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Introduction

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

The several studies in this inquiry deal with trends in capital accumulation and its financing in each of the major capital-*using* sectors of the economy. Of these, manufacturing is among the more important, both as capital user and producer. It is, therefore, fortunate that trends in output of manufacturing industries and in their use of labor have been studied before and, particularly, that data are available for the preparation of a fairly long record of capital accumulation or formation. The information is not, of course, available in the detail, consistency, and continuity that we might wish. Far from it: the data relating to capital in manufacturing are given, before the late 1920's, only at distant census intervals, their scope varies from one census date to another, and they are accompanied by solemn warnings from the data-collecting authorities of possible errors resulting from vagueness of concept and basis of valuation. To cap the difficulties, the census data cease after 1919 and must be linked with corporate balance sheet data reported and tabulated by the Bureau of Internal Revenue, with some detail from the late 1920's and with satisfactory breakdowns only in later years. The effort, patience, and ingenuity that had to be devoted to overcoming these defects of the data in order to establish a bare outline of the long-term trends in capital formation, in relation to the better-

known trends in output, are more concealed than revealed in the straightforward story told in Dr. Creamer's paper. Much more of the detail will be given in a forthcoming monograph, which will deal also with trends in financing of capital accumulation in manufacturing. This paper is limited to a presentation of the major findings and of a series of tests indicating whether the findings are likely to stand up under further probing.

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Dr. Creamer centers most of his discussion on trends in the capital-output ratio, i.e. the fraction in which the capital used in manufacturing is the numerator and the output or product of the manufacturing industries the denominator. This follows the usage that has become customary both in theoretical analysis emphasizing capital coefficients and in empirical projections using past ratios of capital to product applied to forward estimates of product levels.

A simple illustration may clarify the notion of a capital-product ratio and demonstrate how it can change. Assume that a stamp press, the cost of which is $200,000, is the only machine employed to turn out an annual output of automobile fenders with a total value of $100,000. The ratio of capital, i.e. of value of resources embodied in the tool, to annual output produced with its help is thus 2. Assume now that a much heavier press can be built, costing $500,000, to produce double this output of fenders at a lower cost per unit, or a total value of $175,000. In current prices, the capital-output ratio becomes $500/$175, or 2.9; and in constant prices, 2.5. The capital-output ratio increases. Assume, alternatively, that in the press in the first example a simple adjustment, costing little, say $10,000, can raise the volume of output by 50 per cent, with a 5 per cent reduction in price. The new capital-product ratio in current prices will be then calculated as $210/($150 $\times$ 0.95) = 1.47; and in constant prices as $210/$150, or 1.40. The capital-output ratio declines.

Behind the usage of capital-output ratios in current economic discussion there lurks a notion of capital requirements, an implication that a *technically necessary* ratio exists, in the sense that an output of a given volume of product cannot be attained without a capital stock of predetermined dimensions. And such a notion is only reinforced by the

kind of illustration adduced above. But the assumption that there exists, at a given time, a single technically fixed ratio of capital to output — even for a narrowly defined product and a single plant — or that the capital-output ratio as actually calculated from statistical data approximates this can be quickly destroyed by a brief glance at Dr. Creamer's data.

The first important impression these data convey is that the size of the capital-output ratio varies widely as the scope of the numerator and denominator is modified. Dr. Creamer distinguishes between working capital (cash, accounts receivable, inventories, and miscellaneous assets) and fixed capital (land, buildings, and equipment). If we limit the concept of capital to the tangible, durable assets, i.e. fixed capital, the ratio in 1929 of capital to annual total output is 0.43. If we add working capital, the ratio rises to 0.88 — the addition of inventories alone would raise the first ratio to about 0.73. If, instead of net depreciated value of fixed capital, we take gross — on the dubious ground that depreciation deductions do not reflect limitations upon the volume of output to which capital is applied — the ratio of total capital to output rises further to 1.20. Even greater variations result from modifying the scope of the denominator. One can argue, and legitimately, that fixed capital contributes to the production of net income originated, i.e. to the contribution of the industry net of costs of materials consumed, and of payments to other industries, not to gross value of output — even though working capital may be more properly related to the latter. Net income originating in manufacturing in 1929 was only 31 per cent of gross value of manufacturing output; and the addition of the ratio of fixed gross capital to net income produced and the ratio of working capital to gross value of output would yield a total ratio for manufacturing of 3.02. Finally, we should note that the ratios discussed so far relate capital to annual output, i.e. of a stock to a flow cumulated for a year. If we were to relate capital to output either for two years or for six months, the ratio would presumably be either cut in half or doubled.

The purpose of these comments is to emphasize that any useful notion of a technically necessary ratio between capital and output should clearly specify the scope of capital in the numerator and the scope and period of output in the denominator. In the process of such

specification it becomes quickly apparent that the only observable elements of technical necessity can be expressed by saying that if we want electric energy in large and steady supply, we do need the electric dynamos and all the relevant apparatus and cannot get along with a piece of soft wool and an amber stick; or that we need some inventories for a continuous process of production. But the moment one passes from such statements about technically indispensable prerequisites to the realm of relationships of measurable magnitudes, it is not only technical but *economic* necessities — costs and returns — that become important. The capital "needed" to produce a certain output would presumably be the stock that would maximize the net economic returns represented by the output — and this amount would depend upon a host of considerations affecting costs and returns, present and prospective. Even an estimate of what, at a given time, would be *technically* the most desirable practice would quickly reduce itself to specifying the *economic* conditions — conditions as to the costs and prices — the specification of which may be quantitatively more important than any differences among currently feasible techniques.

When we deal with the empirical capital-output ratios even for a single plant, there is no escaping the effects of the economic and social determinants that overlie the technical relationships which make the process of production physically possible. This is all the more the case when the ratios are calculated for more comprehensive aggregates — be they firms, industries, or complexes of the latter — where a wide variety of diverse technical bases exist and are combined.

When we measure the actual output ratios and their changes over time, it is economic and social processes that we are observing. Our analysis must, therefore, emphasize the economic and social factors and must draw upon whatever wealth of information and suggestion past research has provided. Our analysis must also proceed upon some implicit theory of the relation between technological change and economic activity, which would indicate to what extent we must pay attention to the sources of change in the additions to our technical knowledge, broadly defined, and to what extent we can take the supply of potential technical change for granted and emphasize the strategic and selective importance of economic and social factors in determining which of the possible technical changes are in fact adopted. A major

obstacle to satisfactory analysis and explanation of the trends in the capital-output ratios, once their course has been established, stems from the absence of a tested theory that would place in its proper perspective the relative contribution of changes in knowledge and of changes in the economic and social forces that determine how societies respond to the possibilities of technical change.

3

Dr. Creamer's major finding concerning trends in the capital-output ratio in manufacturing is that a significant rise in this ratio from 1880 to about 1909-1919 was followed by a definite and substantial decline to the most recent date studied by him, 1948. Of course, the absolute volume of capital in manufacturing, measured at constant prices, rose throughout the period. But during the first part the relative increase in the volume of capital was greater than in output, so that the capital-output ratio rose; after 1909-1919, the rise in the volume of capital was significantly lower than that in the volume of output, so that the capital-output ratio dropped. Indeed, by 1948 the ratio of capital to total gross output was only about a fifth higher than it was in 1880 and lower than it was in 1890 (see Table 8, column 2 below).

Two aspects of Dr. Creamer's analysis, set forth in detail in his paper, lend particular significance to the major finding just summarized. First, this upward movement of the capital-output ratios to the World War I decade and their decline since then are found not only for manufacturing as a whole, but for practically all major industrial subdivisions that can be traced continuously in the available data. The finding is also confirmed whether we deal with total capital or with working capital and fixed capital separately, and for the recent period the decline in the ratio is observed whether we take fixed capital net or gross of accumulated depreciation. The finding is further confirmed with all the possible variations in the denominator: when we take the ratio of capital to gross value of output or to value added in manufacturing.

Second, this general trend was accompanied by differences in the movement of the capital-output ratio for subgroups within manufacturing consistent with what one would expect on the basis of economic reasoning. To quote Dr. Creamer: ". . . during the period 1880 to 1919, when the capital-output ratio was rising, industries with rela-

tively low ratios in 1880 tended to have larger per cent increases in their ratios than industries with relatively high ratios in 1880; in the following decades of a declining capital-output ratio, industries showing larger decreases in the ratio tended to be those which had relatively high ratios in 1919." This pattern suggests the hypothesis, which we cannot test, that because industries with high capital-output ratios are likely to have more sizable shares of their costs accounted for by depreciation and interest charges, they would, therefore, be under greater pressure to effect economies in use of capital than industries with lower capital ratios; and we should consequently find, as Dr. Creamer does, that the rise in the ratios would be less pronounced and the decline more pronounced in the former group of industries.

Dr. Creamer does not attempt to provide an explanation of the trends that he finds, properly recognizing the wide scope and the difficulty of the task. It is instructive in this connection that the two statistical explorations he does attempt, which would have at least narrowed the task of explanation had they yielded significant associations, fail to do so. The first, already hinted at above, is a test of the extent to which the trend in the capital-output ratio for manufacturing as a whole has been due to shifts in relative weights of various industries, industries with different levels of the ratio of capital to output. If it were shown that most of the rise from 1880 to 1919 and of the decline from 1919 to 1948 in the ratio for total manufactures were due to such interindustry shifts, the inquiry could be directed at accounting for the reasons why certain industries rose in relative importance and others declined — not for reasons of movements of capital-output ratios within each of the several industries. But Dr. Creamer finds that "about one sixth of the rise between 1880 and 1919 can be attributed to the altered composition of the manufacturing total" and that "the decline in the actual ratios [in the later period] occurred *despite* the changing composition of industry." The other analysis dealt with the relation between size of firm and capital-output ratios: the cross-section relation indicates that within most industries the larger firms have the higher capital-output ratio. This cross-section relation, applied to trends over time, might have explained the rise in the capital-output ratios from 1880 to 1919; but it would also have produced a rise in these ratios after 1919, rather than the significant decline that was observed. Here then is another

case where cross-section relations are a poor guide as to what may happen in changes over time.

A tested explanation of the observed trends in capital-output ratios in manufacturing is a major task, far beyond the present scope of our inquiry. But a few suggestions may be advanced, which may at least provide tentative guides for further thinking and place the finding in a somewhat wider context.

In general, one would expect entrepreneurs to economize, to attempt production of increasing volume with less input of costly resources. It is, therefore, easier to explain a secular decline in the capital-output ratio in purely economic terms: unless there are major capital-demanding technological changes or factors disturbing the drive toward more efficient use of resources, one would expect a downward trend in the ratio.

This trend is reinforced by another factor of somewhat more specific character. A decline in the rate of growth of depreciable gross fixed capital formation in manufacturing means, all other conditions being equal, a rising ratio of depreciation to gross capital formation and, what is more important, a rising ratio of depreciation to either net or gross capital stock. In our estimates this means that the percentage of current capital stock renewed by replacement is growing, as the rate of growth in gross capital formation declines. It is also fairly clear that the adjustment for price changes of current price totals of fixed capital goods, particularly equipment, does not reflect, and is not intended to reflect, the amount and kind of productive service that these capital goods can render. In other words, an item of equipment costing $100,000 in 1929 prices is a far more serviceable item if it was purchased in 1950 than it is if purchased in 1930 or in 1910. This aspect of our estimates would mean that, with everything else held constant, the greater the proportion of capital stock replaced every year — without any change in the constant price value of the net or gross capital stock — the greater will be the increase in its serviceability and the depressing effect upon the capital-output ratio.

Further, one may emphasize the salient characteristics of the post-World War I decades in this country, characteristics that may have accentuated the forces making for a lower capital-output ratio. In the 1920's restrictions upon immigration were initiated. This decade was

also characterized by relative inefficiency in the early years (1919-1921) because the productive system had been allowed to run down from 1914 through 1919, and it was dominated by expectation, after the price collapse of 1920, of declining or, at most, stable price levels. With the emphasis on high labor costs, one might have expected pressure toward intensive capital accumulation, toward replacement of labor by capital. And, as Dr. Creamer indicates, the volume of capital per worker did rise sharply. But the ratio of capital to output also declined over the decade. Presumably, in recasting their operations, lowering costs, and raising productivity, manufacturers succeeded in raising output at an even greater rate than they were obliged to add to their capital stock.

There is less of a puzzle as to why the capital-output ratio should have continued to decline in the 1930's and the 1940's. In the depression-dominated decade of the 1930's there would naturally be great pressure for economical use of capital and for a high ratio of replacement to gross capital formation. Hence, once the acute decline in volume of output (which lowers the denominator and raises the capital-output ratio) had passed (1937 is the date assigned by Dr. Creamer), one would expect a lower ratio of capital to output than in 1929. In the 1940's the extraordinary pressure, first of World War II and then of demand for peacetime goods during the postwar years, would make for a high and intensive rate of use of existing capital stock — and hence for a low capital-output ratio again in 1948.

But what about the significant rise in the capital-output ratio in manufacturing before World War I? One suggestion is made by Dr. Creamer at the very outset of his discussion when he observes the slackening of the rate of growth in manufacturing, particularly pronounced in number of establishments but notable also in the total numbers employed, in volume of output, and in volume of capital. Dr. Creamer says: "This trend suggests that during the later decades of the nineteenth century, entrepreneurial ability in manufacturing was primarily directed toward organizing new enterprises and during the first four decades of the twentieth century, entrepreneurial energies shifted on balance toward enlarging the scale of operations and promoting other measures — technological and managerial — resulting in a more efficient utilization of resources." The significance of this observation is

enhanced by the fact that we find a parallel in agriculture and mining. In agriculture, extensive expansion — reflected in acreage, numbers of farms, and numbers of people engaged — slowed down perceptibly after 1910 and gave place to more intensive growth — with the corollary that whereas the capital-output ratio declined only slightly from 1870 to 1910, it dropped more markedly from 1910 to 1950 (see Dr. Alvin S. Tostlebe's forthcoming monograph in this series). Likewise, we shall find a similar pattern of growth in the mining industries, accompanied by the same trends in the capital-output ratio (see forthcoming Occasional Paper, *Capital and Output Trends in Mining Industries, 1870-1948* by Dr. Israel Borenstein).

The very addition of new plants, built for the longer range future, may mean that equipment for the time being is not used at full capacity, aside from the consideration that new plants need a period of settling down before they can be operated at the most economical level. Large increases in numbers of plants and firms may be accompanied by greater territorial dispersion and may mean larger ratios of both fixed and working capital to output. In that sense, extensive expansion contributes to a higher capital-output ratio. But in order to explain *rising* ratios, one would have to demonstrate a *rising* rate of extensive expansion: if the capital-output ratio for, say, 1880 was inflated by the process of expansion during the 1870-1880 decade, the ratio would not rise from 1880 to 1890 unless the proportional rate of expansion was greater in the 1880-1890 than in the preceding decade. Yet such acceleration in the rate of extensive expansion is unlikely.

One must, therefore, consider other forces at play. It is quite possible that a new technology, requiring larger fixed capital per unit of output, was penetrating into the manufacturing industries under the impact of steel, steam, electricity, and, later, the internal combustion engine — to name only the more outstanding of a multitude of technological changes. Such a process, accompanied and facilitated by parallel changes in the organization and administration of the plant and the firm, could affect every major industrial group within manufacturing — although naturally with differences in the date of the initiation and relative slackening of the process. The spread of technological change within each industrial sector might mean a rise in the ratio of fixed capital to output, more than outweighing the decreasing effects of

economies by plants and firms that had adopted the modern technology earlier and had time to introduce more intensive patterns of operation. It is also possible that the demands of modern technology for a steadier and larger scale rate of operation meant a need for a larger supply of inventories relative to volume of operations, and that the greater size and economic strength of the firms made for a larger relative supply of cash and receivables — these factors operating to raise the ratio of working capital to output. Finally, one should not overlook the fact that the major rise in the ratio of *fixed* capital to output in the manufacturing industries was from 1880 to about 1910 and that most of this period was characterized by declining and low interest rates — a factor that might have encouraged a shift to capital investment of longer life, which would have had a lifting effect on the capital-output ratios.

The observations above can obviously be no more than tentative suggestions, or leads to further exploration. The possible variety of factors at play must be seen against the great variety of industries comprised under manufacturing; and the former cannot be adequately explored, perhaps not even completely seen, unless the latter are distinguished in the statistical record. The greater detail in Dr. Creamer's forthcoming monograph will therefore be of high interest, not only for reference purposes but for channeling the task of explanation and analysis somewhat more precisely than can be done now.

4

With an eye to the main goal of the inquiry, one should ask to what extent the rise and then the decline in the capital-output ratio in manufacturing can be interpreted as a rise and decline in the demand by manufacturing industries for a proportionate share of the capital funds and savings of the country. A brief comment might clear the way to answering this question.

The output of manufacturing industries is, of course, part of the total product and income of the nation; savings of either individuals or firms are, in turn, part of the country's total product or income. If both the proportion of manufacturing output to national product and the ratio of capital stock to output in manufacturing rise, the proportion of national product or income embodied in capital additions to manufac-

turing must also rise. Whether in such a case manufacturing absorbs an increasing proportion of the country's savings depends upon whether the share of the latter in national product or income rises less or more than does the proportion of national income absorbed in capital formation in manufacturing. In short, three variables determine the proportionate share of the country's savings absorbed by capital formation in manufacturing: the capital-output ratio in manufacturing, the share of manufacturing output in national product or income, and the share of total savings in the latter.

Some rough indications of the trends in the share of manufactures in national income are provided by Dr. Creamer in Table 1, below. It shows that the share rises from the 1870's to the 1920's, declines during the 1930's, and rises again during the 1940's. The percentages are in current prices, but in constant prices the major movements would be in the same direction. If we combine this evidence with Dr. Creamer's findings concerning trends in the capital-output ratio, there is a strong presumption that the proportion of national income absorbed in capital formation in manufacturing industries must have risen from 1880 to the early 1920's, declined during the 1930's, and may have declined further or become stable in the 1940's.

To derive the movements in the share of the country's savings absorbed by capital formation in manufacturing, we need, in addition, evidence on the trends in share of savings to national income. If one may judge by the nation-wide series prepared for a volume that will summarize the complete capital formation study, the share of net savings to national income rises somewhat until the end of the nineteenth century, and then declines moderately (sharply, of course, during the 1930's). It would require more elaborate calculations than are possible here to derive the proper trends, and such calculations can be best deferred to Dr. Creamer's monograph. But the preliminary impression is that the ratio of capital formation in manufacturing to the total savings of the country would probably rise from 1880 to the 1920's, and then decline somewhat — with the rise and decline, however, less pronounced than they are in the movements of the capital-output ratio.

One should note that calculations along the lines just suggested should be carried through not only for net capital formation but also for gross, in relation not only to net country-wide savings but also to such

savings gross of the depreciation allowance. It can be argued that decisions to save and to invest are in many cases arrived at without allowance for the current consumption of durable capital implied in the depreciation deduction; and that in considering questions of financing capital formation, we would be on safer ground to carry on the analysis in the more inclusive gross terms than in the more narrowly defined net terms. This alternative will have to be faced in the combined analysis of capital accumulation and financing that Dr. Creamer's monograph will undertake, and it is hoped that the available data will permit development of the analysis on both gross and net bases.

5

What can Dr. Creamer's major finding tell us about the future? Is the decline in the capital-output ratio in manufacturing, observed since the early 1920's, likely to continue after the 1940's — and continue for a substantial period of time?

While no firm answer can be given to this question, perhaps not even after an arduous and time-consuming exploration, two considerations would strongly militate against a simple and mechanical extension of a decline in capital-output ratio into the future. The first is already suggested by our comments above on the specific characteristics of the 1930's and the 1940's. There was an element of historical chance in this combination of a decade of depression and of obvious pressures for the reduction of the capital-output ratio with a decade of war and postwar readjustment which meant straining the productive capacity of the country and thus again lowering the capital-output ratio. It is unlikely that in the decade of the 1950's there will be a repetition of such a combination of forces serving to depress the capital-output ratio even further. It is already apparent that the large capital extension program initiated after World War II is adding greatly to the existing capital stock in the manufacturing industries and may result in either stability or a rise in the capital-output ratios. It is of interest that one of Dr. Creamer's tables shows a rise in the ratio of fixed capital to output in total manufacturing from 0.308 in 1948 to 0.327 in 1950 and 0.321 in 1951 (see Table 9).

The other consideration lies in the distinct possibility that the process of economizing on capital may be reaching its limits and that if such

limits have been approached, further absolute reductions in the capital-output ratio are likely to be rather minor in character. This suggestion could be explored further by detailed analysis of older industries in which the decline in the capital-output ratio began earlier and may have run more of its full course than is the case with the younger industries.

Whatever answer, firm or tentative, can be given to this question will have to be combined with some prognosis of the future share of both manufacturing and total savings in national income to provide some idea of the share of future savings which capital formation in manufacturing may be expected to absorb. And there are further questions relating to sources of such savings, and the channels of financing, which have not even been touched upon either in Dr. Creamer's paper or in this Introduction, but to which consideration should be given in the monograph.

The findings in this paper can reflect only part of a complex economic universe. Capital formation in any important sector is a key process in the functioning of the whole economy, particularly in the longer run. This only means that the *full* significance of these findings will not emerge until other related processes have been studied — in manufacturing and in other sectors of the economy — and until a tested theory has been evolved that would place this, and other findings, into an acceptable framework giving it more general bearing than attaches to a specific historical fact. But this observation should help, rather than prevent, recognition of the key importance of such findings as have been assembled by Dr. Creamer in this paper — importance arising from the fact that they tell us something new about the past, and document the story with richness that compels acceptance. Such findings force us to look at any theories or notions that we may have entertained and attempt to revise them if they are not consistent with, or relevant to, the new information; and they raise questions suggesting directions for further fruitful inquiry, or at least a somewhat better perspective for consideration of policy prospects and problems.

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