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Appendix G

REGRESSION ANALYSIS, THIRTY LOCAL RESIDENTIAL BUILDING SERIES

Four basic long cycle measures for all local residential series are listed in Table G-1. Bivariate cross-relationships were exhibited in scatter diagrams to test the hypothesis that total amplitude is significantly influenced by either total duration, rates of secular growth, or fall rate per year. The scatter is wide and any correlation, if present, is of low degree. For areas of very high amplitude, excepting only Detroit, there was a clear tendency for growth to be inversely associated with amplitude. For the next ten cities on the amplitude scale, the same tendency for correlation is indicated but with more scatter and another structural set of coefficients. For areas of moderate to low amplitude, including Paris, London, and the Ohio sample groups, little systematic relationship of growth rates to amplitude is indicated. It will be noted that all amplitudes below 250, including London, Paris, the Ohio rural group, and three English cities, fall within a low and narrow band of growth rates. The three exceptions to this are the other Ohio sample groups, whose amplitude, it may be assumed, has been cut down by inclusion of farm building or by aggregation. If these three observations are adjusted up to their presumed individual city or county levels, then it would appear that our thirty urban areas subdivide into three basic types:

(a) a group of high-amplitude (350 and higher) central cities for whom growth rates are linearly and inversely related to amplitude with relatively high coefficients of relationship;
(b) a larger group of central cities at a lower amplitude level (280-350) with a clear linear inverse relation of growth rate to amplitude and reduced slope terms:
(c) a group of cities of mixed character—including metropolitan capitals like Paris and London, rural Ohio counties, and South Wales coal mining areas—with lower amplitudes (below 250) and very moderate growth rates.

The relation between amplitude and duration seems to involve

TABLE G-1
Array of Thirty Local Residential Building Series, Mean Amplitude, Growth, Duration

Residential Building Series	Mean Amplitude Specific Total (+)	Mean Amplitude Specific Fall Per Year (−)	Mean Average Specific Long Duration (Years)	Secular Weighted Average[a] (% Per Year)
1. Sydney	551.9	16.10	29.0	.023
2. Detroit[a]	482.0	41.31	27.5	8.131
3. Glasgow	453.0	21.82	24.0	−2.790
4. Victoria	445.6	21.38	33.0	−1.229
5. Stockholm	421.9	17.41	23.3	1.630
6. Chicago[b]	407.5	26.21	17.8	3.890
7. Hamburg	363.6	29.35	16.0	9.489
8. Swindon	350.3	40.45	10.5	−1.106
9. Montreal[b]	347.0	19.44	20.5	3.527
10. Exeter	334.0	19.08	19.0	1.167
11. Birmingham	316.4	18.79	26.5	1.856
12. St. Louis	314.8	13.88	16.5	2.757
13. Manhattan	304.5	17.51	18.4	1.154
14. Berlin	296.1	17.87	16.3	3.566

15.	Amsterdam	290.9	22.46	15.3	3.391
16.	Cleveland	284.1	15.46	20.5	5.557
17.	Liverpool	282.8	14.03	18.5	.517
18.	Manchester	273.4	12.22	28.0	1.304
19.	Cincinnati	271.2	13.22	16.0	4.213
20.	Bremen	266.4	17.02	18.4	1.459
21.	Bradford	254.8	13.51	17.3	.462
22.	Hull	232.2	14.23	19.3	.981
23.	Ohio Sample V	225.6	12.90	17.0	1.745
24.	South Wales House Building	223.6	27.53	18.5	1.800
25.	Newport	210.9	11.82	12.5	.474
26.	Ohio Sample IV	205.1	14.96	15.3	3.797
27.	London	201.8	9.06	19.3	.557
28.	Ohio Sample II	196.5	9.71	19.5	4.614
29.	Paris	191.9	12.05	20.8	1.144
30.	Ohio Sample III	181.2	11.33	16.0	4.177

[a] Per cent change in secular weighted average growth per year, successive short cycle standings.
[b] Total building activity.

a corresponding set of boundaries. For the middle group of amplitudes—between 290 and 360—the higher the amplitude the shorter the duration. But with the high amplitude group above 350, the higher the amplitude the more extended the duration. Below 290 no relation seems indicated. Why relation should shift in character at a size breaking point is not clear, though the breaking point is common to both growth and duration measures. Apparently structural relationships change in character or intensity as an amplitude boundary line nears 350 in magnitude.

A corresponding change in boundary behavior seems to hold for amplitude fall per year when related to total amplitude. Within the enclosed boundaries, rate of fall to total amplitude shows a very consistent and positive linear relationship. A freehand regression has the form $X = 25 + 15.5\ Y$, where X = total specific amplitude percentage fall per year. Here again, the regression holds up to a total amplitude value of around 350 and a rate of fall of 21 per cent per year. Beyond these boundaries an inverted relationship appears to set in.

The appearances may of course be deceptive, as in all cases of simple bivariate correlation in a system of intercorrelated variables. Clearly, in this case we need to sort out the influences of duration, total amplitude, and growth rate through multiple regression, using the 350 amplitude boundary line to separate a group of "high" and "low" amplitude urban areas. In two successive regressions total amplitude was regressed separately against fall rate and growth rate and duration. The principal results are set forth in Table G-2. They may be summarized as follows:

1. The relationship between fall rate and total amplitude differs strikingly between the low and high amplitude groups (referred to hereafter as L and H). In the L group, fall rate is substantially and steadily associated with total amplitude. Each per cent change in fall rate is associated with a 4.7 ± 1.9 per cent change in total amplitude. The relationship is more scattered with the H group, but the tendency is for a reverse association, with negative correlation and statistically unreliable regression coefficients (-2.9 ± 2.5). Causation may be indicated by the simple correlations of fall rate of growth and duration (Table G-2, lines 11 and 12). The H fall rate is negatively associated with H duration ($-.454$) and just as strongly associated with H

TABLE G-2

Summary Results of Correlation Analysis: Thirty Local Building Series, Total Amplitude Fall per Year, Growth Rate per Year, and Duration

Line	Item	*Eight High Amplitude Cities from 350.3 to 551.9*		*Twenty-Two Lowest Amplitude Cities from 217.0 to 347.0*	
1.	X1 Mean total specific amplitude	434.5	(60.73)	266.7	(42.23)
2.	X2 Mean specific amplitude per year fall	−26.88	(9.00)	−15.80	(4.42)
3.	X3 Mean duration	22.38	(7.21)	18.58	(4.16)
4.	X4 Per year growth rate	2.896	(3.65)	2.260	(1.53)
	Correlation coefficients				
5.	$R_{1.2}$ (norm.)	−.2291		.4461	
6.	$R_{1.3}$	.8173		.0342	
7.	$R_{1.4}$	−.2303		.2015	
8.	$R_{13.4}$	.806		.0706	
9.	$R_{14.3}$	−.0303		.2104	
10.	$R_{1.34}$ (norm.)	.7318		.000	
11.	$R_{2.3}$	−.4539		.2418	
12.	$R_{2.4}$	.4635		.0257	
13.	$R_{3.4}$	−.2611		−.1685	
	Slope coefficients				
14.	Simple bX2	−2.924	(2.48)	4.654	(1.87)
15.	Multiple bX3	6.837	(2.25)	.7119	(2.30)
16.	Multiple bX4	−.30	(4.43)	5.879	(6.27)

NOTE: Figures in parentheses are standard errors or deviations.

growth rate (.464). But whereas H duration dominates total H amplitudes both on the simple and multiple regression ($R_{13.4}$ = .81) and emerges with statistically significant regression coefficients (6.8 ± 2.2), H growth rate emerges with zero influence on H total amplitude ($R_{14.3}$ = .03) and with a statistically unreliable regression coefficient (−.30 ± 4.43). The hypothesis is thus suggested that H fall rates influence total amplitude inversely through an inverse influence on H duration. The L fall rate has simpler relationships at lower amplitudes. It is strongly associated with total amplitude ($R_{1.2}$ = .45) but weakly with duration (R_2 = .24) and is dissociated with growth rate ($R_{2.4}$ = .03). Whatever causes more violent rates of fall will generate higher total amplitudes without significantly affecting growth rate or duration. But at the critical amplitude boundary, the higher fall rate recoils and reduces amplitude by shortening duration. This conclusion seems to be indicated by the regression.

2. Growth rate per se exerts little influence on total amplitude, as indicated by low partial correlation coefficients ($R_{14.3}$ = − .03, .21) and unreliable net regression coefficients.

3. The influence of duration is more complex. Whatever it is that shapes duration exerts little influence on total amplitude because of an implicit inverse association of duration and per year rates of change. Longer durations do not cumulate more amplitude but result in slower movements up to the critical boundary. Thereafter, rates of movement are nearly constant and whatever stretches out duration builds up amplitude. For this reason, the duration variable is strongly associated with H total amplitude ($R_{13.4}$ = .806), with a reliable and high-valued net regression coefficient (6.8 ± 2.2), while L durations bear no influence on total amplitude ($R_{13.4}$ = .07) and emerge with a weak and unreliable net regression coefficient (.71 ± 2.3).