"Bones, Bombs, and Break Points: The Geography of Economic Activity", Davis and Weinstein, *AER*, 2002

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April 21, 2010

Three Theories of City Growth

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- Example: Gabaix (1999).
  - N_t^i is size of city i at time t.
  - The law of motion for city sizes is $N_{t+1}^i = g_{t+1}^i N_t^i$ where g_t^i's are iid across i and t with distribution $f(g)$.

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- Advantages:
  - Only regional data available.
  - Cities poorly defined: threshold to be counted as a city changes over time.
  - In early periods, hardly anyone lived in a city.
- Disadvantages: rest of the literature focuses on cities.

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- Since 1920, population available from government census for 47 prefectures.
- These are matched to provide data for 39 regions.
- Population is then divided by area to get density, which is the main variable of interest. Necessary because regions are arbitrarily defined.

1. Large variation in regional densities throughout history.

TABLE 1—PRINCIPAL FEATURES OF HISTORICAL ECONOMIES

Year	Population in thousands	Share of five largest regions	Relative var of log population density	Zipf coefficient	Raw correlation with 1998	Rank correlation with 1998
−6000 to −300	125	0.39	2.46	−0.809 (0.217)	0.53	0.31
−300 to 300	595	0.23	0.93	−1.028 (0.134)	0.67	0.50
725	4,511	0.20	0.72	−1.207 (0.133)	0.60	0.71
800	5,506	0.18	0.75	−1.184 (0.152)	0.57	0.68
900	7,442	0.29	0.68	−1.230 (0.166)	0.48	0.65
1150	6,836	0.20	0.66	−1.169 (0.141)	0.53	0.73
1600	12,266	0.30	0.64	−1.192 (0.068)	0.76	0.83
1721	31,290	0.21	0.43	−1.582 (0.113)	0.85	0.84
1798	30,531	0.21	0.37	−1.697 (0.120)	0.83	0.81
1872	33,748	0.18	0.30	−1.877 (0.140)	0.76	0.78
1920	53,032	0.25	0.43	−1.476 (0.043)	0.94	0.93
1998	119,486	0.41	1.00	−0.963 (0.025)	1.00	1.00

Notes: Population for years prior to 725 is based on Koyama (1978). All time periods have 39 regions with Hokkaido and Okinawa dropped from all years. The relative variance of the log population is the variance of the log of population density in year *t* divided by the variance of the log of population density in 1998. The Zipf coefficient is from a regression of log rank on log population density using 1920 log density as instruments for the years prior to 725 and 1998 data for later years. Standard errors are in parentheses. The correlation columns indicate the raw and rank correlations between regional density in a given year and regional density in 1998.

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- Possible explanation: port cities declined over 1721 – 1872 period due to the closure of trade.

3. Rise in variation in densities corresponding to Industrial Revolution.

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- Gabaix and Ibragimov (2009) show that using $\log(rank - 1/2)$ minimizes bias. Clauset, Shalizi, and Newman (2009) suggest that MLE is better than OLS for estimating the coefficients of power laws.

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- Could high ancient correlation be due to correlation of archaeological digs and current population?

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- Necessary to control for government spending on reconstruction.

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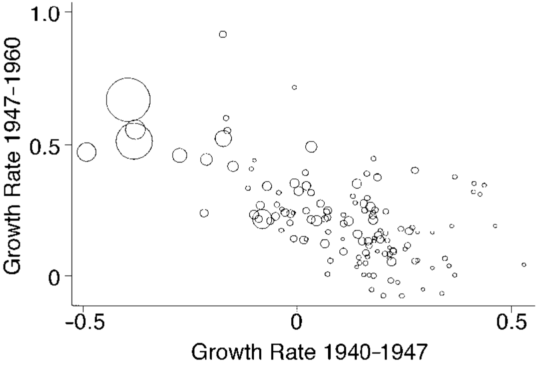

FIGURE 1. EFFECTS OF BOMBING ON CITIES WITH MORE THAN 30,000 INHABITANTS

Note: The figure presents data for cities with positive casualty rates only.

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- Suppose city size follows $\log S_t^i = \Omega^i + \varepsilon_t^i$ and shocks are $\varepsilon_{t+1}^i = \rho\varepsilon_t^i + \nu_{t+1}^i$ where $\rho \in [0, 1]$ and ν_t^i is iid.

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- If $\rho = 1$, log city size follows a random walk. If $\rho = 0$, log city size is iid.
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- Because this might be correlated with past growth rates, they instrument with buildings destroyed per capita and deaths per capita.

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- The estimate of $\rho - 1$ is -1.027, so this implies that $\rho \approx 0$.
- Over a $15 - 20$ year period population is highly stationary.
- Government spending on reconstruction significant and positive (σ increase leads to 2.2% increase in size of city). However, these sums were typically small.
- To see if US targeted fast growing cities, control for $1925 - 1940$ growth. Reduces coefficient for 1960, but extending to 1965 gets $\rho \approx 1$.
- Another objection is that perhaps refugees left the city, then later returned. So, consider Hiroshima and Nagasaki where deaths were very high.

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TABLE 2—INSTRUMENTAL VARIABLES EQUATION (DEPENDENT VARIABLE = RATE OF GROWTH IN CITY POPULATION BETWEEN 1940 AND 1947)

Independent variable	Coefficient
Constant	0.213
	(0.006)
Deaths per capita	−0.665
	(0.506)
Buildings destroyed per capita	−2.335
	(0.184)
R^2:	0.409
Number of observations:	303

Note: Standard errors are in parentheses.

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TABLE 3—TWO-STAGE LEAST-SQUARES ESTIMATES OF IMPACT OF BOMBING ON CITIES (INSTRUMENTS: DEATHS PER CAPITA AND BUILDINGS DESTROYED PER CAPITA)

	Dependent variable = growth rate of population between 1947 and 1960		Dependent variable = growth rate of population between 1947 and 1965
Independent variable	(i)	(ii)	(iii)
Growth rate of population between 1940 and 1947	−1.048 (0.097)	−0.759 (0.094)	−1.027 (0.163)
Government reconstruction expenses	1.024 (0.387)	0.628 (0.298)	0.392 (0.514)
Growth rate of population between 1925 and 1940		0.444 (0.054)	0.617 (0.092)
R^2:	0.279	0.566	0.386
Number of observations:	303	303	303

Note: Standard errors are in parentheses.

5. Mean reversion in populations after temporary shocks.

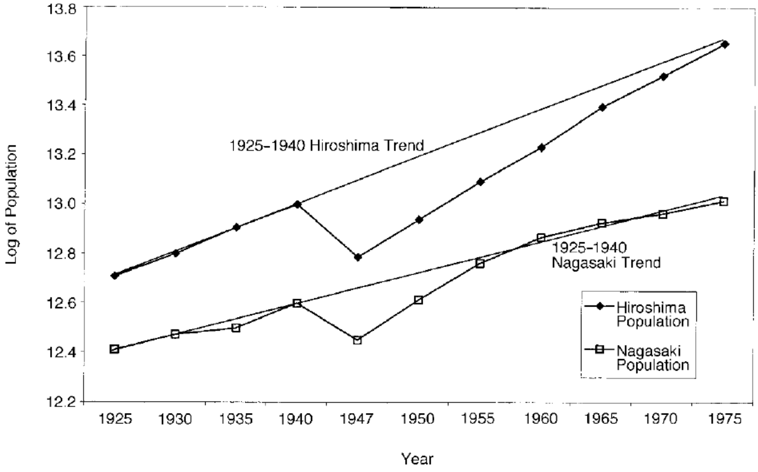

FIGURE 2. POPULATION GROWTH

Which theory fits the data?

TABLE 4—MATCH BETWEEN THEORIES AND PREDICTIONS

Stylized fact	Increasing returns	Random growth	Locational fundamentals
Large variation in regional densities at all times	−	+	+
Zipf's Law	−	+	+
Rise in variation with Industrial Revolution	+	−	−
Persistence in regional densities	?	?	+
Mean reversion after temporary shocks	?	−	+

Which theory fits the data?

- Increasing returns theory's strongest point is predicting the rise of densities during the Industrial Revolution.
- Random growth theory's strongest point is predicting Zipf's Law but fails at describing mean reversion.
- According to Davis and Weinstein, location fundamentals does best at explaining the data, with the exception of the Industrial Revolution.

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- Suppose there is a steady-state process $G(S)$. One candidate that is a fixed point of this equation is $G(S) = a/S$, i.e. a Zipf's Law with coefficient -1.

Conclusions

- Since there is high persistence, and no evidence of break points, policy doesn't do much?
- Variation in densities has always been high.
- Zipf's Law seems to hold. (maybe?)
- Variation rose during the Industrial Revolution.
- Densities persist in the face of strong temporary shocks.
- Random growth theory can be rejected, but parts of increasing returns and location fundamentals cannot.