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CHAPTER 3

Building Activities in Local Long Cycles

A. DURATION AND AMPLITUDE

Buildings of different types are complementary to each other, and an increase in demand for one type of building cannot long be extended without involving other types. We will thus, at the outset, review the findings of our survey of 62 building series and 162 specific buildings long cycles without distinction to the type of building involved. In later sections of this chapter the characteristics of long swing fluctuations for each type of building are separately reviewed. Findings with regard to amplitude and duration are presented separately, by cycle phases and with breakdowns between Ohio and non-Ohio building in Table 3-1.

Nearly 54 per cent of our recorded cycles are from Ohio data. An exact parallel between types of building within and outside Ohio does not, of course, occur. The distribution patterns emerging from our tables will reflect to some degree these differences in the raw data. At the same time, the sample of cycles is broad enough to permit certain of their structural features to emerge.

The most prominent feature of our distribution is the wide range of recorded durations. At the lower end of the range the count is inherently arbitrary, for cycles with total durations under seven to eight years or with contractions of less than three years were not distinguishable from (short) business cycles. Even so, some 14 per cent of all long building cycles recognized in this work had a duration under ten years. At the other end of the array, some 20 per cent of recorded cycles had a duration exceeding twenty-two years, with a broad distribution in between. Ohio building had modal durations between thirteen and twenty-one years, while for non-Ohio areas the mode is between thirteen and eighteen years. As measured by the coefficient of variation, relative dispersion around the two mean durations was nearly the same (36.7, and 35.4). The Ohio distribution pattern

TABLE 3-1
Number and Percentage Distribution of 162 Long Local Specific Cycles, Ohio and Non-Ohio, by Duration and Cycle Phase

	Building					
	Ohio		*Non-Ohio*		*Total*	
Years	*No.*	*Per Cent*	*No.*	*Per Cent*	*No.*	*Per Cent*
			Expansion			
2 & under	1	1.1	0	0	1	.6
3–4	17	18.9	6	8.0	23	13.9
5–6	19	21.1	10	13.3	29	17.6
7–8	8	8.9	17	22.7	25	15.2
9–10	19	21.1	10	13.3	29	17.6
11–12	10	11.1	10	13.3	20	12.1
13–14	7	7.8	10	13.3	17	10.3
15 & over	9	10.0	12	16.0	21	12.7
Total	90		75		165	
Mean	8.5	(4.08)	10.7	(5.01)	9.5	(4.64)
			Contraction			
2–3	11	12.5	6	7.6	17	10.2
4–5	28	31.8	18	22.8	46	27.5
6–7	18	20.5	16	20.2	34	20.4
8–9	14	15.9	16	20.2	30	18.0
10–11	13	14.8	13	16.4	26	15.6
12 & over	4	4.5	10	12.7	14	8.4
Total	88		79		167	
Mean	6.6	(2.76)	7.8	(3.38)	7.2	(3.29)
			Full Cycle			
Under 10	16	18.4	6	8.0	22	13.6
10–12	11	12.6	5	6.7	16	9.9
13–15	19	21.8	16	21.3	35	21.6
16–18	16	18.4	15	20.0	31	19.1
19–21	16	18.4	8	10.7	24	14.8
22–24	7	8.0	11	14.7	18	11.1
25–27	2	2.3	7	9.3	9	5.6
28 & over	0	0	7	9.3	7	4.3
Total	87		75		162	
Mean	15.0	(5.5)	18.6	(6.6)	16.6	(6.2)

NOTE: Figures in parentheses are standard deviations.

for the longer durations thinned out. In consequence the mean duration of Ohio building cycles at 15.0 years was considerably lower than mean duration of non-Ohio building cycles at 18.6 years.

The tendency to shorter duration in Ohio is characteristic both of expansion and contraction phases. The mean building expansion in Ohio was 8.5 ± 4.1 years or 79.4 per cent of the mean expansion elsewhere; the mean contraction in Ohio was 6.6 ± 2.76 years, or 84.6 per cent of the mean contraction elsewhere.

Another feature exhibited in Table 3-1 is the comparative length of contraction phases. Over 19 per cent of Ohio and 24 per cent of non-Ohio long building contractions were ten years or over in duration, and the mean contraction comprised between 42 and 44 per cent of the total span of building cycles. A statistical record of the relative proportion of contractions in business cycles and in short specific cycles in production and building is presented in Table 3-2. Over the same years the short business cycle reference chronologies of the four countries from which most of our measures are taken had a mean contraction share of 43.9 per cent.

Duration of building cycles will vary slightly when considered by class of building. Thus, our thirty residential building series, spanning some eighty-one specific cycles, had a mean duration of 19.7 years, or nearly two years longer than that of cycles in all types of building. Our seven series of total nonresidential building covering 15.5 specific long cycles had a mean duration of 17.5 years, considerably less than those for total building. Both Ohio and non-Ohio territories exhibit the same characteristic of a mean residential duration in excess of all building durations—in Ohio by 11 per cent, outside Ohio by 2 per cent. In part this arises because of a tendency for a special rhythm to occur in nonresidential building, which produces "extra cycles" and hence shorter durations. Thus, our five Ohio industrial building series experienced an altogether shorter rhythm, with a mean duration of 11.2 years.

Average amplitudes of the series have been studied in terms of total rise and fall during reference and specific cycles, rise and fall per year during specific cycles, and ratio of reference to specific amplitude. Since central tendencies for these measures are affected by the composition of the groups of series, caution will be needed in drawing conclusions. Table 3-3 presents

TABLE 3-2
Contraction Expressed as a Per Cent of Total Duration—Building and Business Cycles

I. Building cycles	
A. Building activity	
1. Ohio mean duration	44.0
2. Non-Ohio mean duration	41.9
B. Nonbuilding activity	
3. Ohio mean duration	37.1
4. Non-Ohio mean duration	41.1
II. Business cycles[a]	
C. Reference cycles, national	
5. U.S. 1854–1933	46.8
6. Great Britain 1854–1932	42.8
7. France 1865–1932	43.1
8. Germany 1879–1932	42.9
D. U.S. production activity	
9. Deflated clearings 1878–1933	26.3
10. Pig iron production 1879–1923	35.6
11. Riggleman's per capita index:	
building permits 1830–1878	47.2
building permits 1878–1932	47.0
12. Manhattan value plans for new building 1870–1933	46.8
13. Chicago value of total building permits 1862–1933	46.0
14. St. Louis value of total building permits 1878–1932	55.0
15. Long's monthly index of building permits 1882–1916	44.1
16. Value building permits (20 to 120 cities) 1908–1933	60.5
17. Business annals—U.S. 1790–1925	40.0[b]
18. Business annals—England 1790–1925	47.4[b]
19. Seventeen countries 1890–1925	36.8[b]

[a] NBER files, Business Cycle Unit.
[b] Ratio of years of "depression" to years of "prosperity" as defined by Thorp in [251] and summarized in Mitchell [192, p. 408 ff.].

summary measures of amplitude with distributions of certain characteristics.

The dominant fact that emerges about the amplitudes of our surveyed activities is that they are, relative to those of business

TABLE 3-3
Mean Amplitude Measures, All Building Series

	Per Cent Distribution of Series	
Mean Total Amplitude	Specific	Reference
400 and over	17.7	2.0
300.0–399.9	27.4	14.3
200.0–299.9	41.9	34.7
150.0–199.9	11.3	36.7
100.0–149.9	1.6	12.2
Number of series	62	49
Mean amplitude, all series	303.4 (100.3)	221.4 (81.8)
Mean amplitude, Ohio	285.8 (99.5)	202.2 (85.9)
Mean amplitude, non-Ohio	324.8 (96.9)	245.0 (69.5)

NOTE: Figures in parentheses are standard deviations.

cycles, "enormous" [41, p. 418]. The mean total reference amplitude or range of fluctuation of a series about its own average reference business cycle level was reported by Mitchell to equal 55.5 for production series and 40.0 for 794 series covering a wide variety of types of economic activity [193, pp. 102–107]. The corresponding mean reference total amplitude for our building series averaged 202 (±86) for Ohio and 245 (±69) for non-Ohio. Mitchell's business cycle amplitudes mainly pertain to nationwide series on a monthly basis; our building cycle amplitudes are for local series on an annual basis. Series which are aggregated differently are smoothed to different degrees, annually more than monthly. Therefore, we cannot tell by how much building cycle reference amplitude exceeds business cycle amplitude, but the difference must be considerable.

In specific form, a long building series will typically rise to peak values three or four times the initial trough over a sweep of ten years and then fall halfway back to the origin over a seven-year period of decline. By contrast, business-cycle movements in total production typically undulate much more gently about their mean level.

The summary table of amplitudes indicates that long cycles tended to be both longer and more severe outside of Ohio. This applies both for building activity proper and, as we shall see later, for the behavior of real estate, prices, and population movements.

The greater amplitude of cycles outside of Ohio is due partly to the somewhat greater intensity in rate of fall and to the somewhat greater relative role of contraction phases. It is probably also attributable to the greater role of smaller towns in our records of Ohio experience and to the presentation of Ohio urban experience for groups of urban communities rather than for these communities separately.

The gap between reference amplitude of building activity and specific amplitude is a wide one. Reference amplitudes are 73.0 per cent of specific amplitudes for all building series. The reference scale for local nonresidential building was the local residential building series; a local residential series was analyzed on a national or regional reference frame.

The disparity between specific and reference amplitudes reflects a tendency for imperfect synchronization in timing and pattern among urban areas of an economy and among the varied types of local building activities.

B. RESIDENTIAL BUILDING

Within building, residential building predominates and has long been regarded as a generating force making for distinct long-wave movements. Altogether, thirty long residential series were analyzed. Table 3-4 presents a summary of cyclical measures covering duration, amplitude, timing, and growth.

The measures point to a basic divergence between Ohio and non-Ohio residential cycle patterns in growth rates, amplitude, and duration. Ohio residential building grew more rapidly, 4.01 per cent per year compared with 1.84 per cent per year elsewhere. At the same time, Ohio mean durations were shorter and amplitudes were less—by 12 and 30 per cent respectively—than for the non-Ohio areas. Long cycles of residential building in Ohio thus conform to the finding of Borts that "rapid growth and cyclical instability do not necessarily grow together" [27, p. 152]. This same finding is confirmed by the results of regression analysis of our residential building series presented in Appendix G. Although rates of secular growth do not appear to affect amplitudes of fluctuation, our records show that long fluctuations typically occur on a rising secular trend of building. The

TABLE 3-4
Summary Measures for Residential Building: Local Specific Long Cycles[a]

Measures	Ohio[a]				Non-Ohio[b]				Total	
	Mean	*Median*	*High*	*Low*	*Mean*	*Median*	*High*	*Low*	*Mean*	*Median*
Full specific duration (annual)	17.38 (1.96)	16.5	20.5	15.3	20.27 (5.25)	18.4	33.0	10.7	19.67 (5.00)	18.45
Specific cycle amplitude (in cycle relatives)										
Full	227.3 (38.1)	215.4	284.1	181.2	325.7 (91.4)	309.6	482.0	191.9	306.0 (92.4)	287.5
Full per year	13.14 (2.17)	13.32	16.95	10.08	16.88 (5.22)	16.9	33.36	9.25	16.13 (5.04)	15.95
Fall per year	−12.93 (1.98)	−13.06	−15.46	−9.71	−20.25 (8.15)	−18.3	−41.31	−9.06	−18.79 (7.89)	−17.22
Secular weighted average growth per year (per cent)	4.017 (1.11)	4.195	5.557	1.745	1.840 (2.71)	1.235	9.489	−2.790	2.275 (2.62)	1.688

NOTE: Mean values are presented plus or minus standard deviations.

[a] Includes the six series 0110, 0123, 0172–0175, covering fifteen specific long cycles.

[b] Includes the twenty-four series 0001–0009, 0022, 0030, 0034, 0035, 0039, 0048, 0052, 0075, 0079, 0081, 0085, 0092, 0098, 0143, 0144, covering sixty-six specific long cycles.

trend on a per year basis was rising at a mean rate of 2.3 per cent per year for all of our series, and only two communities had a declining annual level of building through two or more long swings. Even in these instances the stock of building was increasing, though at a diminishing linear rate.

The measures exhibit the diversity of duration and amplitude of fluctuation previously noted. Duration ranges from 10.7 to 33.0 years, while amplitudes range between 192 and 482. Smaller amplitudes tend to be associated with shorter durations, so that the range of amplitude per year is less than that of total amplitude (for details see Appendix G).

C. INDUSTRIAL AND COMMERCIAL BUILDING

Statistical series on industrial and commercial building are available as distinct types only for Ohio. The results are set forth in Table 3-5 and the average cycle patterns are in Charts 3-1 and 3-2.

The relatively short duration of industrial cycles, noted earlier, stands out prominently, as does the high secular growth rate. Specific industrial cycles have both higher growth and higher specific amplitudes—total and per year—than commercial building cycles; and the degree of cyclical conformity as measured by the ratio of reference to specific amplitude is higher. It is not clear, however, whether this set of results is due to the very short durations of Ohio patterns of industrial building or, more precisely, to a greater influence of standard business-cycle rhythms within observed long movements. The high amplitude of industrial building relative to residential or commercial building is characteristic of short as well as long building cycles in the United States.[1] Only the ranking of American commercial and residential amplitudes for building cycles is different. The building cycle ranking runs: industrial, commercial and residential; the business cycle ranking runs: industrial, residential, commercial.

The higher amplitude of industrial building is accompanied by earlier timing. The mean lead of industrial over commercial building ranges from a low of 3.6 months at turning points to 12 months pointed to by correlograms.[2] The respective correlograms of industrial and commercial building indicate a tendency of industrial building to lead considerably relative to commercial building, particularly in the rural Ohio groups.

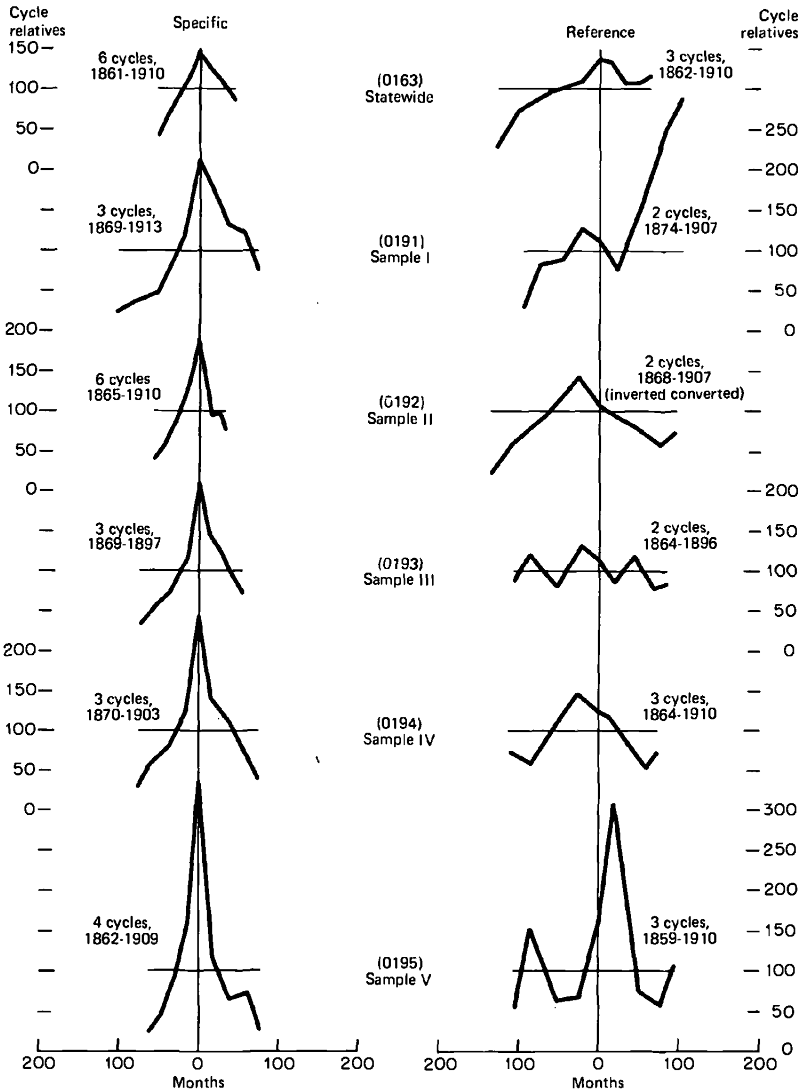
TABLE 3-5
Summary Measures for Industrial and Commercial Building: Local Long Cycles; Ohio Sample Groups

	Industrial Building[a]				Commercial Building[b]			
Measures	*Mean*	*Median*	*High*	*Low*	*Mean*	*Median*	*High*	*Low*
Full specific duration (years)	11.2	11.7	14.6	7.5	14.2	11.7	21.0	10.8
Specific cycle amplitude (cycle relatives)								
Full	383.9	330.6	625.6	262.6	272.1	252.8	348.0	194.8
Full per year	34.82	32.99	53.99	22.54	20.19	18.12	29.76	16.31
Fall per year	−34.66	−32.15	−47.83	−23.02	−20.71	−16.66	−28.57	−16.10
Full reference amplitude (cycle relatives)[c]	338.4	292.6	560.3	206.3	196.5	197.8	232.8	158.8
Secular weighted average growth per year (per cent)	5.952	5.999	8.614	4.169	4.589	5.674	6.779	1.708
Lead-lag turning points (years)[d]	.09	.57	3.50	−2.83	.39	.29	4.67	−2.20
Average deviation (years)	2.04	2.17	2.70	1.30	1.90	1.89	2.41	1.36
Lead-lag reference pattern (years)[c]	.13	−.85	4.30	−2.10	.70	1.40	3.10	−2.40
Optimal serial correlation, trend adjusted								
Lead-lag (years)	−1.6	−1.0	−.5	−2.0	−.60	0	2.0	−3.0
Correlation coefficient (r)	.674	.671	.921	.369	.696	.676	.962	.343

[a] Includes series 0191 through 0195, which had nineteen specific long cycles in which twenty-nine turning points were matched and sixteen were unmatched.
[b] Includes series 0187 through 0190 and 0227, which had fourteen specific long cycles in which twenty-nine turning points were matched and three were unmatched.
[c] Excludes series 0190, 0227 for commercial and series 0193 for industrial.
[d] Excludes series 0193 for industrial.

CHART 3-1

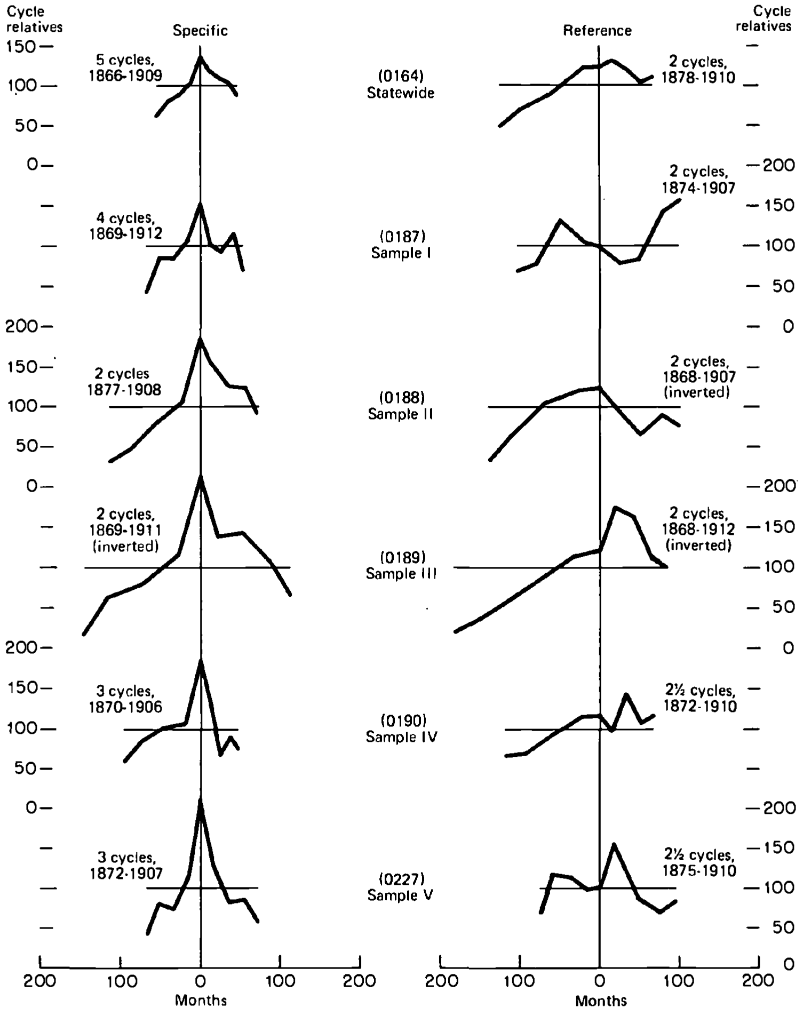
Patterns of Average Specific and Reference Long Cycles, Ohio Statewide and Samples, Value Industrial Building



There is more uncertainty regarding the timing relation of industrial to residential building. So far as means go, reference phase analysis points to a slight lag of industrial building by about five weeks; in turning point analysis, a lag of seven weeks occurs. But extreme lag values have affected these means. Three

CHART 3-2

Patterns of Average Specific and Reference Long Cycles, Ohio Statewide and Samples, Commercial Building



of the five sample groups exhibited leads of between eight and ten months by both types of analysis. The median reading for the sample groups is confirmed by correlation analysis, which points to a mean lead of 19.2 months. The tendency to lead in correlograms prevailed among all of the Ohio sample groups, though more strongly and with least variability among the medium urbanized groups III and IV. Correlation analysis takes account of all recorded values and correlated series were smoothed to scale down the unusually strong short cyclical influences. These influences unavoidably affected judgments on turning point analysis based upon unsmoothed data. These same influences show up in the reference cycle patterns and dominate the pattern for group III. It thus seems likely that, while on recorded turning points a highly variable relationship existed, industrial building generally responded more quickly to influences of expansion and contraction than residential building. Reference cycle patterns (see Chart 3-1) indicate that the tendency of industrial building to lead was marked and most uniform on upturns and was most variable and irregular at peaks.

A tendency for industrial building to lead local long cycles on upturns may readily be rationalized. Industrial building provides the facilities which expand local jobs and production and thus generates local commercial and residential expansion. This pattern was clear for Ohio groups I, II, and IV, but more erratic for groups III and V.

Since the course of industrial building responds to influences running through product and investment markets on a nationwide scale, it is consistent with our hypothesis that local industrial building should exhibit some indication of the intermediate rhythm of eight to ten years which some observers have found in so-called major cycles. This is quite clearly the case. The smoother time series charts of industrial building (see Chart 2-2) exhibit the major decennial rhythm characteristic of the seventy years before 1914. Because of these "extra" cycles, the mean long specific cycle duration for industrial building is only 11.2 years, compared with 14.2 for commercial and 17.4 years for residential. For the same reason, the annual rate of change of industrial building is greater, 34.82 cycle relatives per year, while commercial building fluctuates at a yearly rate of only 20.2 and residential building at a rate of 13.1 cycle relatives.

D. CHICAGO MANUFACTURING EXPERIENCE

Long swings in industrial building should generate long swings in industrial capacity; and it would be strange if these swings would fail to become associated with long swings in the flow of industrial output. For well-known reasons, amplitude of fluctuation of output from durable facilities will be considerably less than for the flow of new facilities themselves. It is, of course, entirely possible that swings in new facilities or standing stocks should be matched on the output side by swings in the rate of plant-utilization so that output flows would be free from any tendency to long swings. It is of interest to know if this were the case, i.e., if there were no feedback effects of long swings in building activity upon the flow of industrial output.

We cannot find the answer to this question for the state of Ohio where our information on industrial building is most detailed, due to lack of suitable annual measures in Ohio for industrial output. We have such measures however, over an extended time period, covering three long building cycles, for the city of Chicago where our information on building and demographic movements points to sizable long swings which in all probability were associated with corresponding movements of industrial building in Chicago. Because of radical price shifting in several of the decades it was necessary to deflate the manufacturing output series with a wholesale price index, which probably overstates both deflation during the 1870's and inflation during World War I. The successive specific and reference cycle patterns are shown in Chart 3-3. The successive reference cycle patterns are shown in inverted form; the average pattern is shown both in inverted and positive form.

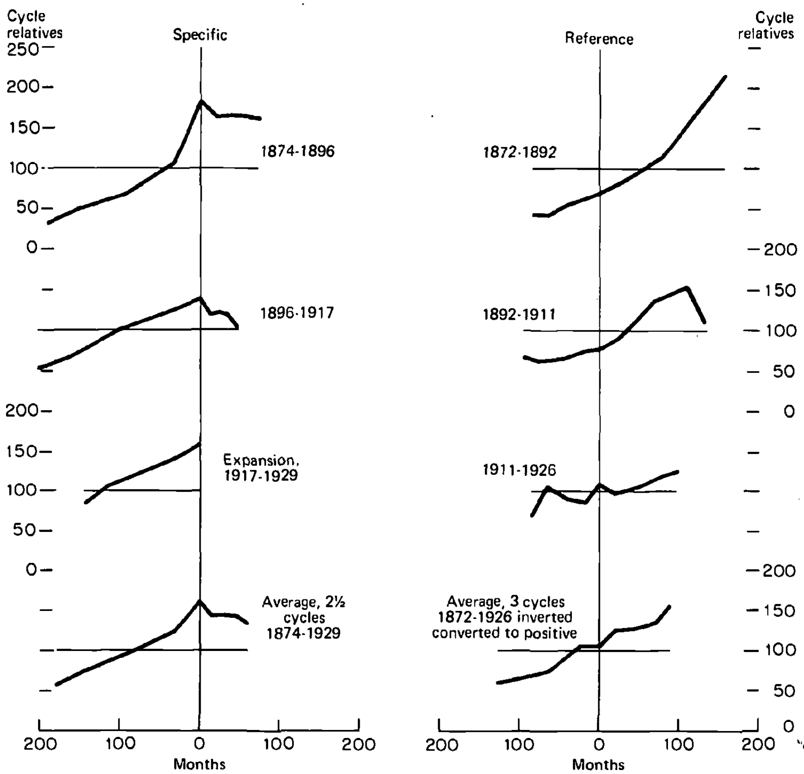
The upward trend of growth is so strong that characteristic reference contractions are difficult to identify in the naked series or cycle relatives. Reference contractions become more discernible, however, when expressed in terms of rates of change. These rate patterns, which are not reproduced, also show that manufacturing activity clearly leads at upturns and lags at peaks with a net lead over the entire period of from one to one and a half years. We recall that industrial building in Ohio also exhibited a net timing lead compared with residential building, with a tendency to lag at peaks. The scale of the timing leads seems to correspond. If we join timing evidence from Chicago and Ohio, we can say industrial firms apparently expand or slacken building as their long-term demand for output expands or slackens in its rate of growth.

E. SCHOOL BUILDING

Summary results for school construction are presented for the five Ohio sample groups in Table 3-6. The respective cycle

CHART 3-3

Patterns of Successive Long Cycles and Their Average, Specific and Reference, Deflated Value Manufactures, Chicago, 1872–1929



patterns are found in Chart 3-4. Mean specific durations are fairly close to those of residential building. Reference cycle patterns all indicate that local school building responds to the influences which govern residential building and with a considerable amplitude. All our measures for timing indicate a considerable lag—1.6 years at matched turning points, 1.79 years on reference cycle phase turns, and a full 2.5 years by correlation analysis. The correlograms, considering the strong trends running through the series, give unambiguous testimony of the lag. Disturbance in the relationship is considerable, as indicated by the mean reference cycle amplitude, which is only 57.3 per cent of specific cycle amplitude.

The reasons for the lag are perhaps related to the greater formality of decision making in public construction. Any growth in demand for new residential building would be reflected in a

TABLE 3-6
Summary Measures for School Building: Local Long Cycles; Ohio Sample Groups[a]

Measures	*Mean*	*Median*	*High*	*Low*
Full specific duration (years)	15.8	16.0	18.0	12.3
Specific cycle amplitude (cycle relatives)				
Full	323.7	334.5	392.3	265.8
Full per year	20.58	18.80	24.52	18.47
Fall per year	−20.81	−22.45	−29.64	−11.63
Full reference amplitude (cycle relatives)[b]	196.8	185.0	278.7	138.5
Secular weighted average growth per year (per cent)	4.257	4.520	5.865	2.666
Lead-lag turning points (years)	1.61	1.83	4.40	−.67
Average deviation (years)	2.56	2.33	4.33	1.11
Lead-lag reference pattern (years)[b]	1.79	1.30	3.80	.75
Optimal serial correlation, trend adjusted[c]				
Lead-lag (years)	2.5	2.0	3.0	2.0
Correlation coefficient (r)	.681	.726	.748	.524

[a] Includes series 0258 through 0262, which contain 13.5 specific long cycles, twenty-six matched turning points and seven unmatched turning points.
[b] Excludes series 0258.
[c] Excludes series 0260.

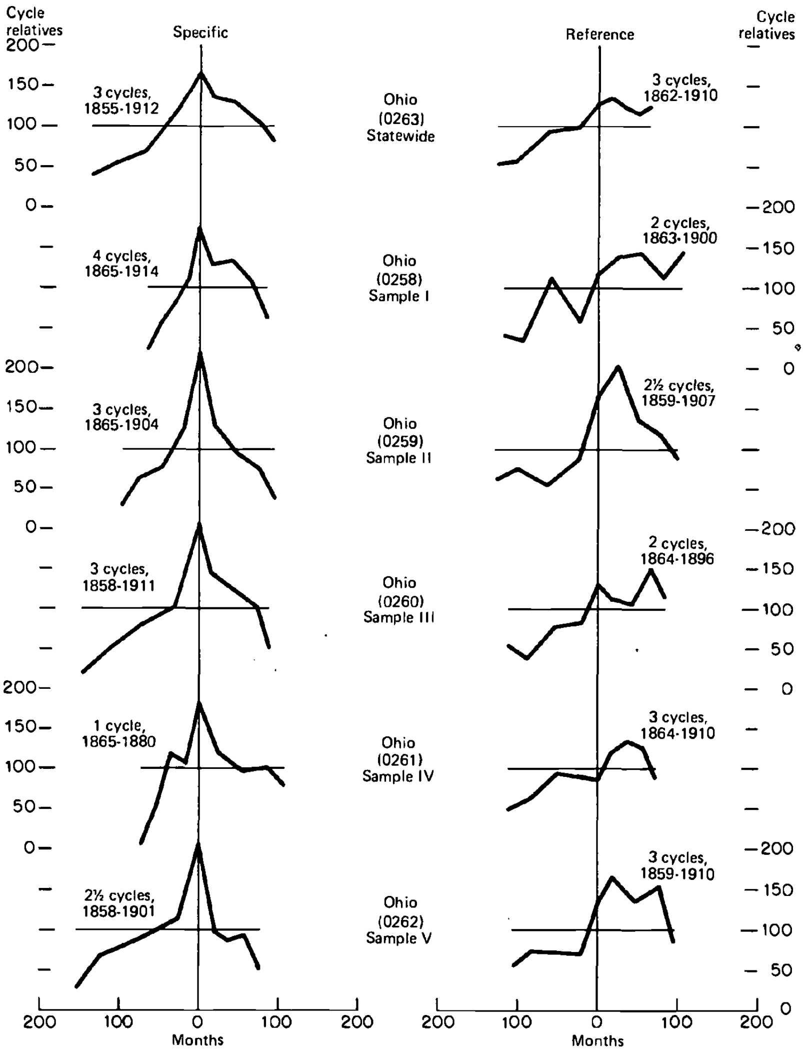
need for additional school facilities. However, the decision to build a dwelling is taken with a minimum of formality. The decision to build a public school involves the decision to build, the search for adequate sites, and the drawing up of building plans, all of which take more time than is usually required for a private dwelling or apartment house. Our computed mean lag, which ranges between 1.6 and 2.5 years, may measure this more cumbersome procedure.

F. TOTAL NONRESIDENTIAL BUILDING

Summary results for seven nonresidential building series are found in Table 3-7 and specific and reference cycle patterns are

CHART 3-4

Patterns of Average Specific and Reference Long Cycles, Ohio Statewide and Samples, Cost of Schools, Riggleman Deflated



presented in Chart 3-5. Our Ohio graphs are on a statewide basis. Four series are of non-Ohio origin and in three instances relate to number rather than value of nonresidential building. Since per-unit values of nonresidential building have high rates of secular growth, the non-Ohio mean growth rate (at 1.3 per cent per year) would understandably be lower than the Ohio rate (8.9 per cent per year). Amplitude measures should also be higher for

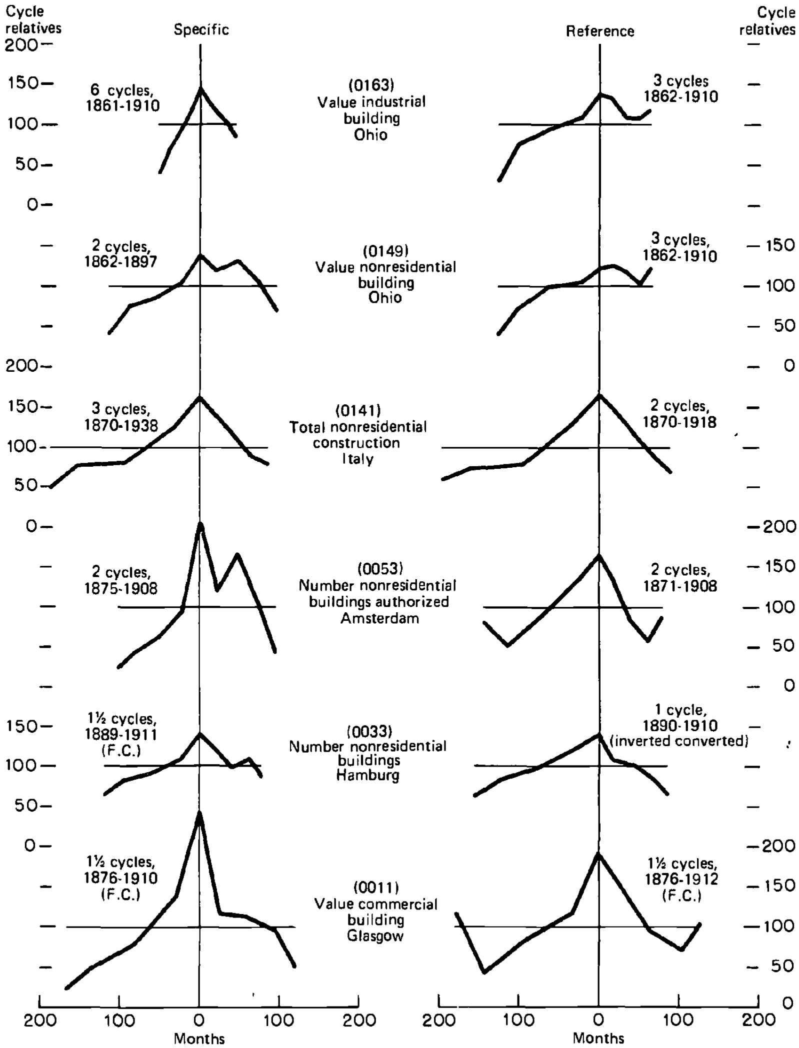
TABLE 3-7
Summary Measures for Nonresidential Building: Local Long Cycles

Measures	Ohio[a]	Non-Ohio[b]		Total	
	Mean	Mean	Median	Mean	Median
Full specific duration (years)	14.2	19.9	19.8	17.5	16.5
Specific cycle amplitude (cycle relatives)					
Full	329.2	315.1	357.7	321.2	347.3
Full per year	23.31	15.74	16.89	18.98	18.69
Fall per year	−25.18	−18.45	−19.98	−21.33	−20.59
Full reference amplitude (cycle relatives)[c]	202.9	239.2	248.6	227.1	231.5
Secular weighted average growth per year (per cent)	8.958	1.276	1.065	4.568	7.940
Lead-lag turning points (years)	−.10	−.11	.05	−.11	−.60
Average deviation (years)	2.19	1.96	1.81	2.06	1.87
Lead-lag reference pattern (years)[c]	.58	1.21	1.33	1.00	1.15
Optimal serial correlation, trend adjusted[d]					
Lead-lag (years)	n.a.	.5	.5		
Correlation coefficient (r)	n.a.	.778	.856		

n.a.—not available.
[a] Series 0111, 0116, 0124, which include 7.5 specific long cycles with fourteen matched and nine unmatched turning points.
[b] Series 0093, 0053, 0033, 0011, which includes 8 specific long cycles with nineteen matched and two unmatched turning points.
[c] Excluding series 0111 from Ohio and total columns.
[d] Includes a nonresidential building series subjected to correlation analysis only.

CHART 3-5

Patterns of Average Specific and Reference Long Cycles, Nonresidential Building



Ohio than non-Ohio series, though the per-year rates of movement are close together.

Our nonresidential series, partly because they are expressed on a numbers basis for non-Ohio areas, yield a divergent pattern of lead-lag. Turning points exhibit a lead; reference cycle and correlation analysis, a lag. This irregularity of pattern may be due to the shifting course of public building, which is least integrated into the mechanism of local building movements. As we have just seen, Ohio school building lags strongly, as did Ohio commercial building. Long's studies of median dates for various cities showed that public building as a whole exhibited lags in two of three long cycles averaging nearly three years. An even more clear-cut and longer lag of public building, approximating inversion of timing on short cycles, is indicated by a fifteen-year span of building in Germany before 1914. This same tendency to inversion is indicated in our more comprehensive study of building in Ohio between 1853 and 1912, which showed between long cycle phases a regular alteration in the proportions of private (taxable) and public (exempt) building. The ratio of net exempt to net taxable building increments of standing stock, as evaluated in periodic statewide tax appraisals, is as follows:[3]

Period	Per Cent
1853–59	41.2
1859–70	16.9
1870–80	42.9
1880–90	9.7
1890–1900	27.3
1904–12	6.1

The long lags and a tendency to inversion in public building may be related partly to the formal process of decision making applicable to school construction as noted above but also to the character of construction and financing. C. D. Long attributes the lag primarily to the large average size of public structures built only upon order and according to precise specifications with long lead times [173, pp. 141–142]. He mentions as a supporting consideration what Hunscha considered primarily, namely, that local building expansions generate realized surpluses over revenue forecasts and thus stimulate in the following years a more or less favorable adjustment of building plans [136, pp. 43–44].

G. STREET PAVING

A form of construction activity, street paving, is reported for three cities for which we have building data and the forms of cycle patterns are worth noting (see Table 3-8 and Chart 3-6). The small sample hinders drawing reliable conclusions. Only some 8.5 long cycles were covered. Street paving conforms as closely to building cycles as nonresidential building does: the mean ratio of total reference to specific amplitude is .66. It is higher for Glasgow and Chicago than for Manhattan.

The cyclical rhythm of street-paving activity may be affected by whether the streets are newly constructed or are being resurfaced and whether innovations in technology are involved. Resurfacing of old streets should lag behind residential building; new street development should lead building; and innovations in traffic design or street construction should vary at random. For the three urban areas, a mixture of these tendencies is indicated with a net tendency to lag.

TABLE 3-8

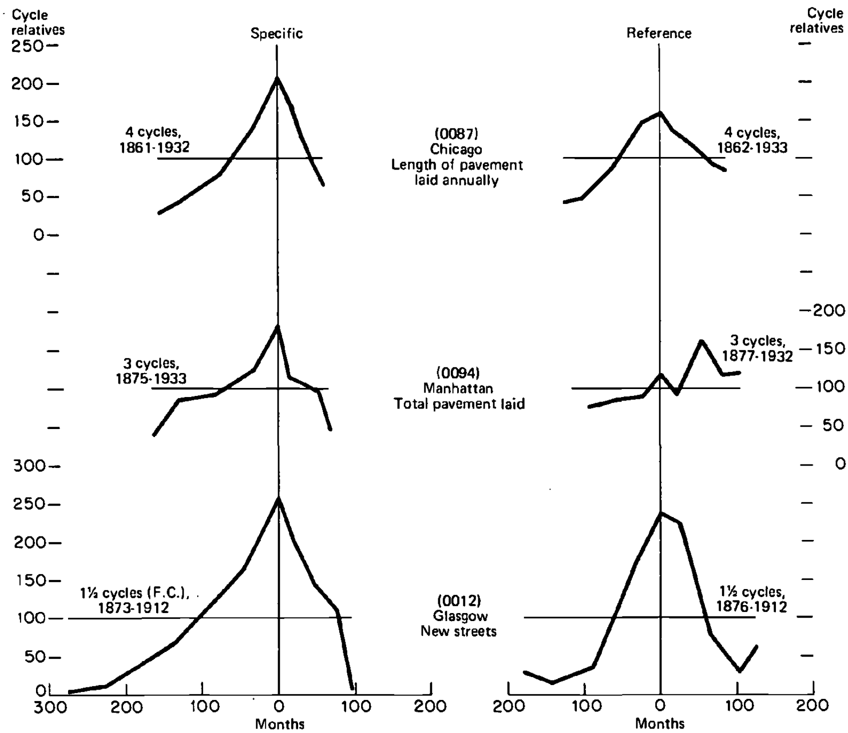
Summary Measures for Street Paving, Local Long Cycles for Three Urban Areas[a]

Measures	*Mean*	*High*	*Low*
Full specific duration (years)	22.73	31.00	17.8
Specific cycle amplitude (cycle relatives)			
Full	370.7	513.3	282.6
Full per year	16.33	17.81	14.61
Fall per year	−28.75	−31.87	−24.63
Full reference amplitude (cycle relatives)	253.3	411.7	166.4
Secular weighted average growth per year (per cent)	1.608	6.216	−2.708
Lead-lag turning points (years)	.523	2.87	−.75
Average deviation (years)	2.56	2.87	2.05
Lead-lag reference pattern (years)	.433	2.30	−1.0
Optimal serial correlation, trend adjusted			
Lead-lag (years)	0	1.0	−1.0
Correlation coefficient (r)[b]	.918	.923	.913

[a] Includes series 0012, 0087, 0094, which cover nine specific long cycles, having twenty-one matched, and no unmatched, turning points. The three areas are Manhattan, Glasgow, and Chicago.

[b] Excluding series 0094.

CHART 3-6
Patterns of Average Specific and Reference Long Cycles, New Streets Laid



H. SUMMARY

Our survey supports the judgment that urban building fluctuated in waves which were impressively regular. These waves develop amplitudes which are enormous relative to ordinary business cycles. Our sample of thirty urban communities experienced eighty-one long waves marked out in our chronologies. These waves had a mean duration of 19.7 ± 5.0 years. Total specific amplitude fluctuated in a high-low range of 181–482 and experienced a mean value of 306 ± 92 cycle relatives. Yearly rates of movement averaged 16.1 ± 5.0 cycle relatives. The implicit monthly rate of movement falls well within the range of rates characteristic of industrial production during business cycles. But whereas an upward movement of industrial production will reverse itself after cumulating for a few years, a comparable upward movement of building will endure for a decade or more, while all building contractions alone have a mean duration of 7.3 ± 3.0 years.

Our survey shows that residential building fluctuates with other types of building. With residential construction goes the work of site preparation and development. Any newly established residential neighborhood will require schools, service facilities, churches, and public buildings which provide important neighborhood services. Moreover, this whole residential development will in turn be complementary to new industrial or service facilities. New industrial and residential facilities will in turn require or grow out of improved or extended facilities of transportation. In short, all new extensive construction appears to be complementary in character, demanded and supplied as a whole.

But the process of growth spreads and works unevenly. For industrial building, specific long local cycle rhythms are decennial in duration (mean duration 11.2 years) and thus correspond to the "major" or Juglar rhythm of the business cycle. The total specific amplitude is relatively large, 384 cycle relatives, and is reflected in high rates of monthly variability (2.9 per cent per month) on both rise and fall, and a very high secular growth rate (5.95 per cent annually). Side by side with this overt rhythm is a longer oscillation which showed up in our reference cycle patterns and correlograms. If our median correlogram and reference pattern values can be trusted, industrial building tended generally to lead residential building by a year, though on twenty-nine matched turning points the lead was reversed and turned into a lag. Probably this reflects no more than the arbitrariness in matching turning points in series with different basic periodicities.

Commercial building was clearly subject to the longer building rhythm: though both total specific and reference amplitudes were nearly a third less than with industrial building, the conformity to residential building rhythms was closer. Commercial building perceptibly lagged behind industrial from a half to a full year, though with variable timing.

Perhaps public and quasi-public building responds most slowly and unevenly to the rhythm of building cycles. School building exhibited a long specific rhythm which corresponded moderately to the rhythm of residential building, but with a lag of two or more years. The lag in public construction probably reflects slower decision making at governmental levels and more elaborate structures which take longer to build. In two of our three communities surveyed for street paving, there was a clear-cut reference pattern of fluctuation, with tendencies both to lag and to lead up to two or more years.

In general, tendencies of public and commercial building to lag are offset by tendencies to lead in industrial building. Amplitude of fluctuation is somewhat scaled down to that approximating the residential, while on balance a moderate lag up to one year tends to prevail. Thus well within the long span of years needed for a completed building cycle, accumulated shortages or surpluses will have aligned building operations of different types into a common movement.

NOTES

1. Four short cycles between 1919 and 1933 in series on the dollar value of American building contracts had mean amplitudes of 258, 176, and 130 for industrial, commercial, and residential building, respectively (see [39]). Comparable German amplitudes, computed on the basis of trend-adjusted data for the fourteen years before 1910, for the three categories of building were 36.3, 57.6, and 33.4 per cent, respectively (see [136, p. 37]).

2. The different methods yield the following mean lead of industrial over commercial building: correlation analysis, 12 months; turning point analysis, 3.6 months; reference cycle phase, 6.8 months. German short cycles in industrial and commercial building for seventeen years before 1914 showed a variable relationship for four short cyclical turning points, with an average mean industrial lead of three months (see [136, p. 35]).

3. See [108, p. 249].