] fuel, and other nonmetals (Table 1). Such historically determined mineral coefficients could be used, in a rough way, for the projection of mineral consumption if they were applied to projected national product aggregates, since the projection of these aggregates is virtually independent of the output projection of any single component.

In all major mining categories there was an increase in the ratio of production to both gross and net national product that continued until about the decade ending in 1919. The same was true of the ratio of consumption to GNP and NNP, as can be inferred from the record for the two decades between 1900 and 1919. The increase in the ratio of mineral consumption to national product reflects the ever-greater use of metals and other minerals in the production of goods and services. Except for other nonmetals, this steadily growing use seems to have reached a climax during the second decade of this century. It is in this period that the sharp retardation occurred in the rate of growth of all branches of mining except the petroleum and natural gas, other nonmetal, and other metal mining industries.

Although the factors working for a decline in mineral use per dollar of national product were certainly present before World War I, the rapid industrialization of the time — the development of railroads, public utilities, and manufacturing — seems to have had the greater impact on mineral use. It was only when the forces acting to increase mineral use lost their impetus that other factors acting to decrease it began to play an important role in shaping the long-term movement of the ratio of mineral consumption to national product. Among them

[3] The concept of consumption, which neglects changes in inventories, as well as the concept of the mineral coefficient used call for separate treatment of gold. This follows from the fact that even during the period covered by ten-year averages, changes in gold inventories may be large because of its monetary uses.

TABLE 1

MINERAL PRODUCTION AND CONSUMPTION AS PERCENTAGES OF GROSS AND NET NATIONAL PRODUCT, AND PRODUCTION AS A PERCENTAGE OF CONSUMPTION, BY MAJOR MINING INDUSTRIES, BASIC FIGURES ON A DECENNIAL BASIS, IN 1935–1939 PRICES, 1870–1949

	Consumption as Percentage of		*Production as Percentage of*		*Production as Percentage of*	*Consumption as Percentage of*		*Production as Percentage of*		*Production as Percentage of*
	GNP	*NNP*	*GNP*	*NNP*	*Consumption*	*GNP*	*NNP*	*GNP*	*NNP*	*Consumption*
	Total Minerals (except Gold)					*Total Metals (except Gold)*				
1870–1879	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1880–1889	n.a.	n.a.	2.73	3.09	n.a.	n.a.	n.a.	.44	.50	n.a.
1890–1899	n.a.	n.a.	3.16	3.66	n.a.	n.a.	n.a.	.55	.64	n.a.
1900–1909	3.66	4.21	3.74	4.30	102.2	.68	.78	.66	.75	96.8
1910–1919	4.29	5.01	4.46	5.20	103.8	.78	.90	.80	.93	102.9
1920–1929	4.23	4.91	4.22	4.91	99.9	.66	.77	.59	.68	88.7
1930–1939	4.16	4.88	4.11	4.83	99.0	.60	.71	.41	.48	68.2
1940–1949	4.35	5.19	4.20	5.01	96.6	.77	.92	.53	.64	69.2
	Total Fuel					*Other Nonmetals*				
1870–1879	n.a.	n.a.	1.68	1.90	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1880–1889	n.a.	n.a.	1.92	2.17	n.a.	n.a.	n.a.	.37	.42	n.a.
1890–1899	n.a.	n.a.	2.23	2.58	n.a.	n.a.	n.a.	.38	.44	n.a.
1900–1909	2.51	2.89	2.65	3.06	105.7	.47	.54	.43	.49	91.7
1910–1919	3.02	3.54	3.21	3.74	105.9	.49	.57	.45	.53	92.4
1920–1929	3.03	3.54	3.13	3.65	103.2	.52	.60	.50	.58	95.3
1930–1939	3.04	3.57	3.20	3.76	105.3	.52	.60	.50	.59	97.9
1940–1949	2.99	3.57	3.09	3.67	103.1	.59	.70	.58	.70	99.0

n.a. = not available.

Note: Mineral production is classified on a mineral rather than an industry basis. For an explanation of this classification see Appendix A.

Source: GNP and NNP series, Simon Kuznets' unpublished estimates in 1929 prices, converted to 1935–1939 price values.

Production and apparent consumption series, 1900–1949, *Resources for Freedom,* a report to the President's Materials Policy Commission, 1952, Vol. II, Tables I and II, pp. 176 ff. Apparent consumption is defined as primary production plus imports minus exports.

Production, 1870–1900, values of coal (anthracite and bituminous), petroleum, natural gas and natural gasoline, iron, copper, lead, zinc, gold, and silver, as reported in *Resources for Freedom,* extrapolated on the basis of the quantities reported by the Bureau of Mines; values of other metals and other nonmetals as reported in *ibid.,* extrapolated using Leong's index (Y. S. Leong, "Index of Mineral Production," *Journal of the American Statistical Association,* March 1950, p. 28), for the appropriate group.

the most important are: the increasing use of scrap metals; the more efficient use of mineral products, as, for instance, the reduction in the amount of coal required to produce a kilowatt-hour of electricity; the more extended fabrication which minerals undergo before reaching the final consumer, which generally adds to aggregate output without a commensurate increase in mineral input; and the substitution for minerals of raw materials that are not mined, such as plastics and rubber products.

This helps to explain the reversal in the movement of the ratio of mineral consumption to national product after 1919: except during the forties, total consumption of minerals other than gold per unit of GNP and NNP declined after 1919. For only one mineral group — other nonmetals — did the ratios of consumption to GNP and NNP continue to rise after 1919, and even for that group no increase occurred during the thirties. Fuel consumption per unit of GNP and NNP remained virtually constant between 1910 and 1949, except for a decline per unit of GNP in the forties. Consumption of metals except gold per unit of GNP and NNP declined drastically after 1919. The increase in the consumption of these minerals per unit of national product during the forties was barely sufficient to bring it back to the 1909–1919 level.

The reversal of trend after 1919 in the ratios of total mineral production to national product was even more pronounced. During the twenties and thirties the decline in the ratios of total mineral production to GNP and NNP was more marked than the decline in the ratios of consumption to the given aggregates. Their rise during the forties was at the same time less pronounced. The ratios of fuel production to GNP and NNP moved after 1919 in about the same way as, though more erratically than, the ratios of consumption to the given aggregates. For metals except gold there was a much sharper drop in the production than in the consumption ratio, to GNP or NNP. Only the other nonmetal group registered an increase in the ratios of production to GNP and NNP.

After World War I, net imports of metals began to play an ever-increasing role in satisfying demand. The metal mining industries changed at that time from surplus producer to net importer, with less than 70 per cent of demand met by domestic production in recent decades. The opposite happened in the other nonmetal group where only 92 per cent of consumption was supplied by domestic production at the

beginning of the century and 99 per cent in the forties. In the fuels group no clear trend in the ratios of production to consumption is evident. This group has been a net exporter throughout the period.[4]

These trends suggest that if we assume that the processes which have shaped the ratios of mineral output to national product in recent decades will continue, a ratio of 4.1 per cent (based on values in 1935–1939 prices) could be accepted as an upper limit for the ratio of all mining production to GNP in the near future. Of this, 3 per cent might be absorbed by fuels, .5 per cent by metals, and .6 per cent by other nonmetals. In relation to NNP the equivalent figures are 5.0, 3.7, .6, and .7 per cent.

Two features of the relationship between mining output and aggregate output of more general interest should be mentioned. The first, indicated by Chart 1 and by the rise and subsequent decline in the ratio of mining output to aggregate output, is that retardation has been greater in mining output than in national product. The latter, as well as the fact of retardation itself, could be expected in the light of Burns'[5] observation that the retardation rate of the majority of individual industries is higher than the retardation rate of total production. Mining output, of course, is also an aggregate, and its rate of growth is sharply influenced by the development of new industries. For example, the recent development of the "rare" metals transformed that industry into a "new" industry just as the development of automobile transportation made a new industry out of the petroleum industry. But mining output is not as comprehensive an aggregate as total production, which includes even more new industries than does mining.

A second interesting feature is the timing of the turning point in the movement of the ratio of mining output to national product. The turning point occurred around 1919 and thus coincides with the timing of the turning points in the capital-product ratios of most of the mining and manufacturing industries[6] and with the retardation in the rate of

[4] The trends are different, however, for the two components of this group — coal, and oil and gas. In the former the trend is toward an increasing surplus of exports over imports, while in the latter the surplus produced has decreased and during the forties there were virtually no net exports.

[5] Arthur F. Burns, *Production Trends in the United States since 1870* (National Bureau of Economic Research, 1934). See especially Chap. 6.

[6] For manufacturing industries see Daniel Creamer, *Capital and Output Trends in Manufacturing Industries, 1880–1948,* Occasional Paper 41 (National Bureau of Economic Research, 1954).

growth of many branches of mining. Expressed another way, the period in which technological and other developments favored a rising capital-product ratio was also the period of increased material use, while the period of declining capital-product ratios coincides with a period of reduced material use. There is no doubt that each of the trends has influenced the other.

Capital

The depreciated net value of structures and equipment is designated as "plant," and the sum of inventories, cash, and receivables as "working capital." The net value of surface land and mineral resources owned by the mining establishment, excluding leased land,[7] we designate "land." The sum of plant and working capital we call "capital," and the sum of capital and land, "total capital."[8]

Chart 2 shows the growth of mining capital (book values adjusted for price changes) by major industries. Like output, capital grew rapidly in all industries to about 1909, but the rate of growth dropped sharply between 1909 and 1919 in all industries except oil. By 1948 capital exceeded the prewar level in the oil industry only. For metal mining, capital was at its highest level in 1909, and for anthracite and other nonmetal mining groups, in 1929. In bituminous coal mining the value of capital assets declined after 1919 but recovered substantially during the forties, though it failed to regain its 1919 level.

These trends, and in particular the negative net capital formation that has taken place during recent decades in all mining industries except petroleum and natural gas, are brought into even sharper focus by showing the changes in value of capital (in 1929 prices) between selected years (Table 2).

In interpreting our capital estimates in constant prices one should keep in mind two problems of the estimating procedure:

1. Our price-adjusted values are supposed to measure the physical stock of capital assets at the different bench marks in terms of 1929

[7] The value of leased land is excluded because of difficulties in estimating it for the period after 1919. For the narrower purpose of this study the omission is not significant (see footnote 15 of Section 2, and Appendix D).

[8] The basic estimates of total capital in book values and of capital in 1929 prices by major industries, together with a short description of the methods of deriving them, are given in Tables A-3 and A-4.

CHART 2

VALUE OF CAPITAL EXCLUDING LAND, BY MAJOR MINING INDUSTRIES, 1929 PRICES, SELECTED YEARS, 1870–1948

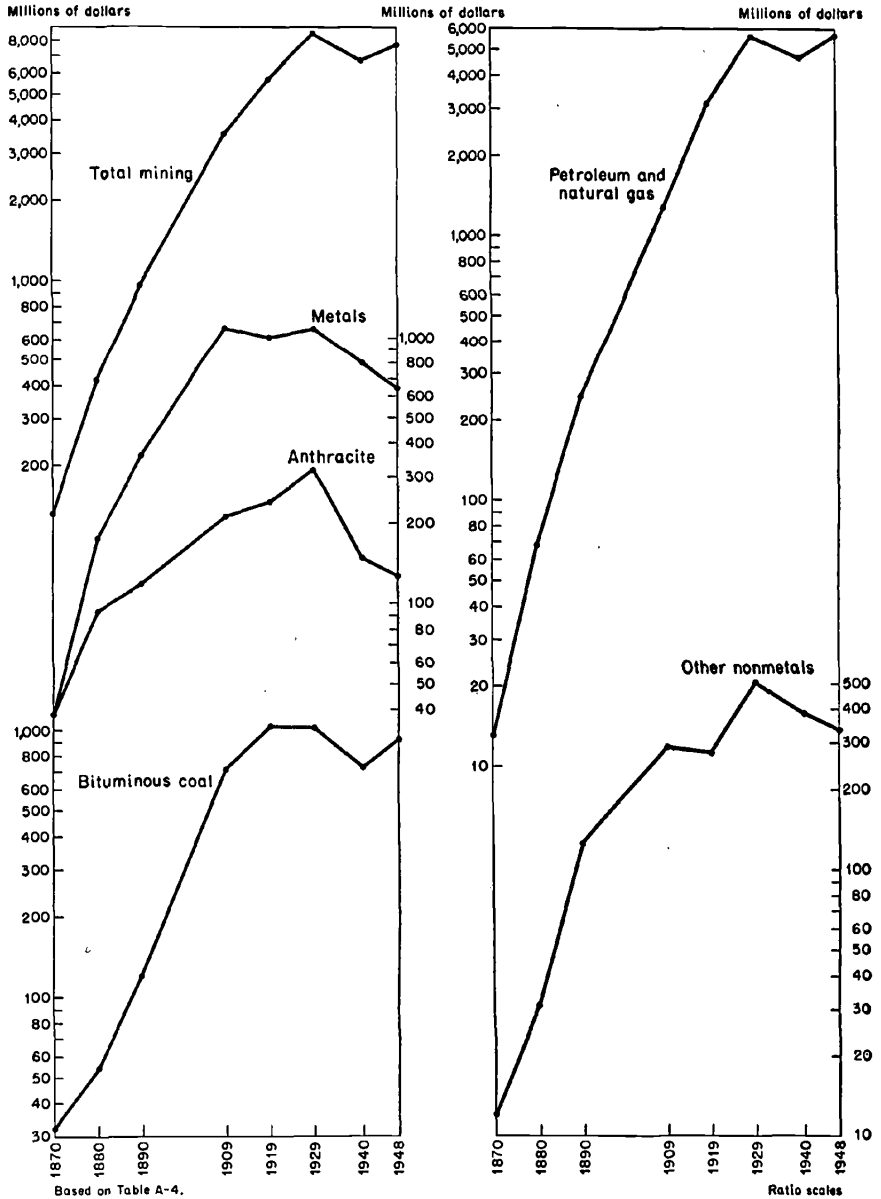


TABLE 2

CHANGES IN VALUE OF CAPITAL BETWEEN SELECTED YEARS, BY MAJOR MINING INDUSTRIES, 1929 PRICES, 1870–1948

(millions of dollars)

	Total Mining[a]	*Metals*	*Anthracite*	*Bituminous Coal*	*Petroleum and Natural Gas*	*Other Nonmetals*
1870–1880	+283	+136	+55	+22	+55	+13
1880–1890	+508	+183	+24	+64	+176	+62
1890–1909	+2,558	+736	+94	+595	+1,020	+111
1909–1919	+2,120	—89	+29	+323	+1,869	—10
1919–1929	+2,846	+82	+78	—10	+2,468	+228
1929–1940	—1,833	—288	—170	—296	—964	—116
1940–1948	+1,023	—154	—21	+197	+1,053	—52

[a] Because of rounding details may not add to total.

Source: Table A-4.

prices. However, our method of adjusting for price changes does not, and is not intended to, take full account either of the differences between the various bench marks in the "real" cost of producing those assets or in their serviceability. Since it is partly the impact of improvements in serviceability of plant and equipment and the physical relationship between capital and output that we shall try to measure by relating capital to product in constant prices, there seems to be good reason for excluding from our estimates the increased serviceability of plant and equipment that develops from one amortization cycle to another.[9]

2. Our adjustments for price changes exclude revaluations and similar capital adjustments that result in changes in the book value of capital. To the extent that such accounting adjustments represent corrections for "deferred" charges for wear and tear and obsolescence, in other words, insofar as they represent long-term adjustments of incorrectly calculated capital consumption, there is no reason to distinguish them from the latter in a long-term analysis like ours. However, to the extent that they change with changing market conditions and profit expectations, they represent a disturbing factor in our analysis. The figures for 1929 may for this reason be considered as overstating, while those for 1940 may be considered as understating, the physical volume

[9] For other purposes, however, this exclusion is a source of a considerable downward bias in the net capital formation estimates in the later as compared with the earlier years.

of capital in those years, and correspondingly, the difference between the change from 1919 to 1929 and that from 1929 to 1940 may be exaggerated. However, to judge by sample data for nineteen large mining corporations for the period 1925–1934, upward revaluations affected only 2.4 per cent of the assets as of 1934, and downward revaluations 7.3 per cent, making a net change of only —4.5 per cent. Only one-third of the sample reported revaluations in either direction.[10] This evidence suggests that the general picture of growth of capital in the mining industries is not distorted by our failure to take account of revaluations.

A more detailed discussion of the differences between the rates of growth of capital and product will be found in Section 2. We shall note here only that while the growth of capital was generally more impressive than the growth of product before 1919, capital lagged behind product in the subsequent period. The growth of output in some mining industries (bituminous coal, base metals, iron, and other nonmetals) after 1909 was inadequate to bring about a secular increase in capital, while the secular decline in output of anthracite was accompanied by an even greater decline in capital. In the petroleum and natural gas industry an increase in output of nearly 500 per cent between 1919 and 1948 was accompanied by an increase of only 80 per cent in capital. The difference would remain appreciable even if allowance were made for the increase in importance of exploration and development costs during recent decades, which is not reflected in capital values carried on the books.

Employment and Hours

The general pattern of change in the number of workers and hours worked in the mineral extracting industries does not differ from that of the product and of the capital series (Table 3). Again, two major periods appear. In the first, ending for the different major industries in a decade between 1909 and 1929, the number of workers and the total of hours worked increased; in the second, the number of workers and of hours worked declined. For obvious reasons the decline in personnel of the different industries began exactly in the order in which the sharp slackening in growth of output occurred. It occurred first in metal, other nonmetal, and anthracite coal mining; next in bituminous

[10] Solomon Fabricant, *Capital Consumption and Adjustment* (National Bureau of Economic Research, 1938), Table 46, p. 217.

TABLE 3

EMPLOYMENT AND HOURS WORKED, BY MAJOR MINING INDUSTRIES, SELECTED YEARS, 1870–1948

	1870	*1880*	*1890*	*1909*	*1919*	*1929*[a]	*1929*[b]	*1939*	*1948*
Total mining:[c]									
Total number of employees (thousands)[d]	n.a.	n.a.	527	997	1,074	n.a.	n.a.	853[e]	945
Number of wage earners (thousands)[f]	154	333	513	954	1,000	957	991	776	851
Number of hours worked by wage earners (millions)	n.a.	722	1,224	n.a.	2,097	2,018	2,112	1,290	1,714
Metals:									
Total number of employees (thousands)[d]	n.a.	n.a.	115	159	141	119	119	99	101
Number of wage earners (thousands)[f]	40	98	113	150	131	110	110	88	90
Number of hours worked by wage earners (millions)	n.a.	207	244	n.a.	333	275	275	188	n.a.
Anthracite:									
Total number of employees (thousands)[d]	n.a.	n.a.	124	174	155	151	151	88	79
Number of wage earners (thousands)[f]	53	70	122	169	147	143	143	83	75
Number of hours worked by wage earners (millions)	n.a.	143	239	320	329	273	273	123	149
Bituminous coal:									
Total number of employees (thousands)[d]	n.a.	n.a.	175	506	579	482	482	390	441
Number of wage earners (thousands)[f]	42	109	169	488	546	459	459	371	412
Number of hours worked by wage earners (millions)	n.a.	201	413	976	980	892	892	545	741
Petroleum and natural gas:									
Total number of employees (thousands)[g]	n.a.	n.a.	21	53	129	n.a.	n.a.	186	206
Number of wage earners (thousands)[f]	5	12	19	47	111	179	179	154	170
Number of hours worked by wage earners (millions)	n.a.	41	67	141	275	413	413	273	n.a.
Other nonmetals:									
Total number of employees (thousands)[d]	n.a.	n.a.	92	106	70	74	112	90	118
Number of wage earners (thousands)[f]	15	44	90	100	64	67	100	81	103
Number of hours worked by wage earners (millions)	n.a.	130	261	n.a.	180	165	259	161	n.a.

NOTES TO TABLE 3

[a] Comparable with earlier years.

[b] Comparable with later years.

[c] Because of rounding details may not add to total.

[d] Includes wage earners and salaried employees.

[e] Includes some unclassified.

[f] Average per year including inactive periods. The figures for 1890 and earlier years presumably represent an average for active periods only. Those for 1870 and 1880 include some salaried employees.

[g] Includes wage earners and salaried employees. Figures for wage earners include those employed by contractors.

n.a. = not available.

Source: Figures for number of salaried employees and for wage earners 1870–1939, except those for wage earners in the petroleum and natural gas industry 1890–1929, were based on census reports; those for 1948 were estimated by linking Bureau of Labor Statistics employment data to the census figures of 1939. Wage earners in petroleum and natural gas 1890–1929 were taken from O. E. Kiessling and Others, *Technology, Employment and Output per Man in Petroleum and Natural Gas Production*, WPA, NRP Report No. E-10, Philadelphia, 1939; salaried employees for the same industry in 1948 were estimated on the basis of the ratio of wage earners to salaried employees in 1939.

Man-hours: 1880–1890 taken from V. E. Spencer, *Production, Employment and Productivity in the Mineral Extractive Industries, 1880–1938*, WPA, NRP Report No. S-2, Philadelphia, 1940, after making minor adjustments in coverage; 1909–1929 from Harold Barger and Sam H. Schurr, *The Mining Industries, 1899–1939: A Study of Output, Employment and Productivity* (National Bureau of Economic Research, 1944) after adjusting to census coverage; 1939 figures reported by the census; 1948 estimated on the basis of the BLS index of man-hours worked.

coal; and finally in the oil and gas industry. Hence, with the exception of the last industry, the decline in the number of workers started either exactly at the same time as, or before the downturn in, the ratio of capital to product. This suggests that the change in the relative growth of capital and product was not the result of a wider use of labor.[11]

[11] In Section 3 we analyze in more detail the changes in output per labor unit and their relation to the amount of capital per person engaged.

A question may be raised whether the rate of use of existing capital did not undergo a considerable upward movement through a trend toward multiple-shift operations. We have no strictly comparable data to check whether such a trend did take place. From the figures published by the *Census of Mineral Industries: 1939*, Bureau of the Census, however, we can see that although multiple-shift operations were frequent in this year, the percentages of the total number of man shifts worked in the first shift remained high in all industries except petroleum and natural gas. The percentages are: for metals 69, for anthracite 85, for bituminous 79, and for other nonmetals 92. Thus, if one assumes the appropriate percentages to have been equal to 100 in the earlier years, the increased rate of capacity used could not exceed the difference between 100 and the above percentages. We know, however, that multiple-

(Continued on page 22)

Horsepower

The horsepower rating of the power equipment used shows an uninterrupted increase in all major mining industries, except between 1929 and 1939 in anthracite coal mining (Table 4). While much the same picture emerges if the figures are converted to a per dollar of product basis, there are exceptions: horsepower used per dollar of product (in 1929 prices) declined markedly in the petroleum and natural gas industry and slightly in metals between 1919 and 1929.

The changes in total mechanical power are a significant indicator of the changes in the relative importance of power equipment in capital. For our purpose, however, the changes in power of the prime movers also have special significance. In the early days when steam was the prevalent type of power used, there was no separation between the prime mover and the plant. The prime mover was part of the mine's capital equipment. Even later, when electric power was introduced, the electric generator was installed at the plant. Measured by their horsepower rating, only 19 per cent of all electric motors used in total mining in 1902 and 29 per cent of those used in 1909 were driven by purchased energy. Since 1909 the number and power of steam engines have not increased, or have even declined in some industries, while the continuing growth in number and power of electric motors has not been accompanied by a corresponding growth in power of the prime movers installed at the plant. By 1939, 79 per cent of all electric motors in use were driven by purchased energy.

This explains the movement of the horsepower of prime movers presented in Table 4. The total horsepower of prime movers continued to increase after 1919 in two major groups only, in petroleum and natural gas and in other nonmetal mining. When horsepower of prime movers is converted to a per product basis, a decline appears in petroleum and natural gas but not in other nonmetals.[12] The partial displacement of

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shift operations were quite frequent in metal mining in the earlier years (*Census of Mines and Quarries: 1902*, Bureau of the Census, p. 110). It is also necessary to allow for the fact that the working day is much shorter now than it used to be. This factor may well have entirely offset the effect of more frequent multiple-shift operations. The census of 1939 does not report appropriate figures for the petroleum and natural gas industry. According to the census of 1902, this industry generally worked "with two shifts of 12 hours each per day" (p. 110).

[12] The increase in the power of prime movers per dollar of product between 1929 and 1939 is somewhat confusing. It could be partly explained by the low employ-

prime movers in the plant by purchased energy has certainly served to reduce capital used in mining or, rather, the capital reported on the balance sheets of mining firms.

Supplies

The value of purchased supplies[13] used in the mineral industries increased continuously during the period of swift growth in capital and output (Table 5). It leveled off, or even declined, in absolute terms as soon as the rate of growth slowed. This was also generally true of the value of supplies per dollar of product. Thus the value of supplies per dollar of product increased in all branches except oil and gas, up to about 1919. This means that value added as a percentage of total value declined. Thereafter a decline or leveling off of the value of supplies per dollar of product is evident. In the petroleum industry during the earlier period of growth, this ratio is remarkably stable if both numerator and denominator are expressed in current prices. Between 1919 and 1939 the sharpest decline is registered in this industry. In general it should be noted that the ratio of supplies to product is relatively low in the mining industries[14] and that the change in this ratio, with the possible exception of that for the oil and gas industry, has been within a narrow absolute range. For total mining this range has not exceeded 7 or 8 cents per dollar of product.

What are the major factors that bring about changes in the supplies-product ratio and how do they affect the behavior of the capital-product ratio? Presumably the major factors are (1) replacement of supplies by other input factors and vice versa, (2) changes in the degree of vertical integration with other industries, and (3) improvements in efficiency of use.

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ment level in 1939, with its depressing impact on the denominator, and by some changes in relative importance of industry components, at least in metal mining. The increase in the relative weight of precious metal mining in this group was considerable during the thirties.

[13] According to the census definition (1939), the figures represent the cost of supplies and materials, fuel, and power, including transportation cost, actually used or consumed during the year for production, development, and maintenance. They exclude the cost of commodities purchased for resale in the condition in which purchased and items chargeable to capital accounts.

[14] In 1948 this ratio was around 60 per cent in total manufacturing (Creamer, *op. cit.*, Table 2).

TABLE 4

HORSEPOWER RATING OF POWER EQUIPMENT AND PRIME MOVERS USED, BY MAJOR MINING INDUSTRIES, SELECTED YEARS, 1902–1939

	1902	*1909*	*1919*	*1929*	*1939*
Total mining:[a]					
Aggregate horsepower (thousands)[b]	2,754	4,608	6,724	n.a.	13,046
Aggregate horsepower per dollar of product[c]	2.21	2.38	2.76	n.a.	3.43
Prime movers total horsepower (thousands)	2,727	4,403	5,112	n.a.	7,149
Prime movers horsepower per dollar of product[c]	2.19	2.28	2.10	n.a.	1.88
Metals:					
Aggregate horsepower (thousands)[b]	559	1,068	1,324	1,699	2,196
Aggregate horsepower per dollar of product[c]	1.88	2.44	2.85	2.68	4.25
Prime movers total horsepower (thousands)	539	924	839	732	833
Prime movers horsepower per dollar of product[c]	1.82	2.11	1.81	1.15	1.61
Anthracite:					
Aggregate horsepower (thousands)[b]	434	676	900	1,042	1,037
Aggregate horsepower per dollar of product[c]	2.03	1.62	1.98	2.71	3.87
Prime movers total horsepower (thousands)	434	675	782	618	492
Prime movers horsepower per dollar of product[c]	2.03	1.62	1.72	1.61	1.83

Bituminous coal:					
Aggregate horsepower (thousands)[b]	521	1,228	2,155	3,124	3,347
Aggregate horsepower per dollar of product[c]	1.11	1.82	2.60	3.23	4.68
Prime movers total horsepower (thousands)	519	1,203	1,384	722	912
Prime movers horsepower per dollar of product[c]	1.11	1.78	1.67	.75	1.28
Petroleum and natural gas:					
Aggregate horsepower (thousands)[b]	1,014	1,222	1,821	n.a.	4,159
Aggregate horsepower per dollar of product[c]	7.84	4.88	3.40	n.a.	2.18
Prime movers total horsepower (thousands)	1,012	1,222	1,770	n.a.	3,714
Prime movers horsepower per dollar of product[c]	7.82	4.88	3.31	n.a.	1.95
Other nonmetals:					
Aggregate horsepower (thousands)[b]	225	414	523	920[d]	2,307
Aggregate horsepower per dollar of product[c]	n.a.	2.73	3.39	3.49[d]	5.92
Prime movers total horsepower (thousands)	224	379	336	349[d]	1,197
Prime movers horsepower per dollar of product[c]	n.a.	2.50	2.17	1.32[d]	3.07

[a] Because of rounding details may not add to total.

[b] Includes prime movers and electric motors driven by purchased energy.

[c] Product valued in 1929 prices.

[d] Figures comparable with those for 1939 for these lines are 1,719, 4.00, 714, and 1.66 respectively.

n.a. = not available.

Source: Based on census data.

TABLE 5

VALUE OF SUPPLIES AND MATERIALS, FUEL, AND ELECTRICAL ENERGY USED, BY MAJOR MINING INDUSTRIES, SELECTED YEARS, 1890–1939

	1890	*1902*	*1909*	*1919*	*1929*	*1939*
Total mining:						
Value in 1929 prices (millions of dollars)	n.a.	176.8	322.6	510.6	n.a.	475.0
Reported value per dollar of product (cents)	n.a.	15	18	21	n.a.	14
Value per dollar of product in 1929 prices (cents)	n.a.	14	17	21	n.a.	13
Metals:						
Value in 1929 prices (millions of dollars)	40.5	61.2	125.7	103.4	125.5	105.4
Reported value per dollar of product (cents)	17	18	24	24	20	19
Value per dollar of product in 1929 prices (cents)	31	21	29	22	20	20
Anthracite:						
Value in 1929 prices (millions of dollars)	18.3	19.6	39.7	58.1	57.3	38.9
Reported value per dollar of product (cents)	15	17	18	20	15	19
Value per dollar of product in 1929 prices (cents)	8	9	10	13	15	15

Bituminous coal:						
Value in 1929 prices (millions of dollars)	13.5	38.2	67.6	142.9	144.7	129.4
Reported value per dollar of product (cents)	9	9	11	16	15	16
Value per dollar of product in 1929 prices (cents)	8	8	10	17	15	18
Petroleum and natural gas:						
Value in 1929 prices (millions of dollars)	n.a.	37.6	61.7	171.7	n.a.	130.7
Reported value per dollar of product (cents)	n.a.	24	24	24	n.a.	8
Value per dollar of product in 1929 prices (cents)	n.a.	29	25	32	n.a.	7
Other nonmetals:						
Value in 1929 prices (millions of dollars)	14.8	20.2	27.9	34.5	55.8[a]	70.6
Reported value per dollar of product (cents)	15	15	18	26	21	21
Value per dollar of product in 1929 prices (cents)	21	n.a.	18	22	21	18

[a] The figure comparable with that for 1939 is 92.2.

n.a. = not available.

Source: Based on census data.

Under (1) are substitutions between supplies and capital. As in the case of substitutions between labor and capital, substitutions between supplies and capital may be "real," that is, they may represent changes in the combination of input factors. However, substitutions between supplies and capital may also have a purely "nominal" character. It is hard to draw an unequivocal line of demarcation between supplies and certain capital items in practical accounting. Changes in the treatment of some of the outlays (such as charging them to the capital assets account) might have the same effect on the capital-product ratio as real substitutions between supplies and capital. In both cases a change in the supplies-product ratio in one direction should result in an opposite change in the capital-product ratio.

Without necessarily altering the combination of input factors in the production process as a whole, changes in the degree of industrial integration will affect the ratio of purchased supplies to product, and at the same time that of capital to product. The greater the self-sufficiency, i.e. the higher the percentage of value added to value of product, the lower is the supplies-product ratio and the higher the capital-product ratio. The lower the percentage of value added to value of product, the higher is the supplies-product ratio and the lower the capital-product ratio.[15] Hence, with regard to this factor, too, changes in the supplies-product ratio run in the opposite direction from the changes in the capital-product ratio.

There is evidently no direct relationship between a decline in the supplies-product ratio resulting from improvements in the efficiency of use of supplies and changes in the capital-product ratio.

According to our figures, increased use of capital relative to product up to 1919 was more or less synchronous with increased use of purchased supplies. Hence, whatever the reasons may have been, the increased use of purchased supplies does not explain the increase in use of capital. Quite the contrary, the increase in use of capital took place despite changes that brought about increases in the supply-product ratio. And, if one assumes that the decline in purchased supplies per dollar of product during the period of retarded growth was the result primarily of increased efficiency in use, a reasonable assumption, then no inverse impact on the capital-product ratio need be expected.

[15] A good example of a development effecting this type of change is the transfer cited above from electric energy generated at the plant to purchased energy.