The Apparent Decline in Capital-Output Ratios
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THE APPARENT DECLINE IN CAPITAL-OUTPUT RATIOS*

By Paul S. Anderson

Most empirical studies of capital-output ratios indicate that these ratios have generally had a declining trend over time. This is shown in Figure I where several well-known ratios are plotted.[1] This declining trend is in conflict with the seemingly common view that capital-output ratios tend to rise with progress.[2] In this study, the ratios shown in Figure I are analyzed with the conclusions that constant dollar ratios have declined mainly because deflation causes a downward bias (the capital asset deflator has risen more rapidly than the output deflator) and that the ratios based on balance sheet data have declined because of inadequacies in the basic data.

I. Goldsmith and MAPI Ratios

The Goldsmith constant dollar ratio declined 32 per cent from 1897 to 1949 (latest year available) while the MAPI (Machinery and Allied Products Institute) ratio (a constant dollar ratio also) declined 16 per cent from 1910 to 1949 and 3 per cent further by 1956. Contrasting with these substantial declines is Goldsmith's current dollar ratio which declined only 9 per cent from 1897 to 1949 (only 7 per cent to 1955). If more recent data were available, the decline

* The author is employed by the Federal Reserve Bank of Boston; the views expressed here are his own.

1. The most widely publicized study seems to be that by John W. Kendrick which is as yet unpublished, but is the basis of the study by Solomon Fabricant, *Basic Facts on Productivity Change, Occasional Paper 63* (National Bureau of Economic Research, 1959), as well as of the productivity indexes in the new *Historical Statistics of the United States, Colonial Times to 1957*, U. S. Bureau of the Census (Washington, 1960), pp. 593 ff.

2. A rising ratio appears to be implied in such concepts as the declining profitability of capital and economic stagnation; Friedman states quite directly that the ratio rises with income but that available statistical evidence is inadequate to show it. Milton Friedman, *The Demand for Money: Some Theoretical and Empirical Results, Occasional Paper 68* (National Bureau of Economic Research, 1959), p. 23, 23n.

might change to an actual rise.[3] Thus it is quite clear that the aggregative constant dollar capital-output ratios have declined

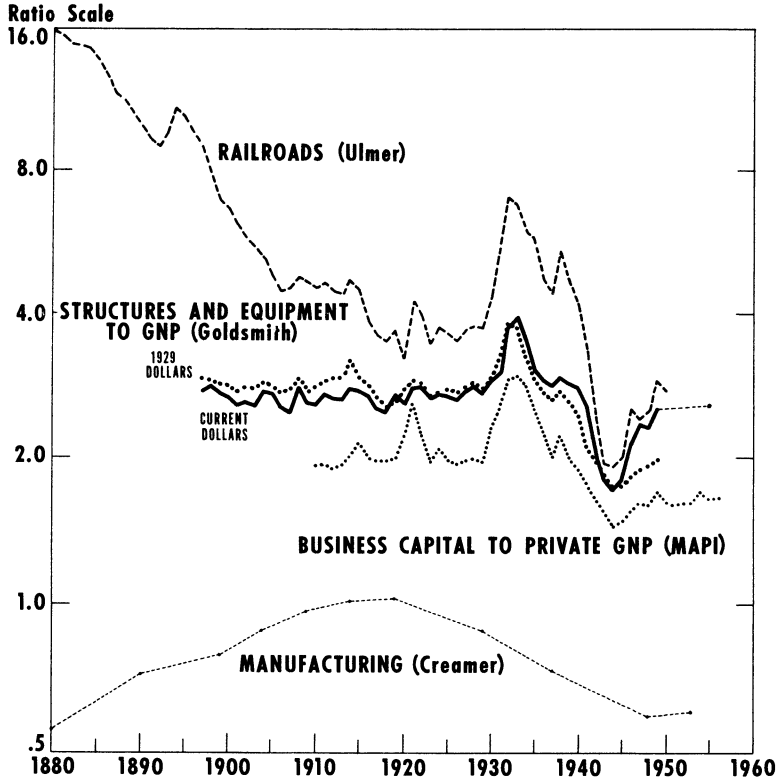

FIGURE I

SELECTED HISTORICAL CAPITAL-OUTPUT RATIOS

Sources: Railroads — Melville J. Ulmer, *Trends and Cycles in Capital Formation by United States Railroads, 1870–1950, Occasional Paper 48* (National Bureau of Economic Research, 1954), pp. 60, 61, 64, 65; Goldsmith ratios — Raymond A. Goldsmith, *A Study of Saving in the United States* (Princeton University Press, 1955), III, 14, 20, 427, 429, except for 1955 which is presented in National Bureau of Economic Research, Thirty-seventh Annual Report (May 1957), p. 36; Machinery and Allied Products Institute (MAPI) and Creamer's ratios — *Productivity, Prices and Incomes, Materials prepared for the Joint Economic Committee Staff* (U. S. Congress, Joint Economic Committee Print, June 21, 1957), pp. 93, 94.

mainly because the capital asset deflator has risen more over this period than the output deflator. For example, Goldsmith's capital

3. This current dollar ratio rose about 10 per cent between 1948 and 1955, two years of prosperity, so presumably there was a further rise of almost 10 per cent between 1955 and 1961, which would bring the current value above that of 1897.

asset deflator rose from 41 in 1897 to 175 in 1949 (with 1929 equal to 100) while his GNP deflator rose from 45 to 149.[4]

This greater rise in the capital asset deflator could simply reflect a greater rise in capital goods prices. But then the question arises as to why the average price of one broad class of output should rise so much more than the average of all classes when the same general raw material and labor inputs are used in the one as in all. There obviously could not be such a growing discrepancy in profits. Other possibilities concerning the widening gap between capital asset and output prices could be discussed, but the answer seems to be a simple one involving index number construction. Most types of output are treated basically as a market basket of similar items over time and their average price is obtained by averaging the prices of these similar units. Capital assets, however, cannot be reduced to similar units as easily because they tend to change more in form. (For example, the steam or diesel-electric shovel as compared with the hand shovel is an example of change in capital goods while the output of these goods remains the same at cubic yards of iron ore loaded.) The usual solution to this capital goods price index problem has been to make these assets comparable through the costs of the inputs used in making them.[5] For example, if a capital good required 100 labor hours to construct both in 1897 and 1961, its deflator would be proportional to the hourly wage rate. If, however, 100 labor hours resulted in twice the consumable output in 1961 as in 1897, the consumer price index would rise only one-half as much as the wage rate.

The result of these differing methods of constructing price indexes is that rising productivity is taken into account with most output but not with capital goods. A current capital good is treated as a unit identical to its predecessor if the same quantity of inputs is used in its manufacture even though it is twice as productive. The constant dollar capital-output ratio thus declines absolutely even if the current stock of capital represents the same amount of resource inputs relative to output as before. While there might be practical reasons for the differing methods of constructing price indexes, they

4. These are the implicit deflators for the Goldsmith capital and output series used in Figure I.

5. Edward F. Denison, "Theoretical Aspects of Quality Change, Capital Consumption, and Net Capital Formation," *Problems of Capital Formation, Studies in Income and Wealth,* Vol. 19 (National Bureau of Economic Research, Princeton University Press, 1957), pp. 215–61. Goldsmith used this procedure as indicated by explanatory notes to his tables on index numbers, *A Study of Saving in the United States, op. cit.*, I, 607.

do render constant dollar capital-output ratios less and less meaningful over time. Furthermore, valuing capital assets on a different basis from their output appears to violate the concept that a capital good's value is a derived value, derived from the value of the output it produces.

II. Rise and Fall in Manufacturing Ratios

According to the Census and Internal Revenue Service data which Creamer used for deriving capital-output ratios in manufacturing, the aggregate and almost all separate industry ratios rose quite steeply from 1880 to 1919, then fell equally steeply to 1948. There are several odd features about this behavior. First, why should the ratio of a component as important as manufacturing rise to 1919, then fall to 1937 when the Goldsmith and MAPI ratios remained quite stable over this period (except for the depression of 1932–33)? Second, within manufacturing why should industries with such totally different time patterns of growth as, for example, textiles and chemicals both show exactly the same time-peak in capital-output ratios?[6]

It is argued here that manufacturing capital was substantially underreported in the early part of the period covered but was relatively fully reported in 1919 as a result of the advantages of taking depreciation allowances in the computation of corporate income and excess profits taxes. Finally, after 1919, this same factor of depreciation has progressively reduced net capital asset values as a proportion of gross, or cost, values. Since the capital-output ratios were based on net values, the decline since 1919 has in large part reflected the growth of depreciation reserves from small amounts to about 50 per cent of gross values.

Creamer himself reports the first clue concerning capital underreporting in the early years:[7] "In the *Ninth Census of the United States, 1870*, Volume III (p. 382), Francis A. Walker, Superintendent of the Census, warned the public, in no uncertain terms, of the gross inadequacies of the census reports on value of capital used in manufacturing industries. He asserted, 'It is a pity, and may almost be said to be a shame, that statistical information, in many respects, of high authority and accuracy, should be discredited by association

6. Daniel Creamer, *Capital and Output Trends in Manufacturing Industries, 1880–1948, Occasional Paper 41* (National Bureau of Economic Research, 1954), pp. 84–88.

7. *Ibid.*, p. 92.

with statements [on capital] so flagrantly false, even to the least critical eyes. . . . The aggregate amount of capital invested in manufactures in the United States is $2,118,208,769. It is doubtful whether this sum represents one-fourth of the capital actually contributing to the annual gross product of $4,232,325,442.' "

Creamer's main defense of the accuracy of Census data involves a comparison of the 1919 Census of Manufacturers data with 1919 data presented in *Statistics of Income* which is prepared from corporate income tax returns. He argues that the income tax resulted in improved accounting methods and the *Statistics of Income* data are likely to be quite accurate. If the Census data agree with *Statistics of Income* data (as they do), then the Census data must be reasonably accurate.[8]

Agreement between Census and income tax data should be expected in any case, however. If the two sources purport to cover the same area, then the same accounting records should be the basic source of data for reporting to both Census and Internal Revenue. It is true that the Census data were collected on an establishment basis while the income tax returns were prepared on a firm basis and in many cases included a number of establishments within one firm. But a discrepancy between the two reports would occur only if the head office reported different figures than did the branch establishments. If the head office did not use branch data to arrive at totals for the firm, what figures would it use? Thus *Statistics of Income* and Census data for the same year necessarily must agree except for differences in coverage. The argument then reduces to the point that accounting records were reasonably accurate in 1919 because the corporate income tax was in effect by then. But this implies nothing about those earlier periods when there was no income tax.

Another source of clues as to the accuracy of the early Census data is comparison with data for that period of individual industries obtained from independent sources. One large industry, cotton goods manufacturing, is analyzed in the Appendix. The evidence seems quite clear that the 1879 Census undervalued total assets in that industry by about 50 per cent.

The next area of investigation of manufacturing capital-output ratio trends is the decline beginning in 1919. The reality of the decline is questioned because depreciation accounting appeared to have caused much of it. The investigation will be limited to the

8. *Ibid.*, p. 103.

bench mark years 1919, 1929 and 1937. The decline from 1937 to 1948 can be accepted quite readily since it agrees with the trends of aggregative capital-output ratios and because capital use appeared to be much more intense than "normal" in the postwar period judging by percentages of capacity operated in many basic industries.[9]

What part of the decline in capital-output ratios was due to depreciation accounting is not known for certain. Gross capital asset values were not given in the basic data source, *Statistics of Income*, prior to 1934, and the issue here involves the relation of net to gross capital asset values. Consequently circumstantial evidence has to be used in the investigation. The conceptual problem of which value base is better for capital assets studies, gross or cost values, on the one hand, or values net of depreciation reserves, on the other, is ignored although it is important. The focus is on the change in the relation of net to gross values and the effect this change had on capital-output ratio trends.

There are several ways in which depreciation accounting can alter the ratio of net to gross values. Creamer discusses two — whether depreciation was taken into consideration at all and whether depreciable lives were shorter than actual lives.[1] A third factor which Creamer did not mention but one which could affect the net to gross ratio substantially over a relatively short period of time, say, ten to twenty years, is the fact of the introduction of depreciation accounting. If fixed assets were carried at, or near, cost, and then depreciation accounting were introduced, the ratio of net to gross values would begin at 100 per cent and fall to near 50 per cent during the period of average capital asset life.

Since the introduction of depreciation accounting can affect net values markedly, the time of the introduction becomes important. Prior to the corporate income tax, it was largely immaterial whether depreciation was taken or not, but after the introduction of the tax in 1909, it became in the interest of corporations to take as much as possible, and in the interest of tax authorities to limit such charges. The corporate income tax rate was low at first, only about 2 per cent in 1916, for example, but later rises and an excess profits tax imposed during World War I raised the effective rate to about 40 per cent in 1918 so that the amount of depreciation charges became extremely

9. Bert G. Hickman, "Capacity, Capacity Utilization, and the Acceleration Principle," *Problems of Capital Formation*, *op. cit.*, pp. 434–35.

1. Creamer, *op. cit.*, pp. 45–48.

important to both taxed and taxers.[2] Thus depreciation accounting probably came into almost universal use during World War I; the result was that depreciation charges of manufacturing corporations were two and a half times higher in 1918 than in 1914.[3]

While accounting and institutional considerations indicate the possibility of a fall in the ratio of net to gross capital asset values during the period from about 1919 to 1937, the case for such decline would be stronger if supported directly by empirical data. Such data are not available on a fully adequate basis, but there is a certain amount of information which can be used for analyzing the problem. The first area of investigation is the decline in net to gross capital asset values of manufacturing corporations as reported in *Statistics of Income*, beginning with 1934, the earliest year available, and the second is a study of data for individual manufacturing corporations from 1919 on.

The ratio of net to gross values of aggregate fixed assets of manufacturing corporations which submitted balance sheets with the income tax returns declined an average of 0.8 per cent a year from 1934 to 1939.[4] As a first approximation, if this rate of decline were extended back to 1919, that year's net to gross ratio would be about 72 per cent, as compared with 55 per cent in 1937. For another estimate of the net-gross ratio in 1919, fifty-five individual large manufacturing corporation balance sheets were studied; based on the change in their net to gross ratios, the net to gross ratio of all manufacturing corporations was 81 per cent in 1919.[5] This results in a gross capital to output ratio of .704 in 1919, and a decline of only 11 per cent in this ratio to 1937, as shown by the data in Table I.

2. Rates computed from U. S. Internal Revenue Bureau, *Statistics of Income*, 1921, Table 12, p. 107.

3. Goldsmith, *op. cit.*, Vol. I, Table C-42, p. 957.

4. See annual issues of U. S. Bureau of Internal Revenue, *Statistics of Income:* 1934, p. 16; 1935, p. 14; 1936, p. 28; 1937, p. 24; 1938, p. 30; 1939, p. 22.

5. These fifty-five concerns were chosen from the National Bureau of Economic Research compilation "Corporate Financial Data for Studies in Business Finance, Section A, Large Corporations, May 1945" (mimeographed), and included all corporations in seven groups — automobiles, chemicals, iron, machinery, meat packing, petroleum, rubber and tobacco — for which *Moody's Industrials* listed gross fixed asset values in 1929. The total net to gross ratio of the corporations was .536 in 1934 and .633 in 1929. Prior to 1929, the average annual rate of change computed from the years for which data were available was .0173, and use of this rate of change results in a net to gross ratio for 1919 of .751, a value 40 per cent above the 1934 ratio. If this same relationship is applied to all manufacturing, the net-gross ratio in 1919 becomes 81 per cent.

TABLE I

SELECTED CAPITAL-OUTPUT RATIOS FOR MANUFACTURING, 1919 AND 1937

	1919	1937
(1) Total capital to output	1.022	.741
(2) Working capital to output	.452	.395
(3) Fixed capital (net) to output	.570	.346
(4) Fixed capital (gross) to output	.704	.624

Source: Creamer, *op. cit.*, — (1), p. 86; (2), p. 49; the 1919 ratio is assumed to be the same as in 1929; (3), row (1) minus row (2); (4), row (3) divided by net-gross ratios of .810 in 1919 and .555 in 1937; see accompanying text.

Furthermore, if such points are taken into account as the much faster than average growth rates of the large corporations, which slowed the fall in their net-gross ratios, and the fact that 1919 was a minor cycle trough while 1937 was a cycle peak, even the deflated manufacturing capital-output ratio probably rose so that the current value ratio probably rose by a fair amount.

III. RAILROADS

The capital-output ratio in the railroad industry had the largest fall of any investigated here. Road and equipment to output fell from about 16.0 in 1880 to below 3.0 in 1950. Most of the fall had occurred by 1915 when the ratio reached 4.3. A fall would not be unexpected since deflated values were used, but the amount of the decline, especially to 1915, seems surprising.

Analysis of this fall will proceed here through a comparison with an alternate capital-output ratio based on Interstate Commerce Commission data. The alternate ratio fell from 5.0 in 1880 to 4.7 in 1915, or only 6 per cent. Although the alternate ratio also has unavoidable weaknesses in its basic data, it is argued here that it is the more reasonable judging mainly by capital values per mile of track. Fortunately, there are in railroading convenient physical measures of capital available in the form of miles of track and number of pieces of major equipment.

Most of the analysis here bears on the period up to 1915 for several reasons. Ulmer relied almost exclusively on Interstate Commerce Commission data after the date also, most of the fall in his ratio had occurred by then, large price rises brought on by World War I make capital value comparisons more difficult and, finally, motor transportation began to be an increasingly important competitive influence after the war.

The basic data on which the following analysis depends is presented in Table II. The Interstate Commerce Commission data do

TABLE II

SELECTED RAILROAD CAPITAL AND OUTPUT DATA, 1870–1915
(In millions of dollars, except (5) which is in thousands of miles)

	1870	1880	1890	1900	1910	1915
Road and equipment						
(1) Ulmer, derived original cost	3,378	5,515	8,193	10,071	13,629	16,715
(2) Ulmer, 1929 prices	6,886	9,728	13,614	15,185	18,413	21,358
(3) Ulmer, book value	3,378	5,004	8,242	10,150	14,552	18,316
(4) I.C.C., book value	2,300[1]	4,653	8,134	10,263	14,558	17,441
(5) Miles of track operated	60	107	200	259	357	396
Output						
(6) Ulmer, 1929 prices	—	610	1,383	2,360	4,229	4,917
(7) I.C.C., operating revenue	—	645[1]	1,052	1,487	2,812	2,956
Capital Stock						
(8) I.C.C., total	—	2,709	4,409	5,845	8,113	8,995
(9) I.C.C., stock paying dividends	—	1,300[1]	1,598	2,669	5,413	5,220

Sources: Two sources were used, Melville J. Ulmer, *Capital in Transportation, Communication, and Public Utilities: Its Formation and Financing* (National Bureau of Economic Research, Princeton University Press, 1960); and the Interstate Commerce Commission as presented in *Historical Statistics of the United States, 1789–1945* (*op. cit.*). Page references for each of the rows are as follows: Ulmer — (1) Table C-13, pp. 280–81; (2) Table C-1, pp. 253–57; (3) Table C-2, pp. 259–61; Table C-3, pp. 262–63; (5) Table C-8, pp. 268–69, except 1915, which is from I.C.C., Series K-30, p. 202; increased by 1910 relation between Ulmer's and I.C.C. mileage; (6) Table I-13, pp. 470–73. I.C.C. — (4) Series K-18, K-60, pp. 201, 204; except 1870 estimated from total capitalization by use of 1876 relation between total capitalization and road and equipment value; (7) Series K-71, p. 205, except 1880 estimated from freight and passenger revenue in that year (Series K-9, K-10, p. 200) increased by 1890 relation of such revenue to total operating revenue; (8) and (9) Series K-20, K-22, K-63, K-64, K-65, pp. 201, 204, except (9) for 1880 estimated by capitalizing 1880 dividends at the 1882 rate.

1. Estimated.

not cover all years desired, so some estimating had to be done as described in the source note. Ulmer evidently felt that Interstate Commerce Commission balance sheets were not a reliable source of capital expenditure information which seemed to be his main concern. Subsequently he obtained capital expenditure data for a sample of railroads and blew them up on the basis of capital investment levels as given by the Interstate Commerce Commission. Expenditures give only additions to capital, however, so to get capital levels he had to rely on the same balance sheet data on which the Interstate Commerce Commission data are based for bench marks at both ends of his expenditure estimation period, 1870–1916.

Ulmer's data thus have the same basic source as the alternate Interstate Commerce Commission data presented in the table, but he processed the data in such a way as to arrive at different capital and output totals. These differences will be analyzed and evaluated in detail.

Both Ulmer's capital-output ratio which declined 73 per cent from 1880 to 1915 and the alternate Interstate Commerce Commission ratio which declined only 6 per cent can be derived from the data in Table II. Ulmer's capital is (2) and output, (6). The alternate ratio takes capital as (4) reduced by the amount of stock not paying dividends, or (8) minus (9), and output as (7). The specific factors that caused the difference between a 73 per cent decline in Ulmer's ratio and a 6 per cent decline in the Interstate Commerce Commission ratio and the approximate percentage points of difference accounted for by each factor are as follows: output deflation, use of (6) in Table II instead of (7), 29 percentage points; capital asset deflation, (2) instead of (1), 18 points; use of derived capital asset data, (1) instead of (4), 12 points; and not subtracting estimated watered valuation, (8) minus (9), 7 points.

Deflation tends to cause a downward bias in a capital-output ratio as discussed earlier. But in Ulmer's ratio the amount of bias was larger than in the case of the Goldsmith ratio. Combined output and capital asset deflation caused a 51 per cent decline in thirty-five years, or 1½ per cent a year, while Goldsmith's deflation bias was a little less than ½ per cent a year. Little analysis can be made of Ulmer's output deflation, however, since data on the structure of the chief component of output, freight ton-miles, are not available for the 1880–1910 period. Ulmer did separately weight the different elements of passenger miles for the 1939–50 period;[6] such separate weighting would probably have been even more important for freight ton-miles. Judging from revenue contribution, a ton-mile of manufactured products should have four times the weight of a ton-mile of mined products.[7]

Ulmer's derived original cost amounts are substantially higher in 1870 than the book value estimate based on I.C.C. data, but about the same in 1915. The 1870 difference resulted from Ulmer's method of interpolating between the 1860 and 1880 bench marks. The adjustment made for watered valuation by subtracting nondividend

6. Ulmer, *Capital in Transportation, op. cit.*, Table I-1, p. 475.

7. Computed from tables on freight tonnage and revenue, *Moody's Transportation Manual*, 1958, p. a21.

stock is not ideal, of course, but was done here in lieu of a better method. It would seem that some adjustment has to be made because padded stock valuations were apparently fairly common, and such padding must have affected the asset side of the balance sheet as well as the liability and net worth side.

The contrast in the results of using the different methods of valuing road and equipment can be brought out sharply by computing average costs per mile of track. Ulmer's deflated values per mile (row (2) divided by row (5) in Table II) were $90,000 in 1880 and $54,000 in 1915. The I.C.C.-based book values per mile (row (4) minus the difference between rows (8) and (9) divided by row (5) in Table II) were $30,000 in 1880 and $35,000 in 1915. It is difficult to believe that the constant dollar value per mile of track fell almost 50 per cent in this period. There could be little doubt that the quality of capital assets rose greatly over this period even if confirming data were not available. But the supporting data are quite clear. The number of locomotives, freight cars and passenger cars quadrupled from 1880 to 1915 as did track miles; the average tractive effort per locomotive, however, rose at the rate of about 3 per cent annually from 1903 to 1915, the period of available data, and the average capacity per freight car rose 2½ per cent annually over the same period.[8] Projecting these annual increase rates over the thirty-five years from 1880 to 1915 results in a tripling of average tractive effort of locomotives and a more than doubling in average capacity of freight cars. Roadbed quality naturally had to keep pace with the heavier loads. So the reasonable conclusion is that there was a doubling in real worth per track mile from 1880 to 1915 rather than a halving.

Since 1915, the railroad capital-output ratio has apparently fallen whether measured in deflated or current values. This is probably explained by the relative decline of the industry and accompanying decapitalization. The increasing use of automobiles and airplanes for passengers, and trucks and oil pipelines for freight, combined with various institutional rigidities, have acted to slow the growth trend of railroads and to turn it into an actual decline.

IV. Implications of the Savings Ratio

Empirical studies appear to show quite clearly that the savings to income ratio has remained secularly constant in the past. As put

8. U. S. Bureau of the Census, *Historical Statistics of the United States, 1789–1945, op. cit.*, Series K-1, -4, -6, -7, -30, -34–38, pp. 200, 202.

by Goldsmith, " . . . The secular trend of the basic ratios (i.e., the proportion of national or personal saving including consumer durables, to net national product or personal disposable income, all calculated by comparable social accounting methods) has been horizontal for the period 1897–1929, and has also been level for the entire first half of this century."[9] The mean ratio of national savings to income from 1897 to 1929 was 13.68 per cent, and a straight-line arithmetic trend fitted to these years rose about .05 per cent per year.[1]

The savings ratio can be used to calculate the incremental capital-output ratio, as follows:

$$S/O \div \Delta O/O = S/\Delta O = \Delta K/\Delta O,$$

where S is saving, O, output, and K, capital stock. Thus the incremental capital-output ratio is equal to the ratio of the percentage of output saved to the percentage growth in output. If the percentage saved were 15, and the annual growth percentage 5, the incremental capital-output ratio would be 300 per cent, while if, with the same savings percentage, the growth rate declined to 3 per cent, the incremental capital-output ratio would rise to 500 per cent. The average capital-output ratio tends toward the incremental ratio, of course.

Growth rates of output are usually highest in a country's history during the early stages of its industrialization. (At least this is claimed or admitted in most of the current analyses comparing growth rates of the United States and the U.S.S.R.)[2] With a secularly constant savings proportion, it follows that the incremental national capital-output ratio is lower during the earlier stages of industrialization than during the latter, more mature, stages. Thus the national capital-output ratio rises as a nation becomes industrialized.

Empirical data on the savings proportion and growth rates for the United States can be used to calculate incremental capital-output ratios. According to Goldsmith's calculations, the mean ratio of national savings to national income from 1897 to 1929 was 13.68 per cent.[3] Since the capital-output ratio is usually based on

9. *Op. cit.*, I, 75.

1. *Ibid.*, Table VIII, p. 81.

2. See for example, G. Warren Nutter, "The Structure and Growth of Soviet Industry: A Comparison with the United States," *Comparisons of the United States and Soviet Economics, Papers Submitted by Panelists Appearing Before the Subcommittee on Economic Statistics* (Joint Economic Committee, Congress of the United States, Washington, 1959), pp. 95–120.

3. *Op. cit.*, Vol. I, Table VIII, p. 81.

gross national product, this savings proportion has to be reduced about one-eighth, so the savings of GNP ratio is about 12 per cent. According to Kuznets' output data, GNP grew at an annual rate of 4.7 per cent from the 1869–1878 decade to 1889–1898, 4.4 per cent from 1889–1898 to 1904–1913, and 3.1 per cent from 1904–1913 to 1919–1928.[4] Combining these results yields incremental national capital-output ratios averaging about 2.70 from 1890 to 1910, and about 3.90 from 1910 to 1930. If the savings proportion had also been 12 per cent prior to 1890, the incremental capital-output ratio from 1870 to 1890 would have been only 2.55.

These U.S. data show a substantial rise in the incremental capital-output ratio during the forty years before the big depression. If anything, the rise seems almost too large. The data may have shortcomings. Accurate measurements of GNP prior to World War I must be difficult to get, and measurement difficulties are many times greater with respect to savings. Even if there might be some questions about the actual magnitudes, however, there is little likelihood that the errors are large enough to reverse the indicated capital-output ratio trend.

There is thus a major discrepancy between the clear upward trend in capital-output ratios up to 1929 as indicated by the savings ratio and the stability of Goldsmith's ratio shown in Figure I. One possible source of the discrepancy is an overestimate by Goldsmith of capital stock at the turn of the century. It would be desirable to have an independent check of the capital estimate for that period, but there appear to be no data available that challenge Goldsmith's for thoroughness of derivation. A partial check, however, is provided by analysis of debt data.

The chief disadvantage to checking asset estimates through analysis of debt totals is that the level of debt is not a perfect indicator of the level of assets. The closeness of the association between debt and asset levels could be evaluated if there were a fairly long period for investigation, but the depression of the 1930's and World War II caused abnormal fluctuations in the level of each so only the period prior to 1930 serves as a good base. Even that period was affected by World War I and the accompanying price rise. Debt figures have the advantages, however, that they are balance sheet data rather

4. Simon Kuznets, "Long-term Changes in the National Income of the United States of America Since 1870," *Income and Wealth*, Series II (Cambridge, England: Bowes and Bowes, 1952), p. 30.

than cumulated flow totals like capital stock, and they result from a contract between two separate entities, rather than involving only one firm, like fixed asset data before the imposition of the corporate income tax.

Goldsmith lists debt figures for selected years in his national balance sheet beginning with 1900. The U. S. Department of Commerce compilations of debt data, presented annually in the *Survey of Current Business*, begin with 1916 and thus cannot be used for evaluating capital asset levels for earlier years. Long-term private debt would probably be most closely associated with capital assets and Goldsmith's debt categories, bonds, and notes and mortgages, were chosen to represent long-term debt. The relevant data are as follows:[5]

(Dollar amounts in billions)

	1900	1912	1922	1929
(1) Long-term private debt	\$13.9	\$30.1	\$ 53.2	\$ 89.9
(2) Structures and equipment	\$47.5	\$89.9	\$196.2	\$270.4
(3) Ratio, (2) to (1)	3.4	3.0	3.7	3.0

The ratio of the value of total structure and equipment to long-term private debt in the nation was 3.0 in 1912 and 1929. This ratio was 3.7 in 1922 but that higher ratio can be explained in large part by the 50 per cent higher price level after World War I than immediately before. Asset prices in current values were inflated while long-term debt figures must have largely reflected the prewar price level as debt levels tend to lag during rising price periods. If this inflation effect amounts to as much as 23 per cent, it would totally explain the excess over 3.0 of the 1922 ratio.

But there was no similar price effect in 1900. The higher ratio in that year means either that debt actually amounted to a lower proportion of capital assets or capital assets were overestimated. Since railroad debt was almost half of private debt in 1900, and railroad debt to asset ratios were high,[6] it would seem that there is some reason to reject the first explanation. If the estimate of the total of structures and equipment in 1900 were reduced by 13 per cent, bringing their ratio to debt to 3.0, this would correspondingly

5. Goldsmith, *op. cit.*, Vol. III; long-term debt consists of bonds, and notes and mortgages listed in Table W-9, pp. 42–49, and structures and equipment are from Table W-1, pp. 14–15.

6. *Historical Statistics of the United States, 1789–1945*, *op. cit.*, Series K-60, K-65, p. 204.

reduce the capital-output ratio so the 1897–98 average ratio of 3.30 would decline to about 2.90, which is close to the value of the ratio derived from the savings proportion for that period. If the average ratio actually had a value of 2.90 in 1897–98, it would then probably have risen to 1929, just as the incremental ratio did.

V. Summary

Capital-output ratios which have been presented in the literature or can be derived from national wealth data show declining trends with near unanimity. There appear to be technical factors, however, which explain most of the declines.

In the case of the aggregative ratios of national wealth to gross national product, there is a divergence between the trends of the ratios based on current values and those based on deflated values. The deflated trend declines much more than the current value trend. This indicates that the deflation procedure biases the capital-output ratio downward. Specifically, the deflator for capital assets rises over time relative to the deflator for output. The reason for this greater rise is that final output is priced basically on a unit basis in the preparation of price indexes while capital assets are priced basically on an elements-of-cost basis. While productivity changes tend to lower the price per unit of output, productivity improvement is not taken into account with capital assets. If a constant amount of labor and materials go into a capital asset, its deflated value is considered constant even though it produces two or three times its former output. Consequently, deflated output value rises over time even though its real cost remains constant but deflated capital asset value remains the same with the same real cost.

Capital-output ratios in manufacturing industries rose sharply according to Census data from 1879 to 1919, but fell almost as sharply from 1919 on. The rise after 1879 appears to have resulted from more complete reporting of capital assets in successive censuses. The fall after 1919 seems to be largely explained by the bookkeeping procedure of subtracting annual depreciation from the cost prices of capital assets which began on a wide scale with the imposition of the federal corporate income tax.

Railroad capital-output ratios in a National Bureau of Economic Research study fell sharply from 1880 to 1915. This fall appears to result from a high estimate of capital assets in 1880 and a rather extreme price index which gave a twice as high deflated value per road mile for capital assets in 1880 as in 1915 even though track quality, and equipment quality per mile of track apparently rose substantially.

Finally, savings studies have shown a fairly constant trend in the savings proportion in this country for over fifty years. Meanwhile, the rate of growth in national output (at least up to World War II) has tended to decline. Combination of these two facts results in a fairly sharply rising incremental national capital-output ratio. This leads to a belief that the current value capital-output ratio has actually had a rising trend rather than remaining approximately constant.

The most important implication of these findings is with regard to investment possibilities in the economy. A secularly rising capital-output ratio signifies an appreciably larger amount of investment in, say, the next decade than a secularly falling ratio. If the long-term trend is actually a rising one, the postwar business and consumer investment boom is not surprising considering the low level of the ratio at the end of the war. But the existence of a trend in the capital-output ratio which, though rising, is rising slowly also implies a ceiling to investment needs. Goldsmith's current value ratio, for example, rose some 10 per cent between the prosperous years of 1948 and 1955. Judging from the past such a rate of rise can hardly be sustained forever, although considering the low level of the ratio in 1955, prospects for the next ten years or so may be bright. At some point the rate of rise will have to slow down and the economy may be faced with an adjustment to a lower investment, and savings, rate.

APPENDIX

Estimating Cotton Goods Manufacturing Assets in 1880

Presented in Table III are data on cotton spindles in operation and reported assets in cotton goods manufacturing for 1879, 1889, 1919 and 1929. Fixed and working capital were separated so that fixed capital values per spindle could be obtained. It was felt that the estimates for working capital in 1879 and 1919 are fairly accurate since there was little change in the working capital to output ratios (in current prices) from 1889 to 1929; the ratios were, respectively, 47 and 52 per cent. The results of the present analysis would be much the same, however, whether total, instead of fixed, capital were used as the basis for analysis.

Fixed capital values per spindle can be obtained by dividing total fixed capital by the number of spindles, and in 1929 prices turn out to be, respectively, \$23, \$36 and \$42 for 1879, 1889 and 1919. The rise of 50 per cent in average values in ten years, from 1879 to

TABLE III

SELECTED CAPITAL AND OUTPUT DATA, COTTON GOODS MANUFACTURING, 1879 TO 1929
(In millions)

	1879	1889	1919	1929
Cotton spindles in operation	10.7	14.4	34.9	32.4
	(In millions of dollars)			
Output				
Current prices	243	298	2,520	1,420
1929 prices	435	543	1,688	1,420
Capital book values				
Total	246	392	2,145	1,603
Fixed	(131)	251	(825)	864
Working	(115)	141	(1,320)	739
Capital, 1929 prices				
Total	408	709	2,334	1,709
Fixed	(251)	513	(1,474)	984
Working	(157)	196	(860)	725

Sources: Spindles — *Historical Statistics of the United States, 1789–1945, op. cit.*, Series J-180, pp. 186–87; numbers listed are those available for the year following except for 1929. Capital and Output — Daniel Creamer and others, *Capital in Manufacturing and Mining: Its Formation and Financing* (Princeton University Press, 1960): output is from Table A-10, p. 252; total capital from Table A-8, p. 241; and fixed capital for 1889 and 1929 from Table A-9, p. 248; working capital for 1889 and 1929 is the difference between total and fixed, working capital for 1879 and 1919 is estimated under the assumption that the working capital to output ratios were the same in 1879 as in 1889 and the same in 1919 as in 1929; fixed capital for 1879 and 1919 is the remainder of total capital.

1889, seems surprising. The comparison is even sharper if incremental values are obtained. Dividing the additional fixed capital value by the additional number of spindles yields \$23 from the industry's beginning to 1879, \$71 from 1879 to 1889, and \$47 from 1889 to 1919. The violent rise of over 200 per cent in capital values per spindle from prior to 1879 to the decade following with a subsequent drop of one-third seems strange indeed. There is nothing in either prices or output volume which would help explain such behavior. Specifically, output per spindle remained about unchanged while most price indexes fell from 1865 to the 1890's.[1]

1. *Ibid.*, Series L-15 to L-35, pp. 233–34.

If it is assumed, however, that fixed capital values were undeı reported in 1879, and, perhaps, to a much lesser extent in 1889, th per spindle value fluctuations are easily explained. If the per spindl fixed capital values were about $42 in 1929 prices over this period then the 1879 fixed capital value for the industry should have beeı about $450 million, or about 80 per cent higher than the reporte $251 million. The first check of the cotton goods industry points t a choice of explanations for the wide fluctuations in fixed capita value per spindle; either there was underreporting in 1879, or els there were wide fluctuations in values even when valued in constan dollars.

The second attempt to obtain average capital asset values peı spindle is based on a doctoral dissertation by T. Y. Shen.[2] Shen obtained the prices of all machinery required in cotton cloth manufacture over this period. From this he derived the total machine

TABLE IV

Machine Costs in Cotton Manufacturing, 1860–1920
(Upper row of each pair is current dollar price, lower row, 1913 dollar price)

	1860	1880	1900	1920
Spindles, per unit	3.00	3.30	3.27	7.00
	4.22	4.18	4.12	4.28
Total cost for a capacity of one pound per hour				
Spindles (spinning frame)	81.08	67.34	60.00	114.75
	108.21	85.31	76.69	70.16
Entire mill	344.18	254.21	273.53	538.52
	478.36	317.15	325.56	318.68

Source: Shen, *op. cit.* (in *Review of Economics and Statistics*), Tables 1 and 3, p. 151.

cost, by twenty year intervals, of a capacity of one pound per hour according to the latest engineering standards. The pertinent results are presented in Table IV. As a first observation there is nothing in Table IV to substantiate the tripling in capital values per spindle and then a fall of one-third, which was indicated in Table III.

2. T. Y. Shen, "A Quantitative Study of Production in the American Textile Industry, 1840–1940," unpublished Ph.D. thesis, Yale University, 1956. The important portions of the dissertation were published in a journal article, "Job Analysis and Historical Productivities in the American Cotton Textile Industry; A Study in Methodology," *Review of Economics and Statistics*, XL (May 1958), 149–58.

Total machine costs per spindle can be derived from Table IV. The ratio of total machine cost to total spindle cost is obtained by dividing one of the bottom two rows of figures by one of the middle two rows. The cost per spindle (top rows) can be multiplied by this quotient to arrive at the total machine cost on a per spindle basis. The results in 1913 prices are, respectively, about $19, $16, $17 and $19 for 1860, 1880, 1900 and 1920. Thus machinery values per spindle in constant dollars were almost as high in 1880 as 1920. There appeared to be no doubling in values as indicated by the Census data and certainly no tripling and then a decline of one-third between 1879 and 1919 as shown by the incremental calculations.

The final attempt to check capital asset values per spindle in 1880 is based on published records of two large cotton manufacturing companies, Pepperell and Amoskeag.[3] The financial statements of the Pepperell Company are in fairly complete form from 1851 to 1945 but a study of them does not inspire confidence in the accuracy of the fixed asset accounting during the nineteenth century.[4] In contrast with the shortcomings in the accounting for fixed assets, Pepperell's records indicate that current asset accounts were accurately maintained. This difference in accounting accuracy is not hard to understand; current assets are much more prone to suffer theft or loss, and bank creditors usually demand working capital records as indications of ability to repay short-term borrowing.

Some information is yielded by the Pepperell fixed asset data, however. First, if such accounting was typical, it is easy to see how the reports to the Census could be badly in error. Second, the 1862 fixed asset amounts may be fairly reliable since this was early in the company's history and fixed asset accounts probably reflected costs quite accurately. Book values of fixed assets were about $21 per spindle in that year. Depreciation should be allowed for, preferably

3. Evelyn H. Knowlton, Pepperell's Progress (Harvard University Press, 1948); Amoskeag Manufacturing Company, *The Amoskeag Manufacturing Company* (Manchester, N. H., 1915).

4. For example, Pepperell had 68,000 spindles in operation in 1862 and a gross plant account of $1.4 million with no depreciation reserve; in 1870 it had 71,000 spindles and a gross plant account of $1.0 million with no depreciation reserve; by 1895 its spindle count had increased to 110,000, the gross plant account totaled $1.2 million and the depreciation reserve was $0.1 million (Knowlton, *op. cit.*, pp. 57, 420, 447–54). Although gross plant book values declined from 1862 to 1895, investment in plant increased as shown by the rising number of spindles; in addition, the "agent's construction account" records indicate that substantial amounts were expended annually on construction and machinery (*ibid.*, p. 423), but since these expenditures were not reflected in the plant account, they must have been charged to current expense.

the same amount as allowed for in 1919 since that was the peak in manufacturing capital-output ratios according to Census data. In Section II above it was estimated that depreciation reserves for all manufacturing corporations amounted to about 20 per cent of gross values in 1919. This would reduce the $21 book value per spindle to $17, as compared with Census book values of $12 of fixed assets per spindle in Table III. The difference would be even greater if the $17 value in 1862 were raised to reflect the effect the higher price level from 1862 to 1879 had on book values in 1879. From 1862 to 1879, wholesale prices averaged 50 per cent higher, because of the Civil War, than in the twenty years or so prior to 1862.[5] Since about half the spindles in operation in 1880 were installed between 1860 and 1880,[6] an estimate of book values in 1880 should be raised some 25 per cent above the 1862 level. This would raise the $17 value to $21, almost double the Census value of $12.

Records for the second mill, the Amoskeag Manufacturing Company, are fragmentary. Balance sheet data are not presented directly, but an indication of total asset values per spindle can be obtained by comparing spindles in operation with total capital stock authorized. Amoskeag began operating its first mill in 1841 and by 1855 had 83,000 spindles in operation; by 1848 it had $3 million authorized capital and since in 1856 it requested an increased authorization of $1 million, it must have issued most of its previous $3 million authorization.[7] Dividing the $3 million in capitalization by the 83,000 spindles gives an average total capital value of $36 per spindle. This compares with the 1879 Census figure of $23 (book value) as shown in Table III. Here again, an adjustment could be made for price trends which would widen the difference.

To summarize, the foregoing investigation of total assets used in the cotton goods manufacturing industry shows that Census data for 1879 and following years give an extremely wide fluctuation in asset values on a per spindle basis. This fluctuation seems to be refuted by other available information. It seems probable, therefore, that Census data understated assets in the industry in 1879. The amount of the understatement appears to be of the magnitude of around 70 to 80 per cent of the reported value for fixed assets alone, or about 50 per cent for total assets.

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5. *Historical Statistics*, *op. cit.*, Tables L-15 to L-35, pp. 233–34.
6. *Ibid.*, Table J-180, pp. 186–87.
7. Amoskeag Manufacturing Company, *op. cit.*, pp. 114, 118.