Volume Title: Trends and Cycles in Capital Formation by United States Railroads, 1970-1950

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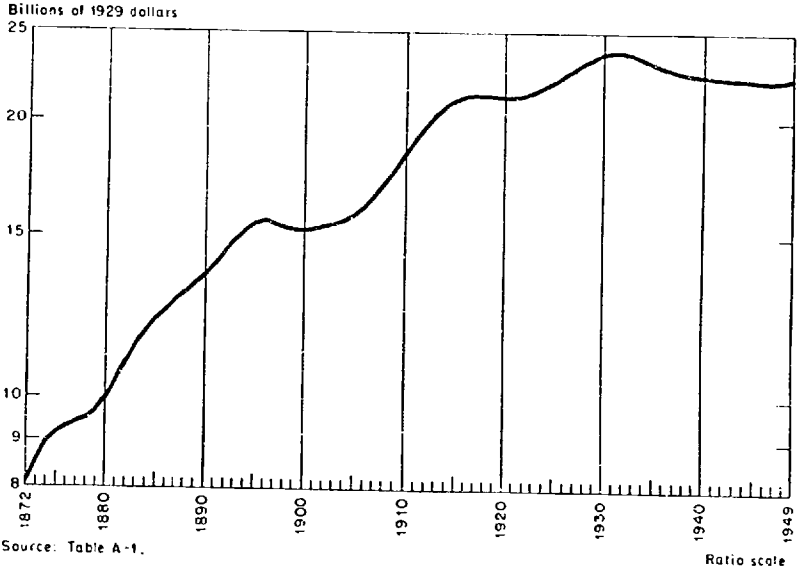
Long-Term Trends

The growth of the railroads since 1870 is best depicted by the value of road and equipment expressed in 1929 dollars, shown in Chart 1. This series is designed as an approximation of fixed physical operating capital, embracing all the physical property of the railroads except unimproved land, the relatively small quantities of working capital (such as coal) held, or those facilities (such as hotels) not used in direct connection with road operation.

The broad pattern of development is distinct. The rate of growth

CHART 1

Value of Road and Equipment, U. S. Railroads
Five-Year Moving Averages, 1872-1949



was obviously brisk in early years and leveled off gradually to the point at which the series reaches its peak at about 24 billions of 1929 dollars early in the decade of the 1930's, about three times its value in 1872. From this year onward there is a nearly steady decline to about 1947, when the total value of road and equipment in 1929 dollars was 22 billion, eight per cent below its peak value. This was by far the longest period of decline in the entire span under review but was followed by a modest recovery. However, at the start of 1951 the value of road and equipment was still 6 per cent below its peak.

Throughout the period 1870-1949 the relative growth of the railroads declined. This is clearly seen when annual rates of change are computed between the peaks of the long cycles that are marked in this series, as given in Table 2.[4] The annual rate of increase declined from 2.9 per cent in the 1874-1884 period to less than 1 per cent in 1915-1931 and, finally, to a small negative rate of change in 1931-1949.

Capital Formation

The *absolute* rates of change in value of road and equipment are of course identical with net expenditures for reproducible capital, which

TABLE 2

Average Annual Per Cent Change in the Value of Road and Equipment, Constant Dollars, 1874-1949

Peak Dates of Long Cycles	*Average Annual % Change*
1874-1884	+2.9
1884-1894	+2.5
1894-1915	+1.6
1915-1931	+0.8
1931-1949[a]	−0.4

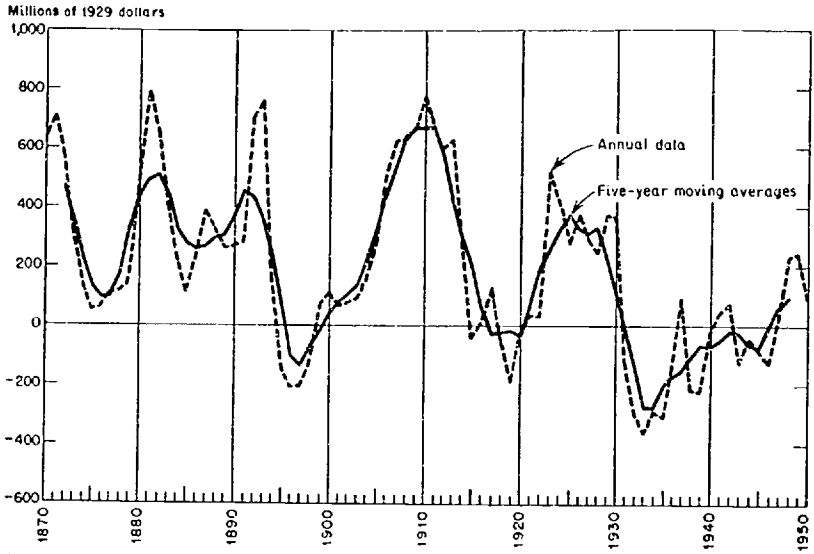
[a] Terminal date rather than peak date.

Source: Forthcoming monograph on capital formation and financing by public utilities.

[4] Peak dates were determined by drawing tangents above each pair of adjoining cycles in the series. This is equivalent to assuming that the secular trend is approximated by a straight line in logarithms (that is, by a curve of constant relative growth) between each pair of adjoining cycles. Experimentally, peaks were determined by reference to a secular trend described by a curve of the form $\log y = a + bt + ct^2$, which fits this series rather well. The results were the same as those achieved by the methods described above.

CHART 2

Net Capital Expenditures, U. S. Railroads
Annual Data and Five-Year Moving Averages, 1870-1950



Source: Table A-1 and estimates to be published in forthcoming monograph.

are depicted in Chart 2. Although it may not be at once visually evident, these absolute rates of change also tend to decline throughout the period studied. To be sure, if attention is centered upon short-run phenomena, the five-year moving average of net capital formation rather clearly reached its all-time peak some time during the period 1907-1911. But from a secular viewpoint it will be noticed that the very high peak in this period is coupled with very low troughs in 1897 and 1920. The effect is clearly illustrated by the figures in the second column of Table 3, which measure the average annual net capital formation in successive long cycles during this period, measured from trough to trough.

Thus net capital expenditures amounted to about 320 millions of 1929 dollars in 1876-1886, dropped to about 260 million on the average during the next cycle, remained about the same during 1897-1920, and dropped precipitously thereafter. During the upswing from 1934 to the end of the series in 1948, a span covering the World War II

TABLE 3

Average Annual Capital Expenditures,[a] 1876-1948
(millions of 1929 dollars)

Long Cycles[b]	*Net Capital Formation*	*Gross Capital Formation*
1876-1886	326	520
1886-1897	253	540
1897-1920	256	682
1920-1934	141	644
1934-1948[c]	−67	459

[a] Terminal years of cycles are weighted one-half to avoid double-counting.

[b] Measured from trough to trough; see Tables 4 and 5. For alternative dates see Tables 6 and 7.

[c] Terminal date rather than cyclical trough.

Source: Forthcoming monograph on capital formation and financing by public utilities.

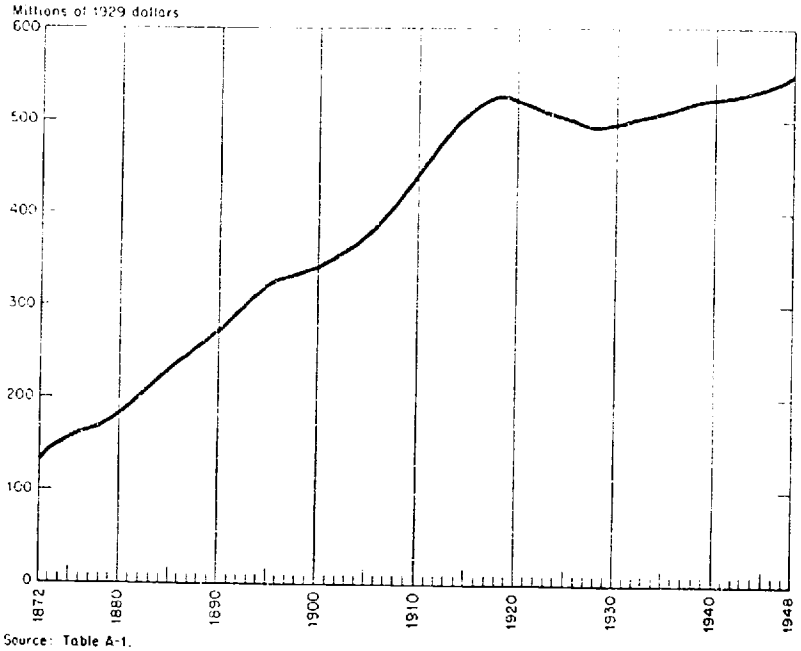
period when investments were limited by government material controls, net capital formation on the average was negative.

From the standpoint of the impact upon the economy, however, the net capital formation series grossly overstates the decline in importance of the railroads. For it must be borne in mind that a positive net capital expenditure, however small, signifies an expansion in the total capital stock and that, as this stock grows, the capital flow required to maintain it generally grows as well. The total volume of capital consumed continued to mount gradually (see Chart 3). The net rise up to 1931 is due to the expanding volume of road and equipment in use. The net rise in subsequent years, during which the total capital stock experienced a small net decline, is due to a shift in the composition of the operating properties of the railroads. Specifically, the proportion of equipment — particularly rolling stock — to the total advanced materially. The average length of life of such equipment is substantially less than that of road.

Hence the expanding capital stock, together with the changing composition of that stock, was a powerful factor in augmenting the gross flow of physical capital to the railroads. During the period of the long cycle 1876-1886, when net capital expenditures amounted to 326 millions of 1929 dollars per year and were higher than the average in any subsequent cycle, capital consumption averaged slightly less than 200

CHART 3

Capital Consumption, U. S. Railroads
Five-Year Moving Averages, 1872-1948



Source: Table A-1.

million annually. This was already a substantial figure. But by the decade 1940-1949, capital consumption had reached an annual average of 525 millions of 1929 dollars, considerably more than the average net capital formation in *any* full cycle, as indicated in Table 3.

The gross flow of physical capital to the railroads includes expenditures for replacement as well as for new capital (see Chart 4). It should be noted at once that while capital consumption proceeds more or less steadily (Chart 3), expenditures for replacement are — generally speaking — made on the same grounds as are other capital commitments. They too rest for their justification upon an expected volume of future business. They are in all probability nearly as sporadic, as volatile, and as sensitive to the changing currents of business prospects as are net capital expenditures; and in some respects they are indistinguishable from them. Even so, the gradual wearing out of operating

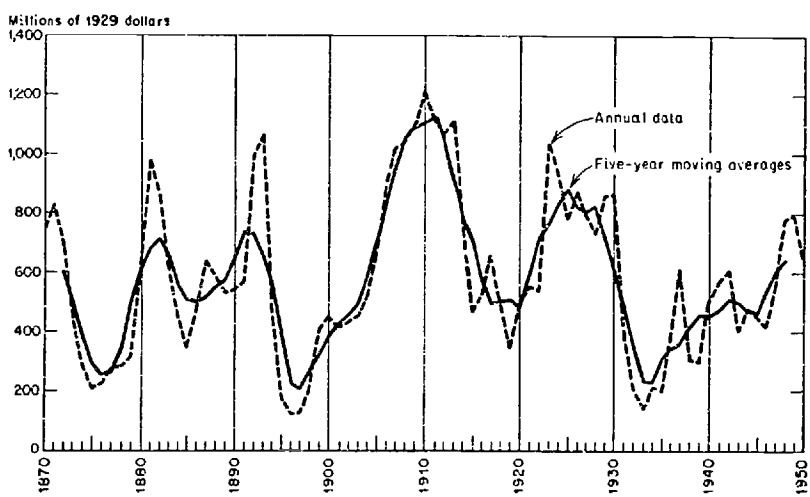
facilities creates a *need* for capital formation that is independent of continued net expansion and in the case of the railroads heavily bolstered the volume of gross capital formation with the passing years.

The general trend of gross capital formation rose appreciably from 1870 through the first decade of the twentieth century, while net capital formation declined (see Chart 4). Then, after 1910, as compared with the precipitous drop of net capital formation, the secular downtrend of gross capital formation was gentle. The all-time high of gross capital formation was reached in the five-year period centered in 1911, at 1,123 millions of 1929 dollars.

Average annual gross capital expenditures during each of the long cycles, shown in Table 3, confirm the general impression given by the chart. They rise from the beginning of the period to a maximum in 1897-1920, when gross capital formation averaged 682 millions per annum. This peak was followed by a fairly moderate decline. The final period 1934-1948 includes some of the depressed or semidepressed years of the thirties, together with the war years during which investment was restricted by government controls. In the five postwar years centered in 1948, the average gross capital expenditure per annum

CHART 4

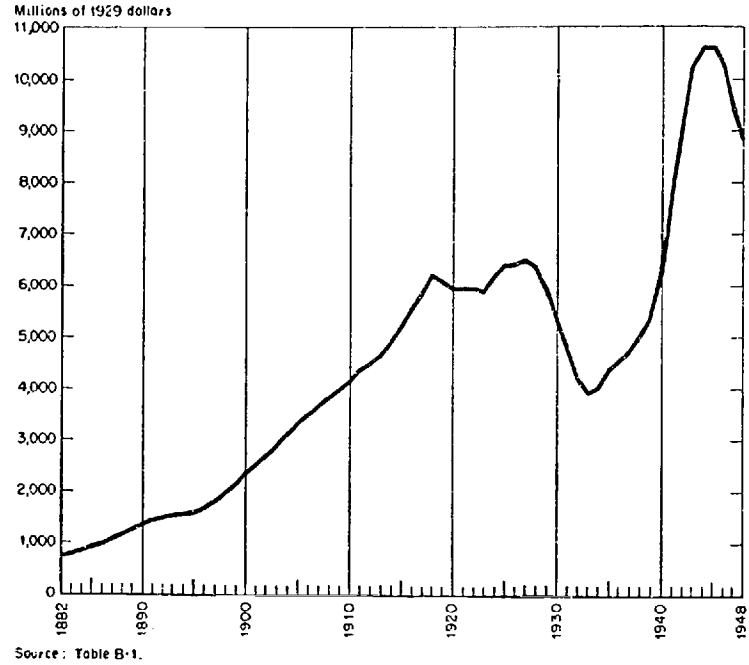
Gross Capital Expenditures, U. S. Railroads
Annual Data and Five-Year Moving Averages, 1870-1950



Source: Table A-1 and estimates to be published in forthcoming monograph.

CHART 5

Output, U. S. Railroads
Five-Year Moving Averages, 1882-1948



Source: Table B-1.

was 642 millions of 1929 dollars. This figure, of which more than 80 per cent was for replacement of currently consumed capital, exceeded materially the average gross capital expenditure during the first two long cycles 1876-1886 and 1886-1897, when the net growth of the railroads was so rapid.

Some Underlying Factors

As indicated above, the capital stock of the railroads declined from its peak of 1931 to the end of 1950 by about 1.5 billions of 1929 dollars or about 6 per cent. This decline is smaller, both in amplitude and duration, than that suggested by some less comprehensive measures used in the past, such as miles of road operated. The growing relative importance of rolling stock, auxiliary structures, safety devices, etc., not

reflected in the latter series, may explain this difference. Indeed, the actual decline may be even less than that measured by our own series if full weight were given to the improved efficiency of currently purchased capital. Undoubtedly, there was considerable stability with some slight net diminution in the capital stock over the third and fourth decades of the twentieth century because of the well-known competition from motor vehicles and (to a lesser extent) air transportation, together with the depressed level of business in the thirties and the limitations upon investment in World War II. But for the fact that the nation as a whole — particularly its population and its national product — showed substantial net growth over this period, the depressing effect upon the railroads of these conditions would have been considerably greater.

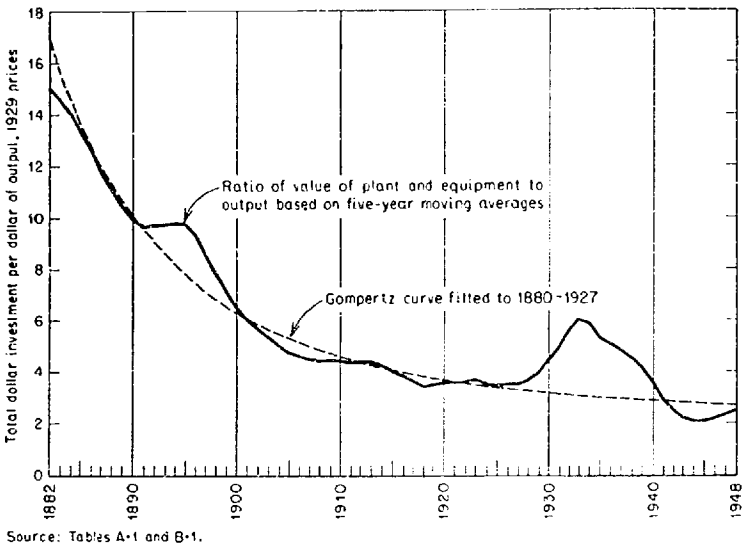
The reasons for the decline in the rate of growth of the capital stock, both in relative and in absolute terms, from 1870 to the outbreak of World War I are not so obvious. This was a period in which population and the nation's productive capacity, as mirrored in the net national product, rose at an increasing absolute rate and in which competition from other forms of transportation was negligible. Aggravating rather than relieving the initial perplexity here was the rise in railroad output (Chart 5 and Appendix Table B-1[5]).

It would be tautological to suggest that the "explanation" of this problem lies in the behavior of the capital-product ratio, depicted in Chart 6. This is the ratio between accumulated, fixed reproducible capital, and annual output. Specifically, this chart presents the ratio of the five-year moving averages of the value of road and equipment to the five-year moving averages of annual railroad output, both expressed in 1929 dollars. Clearly an alteration in the ratio reflects nothing more than the results of changes in output and in the concomitant flows of net investment. Yet the behavior of the capital-product ratio warrants some attention, for the pattern of its trend is striking and suggestive of other underlying factors of importance. Its level in the early years was extremely high — at 15.0 in 1882, meaning that for every dollar's worth of annual output there were fifteen dollars of accumulated in-

[5] This series on output could be carried back only to 1880 because of the absence of comparable source material in preceding years. It is based on weighted averages of passenger miles and freight ton miles. See Appendix B for the details of its content.

CHART 6

Capital-Product Ratio, U. S. Railroads, 1882-1948



Source: Tables A-1 and B-1.

vestment in road and equipment. It fell rapidly, reaching 3.7 in 1917, then continued down, though more gradually, to 2.5 in 1948. The trend line drawn through this series is intended to highlight this tendency for steady decline at a diminishing rate.[6] Why did the capital-product ratio assume so lofty a level at the start of the period covered and then decline, sharply at first but at a diminishing rate in succeeding years? What does this behavior imply about the volume of investment?

An outstanding characteristic of the railroad industry is the indivisibility of many of its units of capital investment. In order to provide any service at all between two points, a minimum amount of investment is required in the grading of roads, in track, auxiliary structures, and equipment. The capacity of this minimum may easily exceed many times the actual demands of business during a road's first years of operation. Furthermore, once the initial huge investment is made in the building of road and the construction of terminals, capacity may be

[6] The trend line is a Gompertz curve, with equation:
Capital-product ratio $= (2.26)\,(8.7263)^{.9533^t}$, where t is measured in years with 1880 as origin.

extended by substantial amounts through relatively small additions of rolling stock, double track, or passing track. This phenomenon would appear to be evidenced in the steady increase in the relative importance of equipment, especially rolling stock, in the total volume of fixed operating capital, which rose from 9 per cent in 1880 to 26 per cent in 1917 and to 35 per cent in 1951.

This technical fact of indivisibility was coupled during the years of rapid railroad expansion with another influence of importance in determining the capital-product ratio — the distant horizon typically envisaged by railroad builders. In numerous instances the completion of lines was followed by strenuous efforts to encourage the establishment of towns and industries along an otherwise barren way. The capacity of roads as initially established — both because of techniques and ambitions — was geared to a volume of business that could be realized only with the passing of decades.

It would appear likely that such characteristics alone explain in the main the high capital-product ratio encountered in the earlier years of railroad operation and its steady decline since then. Two other factors, however, became increasingly important in the post-World War I period. First, there was a substantial rise in the average length of haul in freight traffic and in the average distance traveled by passengers. The former rose by more than 30 per cent and the latter by nearly 70 per cent between 1919 and 1950. These advances mirror in part the development of the Western states and the concomitant rise in transcontinental traffic and in part the greater diversion of short-distance business to the automobile and truck.[7] Their effect was to augment the capacity output (as measured in passenger miles and freight ton miles) of existing road and equipment.

Coupled with this change was a succession of technological innovations increasing the work capacity of freight cars, track, ties, locomotives, etc. These can of course be more adequately described in engineering literature.[8] Suffice it here to note that the changes were substantial, that they were not fully reflected in prices and that their net effect

[7] For a description of these trends see Harold Barger, *The Transportation Industries, 1889-1946: A Study of Output, Employment, and Productivity* (National Bureau of Economic Research, 1951).

[8] Some examples of such technological advances are provided in Barger, *op. cit.*

would be to lower the capital-product ratio as it is measured in this study.

Passing reference must be made to the fact that the declining capital-product ratio had virtually no relationship to changing proportions of capital and labor used in this industry. Indeed, the very factors discussed above, which contributed to the decline in the capital-product ratio, were also in part responsible for a sharp reduction in the labor-product ratio — i.e. for an increase in labor productivity. Output per worker nearly tripled between 1890 and 1946.[9] Furthermore, the price of labor rose much more rapidly over the period encompassed by this study than did the price of capital — a factor which, *considered alone*, would have made for a *rising* capital-product ratio. That the latter did not in fact materialize attests in some degree to the relative inelasticity of substitution between capital and labor in railroading; much more significant was the overshadowing force of the other factors described above.

Given these factors which progressively reduced the amount of capital employed per unit of output, the behavior of railroad investment over the period of study is more easily understood. In 1880 the capital-product ratio was 15.0. By 1900 this ratio had declined to 6.5, by 1948 to 2.5. This sharp downward trend mirrors the tendency for each dollar's increase in output to be accompanied by a progressively smaller amount of investment over the time span studied. A dollar's increase in the annual volume of output was accompanied on the average by $3.10 of net investment between 1880 and 1900, by $1.38 of net investment between 1900 and 1920, and by $0.74 between 1920 and 1950.

This differential impact over time of demand upon investment is of course not purely technological in origin. It expresses, quantitatively, the joint play of *all* the factors influencing the capital-product ratio, described in preceding paragraphs. As such — i.e. the quantitative expression of a composite of forces — it provides the essential explanation for the declining rate of increase in investment during the pre-World War I period. It serves, along with the growing competition of other forms of transportation, to explain the continuance of this trend and the ultimate appearance of substantial negative net investment in the period subsequent to World War I, when the previous nearly steady rise in the volume of railroad traffic was finally interrupted.

[9] *Ibid.*, pp. 96-97.