Basic facts about cities relevant to the monocentric city model[1]

Matthew Turner

Brown University

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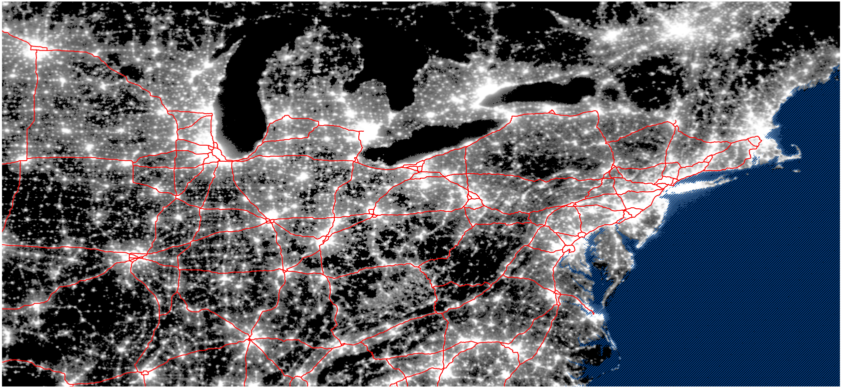


This is the basic phenomena that we would like to explain.

- Many cities are approximately circular.
- Transportation seems important to location patterns.
- Cities look like part of a system of cities.
- We start with studying cities in isolation, then worry about how they interact.

Population density decreasing in distance

The monocentric city model rationalizes density gradients. One of the earliest demonstrations of such gradients was Clark (Royal Statistical Association, 1951).

Clark conducts a remarkable, pre-computer empirical exercise. Define,

$$y = \text{population density} \tag{1}$$

$$x = \text{distance to center,} \tag{2}$$

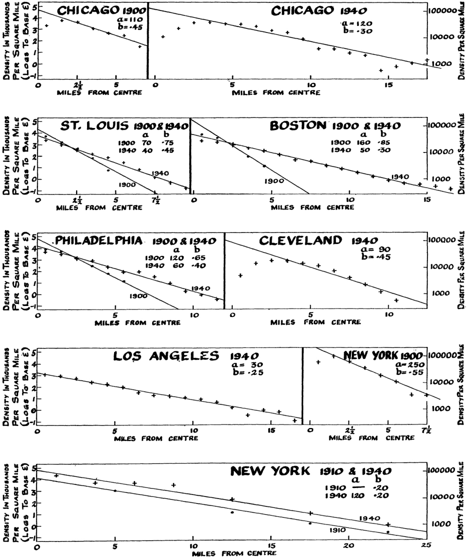
and estimate

$$y = Ae^{-bx}$$

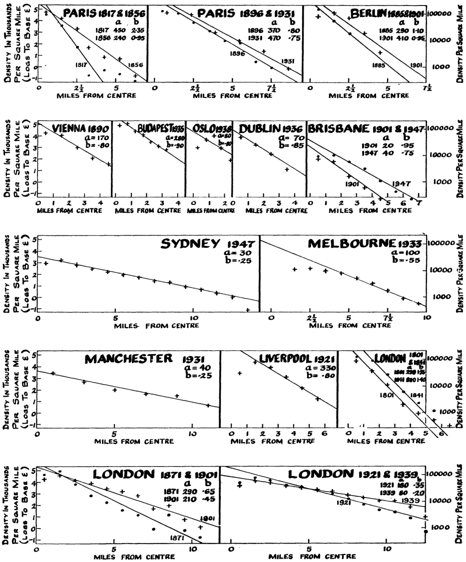
or equivalently,

$$\ln y = \ln A - bx,$$

He uses data from about 20 cities, several years.



CHICAGO 1900
a=110
b=·45
CHICAGO 1940
a=120
b=·30
ST. LOUIS 1900 & 1940
a b
1900 70 ·75
1940 40 ·45
BOSTON 1900 & 1940
a b
1900 160 ·85
1940 50 ·30
PHILADELPHIA 1900 & 1940
a b
1900 120 ·65
1940 60 ·40
CLEVELAND 1940
a= 90
b= ·45
LOS ANGELES 1940
a= 30
b= ·25
NEW YORK 1900
a=250
b=·55
NEW YORK 1910 & 1940
a b
1910 — ·20
1940 120 ·20
1900
1940
1910
MILES FROM CENTRE
DENSITY IN THOUSANDS PER SQUARE MILE (LOGS TO BASE E)
DENSITY PER SQUARE MILE
100000
10000
1000



Density in Thousands Per Square Mile (Logs to Base e)
Density per Square Mile
Miles from Centre
PARIS 1817 & 1856
a b
1817 450 2·35
1856 240 0·95
PARIS 1896 & 1931
a b
1896 370 ·80
1931 470 ·75
BERLIN 1885 & 1901
a b
1885 290 1·10
1901 410 0·95
VIENNA 1890
a = 170
b = ·80
BUDAPEST 1935
OSLO 1938
DUBLIN 1936
a = 70
b = ·85
BRISBANE 1901 & 1947
a b
1901 20 ·95
1947 40 ·75
SYDNEY 1947
a = 30
b = ·25
MELBOURNE 1933
a = 100
b = ·55
MANCHESTER 1931
a = 40
b = ·25
LIVERPOOL 1921
a = 330
b = ·80
LONDON 1801 & 1841
LONDON 1871 & 1901
a b
1871 290 ·65
1901 210 ·45
LONDON 1921 & 1939
a b
1921 180 ·35
1939 80 ·20

Parameters in the Expression $y = Ae^{-bx}$ *Relating Density of Resident Population in Thousands per Square Mile to Distance in Miles from the Centre of the City*

Region, City and Date	*A*	*b*	*Region, City and Date*	*A*	*b*
Australia—			Continental Europe (*continued*)—		
Brisbane			Oslo		
1901	20	·95	1938	80	·80
1947	40	·75	Paris		
Melbourne			1817	450	2·35
1933	100	·55	1856	240	·95
Sydney			1896	370	·80
1947	30	·25	1931	470	·75
British Isles—			Vienna		
Dublin			1890	170	·80
1936	70	·85	United States of America—		
Liverpool			Boston		
1921	330	·80	1900	160	·85
London			1940	50	·30
1801	290	1·35	Chicago		
1841	800	1·40	1900	110	·45
1871	290	·65	1940	120	·30
1901	210	·45	Cleveland		
1921	180	·35	1940	90	·45
1939	80	·20	Los Angeles		
Manchester			1940	30	·25
1931	40	·25	New York		
Ceylon—Colombo			1900	250	·55
1946	60	·40	1910	?	·20
Continental Europe—			1940	120	·20
Berlin			Philadelphia		
1885	290	1·10	1900	120	·65
1901	410	·95	1940	60	·40
Budapest			St. Louis		
			1900	70	·75
1935	280	·90	1940	40	·45

Notice:

- All have broadly downward sloping density gradients (except near zero where there is industry).
- All get flatter and lower over time – cities are spreading out.
- Population densities were MUCH higher than they are now. Several large cities recorded densities of 100,000/sq mile. Very few modern cities are anywhere near that dense. Toronto Ward 20 is about 26,000/mile.
- Over time, we've seen population and income go up, and transportation costs go down. Thus, we can't really check more than the basic comparative static of a downward sloping gradient.
- There are many more of these papers: Mills and Tan (Urban Studies,1980), Harrison and Kain (JUE 1974), Arnott and Small (JEL 1998).

Population density gradient and transportation costs

Baum-Snow (QJE 2007) conducts the following regression for 139 US MSA's between 1950 and 1990.

$$
\begin{aligned}
\Delta \ln N_i^{\text{CBD}} &= \delta_0 + \delta_1 \Delta \text{ray}_i + \Delta_2 \ln N_i^{\text{MSA}} + \delta_3 X_i + \epsilon_i \\
N &= \text{population for CBD or MSA} \\
X &= \text{Controls; area, income distribution, mean income} \\
\text{ray} &= \text{Interstate highway rays through CBD}
\end{aligned}
$$

- Sample is populations for constant boundary centers and whole metropolitan region. $\delta_1 < 0 \implies$ expansion when transport cost down (rays up).
- With logs on both sides, this is really estimating population share in center.
- This is a test of the main comparative static of the monocentric city model.

TABLE I

AGGREGATE TRENDS IN SUBURBANIZATION, 1950–1990

	1950	1960	1970	1980	1990	Percent change 1950–1990
Panel A: Large MSAs						
MSA population	92.9	115.8	134.0	144.8	159.8	72
Total CC population	44.7	48.5	51.3	49.2	51.0	14
Constant geography CC population	44.7	44.2	42.6	37.9	37.1	−17
N for constant geog. CC population	139	132	139	139	139	
Panel B: Large Inland MSAs						
MSA population	39.2	48.9	57.0	65.0	73.5	88
Total CC population	16.8	19.7	22.1	22.1	23.2	38
Constant geography CC population	16.8	16.5	15.4	13.3	12.5	−26
N for constant geog. CC population	100	94	100	100	100	
Total U. S. population	150.7	178.5	202.1	225.2	247.1	64

Notes: All populations are in millions. CC stands for central city. The sample includes all metropolitan areas (MSAs) of at least 100,000 people with central cities of at least 50,000 people in 1950. The sample in Panel B excludes MSAs with central cities located within 20 miles of a coast, major lake shore, or international border. MSA populations are for geography as of year 2000. Constant geography central city population uses 1950 central city geography. Census tract data are not available to build constant geography central city populations for some small cities in 1960. These cities are assigned a population of 0 for constructing the aggregates. Reported total U. S. population excludes Alaska and Hawaii.

Long-Difference Regressions of the Determinants of Constant Geography Central City Population Growth, 1950–1990

	Large MSAs in 1950					
		Change in log population in constant geography central cities				
	OLS3	IV1	IV2	IV3	IV4	IV5
Change in number of rays	−.059	−.030	−.106	−.123	−.114	−.101
	(.014)**	(.022)	(.032)**	(.029)**	(.026)**	(.046)*
1950 central city radius	.080		.111	.113	.106	.125
	(.014)**		(.023)**	(.023)**	(.023)**	(.021)**
Change in simulated log income	.084			.048	−6.247	−.137
	(.378)			(.417)	(6.174)	(.480)
Change in log of MSA population	.363			.424	.374	.405
	(.082)**			(.094)**	(.079)**	(.108)**
Change in Gini coeff of simulated income					−23.416	
					(23.266)	
Log 1950 MSA population						−.062
						(.062)
Constant	−.640	−.203	−.359	−.588	4.580	−.611
	(.260)*	(.078)*	(.076)**	(.281)*	(5.091)	(.265)*
Observations	139	139	139	139	139	139
R-squared	.39	.00	.01	.30	.33	.37

Notes: In columns IV1–IV5, the number of rays in the 1947 plan instruments for the change in the number of rays. Standard errors are clustered by state of the MSA central city. Standard errors are in parentheses. ** indicates significant at the 1 percent level, * indicates significant at 5 percent level. Summary statistics are in the Appendix Table. First stage results are in Table II.

Roads and population density

- This basic research design has been replicated on Chinese data (Baum-Snow et al, 2018) and Spanish data (Garcia-Lopez etal, unp 2013). Roads have the same effect everywhere?
- The effects are huge. Central city population declined 17% over study period, while MSA population grew by 72%. Each highway ray causes about a 9% decrease, sample mean is about 2.2, so highways cause about 20% decrease in mean central city. Slope of population density gradient is sensitive to transportation costs.

Conclusion

- Many of the basic predictions of the monocentric city model with housing are consistent with observation:
  - Decreasing density gradient of population and density.
  - Gradients flatter, city larger with falling transportation costs.
- Some are not:
  - Non-contiguous development
  - non-monocentric pattern
- Monocentric city model does not answer the question of why cities exist at all.