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Introduction

This paper is one of a series originating in a study of long-term trends in capital formation and financing in the United States. The study was initiated in mid-1950 and has been conducted with generous financial assistance from the Life Insurance Association of America.

The paper is devoted to a detailed examination of trends since 1870 in the ratio of capital (the stock of assets in use) to output in the mining industries of this country. In Section 1 Dr. Borenstein provides, as background, an account of the patterns of growth of output in the mining industry, showing changes in the rate of increase and in the ratio of output to a comprehensive total such as gross national product. Section 2 presents the capital-output ratios and examines the effect on these ratios of secular shifts in the shares of the various subdivisions of mining. The concluding Section 3 deals with some of the measurable factors that might account for the trends observed in the capital-product ratios and compares these trends in mining with those in manufacturing. A description of the sources and methods used, and, particularly important, a discussion of the reliability of the data are included in the Appendixes.

Two aspects of Dr. Borenstein's findings deserve special emphasis (see his Summary). The first is the consistency in the movement of certain measures of the growth of mining industries — output, employment — and of the capital-output ratio. The early period, roughly to about 1919, was marked by a high rate of growth of output, by an increasing volume of employment, and by a rise in the capital-output ratio, i.e. by a greater increase in capital than in output. The later period, covering the last three decades, was marked by a much lower rate of growth of output, by a decline in employment, and by a significant drop in the capital-output ratio. This correlation between higher rates of growth in output and employment and the rise in the capital-output ratio, and between lower rates of growth, declining employment, and the downward trend in the capital-output ratio is a distinctive and intriguing feature of the findings.

Second, the major trends in the several aspects of the growth of

mining parallel those found by Dr. Creamer for manufacturing.¹ In manufacturing, also, the trend in the capital-output ratios was generally upward until about 1919 and distinctly downward thereafter; the period up to 1919 was marked by higher rates of growth in output and by an upward trend in employment, whereas the decades after 1919 witnessed a much lower rate of growth in output and in employment.

These trends in output, employment, and capital in mining and manufacturing might be expected to be similar: there is a close connection between these industries. A high rate of growth of output in one would tend to contribute to a high rate of growth in the other; a series of technological and other changes producing increased capital investment and a higher ratio of capital to output are likely to spread from one commodity-producing sector of the economy to another. This would also be true of changes contributing to more intensive use of capital — the capacity to turn out more goods with the same capital investment. Yet there are some differences, and Dr. Borenstein's discussion is particularly valuable in bringing out these differences between mining and manufacturing and also those among the various divisions of the mining industry itself. His analysis of capital by the various types — plant, working capital, land — sheds additional light on the processes of capital use.

As is always the case with empirical studies disclosing new factual knowledge, numerous questions arise as to the identity of the specific factors which produced the patterns observed in the past. Given the considerable changes in the capital-output ratios in mining during the past eighty years, one naturally is impelled to ask what factors determine the amount of capital used per unit of product at any given point in the history of the industry. To what extent is this amount determined by compelling technical considerations? To what extent is the technique merely a result of the accumulation of knowledge in a particular field of production, and to what extent is it a result of broader social and economic processes, such as the amount of funds available, the rate of growth of the economy at large, and the rate of growth of the given industry? How does the scale of operations, a primary factor in the type of technique applied, fit into the picture?

The very scope of these questions precludes the possibility of finding

¹ Daniel Creamer, *Capital and Output Trends in Manufacturing Industries, 1880-1948*, Occasional Paper 41 (National Bureau of Economic Research, 1954).

the answers to them in this paper; nor is it likely that tested answers will be given either in the more detailed monograph of which this paper is a partial preview or in the summary volume that will bring together the empirical findings of the several monographs in our inquiry. The most that could be done here was to experiment with the factors which could be most easily measured (e.g. the changing shares of the several divisions in total mining) to see the extent to which they contributed to the trends observed in the capital-output ratio for mining as a whole. These and similar statistical analyses, even though more intensively treated in the monograph or more extensively covered in the study as a whole, will only narrow the area of speculation, limit the field about which questions of this kind will still be raised. They can scarcely serve to answer these questions in a specific and tested fashion.

Indeed, one may argue that, in the nature of the case, no thorough explanation of past historical change, no fully testable identification of the factors at play, is possible when we deal with so variable and complex a phenomenon as social change, which operates under conditions in which experimental controls are impossible, and even comparative analysis is severely limited by lack of basic data for a large variety of relevant experience. Despite its wide scope, this study is restricted to a single country and a few decades; the available data force us to deal with aggregates without allowing penetration into the confines of single firms, which are, after all, the units of decision; and many important factors, such as technological change, are not yet susceptible of quantitative measurement. Under such circumstances, we can only hope to add to the stock of tested knowledge about what actually took place within the field of our interest, and, by dint of additional analysis, limit the area within which speculation about the specific factors responsible for the observed change may legitimately roam. But it would be over-sanguine to expect to identify these factors completely, weigh their specific contributions, and establish the precise nature of their inter-relations.

This limitation upon our hopes, relative to an ideal goal of research, is, of course, no basis for minimizing the value of careful and methodical examination of the past, guided by some preliminary notions of the importance of the economic processes studied and of the nature of their interrelations. Meticulous and penetrating examination of the kind made by Dr. Borenstein is surely the most effective way of progress from

speculation and theory based upon a vague and conjectural picture of what presumably happened and why, to a more acceptable record of the past upon which useful, though not necessarily final, interpretations can be based.

SIMON KUZNETS

Summary

This study examines past trends in output and capital invested in the mining industries for the light they may throw on the future trend of capital investment in this field. It is primarily from this point of view that we are concerned with the trends in the ratios of capital to output (product), but the ratios and their changes over time may also serve as an empirical basis for examining a variety of other problems. Knowledge of the past movements of the capital-product ratios assumes considerable importance because of their role in one of the methods used to forecast future capital investment. This approach starts with a projected figure of the product of a given industry to which a capital-product ratio is applied. Obviously, the more that is known of the past history of the capital-product ratio, the greater the likelihood of accuracy in the projection of capital investment. However, while concern with the future has motivated our study of the past, numerical projections were not considered the immediate task of this study.

It should be stressed that the data available for an analysis of past trends in capital are exceedingly fragmentary and affected by numerous changes in accounting practice. The treatment of capital assets in the mining industry has differed considerably among companies, and even within the same company has changed from time to time. Mention may be made, for example, of the changes in depletion and capitalization practices which occurred as a result of the establishment of the income tax in the United States in 1913, the growth of the petroleum industry with its peculiar devices for handling oil wells (leasehold arrangements, the treatment of intangible drilling costs, and so on), and the appearance of accelerated amortization during World War II. Because of the difficulties raised by these peculiarities of the accounting data, the figures we present in the body of the paper should be regarded as only approximate, and for some purposes they are admittedly inadequate. We think, however, that they are sufficiently accurate for the uses to which we have put them. Careful study of the details of the data, comparison with other bodies of information, and calculations of

experimental alternative estimates lead us to believe that the idiosyncrasies of the data do not undermine our conclusions. We feel that the general outlines of the trends we find in mining are sufficiently well established.

The long-term tendencies in growth of mining output have been brought out by relating the consumption and production of minerals during the last seventy years to national product. We found that from 1880 to the 1910–1919 decade aggregate production of minerals grew faster than national product; since then, however, the reverse has been true. Expressed in 1935–1939 prices, each \$100 of gross national product was accompanied by the production of \$2.7 worth of minerals in the decade 1880–1889, \$4.5 in the decade 1910–1919, and \$4.2 in the decade 1940–1949 (Table 1). The reversal in this relationship was due partly to a relative increase in imports of some of the minerals or to a relative decrease in exports of others. However, although this seems to be responsible to a considerable extent for the decline in the ratio after 1910–1919, another factor has contributed to the reversal in the ratio of mining production to national product. When we examine the trend in the consumption of minerals we find that the value consumed per \$100 of national product increased until the 1910–1919 decade and then leveled off. This suggests that the reversal in the trend of the ratio of mineral production to national product was due primarily to the predominance of mineral-saving over mineral-demanding developments which began to occur after World War I. (The technological changes resulting in mineral savings are broadly discussed in the technical literature and are therefore not analyzed in this paper.) The clearly defined character of these trend movements as expressed by our figures indicates that a declining ratio of mineral output to national product must be taken as a datum in the projection of future mining output — unless one can see new factors shaping the long-run relationship between production and consumption of minerals per unit of national product.

Because of the lack of information on the historical behavior of the capital-product ratio, capital use has usually been projected by the capital-product ratio existing at the time of projection. Since our findings indicate great variability in that ratio during the last seventy years, such an approach has little justification. We find that in each mining industry, up to a certain point in time, an ever-increasing stock of capital — the latter defined as the net value of fixed and working assets — was

employed in order to extract a dollar's worth of mineral. Thereafter the reverse has been true. This pattern is clear when capital is measured in book values and product at market price values, but is particularly marked when the values of capital and product are adjusted for changes in price level. On this basis the turning points in the ratio of capital to product for the different industries occur between 1909 and 1929 — in the majority of cases around 1919. Thus, when we express the values of capital and product in 1929 prices (product taken on an annual basis), the ratio of capital (excluding land) to output in total mining was .7 in 1870, 2.3 in 1919, and 1.3 in 1948. In the bituminous coal industry the comparable ratios were .9, 1.3, and .9, and in the petroleum and natural gas industry, 1.8, 5.9, and 1.8 (Table 7). The changes in the ratio for the latter industry demonstrate how substantial the increase and subsequent decline in the capital-product ratio can be. In 1919 this ratio was about 3.3 times as high as it was in either 1870 or 1948. In view of these considerable variations in the ratios in the past it is evident that trends in future capital use can be projected only by means of assumptions far more complex than those now generally in use concerning the future direction of, and degree of variation in, these ratios.

True, the above figures do not include capital invested in land and therefore do not reflect the changes in the total amount of wealth used per unit of mining output. They do not even represent to any satisfactory extent the changes in the total amount of reproducible wealth employed, since exploration and development costs of mineral lands are commonly charged off to current operations and for that reason do not appear in our estimates. These "intangible" capital items have certainly grown in importance, and their increase in the petroleum and natural gas industry has been particularly substantial. No reasonable estimate of the current value of this type of capital investment, however, suggests that its increase during recent decades has been so large as to offset the observed decline per unit of output in capital carried on the books. If this is true, the *total* amount of reproducible wealth employed per unit of output has declined.

A question immediately arises: Will the observed decline in the capital-product ratios continue? It is clear that the answer to this question is to be found, if at all, by trying to identify the factors that have brought about the observed increase and subsequent decline in these ratios, a task which far exceeds the scope of this study. We have limited

ourselves to the examination of a few factors that lend themselves to measurement and that in one way or another may be associated with the trends in the ratios.

There is evidence in our data pointing to a causal relationship between the speed of an industry's growth and the behavior of its capital-product ratio. We find that the period of increase in the capital-product ratios has generally coincided with the period of high rates of growth in the mining industries, whereas the period of decline in the capital-product ratios has been a period of slackened growth — growth being measured in terms of employment and output. Thus, from 1870 to 1919 the number of wage earners employed in the mining industries increased from 150,000 to 1,000,000, but from 1919 to 1948 this number declined to 850,000 (Table 3). The average annual percentage rate of growth in output of aggregate mining between 1870 and 1919 was 5.4 per cent, and was accompanied by a 7.9 per cent annual increase in capital, but between 1919 and 1948 the annual percentage increase in output was only 2.9 and was accompanied by a 1.1 per cent growth in capital. While a roughly similar pattern is found for each mining industry (Table 6), the relationship between the rate of an industry's growth and the movement of the capital-product ratios appears more complex (see pages 56 ff.).

Differences among the mining industries in their rates of growth together with consistent differentials in their capital-product ratios have had an important impact on changes in the capital-product ratios for mining as a whole. Shifts in the relative importance of the individual industries have tended to increase it. Its increase up to 1919 was therefore due partly to these shifts, while the decline since 1919 has taken place in spite of them. Hence, in projecting a capital-product ratio for aggregate mining, consideration must be given to the composition of the projected aggregate output.

Changes in the various components of capital — land, plant, and working capital — have not been similar, as is evidenced by differences in the movement of their ratios to product (Tables 7 and 8). The ratios of land to product increased less and declined earlier and more markedly than did those of the two other components. The decline in the ratio of plant to product, in turn, was greater than the decline in the ratio of working capital to product. Analysis of the components of working capital shows that cash, the largest component in 1948, increased more

rapidly than product, its ratio to product rising continuously even when the ratios of the other components declined (Table 9). This finding suggests that a projection of capital-product ratios will tend to be more accurate if calculated separately for each type of capital.

Last but not least important to our understanding of the possibilities for forecasting future capital investment is our finding that change in capital per employed worker during the past was not consistent enough to be useful in making projections. The amount of capital used per wage earner or man-hour in the mining industries increased rapidly up to 1929. Since then the increase has been moderate, and in some of the industries we find a decline (Table 13). Output per labor unit, on the other hand, has continued to increase with great vigor. The fact that this great increase in output per worker was won with only a moderate increase in capital per worker underscores the importance of those innovations that make more effective use of resources and shows how rash it would be to assume any fixed pattern in the growth of capital per worker in order to forecast future capital investment.