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Long-Term Changes in Total Capital-Product Ratios in Mining, 1870–1948

Rate of Change in Capital and in Output, by Industries

Before analyzing the changes in the capital-product ratios we shall compare the average annual percentage rates of change in capital and product. Although both types of comparison bear on the same subject, there is some advantage in the latter comparison. While the capital-product ratios reflect the different rates of movement in the two variables, they do not indicate the direction of movement in a single variable at a given time.

Table 6[1] shows that the highest rate of growth for total mining took place between 1870 and 1880 and that in all major branches except bituminous coal capital grew faster than output.[2] In the next decade, total mining output continued to grow rapidly, at a rate slightly less than that of the 1870–1880 period. Capital increased more than product in all major industries except anthracite mining.[3] The pattern of

[1] The comparison given here and in Tables 7, 8, and 13 is somewhat affected by differences between the bench marks with respect to employment levels. For a discussion of this problem see Appendix C.

[2] The rates of growth for this period are probably somewhat overstated because the coverage of the 1870 census is incomplete, particularly in the case of precious metals.

[3] Note that during this decade the growth of capital in bituminous coal conformed strictly to the growth of product and that in copper mining the increase in product was steeper than in capital. The statistical record for the latter industry is unreliable, however, in the earlier years.

The high capital figure reported for anthracite in 1880 seems to have worried the census authorities (*Report on the Mining Industries of the United States: 1880,* Bureau of the Census, p. 639). The inclusion of the value of nonproducing mines of the then largest anthracite mining company — the Philadelphia and Reading Coal and Iron Company — may have contributed to the overstatement (*ibid.,* p. 631). Chart 2 shows that the 1880 figure lies far above a smooth curve connecting the 1870 with the later figures. This would be the case even if we made a reasonable allowance

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TABLE 6

AVERAGE ANNUAL PERCENTAGE RATES OF GROWTH IN CAPITAL AND IN PRODUCT BETWEEN SELECTED YEARS, BY MAJOR AND MINOR MINING INDUSTRIES, BASED ON VALUES IN 1929 PRICES, 1870–1948

A

	TOTAL MINING		METALS		ANTHRACITE		BITUMINOUS COAL		PETROLEUM AND NATURAL GAS		OTHER NONMETALS	
	Capital	*Value of Product*	*Capital*	*Value of Product*	*Capital*	*Value of Product*	*Capital*	*Value of Product*	*Capital*	*Value of Product*	*Capital*	*Value of Product*
1870–1880	14.7	7.1	16.5	10.0	9.5	5.0	5.5	8.3	18.2	16.3	10.5	n.c.
1880–1890	8.4	6.6	7.4	5.6	2.3	4.7	8.2	8.3	13.6	7.0	14.6	13.3
1890–1909	6.8	5.4	5.8	6.2	3.0	2.9	9.4	7.1	8.6	7.0	4.4	3.9
1909–1919	4.9	2.4	—.9	.6	1.3	.9	3.8	2.0	9.5	7.9	—.5	.1
1919–1929	4.1	4.7	.8	3.2	2.8	—1.7	—.1	1.6	6.0	11.3	6.3	6.8
1929–1940	—2.2	.5	—2.8	.1	—7.2	—3.3	—3.1	—1.4	—1.7	2.5	—2.4	—.4
1940–1948	1.8	4.1	—2.7	—.1	—1.9	—1.3	3.0	3.2	2.6	5.7	—1.8	4.8
1870–1919	7.9	5.4	6.8	5.7	3.8	3.3	7.2	6.6	11.6	9.0	5.6[a]	4.1[a]
1919–1948	1.1	2.9	—1.5	1.1	—2.2	—1.5	.4	.9	2.1	6.4	.7	3.4

B

	IRON		COPPER		LEAD AND ZINC		PRECIOUS METALS	
	Capital	*Value of Product*	*Capital*	*Value of Product*	*Capital*	*Value of Product*	*Capital*	*Value of Product*
1870–1880	13.6	7.7	17.3	8.2	10.2	11.0	n.c.	n.c.
1880–1890	9.9	7.3	6.4	14.6	4.0	3.7	7.1	1.4
1890–1909	8.5	6.6	12.2	9.0	11.0	7.3	2.9	2.9
1909–1919	.4	1.7	5.3	.1	5.3	7.0	—11.6	—6.3

[a] 1880–1919.

n.c. = not comparable.

Source: Based on Tables A-2 and A-4 and work sheets.

rapid mining growth continued at an only slightly lessened rate in the third period, 1890–1909, and in these years capital grew faster than product in all the major industries except metals.[4]

In 1909–1919, for the three major industries enjoying relatively high rates of growth — oil and gas, bituminous coal, and anthracite — capital continued to increase at a faster rate than product. The other two industry groups, metals and other nonmetals, with a very moderate increase, if any, in product, show an absolute decline in the amount of capital invested. Has this decline in capital been a result of shifts in the relative importance of component industries or a result of lessened use of capital in each of the industries? In the case of other nonmetals the answer cannot be readily given. For metals, a glance at panel B of Table 6 suggests that the shrinkage of the precious metal mining industry, an unusually large capital user, was as much responsible as the decrease in the use of capital per unit of product in iron, lead and zinc, and precious metal mining.

What appeared a decade earlier to be an exceptional relationship (the faster growth of product than of capital in metals and other nonmetals) became the rule during the decade 1919–1929. In metal mining, capital increased slightly, while output increased substantially. In bituminous coal a moderate increase in product was accompanied by a slight decline in capital, while in oil and other nonmetal mining there was a substantial increase in product with a relatively smaller increase in capital. The only exception to the new relationship of growth is in anthracite mining, where we find an increase in capital and a decline in product.[5] Offsetting this increase in capital in the twenties, the shrinkage of capital in anthracite during the thirties appears unusually rapid.

The story of the thirties is one of capital shrinkage in all mining industries, accompanied by a less than proportional shrinkage in product, and even an increase in the case of oil. That of the forties is one

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for any possible understatement of the figures for 1870, suggesting that there may well be an overstatement of the value of capital in anthracite mining by the census of 1880.

[4] The latter is affected by the shifts in industry weights (Table 6, panel B).

[5] This somewhat strange increase in capital at a time of a sustained downward trend in production is also indicated by the capital figures reported by the Pennsylvania State Bureau of Statistics in its *Report on Productive Industries.*

of decline in capital and less than proportional decline in product (metals and anthracite), decline in capital and increase in product (other nonmetals), and increase in capital with more than proportional increase in product (oil and bituminous coal).

Dividing the period into two parts, 1870–1919 when growth was rapid, and 1919–1948 when growth was at a much lower rate, we find that during the first period capital grew at a steeper rate than product in all mining industries and that in the second period product either grew at a faster rate or declined at a less rapid rate than capital.

Capital-Product Ratios, by Industries

The above differences between the rate of growth of capital and of product are reflected by the changes in the capital-product ratios. The ratios of capital to product, both expressed in 1929 prices, show an upward trend in all industries in the early decades of the period (Chart 3 and Tables 7 and 8, line 1).[6] At some point between 1909 and 1929 the capital-product ratio in each of the industries reached a peak and started downward. The industries in which the reversal in trend occurred first are iron, lead and zinc, precious metals, and other nonmetals (1909). The trend reversal came later in bituminous coal, petroleum and natural gas, copper, and total mining (1919). The anthracite industry was the last to show a reversal in the trend in its capital-product ratios (1929).

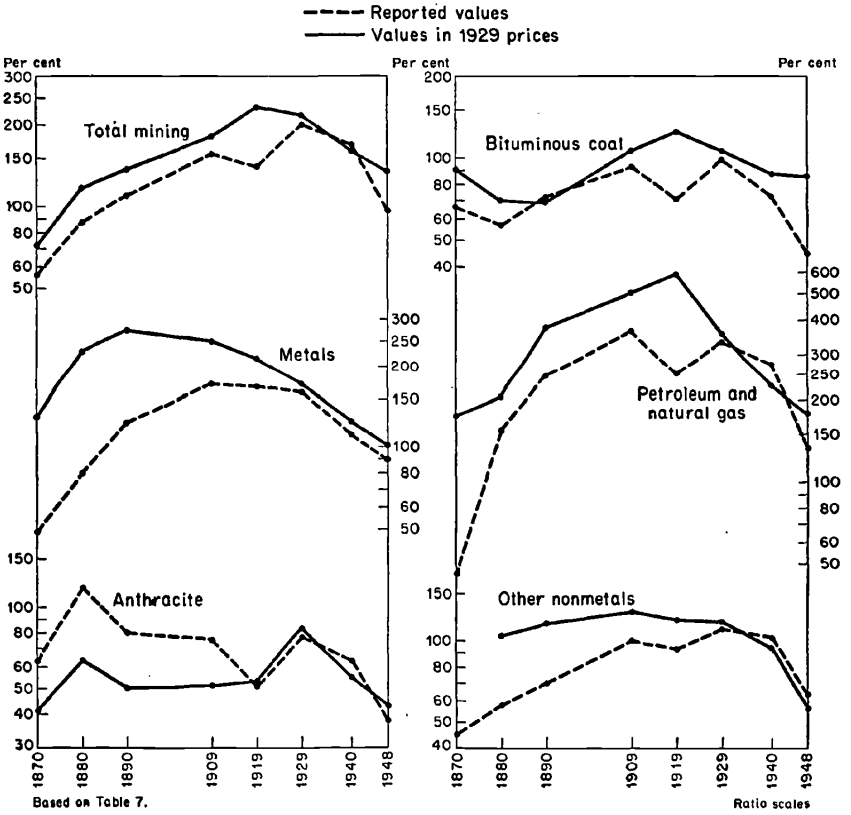
The movement of the ratios of capital to product based on reported values (Chart 3 and line 6 of Tables 7 and 8) is similar; what differences there are consist of a steeper rise, a sharper decline, and a hollow in 1919 not apparent in the ratios of deflated capital to product. The reason for these differences is the fact that 1870, 1919, and the period of the forties were years of war or postwar inflation, when price increases were incorporated into the market value of the product more promptly than into the book value of capital. Thus the ratios based on reported values are too low in those years. The capital-product, and especially the plant-product, ratios based on reported values are useful chiefly as a check on the results of the adjustment for varying price levels. Their only virtue is that they are based on figures obtained by less statistical processing than those based on values in 1929 prices.[7]

[6] See footnote 1.

[7] There is obviously another alternative — to express both numerator and denomi-

CHART 3

CAPITAL-PRODUCT RATIOS, BY MAJOR MINING INDUSTRIES, BASED ON REPORTED VALUES AND VALUES IN 1929 PRICES, SELECTED YEARS, 1870–1948



Capital-Product Ratios, by Capital Components

During the early decades there was an increase in both the plant-product ratio and the working-capital–product ratio (Tables 7 and 8, lines 2, 3, 7, and 8). In some of the industries the increase was steeper in the plant-product ratios and, in the others, in the working-capital–product ratios. These differences might, however, be due to reporting errors or to errors introduced by our estimates of the breakdown of total capital by type of asset for the years in which no breakdown was reported. For

nator in current market prices. Inspection shows that the movement of such ratios would not differ significantly from the movement of those based on constant price values.

TABLE 7

CAPITAL[a]-PRODUCT RATIOS, BY MAJOR MINING INDUSTRIES, BASED ON REPORTED VALUES AND VALUES IN 1929 PRICES, SELECTED YEARS, 1870–1948

	1870	*1880*	*1890*	*1909*	*1919*	*1929*	*1940*	*1948*
Total Mining								
Values in 1929 prices, ratio of:								
1. Capital to product	.72	1.16	1.36	1.80	2.30	2.14	1.59	1.33
2. Plant to product	.61	1.02	1.19	1.52	2.00	1.57	1.10	.92
3. Working capital to product	.11	.14	.17	.28	.30	.57	.49	.41
Reported values, ratio of:								
4. Total capital to product	1.39	2.21	2.55	2.77	2.23	2.88	2.18	1.08
5. Land to product	.83	1.34	1.46	1.22	.84	.89	.50	.12
6. Capital to product	.56	.87	1.09	1.55	1.39	1.99	1.68	.96
7. Plant to product	.43	.74	.92	1.22	1.05	1.41	1.20	.59
8. Working capital to product	.13	.13	.17	.33	.34	.58	.48	.37
Metals								
Values in 1929 prices, ratio of:								
1. Capital to product	1.29	2.30	2.73	2.50	2.16	1.71	1.24	1.01
2. Plant to product	1.14	2.11	2.37	1.84	1.49	1.10	.59	.56
3. Working capital to product	.15	.19	.36	.66	.67	.61	.65	.45
Reported values, ratio of:								
4. Total capital to product	1.69	2.78	4.13	3.34	3.45	3.68	1.98	1.10
5. Land to product	1.20	1.98	2.90	1.63	1.78	2.09	.87	.20
6. Capital to product	.49	.80	1.23	1.71	1.67	1.59	1.11	.90
7. Plant to product	.40	.71	1.03	1.12	.84	.99	.55	.42
8. Working capital to product	.09	.09	.20	.59	.83	.60	.56	.48
Anthracite								
Values in 1929 prices, ratio of:								
1. Capital to product	.41	.63	.50	.51	.53	.83	.55	.43
2. Plant to product	.35	.54	.45	.43	.45	.45	.34	.25
3. Working capital to product	.06	.09	.05	.08	.08	.38	.21	.18
Reported values, ratio of:								
4. Total capital to product	1.33	2.38	1.46	1.66	1.19	1.52	1.39	.68
5. Land to product	.70	1.21	.66	.91	.68	.75	.76	.30
6. Capital to product	.63	1.17	.80	.75	.51	.77	.63	.38
7. Plant to product	.50	.98	.71	.60	.37	.40	.40	.19
8. Working capital to product	.13	.19	.09	.15	.14	.37	.23	.19

Bituminous Coal								
Values in 1929 prices, ratio of:								
1. Capital to product	.91	.70	.69	1.06	1.25	1.06	.88	.86
2. Plant to product	.66	.52	.59	.90	1.07	.72	.53	.47
3. Working capital to product	.25	.18	.10	.16	.18	.34	.35	.39
Reported values, ratio of:								
4. Total capital to product	1.68	1.47	1.54	2.39	1.66	2.22	1.45	.59
5. Land to product	1.02	.90	.92	1.46	.95	1.23	.72	.14
6. Capital to product	.66	.57	.62	.93	.71	.99	.73	.45
7. Plant to product	.42	.41	.51	.75	.52	.65	.46	.21
8. Working capital to product	.24	.16	.11	.18	.19	.34	.27	.24
Petroleum and Natural Gas								
Values in 1929 prices, ratio of:								
1. Capital to product	1.75	2.06	3.78	5.05	5.86	3.58	2.26	1.78
2. Plant to product	1.64	1.95	3.45	4.75	5.51	2.79	1.73	1.32
3. Working capital to product	.11	.11	.33	.30	.35	.79	.53	.46
Reported values, ratio of:								
4. Total capital to product	.52	1.75	2.71	3.89	2.68	3.51	2.91	1.40
5. Land to product	.06	.20	.22	.24	.17	.20	.17	.07
6. Capital to product	.46	1.55	2.49	3.65	2.51	3.31	2.74	1.33
7. Plant to product	.42	1.45	2.23	3.34	2.21	2.52	2.15	.89
8. Working capital to product	.04	.10	.26	.31	.30	.79	.59	.44
Other Nonmetals								
Values in 1929 prices, ratio of:								
1. Capital to product	n.c.	1.04	1.16	1.28	1.19	1.17	.94	.56
2. Plant to product	n.c.	.78	.88	1.02	.95	.69	.43	.32
3. Working capital to product	n.c.	.26	.28	.26	.24	.48	.51	.24
Reported values, ratio of:								
4. Total capital to product	.94	1.23	1.51	1.96	1.92	2.14	1.62	.86
5. Land to product	.49	.65	.81	.97	.99	1.04	.60	.23
6. Capital to product	.45	.58	.70	.99	.93	1.10	1.02	.63
7. Plant to product	.34	.42	.50	.72	.60	.63	.50	.30
8. Working capital to product	.11	.16	.20	.27	.33	.47	.52	.33

[a] For definition of terms relating to capital see page 16.

n.c. = not comparable.

Source: See notes to Tables A-1–A-4.

TABLE 8

CAPITAL[a]-PRODUCT RATIOS, BY MINOR MINING INDUSTRIES, BASED ON REPORTED VALUES AND VALUES IN 1929 PRICES, SELECTED YEARS, 1870–1947

	1870	*1880*	*1890*	*1909*	*1919*	*1940*	*1947*
Iron							
Values in 1929 prices, ratio of:							
1. Capital to product	.71	1.22	1.53	2.21	1.95	n.a.	n.a.
2. Plant to product	.47	.83	.85	1.58	1.41	n.a.	n.a.
3. Working capital to product	.24	.39	.68	.63	.54	.25	.37
Reported values, ratio of:							
4. Total capital to product	1.35	1.98	2.24	2.74	2.30	1.36	1.03
5. Land to product	.98	1.40	1.30	1.21	1.00	n.a.	n.a.
6. Capital to product	.37	.58	.94	1.53	1.30	n.a.	n.a.
7. Plant to product	.21	.37	.47	.98	.71	n.a.	n.a.
8. Working capital to product	.16	.21	.47	.55	.59	.22	.44
Copper							
Values in 1929 prices, ratio of:							
1. Capital to product	.76	1.74	.82	1.47	2.46	n.a.	n.a.
2. Plant to product	.63	1.46	.64	.88	1.48	n.a.	n.a.
3. Working capital to product	.13	.28	.18	.59	.98	.72	.49
Reported values, ratio of:							
4. Total capital to product	1.50	3.14	3.24	2.43	4.75	2.42	1.12
5. Land to product	1.15	2.40	2.57	1.27	2.49	n.a.	n.a.
6. Capital to product	.35	.74	.67	1.16	2.26	n.a.	n.a.
7. Plant to product	.27	.60	.49	.59	.92	n.a.	n.a.
8. Working capital to product	.08	.14	.18	.57	1.34	.78	.57

Lead and Zinc							
Values in 1929 prices, ratio of:							
1. Capital to product	.77	.74	.75	1.49	1.27	n.a.	n.a.
2. Plant to product	.58	.57	.59	1.11	.95	n.a.	n.a.
3. Working capital to product	.19	.17	.16	.38	.32	.51	.39
Reported values, ratio of:							
4. Total capital to product	1.99	1.66	1.71	2.13	2.62	1.00	.58
5. Land to product	1.09	.91	.93	1.02	1.47	n.a.	n.a.
6. Capital to product	.90	.75	.78	1.11	1.15	n.a.	n.a.
7. Plant to product	.62	.56	.58	.75	.68	n.a.	n.a.
8. Working capital to product	.28	.19	.20	.36	.47	.44	.30
Precious Metals							
Values in 1929 prices, ratio of:							
1. Capital to product	2.55	3.15	5.41	5.44	3.35	n.a.	n.a.
2. Plant to product	2.48	3.08	5.13	4.44	2.72	n.a.	n.a.
3. Working capital to product	.07	.07	.28	1.00	.63	.95	.77
Reported values, ratio of:							
4. Total capital to product	1.89	3.05	5.22	5.71	4.80	2.26	3.09
5. Land to product	1.35	2.18	3.73	2.85	2.88	n.a.	n.a.
6. Capital to product	.54	.87	1.49	2.86	1.92	n.a.	n.a.
7. Plant to product	.51	.84	1.40	2.16	1.26	n.a.	n.a.
8. Working capital to product	.03	.03	.09	.70	.66	.46	.68
Other Metals							
Reported values, ratio of:							
4. Total capital to product	n.c.	n.c.	n.c.	n.c.	2.51	3.01	1.99

[a] For definition of terms relating to capital see page 16.
n.a. = not available.
n.c. = not comparable.
Source: See notes to Tables A-1–A-4.

aggregate mining the increase in the plant-product ratio appears to have been steeper than that in the working-capital–product ratio. Here the impact of errors in measurement is certainly smaller than in the case of the individual industries. On the other hand, the significance of the differential is reduced by the changes that occurred in the relative weights of the individual industries.

In the following decades, 1919–1948, we are on firmer statistical ground, and the differences in the pattern of change in the ratio of plant and of working capital to product can be seen more clearly. It appears that the ratios of working capital to product began to decline much later than the ratios of plant to product in most industries, and that the decline was much smaller. Thus, for aggregate mining, the ratio of working capital to product, whether based on reported values or values in 1929 prices, shows an increase until 1929. On the other hand, the ratio of plant to product based on values in 1929 prices began to decline in 1919, and much more markedly than did the ratio of working capital to product. In the petroleum and natural gas industry the ratio of working capital to product, whether based on 1929 price values or reported values, continued to increase until 1929, while that of plant to product based on 1929 price values began to decline in 1919. The same pattern is found in the metal mining industry, except that here the decline in the working-capital–product ratio began in 1919 and that in the plant-product ratio in 1909. In bituminous coal mining the ratio of working capital to product based on 1929 price values continued to increase up to the last recorded year, 1948, and that based on reported values, until 1929; the ratio of plant to product based on 1929 price values began to decline in 1919, however. For the other nonmetal group the ratio of working capital to product increased until 1940, but the ratio of plant to product began to decline in 1909. Anthracite mining appears to be the only industry where the reversal of trend in the plant- and working-capital–product ratios occurred at the same time and where both ratios show an equally abrupt decline.

How can the difference in movement between the plant- and working-capital–product ratios be explained? The factors responsible for this difference are presumably among those unique to the mining industries rather than among those whose impact is more general. This is the inference to be made from the fact that in the manufacturing industries the ratio of working capital to product declined as much as the ratio of

plant to product.[8] High tax liabilities might have been considered a general factor in the slower decline in the working-capital–product ratio than in the plant-product ratio, especially during the very recent period. Indeed, a survey (taken from Moody's) of the balance sheets as of December 1948 of eighty large corporations engaged primarily in mining activities discloses a high share of tax liabilities. Thus the sum of the items "accrued taxes" and "reserves for taxes" (reported under current liabilities) accounted for 7 per cent of total liabilities and 48 per cent of current liabilities. Translated into terms of current assets, using a 1 to 1 ratio between tax liabilities and tax funds, this sum would account for around 20 per cent of working capital.[9] However, another factor whose importance is difficult to assess has worked in the opposite direction, at least in connection with working-capital–product ratios based on reported values. This is the wide application of last-in, first-out (Lifo) accounting during the recent period. First sanctioned by law in 1938, this method tends to understate working capital by leaving the inventory account evaluated at the prices of inventory initially acquired or of inventory held when Lifo was introduced. These prices have lagged substantially behind current market values.[10]

At least two factors may help to explain some of the difference in the behavior of the plant-product and working-capital–product ratios in mining and manufacturing. The first is the different composition of working capital in the two sectors. In mining, cash accounts for a substantially greater proportion of working capital than in manufacturing. Cash in the great majority of mining industries in 1948 was more than 40 per cent of total working capital. It is this component of working capital, however, whose ratio to product has not only failed to decline but has even increased in all mining industries during the last decades. Our record begins with 1930, the first year of the Great Depression, when the cash-product ratios are certainly overstated. In

[8] See Daniel Creamer, *Capital Output Trends in Manufacturing Industries, 1880–1948,* Occasional Paper 41 (National Bureau of Economic Research, 1954).

[9] This figure is rather exaggerated, first, because tax liabilities are presumably lower in smaller corporations than in those studied and, second, because there is no good reason to assume a 1 to 1 relationship between tax liabilities and funds available for taxes.

[10] Quite possibly this factor is less important in mining than in manufacturing industries. If so, that would explain part of the difference between manufacturing and mining.

spite of this initial overstatement, however, an increase in the ratios of cash to product between 1930 and 1948 is registered (Table 9).[11] We have, unfortunately, no data to trace those ratios in earlier years.

The second factor is the relatively higher ratio of depreciable and depletable assets to product and the relatively greater retardation in growth of product and capital in mining than in manufacturing, described in the following section. Other conditions being equal, a decline in the rate of growth of capital means a rising ratio of accumulated depreciation and depletion reserves to net capital. Thus "self-generating" liquidity becomes relatively more important the higher the total capital-product ratio, the greater the decline in this ratio, or the greater the slackening of the rate of growth. For this reason the range of substitutability between fixed and working capital via depreciation and depletion charges may have been particularly wide in the mining industries. The combination of these factors may have reduced the incentive for more intensive use of working capital in mining. On the other hand, the greater retardation in growth of the mining industries during that period implies also a relatively higher increase in the ratio of replacements to the net value of plant. This in turn should have contributed to a greater increase in plant efficiency, with its depressing effect on the plant-product ratio.

The fact that a declining rate of growth in an industry's capital formation is coincident with a rising ratio of depreciation charges to either net or gross capital raises a problem of a different character. Is not at least a part of the observed decline in the plant-product ratio the result of accounting practices? If depreciation charges exceed the real functional deterioration of structures and equipment due to age, obsolescence, and undermaintenance, would it not mean that, in periods of sharp retardation in the rate of growth of the industry's capital outlays, the accumulated depreciation reserves will increasingly overstate, and therefore the net capital value increasingly understate, the "true" operational value of the capital assets?

Since its premise is that statutory depreciation charges exceed the real functional deterioration of the capital units, this question cannot be

[11] Note that the ratios of notes and accounts receivable to product dropped sharply during that period. The decline was so substantial that, taken as a sum, the ratios of cash and receivables to product also declined. The failure of the cash-product ratios to decline could thus be partly explained by substitutions between cash and receivables.

TABLE 9

RATIOS OF WORKING CAPITAL AND ITS COMPONENTS TO PRODUCT, BY MAJOR MINING INDUSTRIES, BASED ON REPORTED VALUES, SELECTED YEARS, 1929–1948

	1929[a]	*1930*[b]	*1940*	*1948*
Metals:				
Cash		.14	.26	.19
Notes and accounts receivable		.40	.13	.16
Inventories		.36	.17	.13
Total working capital[c]	.60	.90	.56	.48
Anthracite:				
Cash		.04	.08	.08
Notes and accounts receivable		.31	.11	.07
Inventories		.04	.04	.04
Total working capital[c]	.37	.39	.23	.19
Bituminous coal:				
Cash		.08	.08	.10
Notes and accounts receivable		.25	.15	.11
Inventories		.05	.04	.04
Total working capital[c]	.34	.39	.27	.24
Petroleum and natural gas:				
Cash		.17	.17	.19
Notes and accounts receivable		.56	.33	.16
Inventories		.16	.08	.10
Total working capital[c]	.79	.89	.59	.44
Other nonmetals:				
Cash		.11	.18	.12
Notes and accounts receivable		.23	.17	.13
Inventories		.19	.17	.08
Total working capital[c]	.47	.53	.52	.33

[a] From Table 7.

[b] Underlying data adjusted for consolidation.

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

Source: *Statistics of Income,* Bureau of Internal Revenue, Part 2, related years.

answered precisely. There is indeed as much ground for believing that the prevailing depreciation rates are too low as for assuming that they are too high, if one considers the accelerated obsolescence of equipment in recent decades resulting from rapid technological advance.[12] This

[12] We are not considering here the accelerated depreciation of emergency defense facilities in the war and postwar period. This development affects a short time span

(Continued on page 42)

functional deterioration component is usually neglected when we compare the length of life assumed as the basis for estimating depreciation rates with the actual operational length of life of a capital asset. Newer capital units are more efficient than the relatively older ones bought for the same values in constant prices, and the use of the newer units should be more profitable than the use of the older units. One might argue that the older equipment will be used at a rate corresponding to its obsolescence rather than to its operational capacity. How completely this relationship is realized depends on the extent of the divisibility of capital units, the necessity of coordinating a variety of machine operations, and the interest of the owner in amortizing the capital value of the old equipment. That older equipment will be used in proportion to its value adjusted for obsolescence, although its operational value may be considerably higher, is clearly the case when we look at an industry as a whole, in the sense that rapidly growing plants have newer equipment and run at higher rates of utilization of operational capacity than older plants. This is valid also within a single plant, although the limiting conditions mentioned above play a much greater role here.

Total Capital-Product Ratios, by Industries

The ratios of capital to product have a close bearing on changes in the mining industries' demand for the nation's savings, and serve to highlight technological and other changes. Such ratios, however, do not reflect the actual amount of wealth used in the mining industries per unit of output, since man uses natural wealth, i.e. the mineral resources themselves, which he has not himself produced. The discrepancy between the actual stock of reproducible wealth ("past labor") used in production and the actual amount of wealth used for the same purpose is unique for mining industries.[13] It is due to the fact that nonreproducible assets — the mineral resources — constitute a large share of the value of total capital used in mining. Conversely, past labor constitutes only a small share of the total value of those assets.

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only. Moreover, as stated in Appendix A, accelerated amortization is relatively unimportant in mining, amounting to only 5 per cent of normal depreciation at its peak in 1943.

[13] The same situation, but to a lesser degree, exists in agriculture. There, however, the share of past labor in the total value of land is much higher, so that the difference between the value of past labor and the total value of land is neglected by certain authors.

This unique characteristic of mineral lands makes it difficult to analyze the movement of the ratio of land, and hence of total capital, to product in a manner similar to that for the other capital aggregates. The ratios of land to product based on reported values are subject to the restrictions imposed by the different valuation bases of numerator and denominator. Moreover, an adjustment for the different valuation bases is hardly warranted in this case for either practical or conceptual reasons. (For conceptual difficulties see Appendix D.)

From the point of view of social accounting there is good reason to assume that the value of mineral lands is equal to the value of their reproduction cost, i.e. the value of the input factors provided for their discovery and development. This approach is probably the most useful for the purpose of this study. Except for the petroleum and natural gas industry, costs of discovery and development per unit of product are low, however, and the estimation of such a series does not seem to warrant the time and effort required. For the petroleum industry such a series may be prepared in the forthcoming full study if the available statistics permit.

This explains why the ratio of total capital (which includes land) to output is given only for reported values in Tables 7 and 8. These ratios increased during the earlier decades and declined during the later in much the same way as the ratios of capital (defined as plant and working capital only) to product. The rise in the former ratios, however, was less pronounced and the decline more marked than in the ratios of capital to product. The same is true, of course, to an even larger extent, of the ratios of land to product (line 5).

In general these findings are what we might expect. Buying of mineral land to ensure supply of a growing market, but beyond the amount necessary to ensure production at current rates for a reasonably long period of time, should have been more frequent at the beginning of the period under consideration, when land prices were low, than in the later years. Also the entrepreneur's early optimism about future developments would have expressed itself at the outset in relatively high evaluation of land. For these reasons the land-product ratios can be expected to begin at a relatively higher level than the capital-product ratios. On the other hand, the more pessimistic outlook during the time of slackened growth should have affected land values seriously, because they are not supported by the value of input of past labor. The market

value of land per unit of product, and consequently the book value, should have declined more than the value of capital.[14]

The precise validity of the above considerations, however, is obscured by several factors other than the difference in the valuation bases of numerator and denominator. First, the land figures do not include the value of leased land. Changes in the form of the land tenure may have contributed to the observed differences in the movement of the ratios. Unfortunately, we have no data to use as a check on such a possibility for the period after 1919. The tendencies for the period before 1919, however, may be indicated by the following percentages (based on census data), of the total number of acres operated that were held under lease:

	1880	*1890*	*1902*	*1909*	*1919*
Anthracite		49.8		33.1	25.6
Bituminous coal		25.3		30.1	29.9
Petroleum and natural gas		81.0		94.6	90.4
Iron	33.0[a]			68.4[a]	
Copper			3.8	3.2	3.6
Lead and zinc				21.4	26.6
Precious metals			5.6	15.4	20.0
All other				16.5	27.1

[a] Percentage of value of total output that was mined from leased land.

It appears that, except in anthracite mining, for which the reverse has been true, there has been a tendency toward more extensive use of leased land. It is doubtful, however, whether this tendency has been strong enough to account for much of the change in the land-product ratios over time.[15]

[14] The last consideration is not valid for the petroleum and natural gas industry. The rate of growth in output of this industry was accelerating rather than decelerating in the decade after World War I. Moreover, because the number of transfers in this industry is high, one would expect high valuations of the book value of land (see later discussion). Indeed, our figures indicate no significant decline in the ratio of book value of land to product in this industry except for the year 1948. The exception is probably entirely due to the postwar inflation of prices for petroleum and natural gas. The low ratio of land to product for this industry appearing in Table 7 results from the fact that the vast majority of oil lands are held under lease and therefore do not appear in our land estimates. For an estimate of the market value of oil leases at different bench marks, see footnote 15.

[15] Our concern with the book value of land stems primarily from its importance in determining the capital dimension of a mining enterprise, the enterprise's asset as compared with its liability structure, etc. No such importance can be ascribed to the value of leases. Moreover, since the only way to approximate the value of leases is

Second, the book value of land is much affected by the extent of market turnover. As long as the mineral lands are not sold, their value may be kept on the books at levels approximating their reproducible costs, i.e. cost of discovery and development. Thus reported land values represent a mixture of different valuation bases, not only with respect to the time the transactions were made but also with respect to the methods of valuation. Since the market value of land exceeds by far its development costs, the total of reported book values will depend to a great extent on the number of transactions made during the period preceding the year in which the reports were made. Transfers of mineral wealth were more frequent in earlier than in recent years. Hence this factor should have worked for higher book values of land in the earlier years.

The tendency toward wider recognition of depletion deductions, strengthened by the inception of the corporation excise tax in 1909, worked to reduce the book value of land. This tendency was counteracted by revaluations of land following passage of the Revenue Act of 1918, allowing depletion charges to be based on the market value as of March 1, 1913, and of the Act of 1921, allowing a further deduction in determining taxable income from operation of oil and mining properties based on the appreciation of value resulting from new discovery of minerals. There is evidence to assume that as a result of the balanc-

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by capitalizing royalties, the amount of which is strictly dependent upon the value of output in a given year, the value of leases is directly related to the output value and is of limited interest for our purpose. We have calculated these values for total mining by industries for those bench-mark years for which statistics could be found prior to 1919, and for oil and gas for the whole period. The estimates for the latter industry are of greater interest because of the magnitudes involved. The estimated value of oil and natural gas leases exclusive of value added by drilling and equipping of wells, in market values in billions of dollars, is .04 in 1890, .3 in 1909, 1.1 in 1919, 1.9 in 1929, 2.0 in 1940, and 8.0 in 1948. The figure for 1890 is as given in *Report on Mineral Industries in the United States: 1890.* For all other years the figures were calculated as the current annuity value of royalties paid to the owners of oil lands, assuming that the latter remain unchanged during the lifetime of the mineral reserves. The assumed average length of life of the oil and natural gas reserves is 20 years in 1909, 15 in 1919, 14 in 1929, 15 in 1940, and 16 in 1948. The applied discount rate is 4.0 per cent in 1909, 4.5 in 1919, 4.0 in 1929, 3.5 in 1940, and 3.0 in 1948. The amount paid for royalties was reported for the years 1909 and 1919 by the *Census of Mines and Quarries.* For the later years the landowners' share in petroleum was assumed to be 12.5 per cent and that in natural gas 10 per cent of output (see H. Foster Bain, "Subsoil Wealth," in *Studies in Income and Wealth, Volume Twelve* [National Bureau of Economic Research, 1950], p. 266). It was also assumed that 90 per cent of petroleum and natural gas was produced from leaseholds in those years.

ing of these two tendencies, book values of land in 1919 are comparable with those in 1909.[16] The picture of the following period is different, however. Relatively high depletion allowances continued and were stepped up during the forties. But upward revaluations of land became less frequent in the second half of the twenties, and in the thirties downward revaluations were predominant. The combination of those two developments is mostly responsible for the sharp decline in the land-product ratio after 1929. It is our hope that our method of breaking down total capital into land and capital (for a description see notes to Table A-4, and footnote 5 of Appendix B) yields figures accounting fully for the shrinkage in book value of land during that period. Indeed, there is good reason to think that if any bias resulted, it is in an understatement of the book values of land in the recent years.

Effect of Industry Shifts on the Capital-Product Ratio for All Mining

Since there are differences in the rates of growth of individual mining industries and in their capital-product ratios (as demonstrated by Tables 6, 7, and 8), it follows that changes in the capital-product ratio of mining as a whole cannot be determined solely by changes in capital-product ratios within the single industries. This raises the question as to the impact of the shifts in the relative weights of the various industries on the movement of the aggregate capital-product ratio. Before we answer this, however, it is helpful to consider in some detail the changing importance of the various mining industries over this eighty-year period as producers and as fields of investment, as well as the consistency over time in differentials among the industries in the amount of capital used per unit of product.

At the beginning of the period studied, 1870, anthracite and bituminous coal mining were the most important industries, accounting together for about 50 per cent of total capital and of output produced by all mining (Table 10). During the next decade, however, coal began to lose its lead to precious metals, particularly gold mining, as a user of capital.[17] In 1880 as well as in 1890, precious metal mining ac-

[16] See, for instance, data on surplus arising from revaluation of property assets and on depletion and depreciation reserves in *Investments and Profits of Bituminous Coal Operators,* submitted by David L. Wing and James E. Black to the U.S. Coal Commission, 1923.

[17] The census data for precious metal mining are seriously understated in 1870. It is possible that precious metal mining was also the leading field of investment in this year.

counted for more than 40 per cent of all mining capital, although its contribution to value of product was considerably less. The "gold period" came to an end in the nineties. Thereafter its relative decline was so pronounced that precious metal mining, once the largest, became one of the smaller mining industries, accounting in 1919 for only 4 per cent of total capital and only 2 per cent of total mining product. During its rise as well as during its decline the share of this industry as user of capital was larger than its share of product.

The period of the relative decline in the precious metal industry coincides with the relative increase in oil and gas mining. Oil and gas mining's share in total capital rose gradually from about 12 per cent in 1890 to about 21 per cent in 1909, thereafter increasing on the average by more than 1 percentage point per year. The rise of its share in mining output was equally impressive. By 1948 the oil and gas industry accounted for about 68 per cent of the total capital invested in mining and for about 53 per cent of its product. The percentage of total capital is significantly understated because it does not include the value of leased land, which accounts in this industry for the overwhelming majority of mineral lands in operation.[18] Like precious metal mining, oil and gas mining accounted for a greater share of capital than of product throughout most of its history.

Other industries use considerably less capital per unit of output. The relative importance of coal output was much greater than that of capital during the whole period except in 1870, when coal was the leading field for mining investment. In the other years before 1929, the coal mining industry was the most important contributor to the value of mining product; its share was about 47 per cent in 1919, while its share in capital in that year was only about 33 per cent. (During the twenties the petroleum and gas industry became the leader in share of product.) The other nonmetal group also uses less capital per unit of product. The iron, copper, and lead and zinc industries occupy an intermediate position in capital used. This is shown more effectively by means of Table 11.

What has been the impact of these shifts on aggregate capital use in mining? Were these shifts partly responsible for the observed increase and subsequent decline in the aggregate capital-product ratio, or, on

[18] This explains why the percentages excluding land run considerably higher than those including land.

TABLE 10

PERCENTAGE SHARE OF MAJOR AND MINOR MINING INDUSTRIES IN TOTAL MINING, SELECTED YEARS, 1870–1947

	1870	*1880*	*1890*	*1909*	*1919*[a]	*1919*[b]	*1929*	*1940*	*1947*
Metals total:									
Value of product in current prices	31.0	43.9	34.5	29.9	17.5	17.0	16.0	17.6	10.6
Total capital in book values	37.7	55.5	55.8	36.1	27.0	26.4	20.4	16.0[c]	10.2
Capital (excluding land) in 1929 prices	29.6	42.5	38.8	31.4	17.9	17.7	12.7	11.9	8.8
Iron:									
Value of product in current prices	8.7	9.2	8.0	9.3	7.0	6.8	5.0	5.0	3.5
Total capital in book values	8.4	8.2	7.0	9.2	7.2	7.1	n.a.	3.1	2.7
Capital (excluding land) in 1929 prices	5.0	5.6	6.4	8.7	5.7	n.a.	n.a.	n.a.	n.a.
Copper:									
Value of product in current prices	3.4	3.9	4.5	10.4	5.8	5.6	7.1	5.6	4.1
Total capital in book values	3.7	5.5	5.7	9.2	12.3	12.0	n.a.	6.2	3.8
Capital (excluding land) in 1929 prices	2.1	3.2	2.7	7.1	7.4	n.a.	n.a.	n.a.	n.a.
Lead and zinc:									
Value of product in current prices	1.0	1.5	1.1	2.5	2.4	2.3	2.0	2.2	1.8
Total capital in book values	1.4	1.1	.8	1.9	2.8	2.7	n.a.	1.0	.9
Capital (excluding land) in 1929 prices	1.5	1.2	.8	1.7	1.8	n.a.	n.a.	n.a.	n.a.
Precious metals:									
Value of product in current prices	17.4	29.3	20.5	7.4	2.0	2.0	.8	3.9	.8
Total capital in book values	23.6	40.5	41.9	15.3	4.4	4.3	n.a.	4.1	2.0
Capital (excluding land) in 1929 prices	20.4	32.4	28.6	13.4	2.8	n.a.	n.a.	n.a.	n.a.

Other metals:									
Value of product in current prices	.5	n.a.	.4	.3	.3	.3	.3	.8	.4
Total capital in book values	.6	.2	.4	.5	.3	.3	n.a.	1.1	.8
Capital (excluding land) in 1929 prices	.6	.1	.3	.5	.2	n.a.	n.a.	n.a.	n.a.
Anthracite:									
Value of product in current prices	25.2	16.7	17.2	12.6	11.6	11.4	9.7	5.8	4.9
Total capital in book values	24.2	18.0	9.8	7.5	6.2	6.1	5.1	3.7	3.1
Capital (excluding land) in 1929 prices	29.5	22.6	12.7	6.1	4.3	4.2	3.7	2.2	1.9
Bituminous coal:									
Value of product in current prices	23.0	21.2	22.5	33.8	36.7	35.7	24.3	24.6	30.9
Total capital in book values	27.9	14.1	13.7	29.3	27.4	26.8	18.5	16.3	15.3
Capital (excluding land) in 1929 prices	24.7	13.1	12.8	20.5	18.5	18.2	12.0	10.9	12.3
Petroleum and natural gas:									
Value of product in current prices	12.6	9.7	11.5	14.8	28.9	28.2	39.2	42.8	46.3
Total capital in book values	4.7	7.7	12.2	20.8	34.8	34.0	48.0	57.2	65.6
Capital (excluding land) in 1929 prices	10.1	16.6	26.7	36.4	56.0	55.1	65.7	69.2	72.5
Other nonmetals:									
Value of product in current prices	8.2	8.5	14.3	8.9	5.3	7.7	10.8	9.2	7.7
Total capital in book values	5.5	4.7	8.5	6.3	4.6	6.7	8.0	6.8	5.8
Capital (excluding land) in 1929 prices	6.1	5.2	9.0	5.6	3.3	4.8	5.9	5.8	4.5

[a] Comparable with earlier years.

[b] Comparable with later years.

[c] Includes some not allocable by minor industries.

n.a. = not available.

Source: Tables A-1, A-3, and A-4.

TABLE 11

AVERAGE CAPITAL-PRODUCT RATIOS, BY MAJOR AND MINOR MINING INDUSTRIES, SELECTED GROUPS OF YEARS, 1870–1947

	1870, 1880 and 1890	*1909 and 1919*	*1937 and 1947*
	Based on Reported Values (Including Land)		
Total mining	2.05	2.50	1.55
Metals total	2.87	3.40	1.79
Iron	1.86	2.52	1.03[a]
Copper	2.63	3.59	1.12[a]
Lead and zinc	1.79	2.38	.58[a]
Precious metals	3.39	5.26	3.09[a]
Anthracite	1.72	1.43	1.28
Bituminous coal	1.56	2.03	1.15
Petroleum and natural gas	1.66	3.29	1.79
Other nonmetals	1.23	1.94	1.32
	Based on Values in 1929 Prices (Excluding Land)		
Total mining	1.08	2.05	1.33
Metals total	2.11	2.33	1.17
Iron	1.15	2.08	n.a.
Copper	1.11	1.97	n.a.
Lead and zinc	.75	1.38	n.a.
Precious metals	3.70	4.40	n.a.
Anthracite	.51	.52	.56
Bituminous coal	.77	1.15	.87
Petroleum and natural gas	2.53	5.46	1.90
Other nonmetals	n.a.	1.24	.78

[a] 1947 only.

n.a. = not available.

Source: Tables 7 and 8 and work sheets.

the contrary, have the trend movements occurred despite the interindustry shifts?

To provide an answer, we assume first that the capital-product ratios of the major industries remain at the 1890 level in all years. We then estimate the hypothetical capital for each of these industries in all other years by relating this constant ratio to the actual output in those years. The sum of these hypothetical capital figures for the major industries, when related to the sum of their actual value of output in the given year, gives a hypothetical aggregate ratio which in turn is compared with the

TABLE 12

ACTUAL AND HYPOTHETICAL CAPITAL-PRODUCT RATIOS IN TOTAL MINING AND RATIO OF ACTUAL TO HYPOTHETICAL CAPITAL, BASED ON VALUES IN 1929 PRICES, SELECTED YEARS, 1870–1948

	1870	*1880*	*1890*	*1909*	*1919*	*1929*	*1937*	*1948*
Capital-product ratio, total mining:								
Actual	.72	1.16	1.36	1.80	2.30	2.14	1.36	1.33
Assuming the industry ratios were as in 1890	1.09	1.36	1.36	1.55	1.75	2.26	2.53	2.66
Assuming the industry ratios were as in 1919	1.22	1.57	1.61	1.89	2.30	3.13	3.58	3.85
Assuming the industry ratios were as in 1948	.68	.77	.78	.87	.97	1.15	1.25	1.33
Ratio of actual to hypothetical capital:								
Hypothetical capital estimated on the basis of the industry ratios in 1890	.66	.85	1.00	1.16	1.31	.95	.54	.50
Hypothetical capital estimated on the basis of the industry ratios in 1919	.59	.74	.85	.95	1.00	.69	.38	.35
Hypothetical capital estimated on the basis of the industry ratios in 1948	1.05	1.48	1.71	2.01	2.32	1.83	1.07	1.00

Source: Tables A-2 and A-4 and work sheets.

actual aggregate ratio. Thus the hypothetical capital figure represents the amount of capital that would have been invested in all mining industries in the bench-mark years if the capital-product ratios within the industries had remained at the 1890 level. Since the differentials in the industry ratios have changed, we repeat the computations using the industry ratios for 1919 and for 1948.

If the only influence had been that of industry shifts, the aggregate mining ratio would have increased consistently during the whole period (see Table 12). The increase would have occurred whether the inter-industry differences in the capital-product ratios had been as they were in 1890, 1919, or 1948, and despite the shrinkage of precious metal mining, with its high capital-product ratio. Thus the actual increase in the aggregate ratio between 1870 and 1919 was in part a result of the shifts in industry weights. And the decline in this ratio since 1919 has taken place *in spite of* these shifts. Indeed, if the 1919 ratios for each industry had prevailed in 1948, almost 3 times as much capital would have been used in mining as actually was used in that year. This means that the rise in capital would have been to about 3.9 times the 1919 level during those twenty-nine years compared with a rise in product to more than 2.3 times the level in 1919. Actually, capital used in 1948 was only 1.4 times that used in 1919. Even if the relatively low industry ratios of 1890 had been maintained through 1948, the volume of capital in that year would have been twice as high as it really was. And, per contra, if the industry's utilization of capital in the other years had been as low as it was in 1948, capital in 1919 would have been only about 43 per cent of the actual amount used in that year, and in 1890, about 57 per cent of the actual amount.