Chapter Title: Long Cycles

Chapter Author: Melville J. Ulmer

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Long Cycles

Railroad investment proceeded in towering waves, as may be seen in Charts 2 and 4, and the impact upon the economy of these expansions and contractions, especially in the earlier years when railroad investments formed so large a proportion of total investment in the economy must have been of prime significance. So pronounced are these waves — even in the annual series shown in the charts — that their identification would seem to present little difficulty. Troughs appear in the

CHART 7

Gross and Net Capital Formation, U. S. Railroads
Nine-Year Moving Averages, 1874-1946

Millions of 1929 dollars

Gross capital formation

Net capital formation
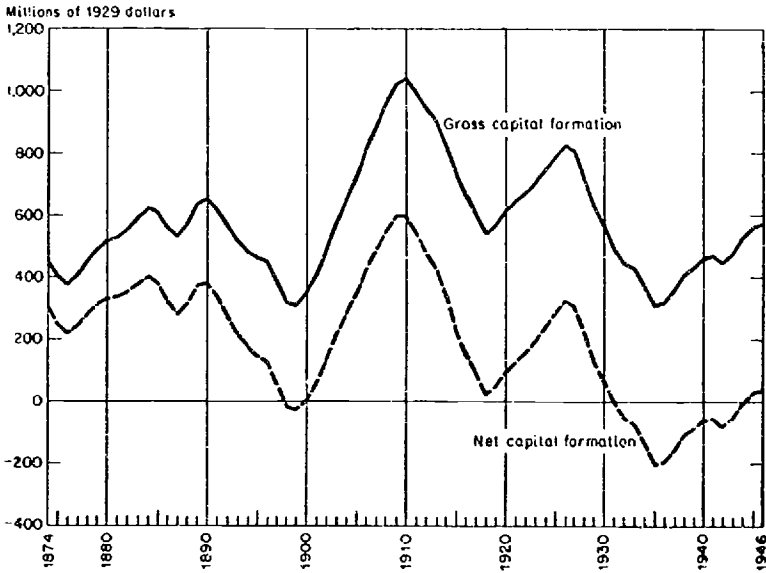
Source: Estimates to be published in forthcoming monograph

TABLE 4

Dates, Duration, and Amplitude of Long Cycles in Net Capital Formation Based on Five-Year Moving Averages, 1872-1948 (millions of 1929 dollars)

DATES OF LONG CYCLES			DURATION (YEARS)			LONG-CYCLE VALUES AT			AMPLITUDE OF			PER YEAR AMPLITUDE OF		
Trough (1)	Peak (2)	Trough (3)	Rise (4)	Fall (5)	Total (6)	Initial Trough (7)	Peak (8)	Terminal Trough (9)	Rise (10)	Fall (11)	Rise & Fall (12)	Rise (13)	Fall (14)	Rise & Fall (15)
....	1872ᵃ	1876	....	4	....	....	472	94	....	378	....	....	94.5	....
1876	1882	1886	6	4	10	94	510	260	416	250	666	69.3	62.5	66.6
1886	1891	1897	5	6	11	260	457	−123	197	580	777	39.4	96.7	70.6
1897	1909	1920	12	11	23	−123	674	−39	797	713	1,510	66.4	64.8	65.7
1920	1925	1934	5	9	14	−39	379	−278	418	657	1,075	83.6	73.0	76.8
1934	1948ᵇ	....	14	....	....	−278	93	....	371	....	....	26.5	....	....
Average			8.4	6.8	14.5	−17	431	−17	440	516	1,007	57.0	78.3	69.9

ᵃ Initial date rather than peak.
ᵇ Terminal date rather than peak.
Source: Table A-1.

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TABLE 5

Dates, Duration, and Amplitude of Long Cycles in Gross Capital Formation Based on Five-Year Moving Averages, 1872-1948

DATES OF LONG CYCLES			DURATION (YEARS)			IN RELATIVES[a] LONG-CYCLE RELATIVES AT			AMPLITUDE OF			PER YEAR AMPLITUDE OF		
Trough (1)	Peak (2)	Trough (3)	Rise (4)	Fall (5)	Total (6)	Initial Trough (7)	Peak (8)	Terminal Trough (9)	Rise (10)	Fall (11)	Rise & Fall (12)	Rise (13)	Fall (14)	Rise & Fall (15)
....	1872[b]	1876	....	4	....	....	143	60	....	83	....	....	20.8	....
1876	1882	1886	6	4	10	49	137	96	88	41	129	14.7	10.3	12.9
1886	1891	1897	5	6	11	92	137	38	45	99	144	9.0	16.5	13.1
1897	1911	1920	14	9	23	30	165	71	135	94	229	9.6	10.4	10.0
1920	1925	1934	5	9	14	75	137	35	62	102	164	12.4	11.3	11.7
1934	1948[b]	....	14	....	....	50	140	....	90	....	....	6.4	....	....
Average			8.3	6.4	14.5	59	143	60	84	84	167	10.4	13.9	11.9
						IN MILLIONS OF 1929 DOLLARS								
....	1872[a]	1876	....	4	....	....	604	254	....	350	....	....	87.5	....
1876	1882	1886	6	4	10	254	711	498	457	213	670	76.2	53.3	67.0
1886	1891	1897	5	6	11	498	738	207	240	531	771	48.0	88.5	70.1
1897	1911	1920	14	9	23	207	1,123	484	916	639	1,555	65.4	71.0	67.6
1920	1925	1934	5	9	14	484	882	228	398	654	1,052	79.6	72.7	75.1
1934	1948[c]	....	14	....	....	228	642	....	414	....	....	29.6	....	....
Average			8.8	6.4	14.5	334	783	334	485	477	1,012	59.8	74.6	70.0

[a] Long-cycle relatives in columns 7-9 represent investment at each of the indicated dates expressed as a per cent of the average annual investment during the full course of the cycle in which the turning point falls.

[b] Initial date rather than peak.

[c] Terminal date rather than peak.

Source: Table A-1.

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mid-1870's, the mid-1880's, the mid- or late 1890's, the end of the second decade of the twentieth century, and again in the early thirties.

When the capital formation series are expressed in five-year moving averages (as in the solid lines of Charts 2 and 4) or in nine-year moving averages (as in Chart 7), there is a tendency toward diminution, in particular, of the trough of the mid-1880's. In the light of its smaller amplitude and duration, when so expressed, a question may be raised as to whether this fluctuation is in basic character similar to that of the other troughs roughly identified above. This question cannot be answered definitely, for the distinction between long cycles and other fluctuations appearing in our series must perforce be one of degree. In each case their peaks coincide with or follow at a fairly moderate distance downturns in general business activity of unusual severity.[10] However, the trough of the mid-1880's is not quite so pronounced as that of the other long cycles but is steeper by a considerable margin than the dips found in other fluctuations. Similarly, the length of the swing from the mid-1870's to the mid-1880's is somewhat shorter than that of the other long cycles but longer than that of the other fluctuations. Finally, the "long" cycle from the mid-1870's to the mid-1880's roughly synchronizes with a single business cycle movement, whereas all the other long cycles embrace more than one such fluctuation. Tentatively, this "questionable" long cycle will be included in our measures as such, though sight will not be lost of the possible effects upon our conclusions which might accrue from its exclusion.

In Tables 4 and 5 are provided the dates, duration, and the amplitudes of these long cycles in net and gross capital formation respectively, as derived from the five-year moving averages of these series. The dates in the two series differ at only one turning point, the peak in the third cycle which occurred in 1909 in net capital formation and 1911 in gross. The lengths of the cycles vary widely from 10 to 23 years — a range which would be reduced somewhat if the trough at 1886 had been ignored. However, the striking feature of these long

[10] The downturns referred to culminated in the six depressions which have been rated by the National Bureau of Economic Research as the most severe on record — those with troughs in 1878, 1885, 1894, 1908, 1920, and 1932. See Arthur F. Burns and Wesley C. Mitchell, *Measuring Business Cycles* (National Bureau of Economic Research, 1946), pp. 78, 455, 462.

swings in general is the extent and vigor of the movements involved, as measured in columns 10-15 inclusive in each of the two tables.

The long-cycle relatives appearing in columns 7-9 in the upper panel of Table 5 represent investment at each of these dates expressed as a per cent of the average annual investment during the full course of the cycles in which the turning point falls. The measures of amplitude in columns 10-12 of the upper panel are derived from these relatives by subtraction. On the average, expansion in gross capital formation involved a rise of 84 per cent of the average annual investment during a cycle, contractions a fall of the same relative amount; rises and falls together involved a gross movement of nearly 170 per cent. Such relative measures are not given for net investment since the existence of negative as well as positive values in this series would seriously limit their meaning.

In Table 4 and in the lower panel of Table 5 the amplitudes and rates of change are expressed in millions of 1929 dollars. From these it will be observed that there has been some tendency for the amplitude of expansions to decline since the giant rise of 1897-1909 and for the amplitude of contractions since 1882 to increase, though neither movement has been perfectly regular. This behavior is, of course, a reflection of the secular trend in investment and of the underlying factors, including the trend in output, noted in the preceding section. Thus until 1918 the rise of railroad traffic had been swift and almost without material interruption, as railroads grew to dominance in United States transportation. During the following decade the volume of traffic remained at a virtual plateau, declined sharply in the thirties and was not to exceed by any appreciable margin its 1918 level until the midst of World War II. Lacking the former buoyancy of steadily increasing business, the advance in capital formation which began in 1921 was relatively modest and short-lived, while the subsequent decline was sharp, vigorous, and relatively lengthy. Finally, the recovery which began in 1934 was hesitant, proceeding at a slower pace than in any previous cycle, as column 13 of Table 4 and the lower panel of Table 5 shows.

An alternative approach to the analysis of the long cycles is presented in Tables 6 and 7. Here, the measures presented are derived from nine-year moving averages of net and gross capital formation, respectively,

TABLE 6

Dates, Duration, and Amplitude of Long Cycles in Net Capital Formation Based on Nine-Year Moving Averages, 1876-1946
(millions of 1929 dollars)

DATES OF LONG CYCLES			DURATION (YEARS)			LONG-CYCLE VALUES AT			AMPLITUDE OF			PER YEAR AMPLITUDE OF		
Trough (1)	Peak (2)	Trough (3)	Rise (4)	Fall (5)	Total (6)	Initial Trough (7)	Peak (8)	Terminal Trough (9)	Rise (10)	Fall (11)	Rise & Fall (12)	Rise (13)	Fall (14)	Rise & Fall (15)
1876	1886ᵃ	1899	10	13	23	218	400	−30	182	430	612	18.2	33.1	26.6
1899	1909	1918	10	9	19	−30	599	21	629	578	1,207	62.9	64.2	63.5
1918	1926	1935	8	9	17	21	324	−206	303	530	833	37.9	58.9	49.0
1935	1946ᵇ	....	11	....	....	−206	32	....	238	....	....	21.6	....	....
Average			9.8	10.3	19.7	1	339	−72	338	513	884	35.2	52.1	46.4

ᵃ The nine-year moving averages show a decline from 1884 to 1887 and a rise from 1887 to 1890. This 1887 trough has been ignored in the above table, and a peak for the entire period 1876-1899 was determined by smoothing the plotted data between 1884 and 1890.

ᵇ Terminal date rather than peak.

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

TABLE 7

Dates, Duration, and Amplitude of Long Cycles in Gross Capital Formation Based on Nine-Year Moving Averages, 1876-1946

| DATES OF LONG CYCLES | | | DURATION (YEARS) | | | LONG-CYCLE VALUES AT | | | AMPLITUDE OF | | | PER YEAR AMPLITUDE OF | | |
Trough (1)	Peak (2)	Trough (3)	Rise (4)	Fall (5)	Total (6)	Initial Trough (7)	Peak (8)	Termi-nal Trough (9)	Rise (10)	Fall (11)	Rise & Fall (12)	Rise (13)	Fall (14)	Rise & Fall (15)
							IN RELATIVES							
1876	1888ᵃ	1899	12	11	23	73	126	60	53	66	119	4.4	6.0	5.2
1899	1910	1918	11	8	19	42	141	73	99	68	167	9.0	8.5	8.8
1918	1926	1935	8	9	17	88	134	50	46	84	130	5.8	9.3	7.6
1935	1946ᵇ	....	11	....	....	68	127	....	59	....	....	5.4	....	....
Average						68	132	61	64	73	139	6.2	7.9	7.2
						IN MILLIONS OF 1929 DOLLARS								
1876	1888ᵃ	1899	12	11	23	377	650	309	273	341	614	22.8	31.0	26.7
1899	1910	1918	11	8	19	309	1,038	539	729	499	1,228	66.3	62.4	64.6
1918	1926	1935	8	9	17	539	824	305	285	519	804	35.6	57.7	47.3
1935	1946ᵇ	....	11	....	....	305	572	....	267	....	....	24.3	....	....
Average			10.5	9.3	19.7	383	771	384	389	453	882	37.3	50.4	46.2

ᵃ The nine-year moving averages show a decline from 1884 to 1887 and a rise from 1887 to 1890. This 1887 trough has been ignored in the above table, and a peak for the entire period 1876-1899 was determined by smoothing the plotted data between 1884 and 1890.

ᵇ Terminal date rather than peak.

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

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TABLE **8**

Conformity of Railroad Net Capital Formation to Business Cycles, 1910-1949

| DATES OF REFERENCE CYCLES[a] | | | CHANGE IN REFERENCE CYCLE RELATIVES DURING | | | | | | AVERAGE CHANGE PER YEAR DURING CONTRACTION MINUS THAT DURING | |
| | | | REFERENCE EXPANSION | | | REFERENCE CONTRACTION | | | | |
Trough (1)	Peak (2)	Trough (3)	Total Change (4)	Inter-val in Years (5)	Average Change per Year (6)	Total Change (7)	Inter-val in Years (8)	Average Change per Year (9)	Preceding Expansion (10)	Succeeding Expansion (11)
....	1910	1911	....	....	....	−16	1	−16.0	....	−14.0
1911	1913	1914	−4	2	−2.0	−62	1	−62.0	−60.0	+346.8
1914	1918	1919	−1,635	4	−408.8	−730	1	−730.0	−321.2	−1,033.0
1919	1920	1921	+303	1	+303.0	+125	1	+125.0	−178.0	+31.5
1921	1923	1924	+187	2	+93.5	−40	1	+40.0	−133.5	−34.0
1924	1926	1927	−12	2	−6.0	−24	1	−24.0	−18.0	−46.0
1927	1929	1932	+44	2	+22.0	−385	3	−128.3	−150.3	−166.1
1932	1937	1938	+189	5	+37.8	−148	1	−148.0	−185.8	−188.5
1938	1944	1946	+243	6	+40.5	−113	2	−56.5	−97.0	−229.5
1946	1948	1949	+346	2	+173.0	+6	1	+6.0	−167.0	....
Average			−34		+28.1	−139		−107.4	−145.6	−148.1
Average deviation			352		112.7	170		136.8	60.9	227.7

Index of Conformity to Reference —

Expansions	33
Contractions	60
Cycles, trough to trough	100
Cycles, peak to peak	56
Cycles, both ways	78

[a] Based on National Bureau of Economic Research reference chronology.

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

TABLE 9

Conformity of Railroad Gross Capital Formation to Business Cycles, 1910-1949

| | | | CHANGE IN REFERENCE CYCLE RELATIVES DURING | | | | | | AVERAGE CHANGE PER YEAR DURING CONTRACTION MINUS THAT DURING | |
| DATES OF REFERENCE CYCLES[a] | | | REFERENCE EXPANSION | | | REFERENCE CONTRACTION | | | | |
Trough (1)	Peak (2)	Trough (3)	Total Change (4)	Interval in Years (5)	Average Change per Year (6)	Total Change (7)	Interval in Years (8)	Average Change per Year (9)	Preceding Expansion (10)	Succeeding Expansion (11)
....	1910	1911	....	....	....	−9	1	−9.0	....	−9.0
1911	1913	1914	+0.2	2	+0.1	−32	1	−32.0	−31.9	−16.2
1914	1918	1919	−55	4	−13.8	−26	1	−26.0	−12.2	−58.0
1919	1920	1921	+32	1	+32.0	+12	1	+12.0	−20.0	−20.0
1921	1923	1924	+64	2	+32.0	−14	1	−14.0	−46.0	−11.0
1924	1926	1927	−6	2	−3.0	−10	1	−10.0	−7.0	−15.5
1927	1929	1932	+11	2	+5.5	−99	3	−33.0	−38.5	−60.2
1932	1937	1938	+13.6	5	+27.2	−103	1	−103.0	−130.2	−109.5
1938	1944	1946	+39	6	+6.5	−14	2	−7.0	−13.5	−35.0
1946	1948	1949	+56	2	+28.0	+3	1	+3.0	−25.0	....
Average			31		12.7	−29		−21.9	−36.0	−37.4
Average deviation			38		13.8	29		21.3	23.7	25.7

Index of Conformity to Reference —

Expansions	56
Contractions	60
Cycles, trough to trough	100
Cycles, peak to peak	100
Cycles, both ways	100

[a] Based on National Bureau of Economic Research reference chronology.
Source: Forthcoming monograph on capital formation and financing by public utilities.

and the shallowest trough of the long cycles — that in the mid-1880's — has been ignored. The general observations made above remain in the main intact. The amplitude of fluctuations is still substantial when viewed in this framework, and the secular tendency toward increasing contractions and declining (since the rise of 1899-1910) expansions is even more regular. The average length of cycles is of course increased — to nearly twenty years — while the range in duration is very substantially reduced.

Long Cycles and Business Cycles

It has been asserted above that long cycles are the "dominating" movements in the record of railroad investment. In one sense this is visually evident from Charts 2 and 4; the amplitude of long swings obviously exceeds that of other fluctuations. It is of interest, however, to investigate explicitly the extent to which long cycles condition the pattern of those fluctuations in railroad investment that mirror business cycles. This question will be explored only for the period subsequent to 1909, when long cycles were less vigorous, because of the more limited reliability of the earlier annual figures.

In the first three columns of Tables 8 and 9 are listed the reference dates, as fixed by the National Bureau of Economic Research, of the nine and one-half business cycles that occur in the 1910-1950 period. The reference cycle relatives that underlie the computations in columns 4-9 are obtained by expressing railroad capital formation in a given year as a per cent of the annual average capital formation during the reference cycle in which it occurs. The final results of the computations in all columns are summarized in the indexes of conformity given in the lower portions of the tables.

In accord with the standard procedure of the National Bureau of Economic Research the index of conformity to expansion was obtained by entering +100 for each positive figure in column 6, and —100 for each negative figure, and computing the algebraic average of these grades. A similar procedure, with the signs of grades reversed, was employed for the index of conformity to contractions using the data of column 9. The indexes of conformity to cycles from trough to trough and from peak to peak were obtained from columns 10 and

11 respectively. In these cases +100 was entered for each negative sign, —100 for each positive sign, and algebraic averages computed. The index of conformity to cycles, both ways, is the weighted average of the two preceding indexes.

It is clear from these indexes that railroad capital formation in every case mirrored the changing currents of general business over the course of reference cycles, including even those noted for their mildness and brief duration. The index of conformity to business cycles as wholes is perfect for railroad gross capital formation and very high for railroad net capital formation. On the other hand, the analysis leaves little doubt that long cycles dominate the railroad investment pattern. For when a long-cycle expansion was under way, conformity to business cycles was often reflected simply in a slower rise during reference cycle contraction than in reference cycle expansion rather than in an actual decline in the former phase. Similarly, when the long cycle was in contraction, there was a tendency for investment to fall more slowly during reference cycle expansions rather than to increase. This is reflected in the relatively low indexes of conformity to reference cycle expansions and contractions taken separately.

Thus during the two long-cycle expansions in this period — from 1920 to 1925 and from 1934 to 1948 — there were four business cycle expansions. In each one, railroad investment rose. On the other hand, in these same intervals there were five business cycle contractions, and in only two of these five did railroad investment decline. There is a corresponding phenomenon on the downside of capital formation long cycles. There were two such contractions in this period — from 1909 to 1920 and from 1925 to 1934. These intervals embraced five business cycle contractions and five expansions. In all of the contractions capital formation declined, but in only two of the five expansions did it increase.[11]

[11] As might be expected from the conformity indexes above, there is a close relationship between the specific (short-term) cycles of railroad investment and business cycles. It will be noted from the turning points listed below that each reference cycle is, in fact, matched by a specific cycle in capital formation and that except for the years of World War II there is a pronounced tendency for railroad capital formation to coincide with reference peaks and to lag one year behind reference troughs. Omitting the cycle from 1938 to 1946, the average lag of net capital formation at the trough is 0.89, in years. At the peak there is a very small average lag of 0.11 years.

Of course it must be acknowledged at once that had monthly data been available for this analysis, it might have developed that railroad investment had actually declined during *every* business cycle contraction and had similarly increased during every business cycle expansion. Nevertheless, the nature of the systematic differences in the behavior of the annual data, as described above, attests to significant variations in the amplitude and duration of such monthly fluctuations and to the power of long swings in altering the pattern of these shorter cycles.

The turning points of the specific cycles are as follows:

Specific Cycles of Railroad Capital Formation

Trough	Peak	Trough
. . .	1910	1912
1912	1913	1915
1915	1917	1919
1919	1921	1922
1922	1923	1925
1925	1926	1928
1928	1929-30	1933
1933	1937	1939
1939	1942	1943
1943	1949	1950 (tentative)

The year 1929 is the peak for net capital formation and the year 1930 is the peak for gross capital formation. All other peaks and troughs are the same for both series.