GSD
Global System Dynamics & Policies

LONDON GSD CONFERENCE
THURSDAY JULY 2ND 2009
THE HOUSE OF LORDS

SYSTEMS FOR SUSTAINABLE CITIES

How Big Can Cities Get?

Explorations in the Dynamics of Shape, Size & Scale

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W Kowloon Corridor
西九龍走廊
King's Park
京士柏
Chatham Rd N
Hung Hom
紅磡
Hung Hom Bypass
Canton Rd
Kowloon Park
九龍公園
Tsim Sha Tsui
尖沙咀
Salisbury Rd
Cross Harbour Tunnel
W Kowloon Hwy
西九龍公路
Sheung Wan
上環
Mid-levels
半山區
中環
Harcourt Rd
Wan Chai
Wan Chai District
灣仔區
Causeway Bay
銅鑼灣
東區走廊
Caroline Hill
Leighton Hill
Morrison Hill
2000 ft
1 km

Outline

- The Key Issue: Macro Stability and Micro Volatility
- Back to Hong Kong: The Dynamics of Tall Buildings
- The Dynamics of Population Size in Rank Space
- The Rank Clock: Cities in the USA from 1790 to 2000
- Distance in the Rank Clock: Growth Dynamics
- The UK from 1901 to 2001
- Very Long Term Dynamics: Cities from 430 BCE
- What Can this Tell Us about Optimal City Size, Density and Agglomeration

The Key Issue: Macro Stability & Micro Volatility

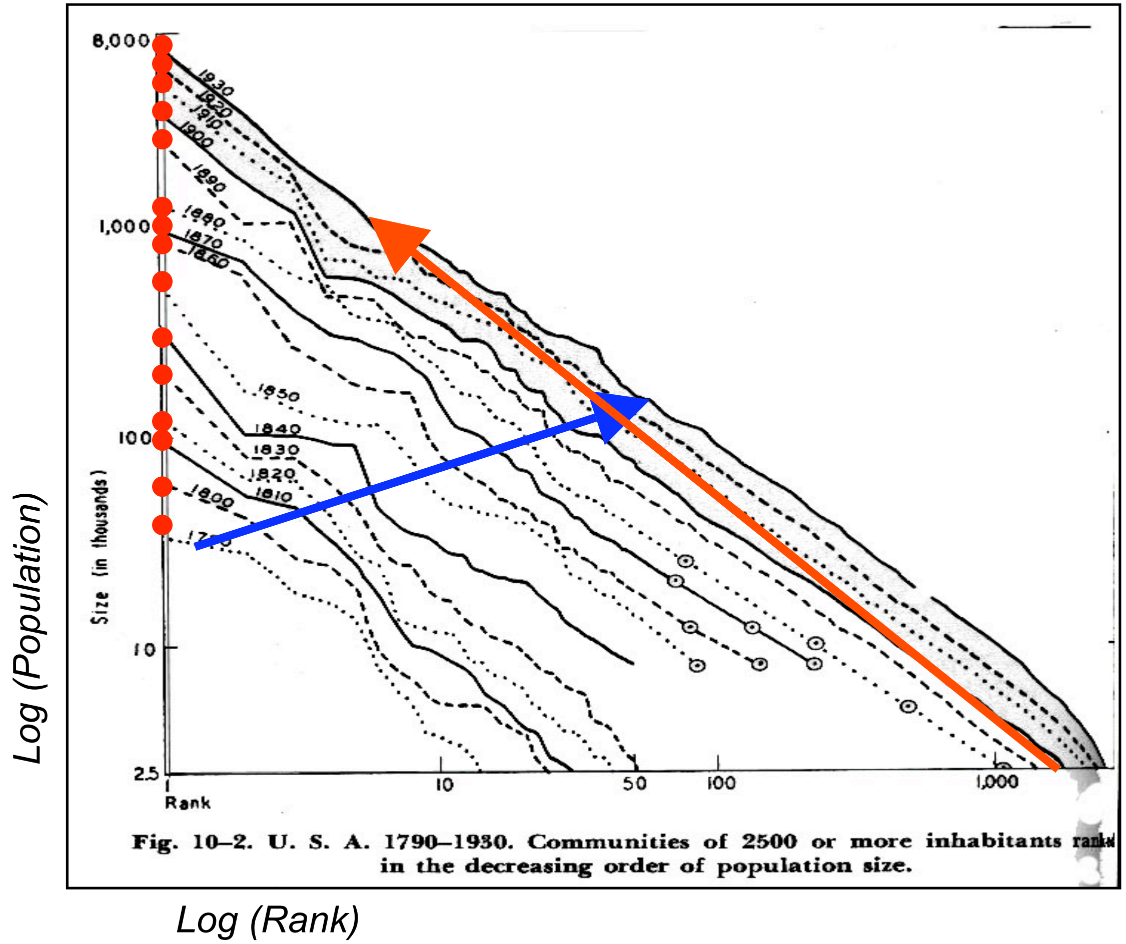


Fig. 10–2. U. S. A. 1790–1930. Communities of 2500 or more inhabitants ranked in the decreasing order of population size.

New York

Houston, TX

Richmond, VA

From George Kingsley Zipf (1949) ***Human Behavior and the Principle of Least Effort*** (Addison-Wesley, Cambridge, MA)

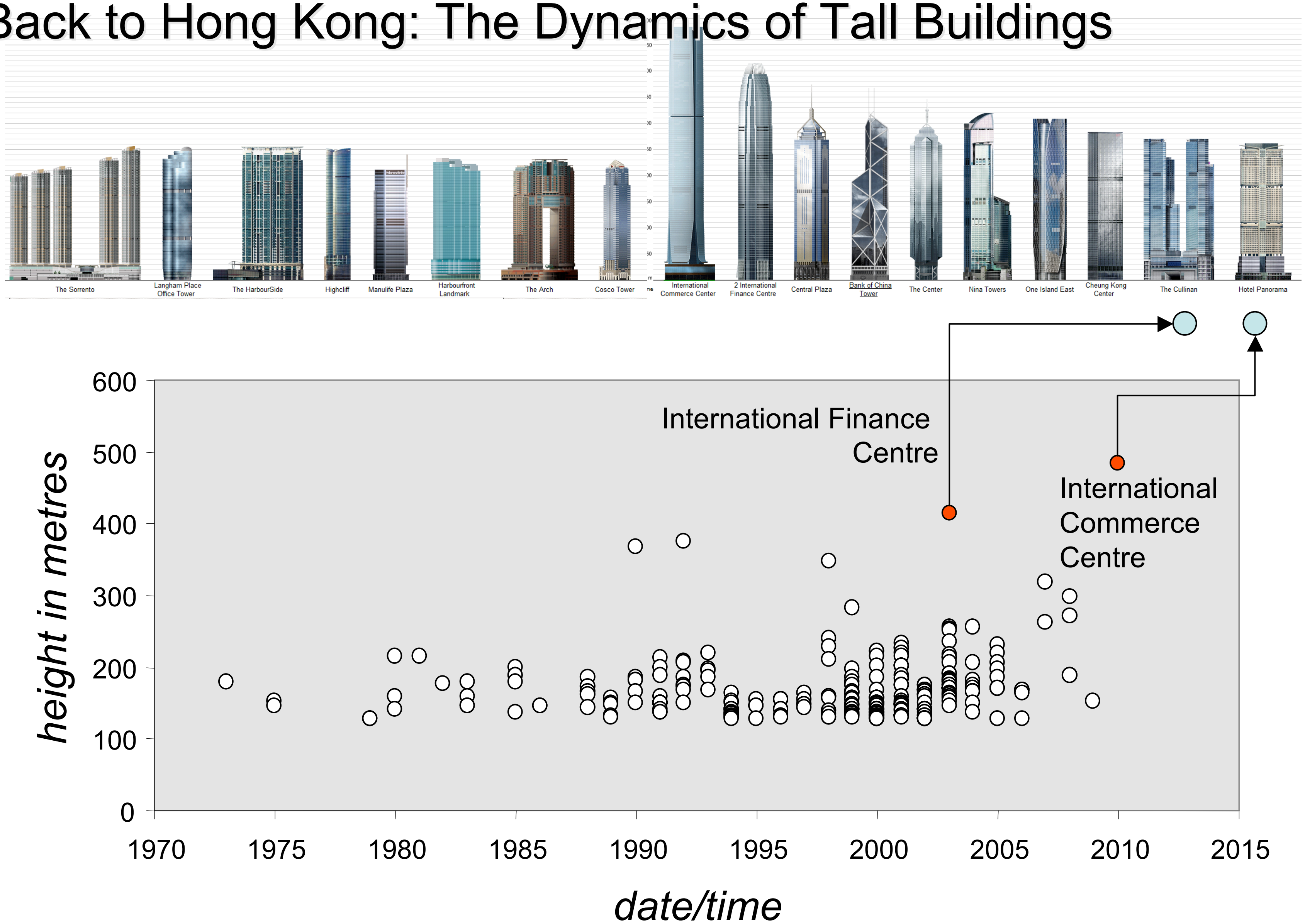
This observation is as old as the hills – here's a nice quote

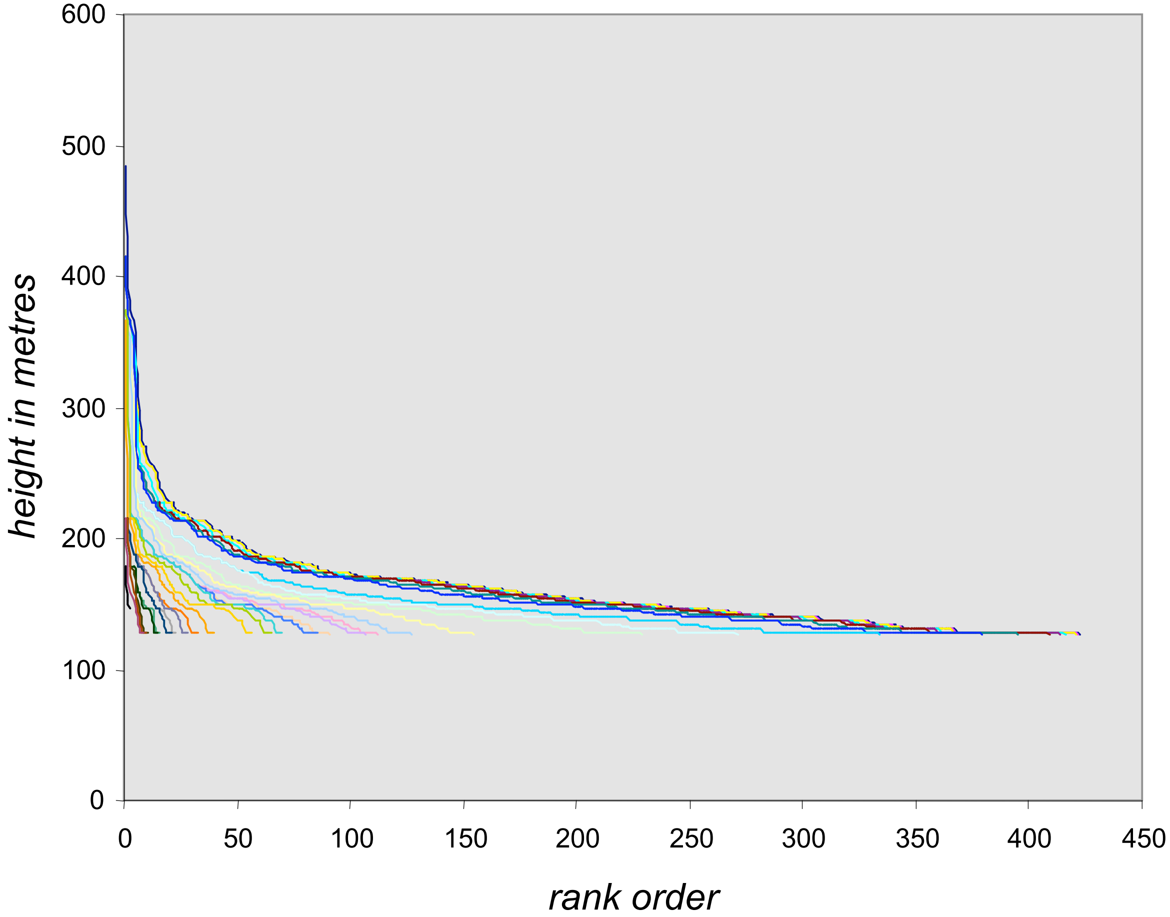
"I will [tell] the story as I go along of small cities no less than of great. Most of those which were great once are small today; and those which in my own lifetime have grown to greatness, were small enough in the old days"

From **Herodotus – The Histories** –

Quoted in the frontispiece by Jane Jacobs (1969) **The Economy of Cities**, Vintage Books, New York

Back to Hong Kong: The Dynamics of Tall Buildings




600
500
400
300
200
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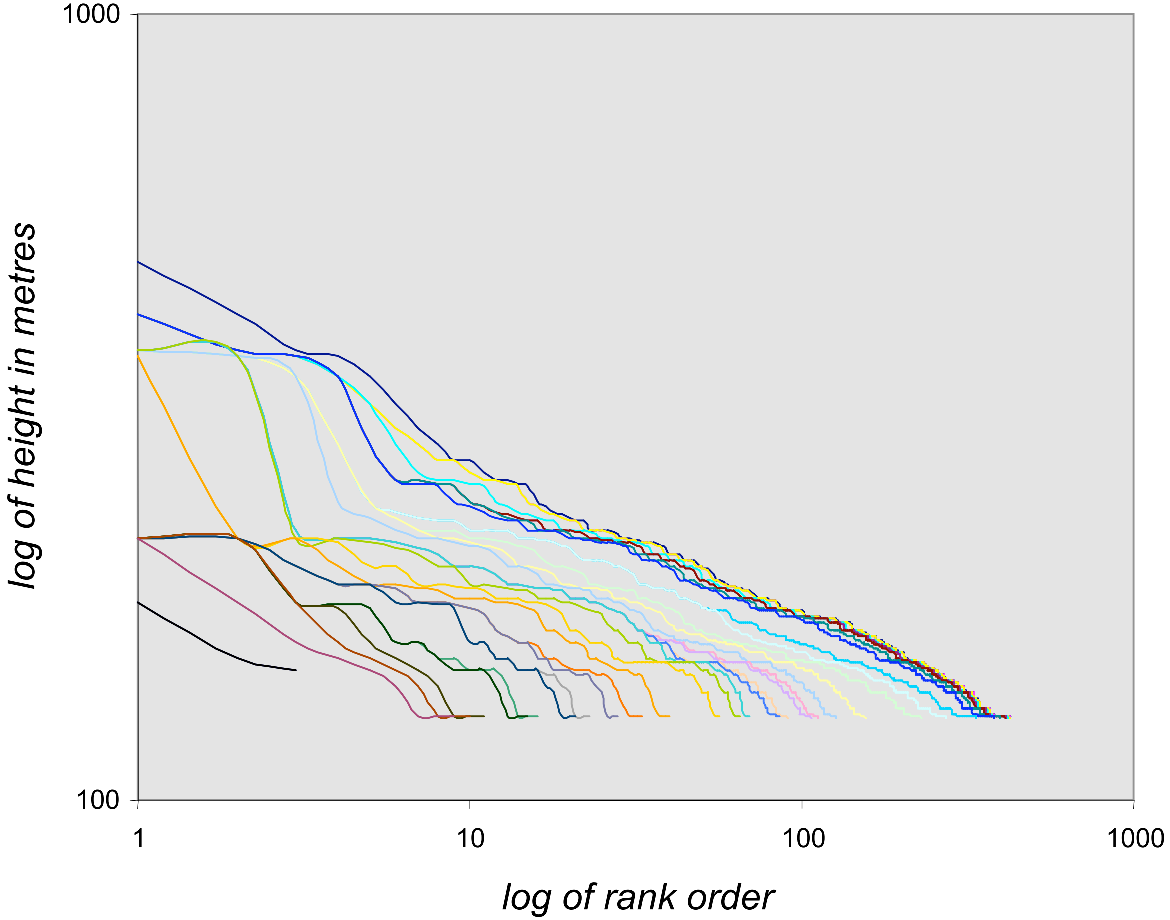
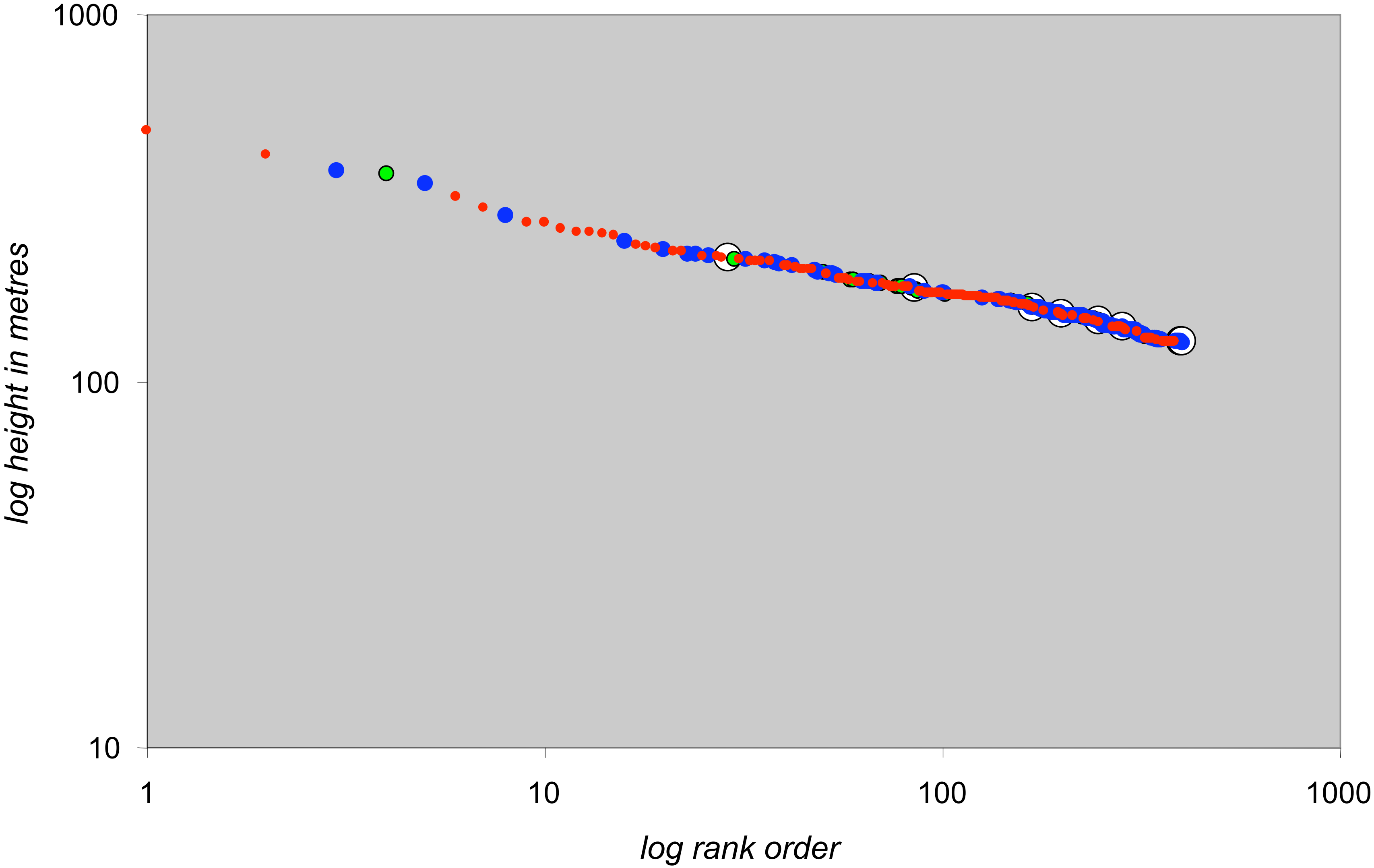
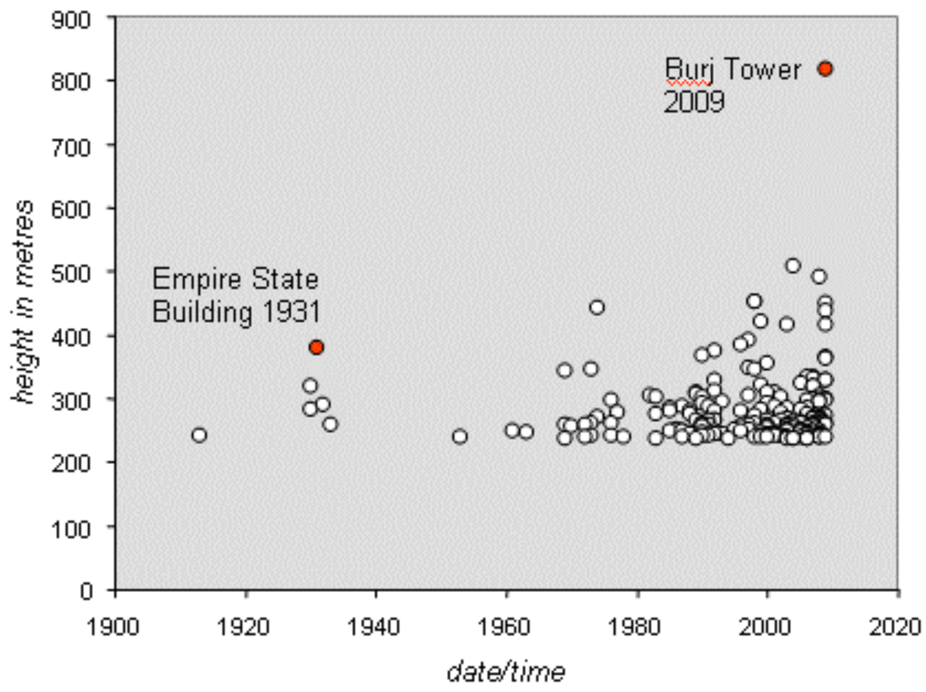
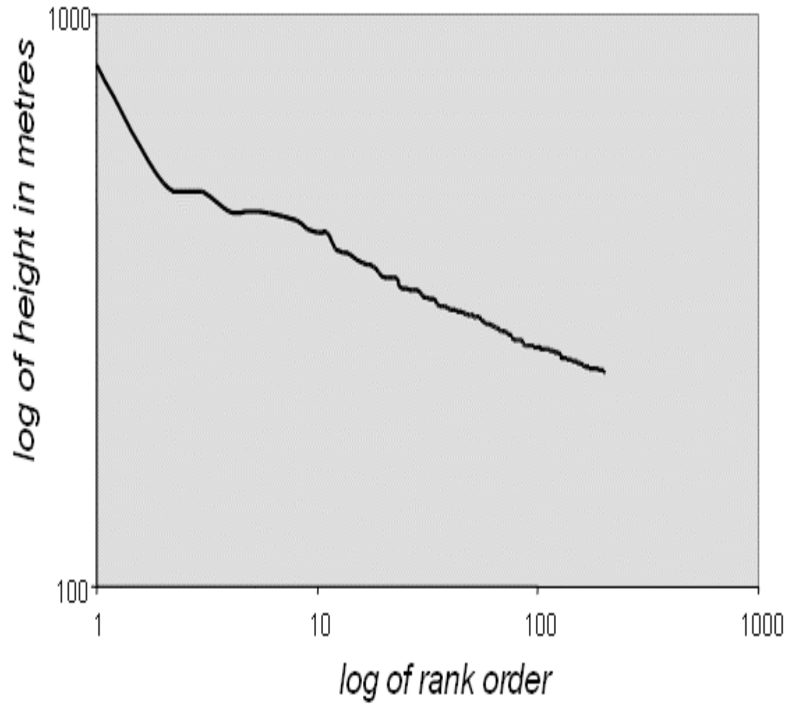
height in metres
0
50
100
150
200
250
300
350
400
450
rank order


1000
100
log of height in metres
1
10
100
1000
log of rank order

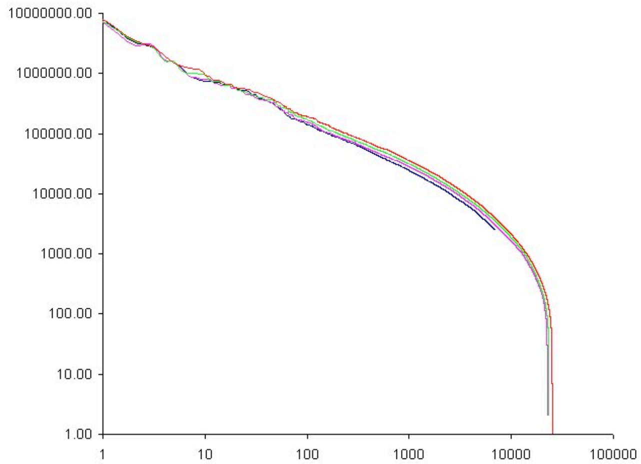

1000
100
10
1
10
100
1000
log height in metres
log rank order

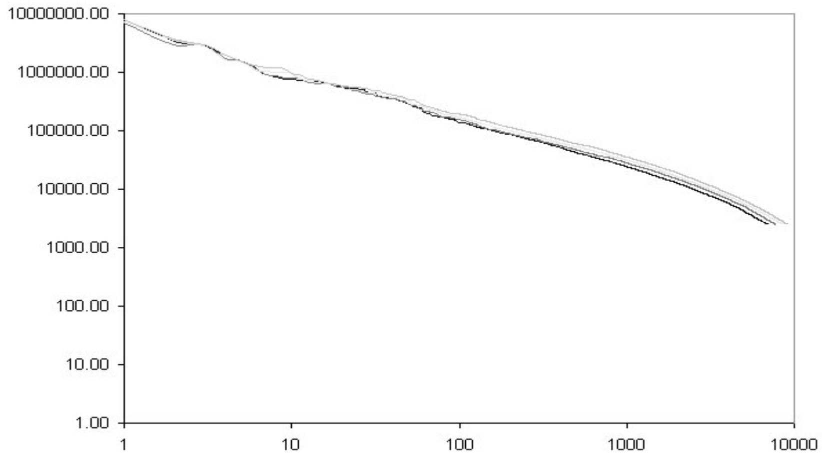
An Indulgence for a Moment as it appear relevant to other speakers later. A Digression on Skyscrapers and Economic Fortunes …





Let me show some other real data on city sizes in rank size terms US 1970 to 2000 for 20000 incorporated places





Parameter/Statistic	1970	1980	1990	2000
R Square	0.979	0.972	0.973	0.969
Intercept	16.790	16.891	17.090	17.360
Zipf-Exponent	**-0.986**	**-0.982**	**-0.995**	**-1.014**

The Dynamics of Rank Size

I have begun to imply something about the dynamics. When we plot the log-log distribution for different periods of time, there is remarkable stability – quite remarkable. Here again is the US system from Zipf with a reworking to 2000

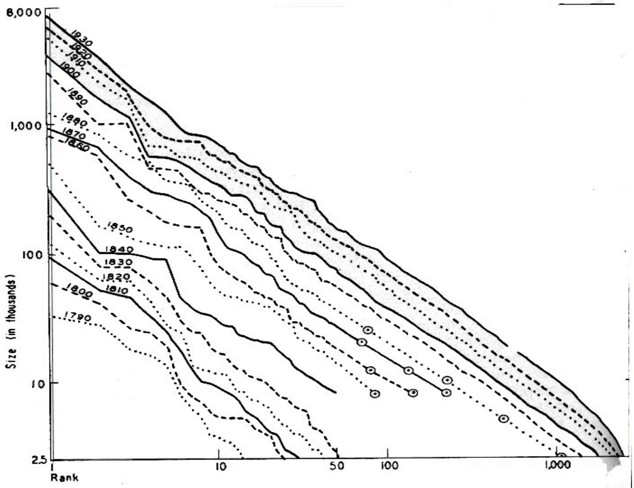
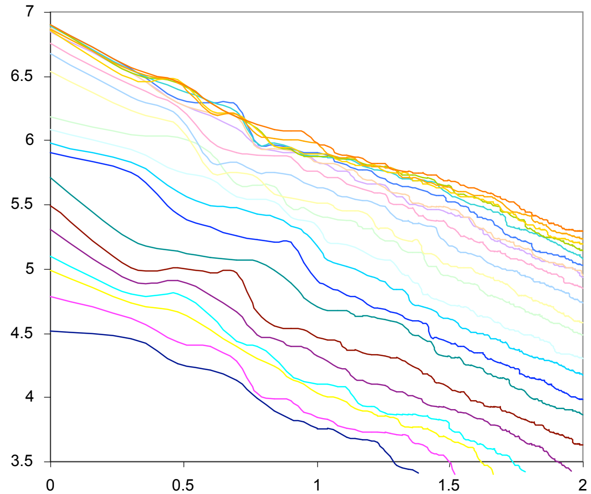


Fig. 10–2. U. S. A. 1790–1930. Communities of 2500 or more inhabitants ranked in the decreasing order of population size.



Year	r-squared	exponent
1790	0.975	0.876
1800	0.968	0.869
1810	0.989	0.909
1820	0.983	0.904
1830	0.990	0.899
1840	0.991	0.894
1850	0.989	0.917
1860	0.994	0.990
1870	0.992	0.978
1880	0.992	0.983
1890	0.992	0.951
1900	0.994	0.946
1910	0.991	0.912
1920	0.995	0.908
1930	0.995	0.903
1940	0.994	0.907
1950	0.990	0.900
1960	0.985	0.838
1970	0.980	0.808
1980	0.986	0.769
1990	0.987	0.744
2000	0.988	0.737

As we have already seen at the beginning of this talk, this remarkable stability is only skin-deep because when we examine how cities rise and fall in the rank-size distribution, then we find that there is equally remarkable volatility.

1. Only 21 cities out of the top 100 in 1840 in the US remain in the top 100 in 2000.
2. For the world city data set we have used, only 6 cities in 1453, the Fall of Constantinople, remain the top 50.
3. There are no cities which were in the top 50 in 430BCE which exist in the top 50 now.

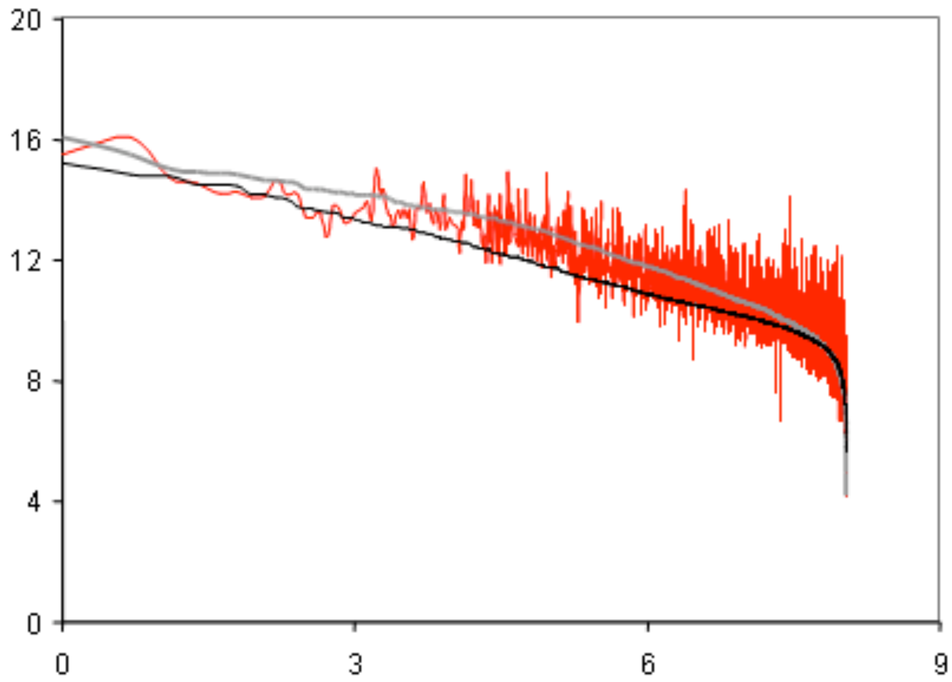
Visualising the Dynamics in Rank Space

So if there is stability of this kind at the aggregate level and such volatility at the micro level, how do we understand it.

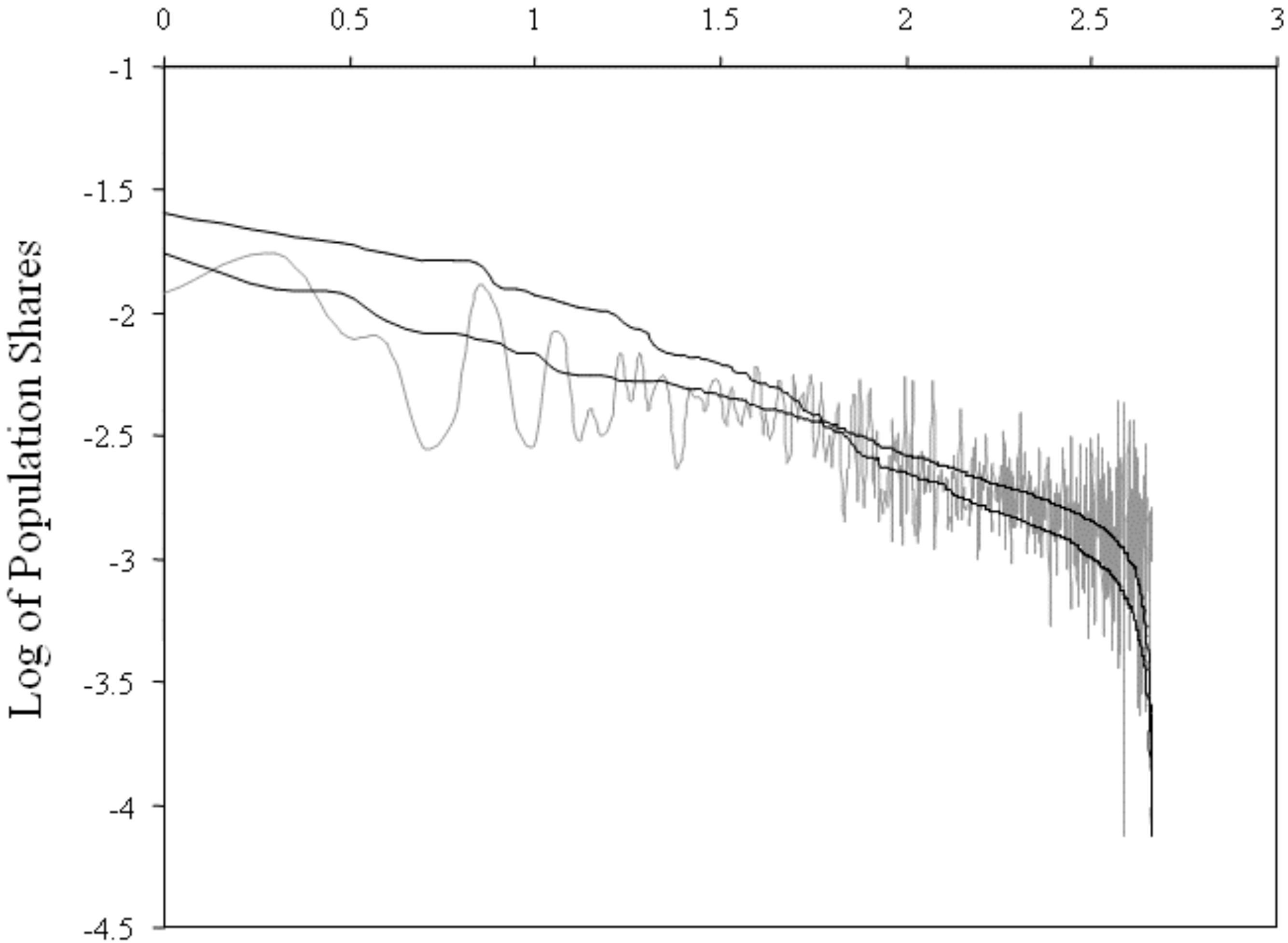
The first thing is to visualise it and the rest of this talk is about such visualisation; I'd like to think we understand it all but we only do so in a phenomenological sense.

There are two devices we have developed: first the Rank Space – i.e. movement in terms of the position of cities on the original rank size or Zipf plot, and secondly a Rank Clock as we will show

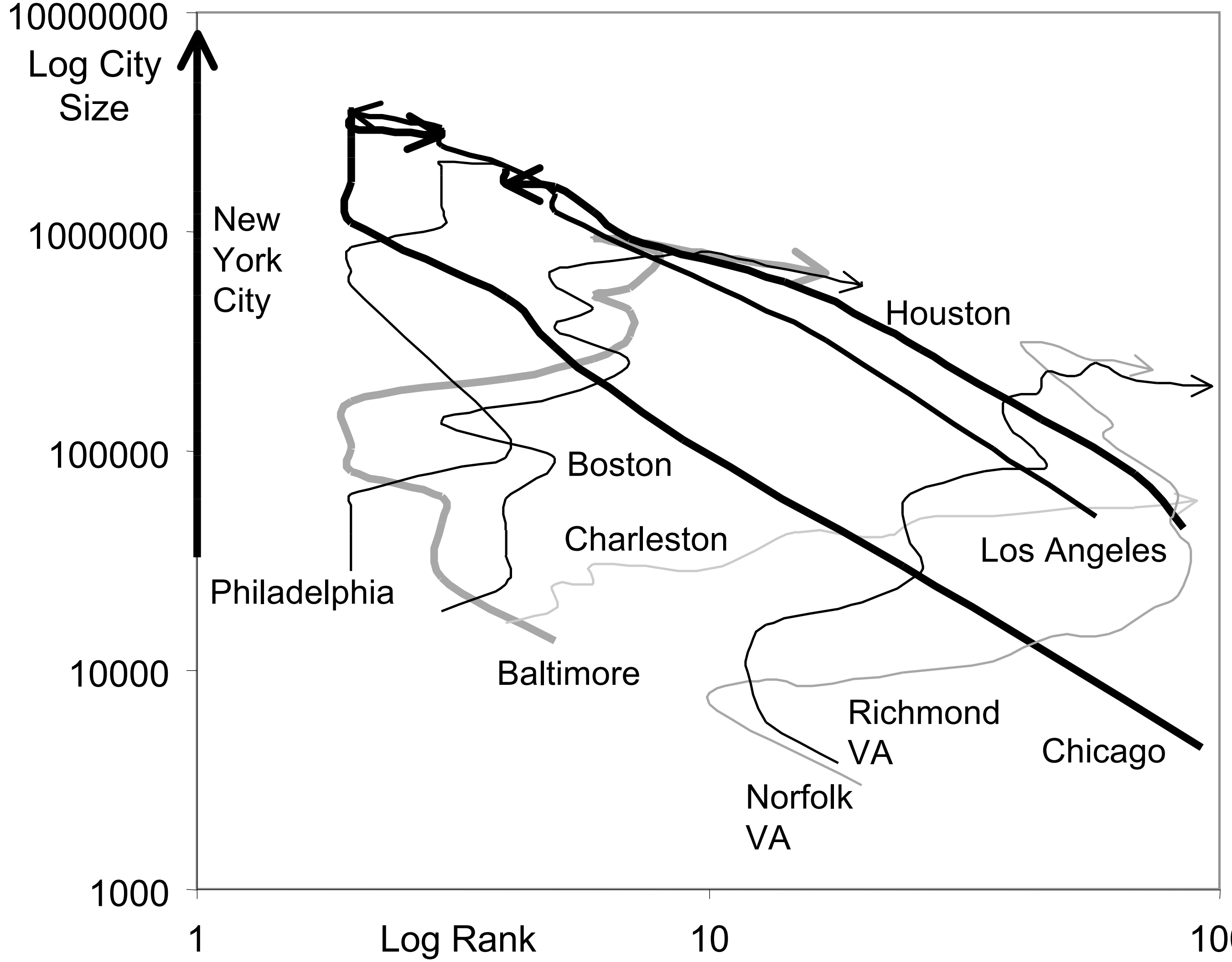
But there is also first the rank shift that we have seen. This is merely plotting a distribution of rank size for a particular year using the ranks at a previous or later year. Here is the US from 1940 to 2000 with switches in rank order when we plot population of the 1901 cities with their 1991 ranks.



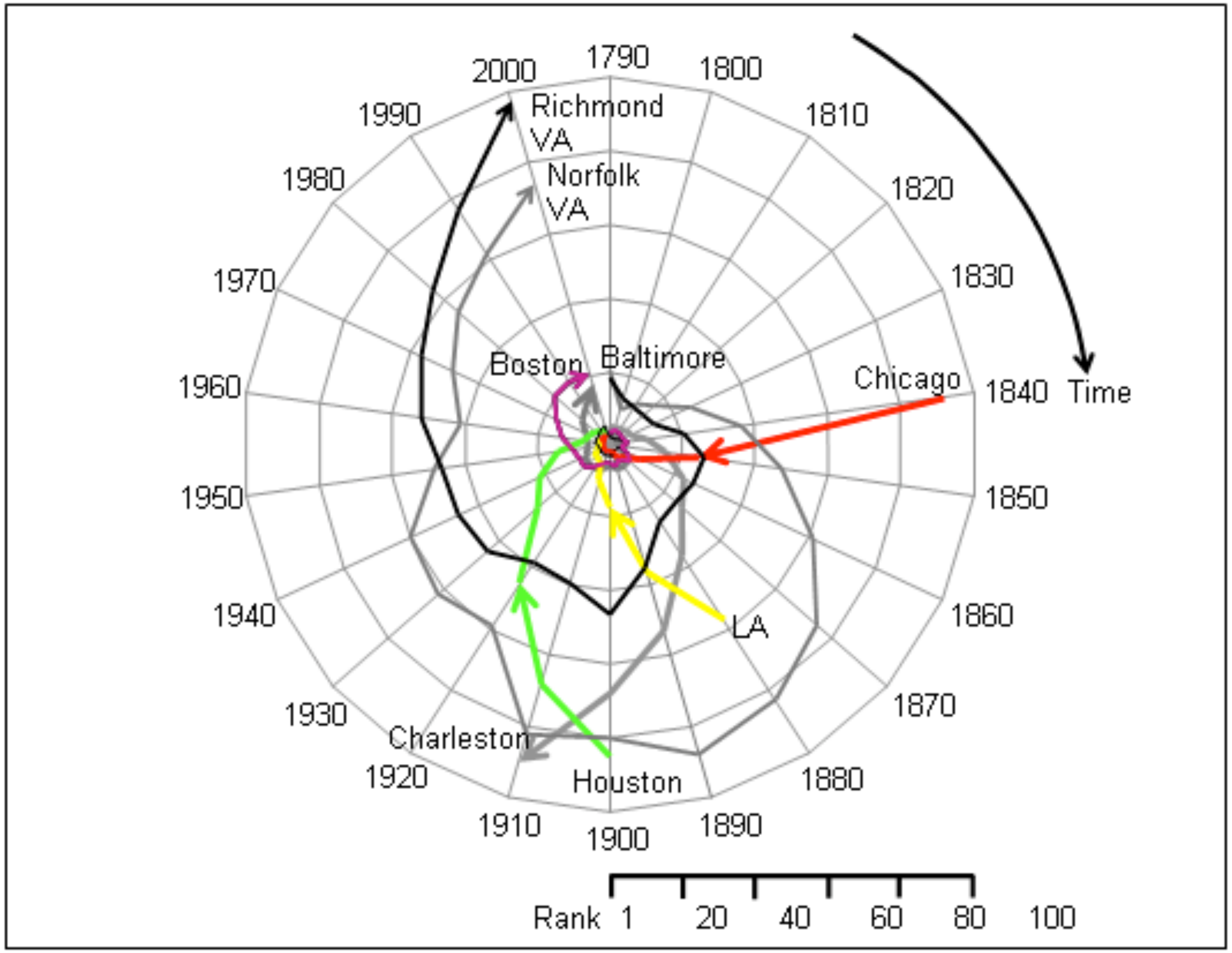
This is for the UK urban system from 1901 to 1991 but the other way around



Here is the change in certain cities from 1790 to 2000 for the US in rank space.



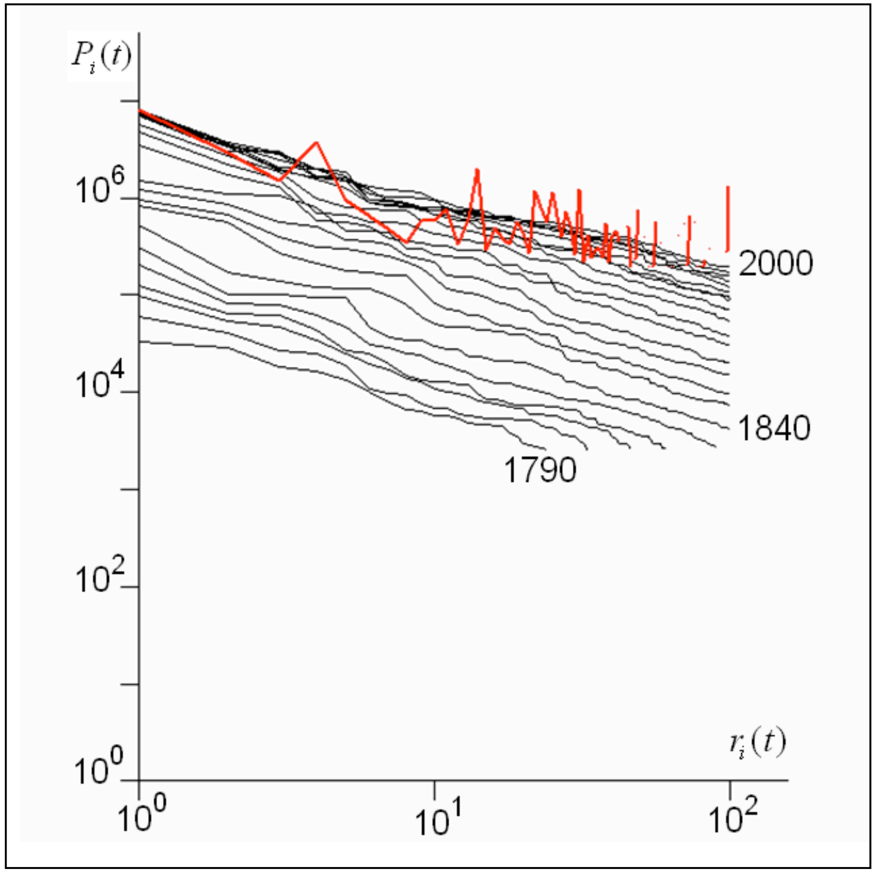
Movement in the Rank Space is confusing hence the Rank Clock

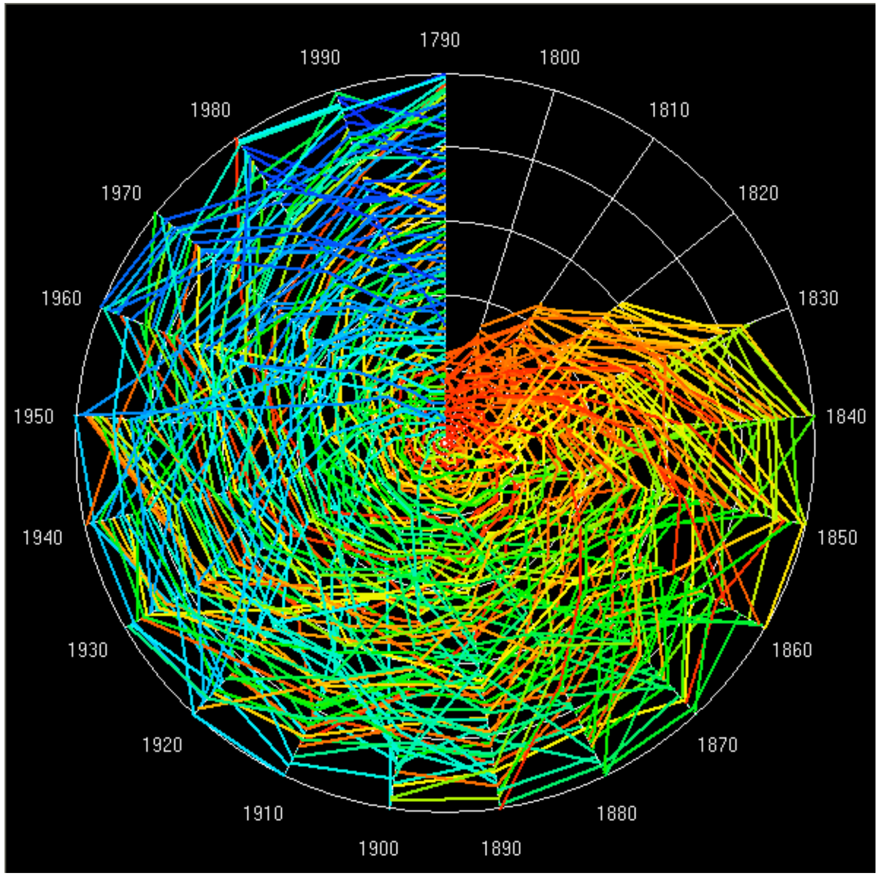


The Rank Clock: Cities in the USA from 1790 to 2000

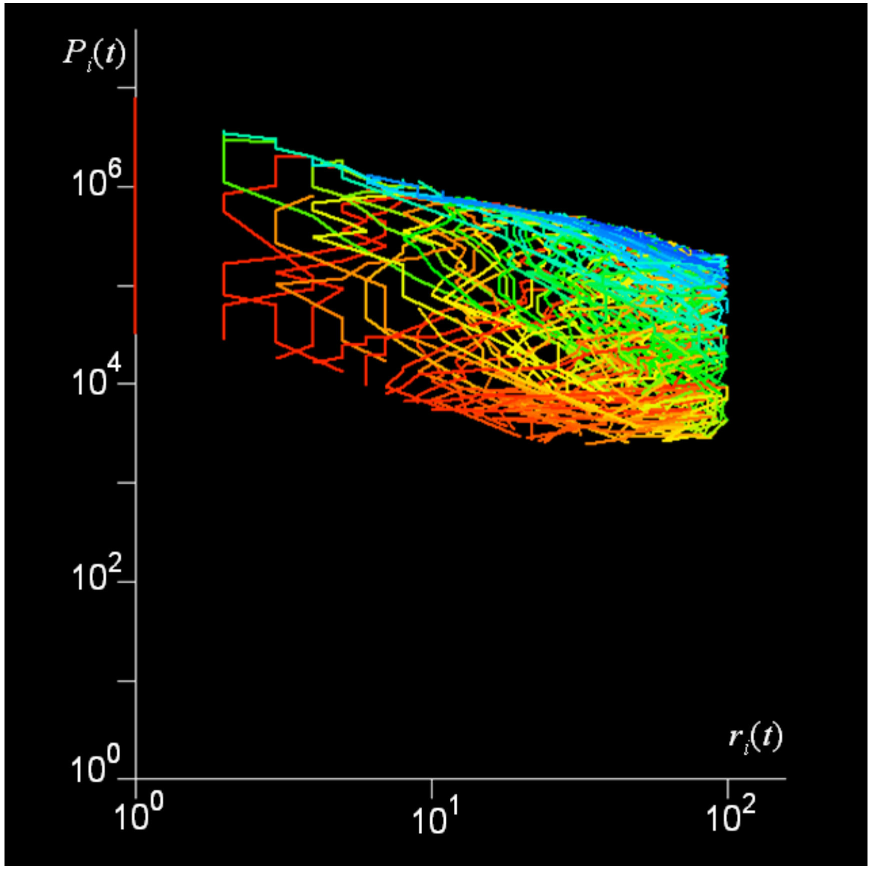
Ok let me now get into the guts of this. We have the US urban system from 1790 to 2000, the UK from 1901 to 2001 and the world from 430BCE to 2000.

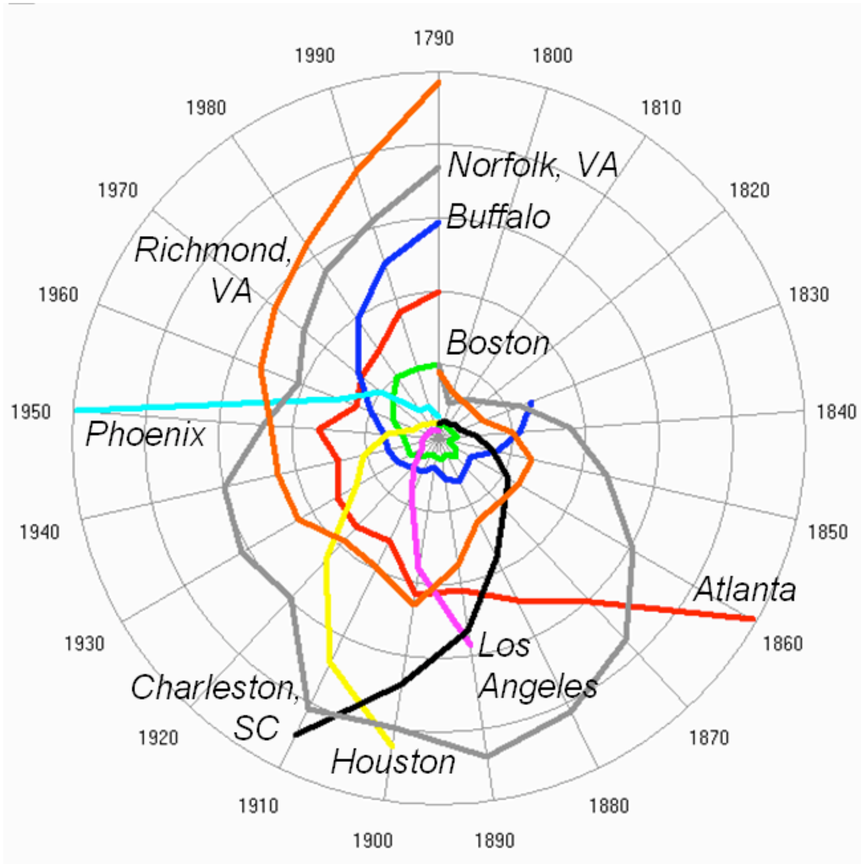
We will start with the US data and let me show first the complete clock and then some examples of individual cities on the clock. I will not load the software from our web site bust just show results for the cities. At the end I will load the software for the plant species example.





My point will be that the 'morphology' of the clock should tell us something – i.e. the increase in cities, the volatility of ranks and so on.





The rudimentary software for this in on our web site at
http://www.casa.ucl.ac.uk/software/rank.asp

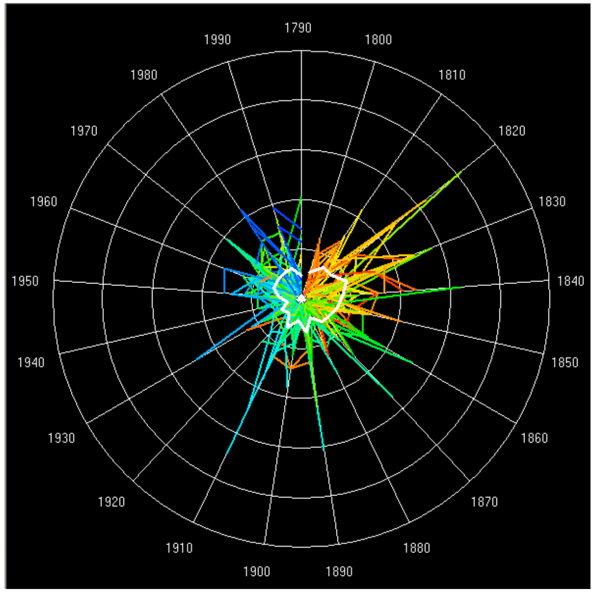
Distance in the Rank Clock: Growth Dynamics

We have developed various measures other than simply plotting the rank on the clock. For example we can plot the distance which is changes in ranks from one period to the next and we can also plot and overall distance which is by how much the system changes to compare this.

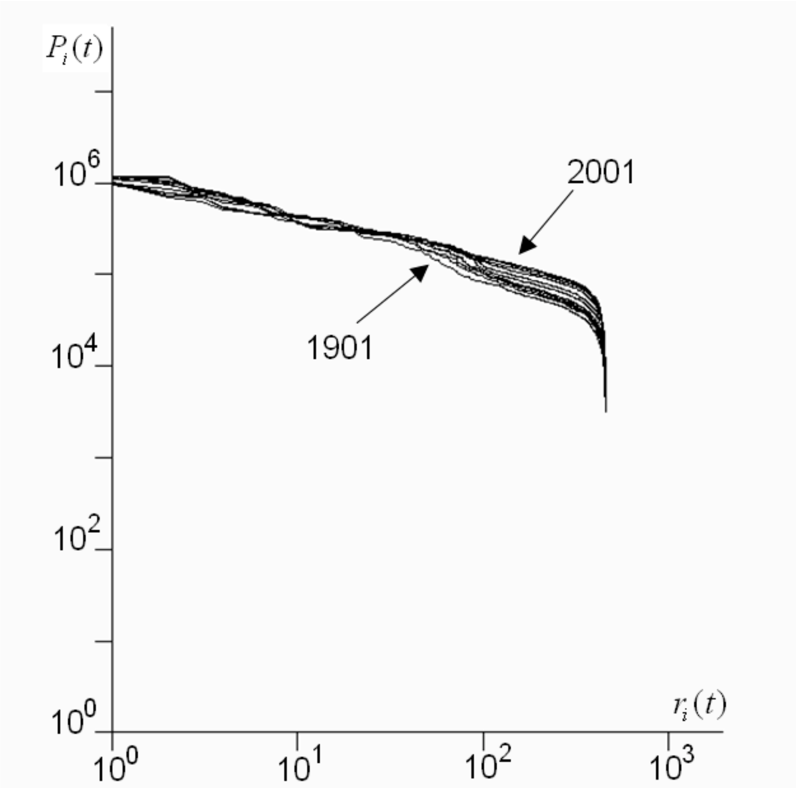
$$d_i(t) = \left| r_i(t) - r_i(t-1) \right|$$

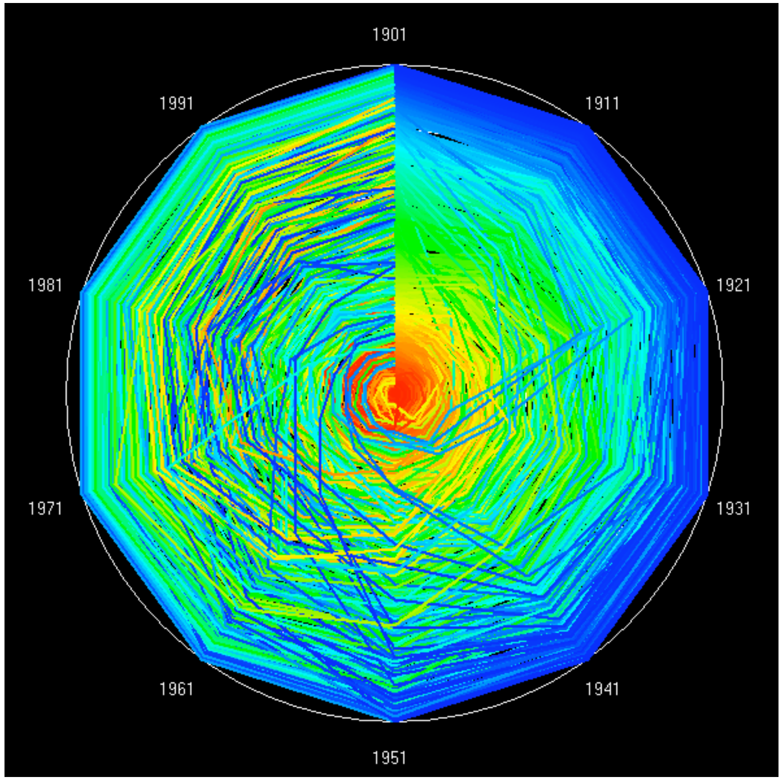
$$d(t) = \sum_i \left| r_i(t) - r_i(t-1) \right| \; / \; N_i(t)$$

$$d = \sum_t d(t) \; / \; T$$



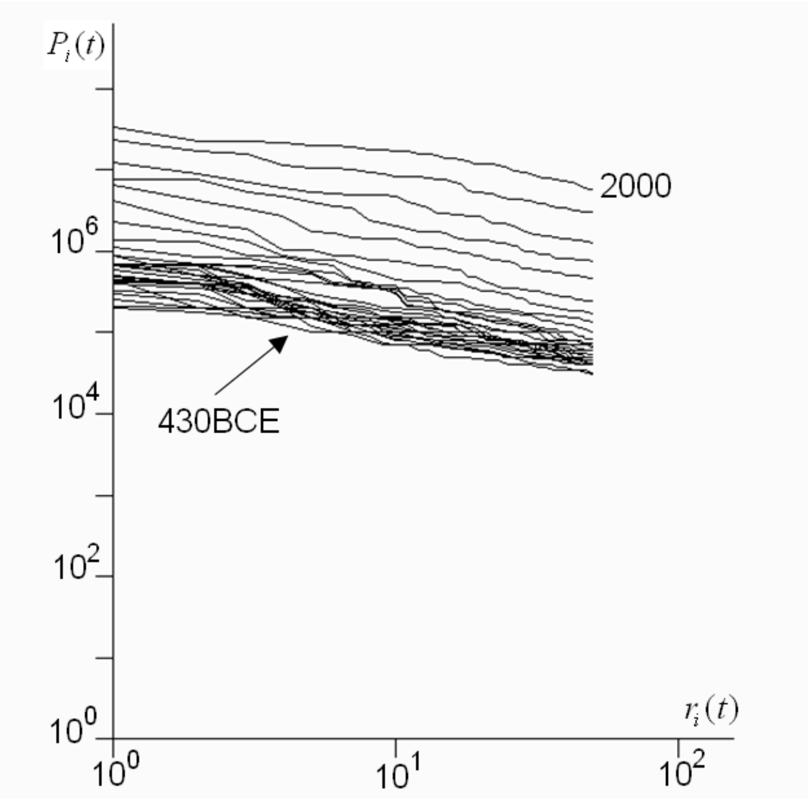
Another Example: The UK from 1901 to 2001

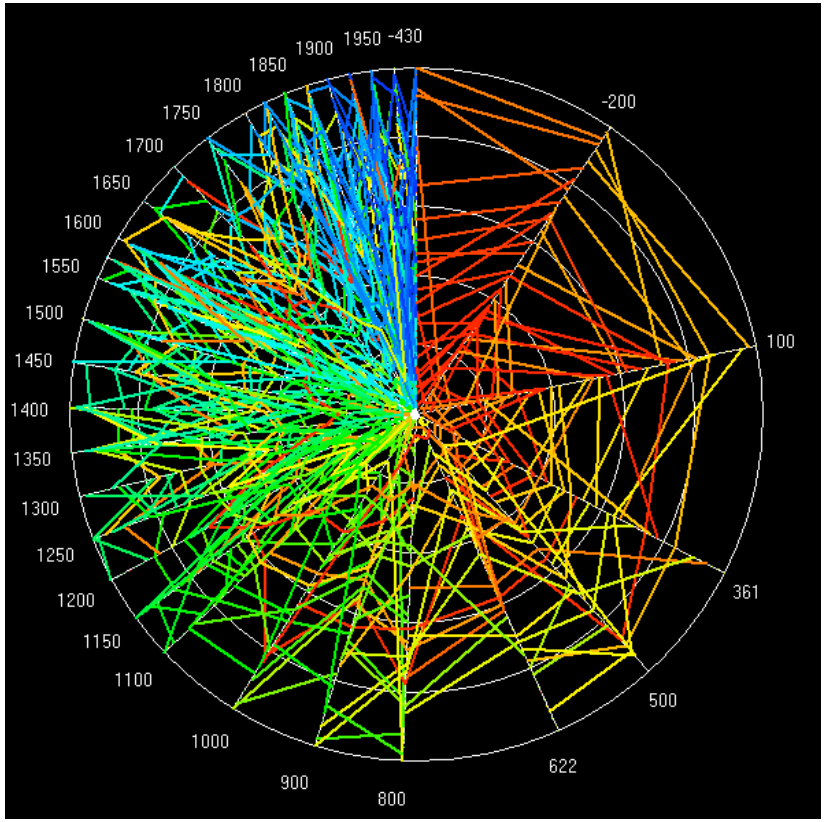


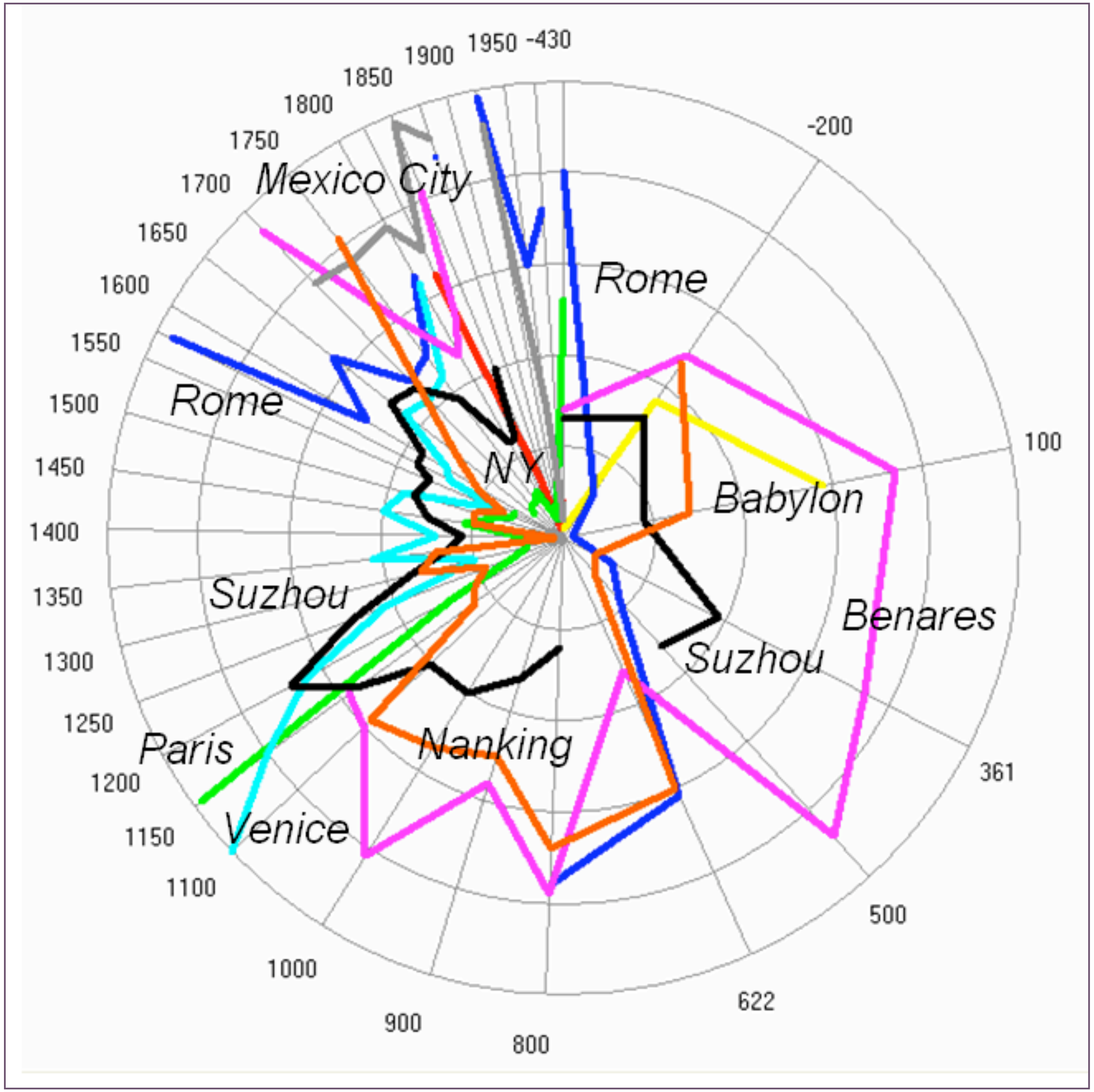


Very Long Term Dynamics: From 430 BCE

From the Chandler data set, for the top 50 cities we have



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1600
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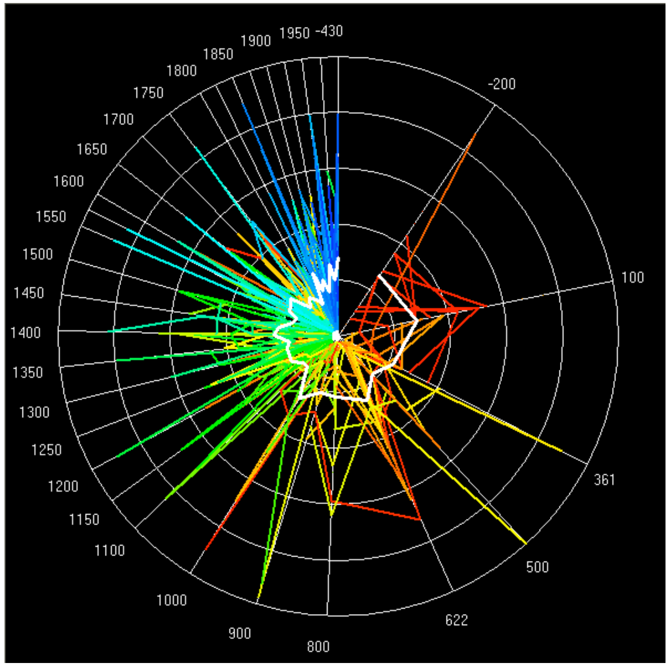
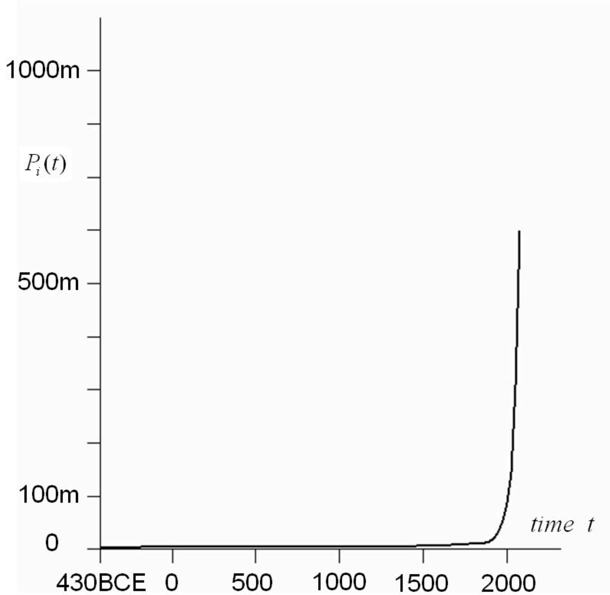
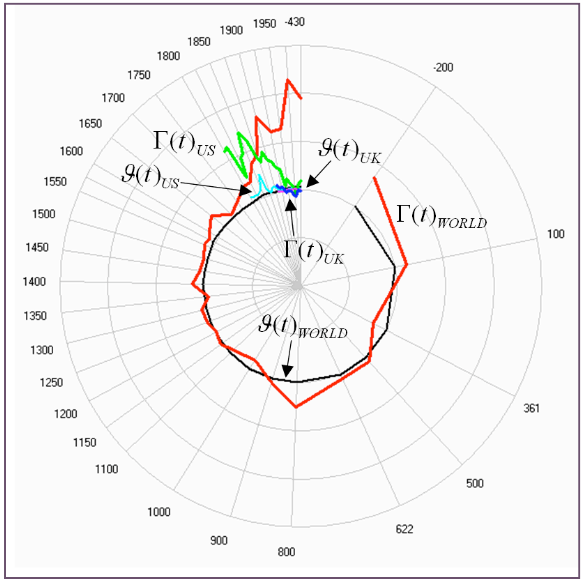
1700
1750
1800
1850
1900
1950
Mexico City
Rome
Rome
NY
Babylon
Benares
Suzhou
Suzhou
Nanking
Paris
Venice

Distances & Growth Rates







And we have also explored models of proportionate effect which generate a subtly different kind of dynamics

What Can this Tell Us about Optimal City Size, Density and Agglomeration

Where can this type of work take us

Links from the geography of populations to buildings – some really useful databases out there now to inform us – synthetic – e.g. London 3.2m blocks, about 2m buildings,

This short talk has only used partial data – we need entire series to make sense of all this, not partial

Links to the growth dynamics of cities – how they change their shape as they grow – the allometry of cities, Proper definitions of density- to date the entire discussion is confused and what little we know about density often leads to the wrong conclusions – particularly about energy

The dynamics of competition – how the macro stability contains the micro volatility – extend these ideas to see how networks behave – network links as well as locations

My title is misleading I know – because I have not said anything about how big a city can grow. The truth is we don't know and perhaps we don't need to care? The optimal city size debate has tended to die down in our field – it was vibrant a century ago, even 50 years ago, but in world where we all live in cities of one form or another ………

nature Vol 444|30 November 2006|doi:10.1038/nature05302

LETTERS

Rank clocks

Michael Batty[1]

Many objects and events, such as cities, firms and internet hubs, scale with size[1–4] in the upper tails of their distributions. Despite intense interest in using power laws to characterize such distributions, most analyses have been concerned with observations at a single instant of time, with little analysis of objects or events that change in size through time (notwithstanding some significant exceptions[5–7]). It is now clear that the evident macro-stability in such distributions at different times can mask a volatile and often turbulent micro-dynamics, in which objects can change their position or rank-order rapidly while their aggregate distribution appears quite stable. Here I introduce a graphical representation

PNAS

Laws of population growth

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Edited by Michael F. Goodchild, University of California, Santa Barbara, CA, and approved September 29, 2008 (received for review July 31, 2008)

An important issue in the study of cities is defining a metropolitan area, because different definitions affect conclusions regarding the statistical distribution of urban activity. A commonly employed method of defining a metropolitan area is the Metropolitan Statistical Areas (MSAs), based on rules attempting to capture the notion

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www.pnas.org/cgi/doi/10.1073/pnas.0807435105

3534 NOTES Ecology, Vol. 89, No. 12

Ecology, 89(12), 2008, pp. 3534–3541

RANK CLOCKS AND PLANT COMMUNITY DYNAMICS

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Abstract. Summarizing complex temporal dynamics in communities is difficult to achieve in a way that yields an intuitive picture of change. Rank clocks and rank abundance statistics provide a graphical and analytical framework for displaying and quantifying community dynamics. We used rank clocks, in which the rank order abundance for each species is plotted

Thanks, Questions

http://www.casa.ucl.ac.uk