

*Discovery of oscillatory dynamics
of city-size distributions in world
historical systems*

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Process: Modeling, Simulating, and Forecasting Global Change”*

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Powerpoint at

<http://eclectic.ss.uci.edu/~drwhite/Conferences.html>

Paper at

<http://>

Outline of paper

PART I: Q METHODS AND DISTRIBUTIONAL TAILS

PART II: CROSS-CORRELATION

PART III: THE Q SCALING

PART IV: HISTORICAL NETWORK AND INTERACTION PROCESSES

PART V: CONCLUSIONS

PART VI GLOSSARY

How to proceed in Vienna

Full paper available – hopefully on the web

The pdf/ppt is simpler in outline to follow

pdf will be projected in Vienna, I will follow:

during my video discussion of pdf thru Skype

you can ask questions, thru Humberto

he will have a chat box to relay questions

I will answer on the video

Similarly for the discussion at the end

Thanks for inviting me and hosting the video !

(early stopping point at slide 34:
peruse the rest on the web or skip to 47 to conclude)

Outline of talk - simpler

PART I: Q varies; these variations are reliable

PART II: Q varies in long phases (runs test)
China leads by 50 years in its Q values – up to 1850

PART III: Scaling Examples: Chinese and world cities

PART IV: 4 basic features of Q scaling
Main Argument and Results

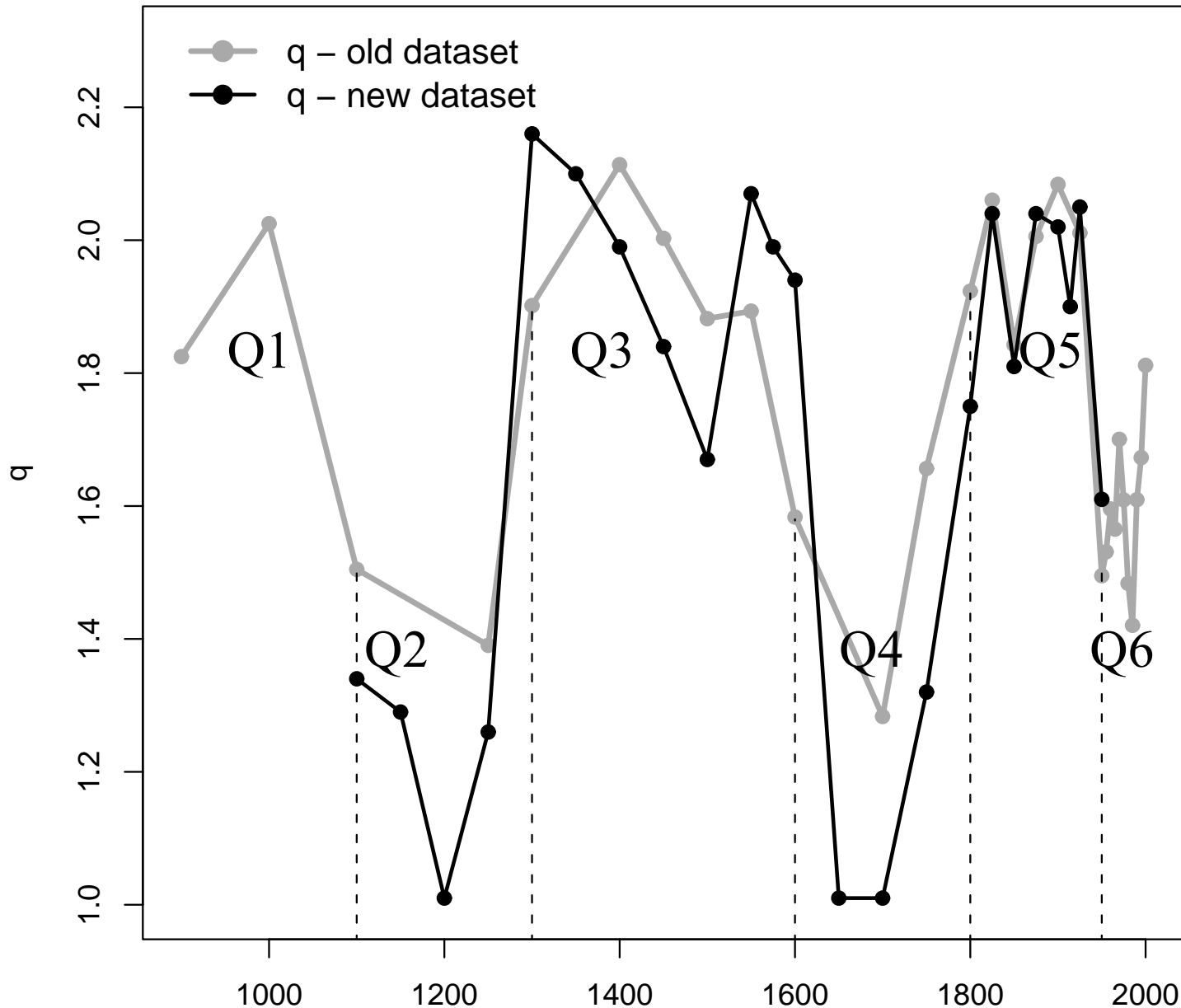
PART V: Q and World Historical Systems
2:1 co-phasing for Secular, Leadership, Economic cycles
Explanations for 2:1 co-phasing

PART V: CONCLUSIONS

VARIATION OF Q

Measures changes in city size
distributions

q from old and new dataset over time



The 1974 Candler and Fox data were greatly improved by Chandler 1984, but the q -results are very similar, as reported for the 1-factor test.

Multiple measures of Q

Are reliable: single factor test

TIME

Figure 1: Spatiotemporal PMN classification of Political/Military Networks & mergers (Wilkinson)

All the measures of city size oscillations correlate to form a 3:1 single-factor structure.

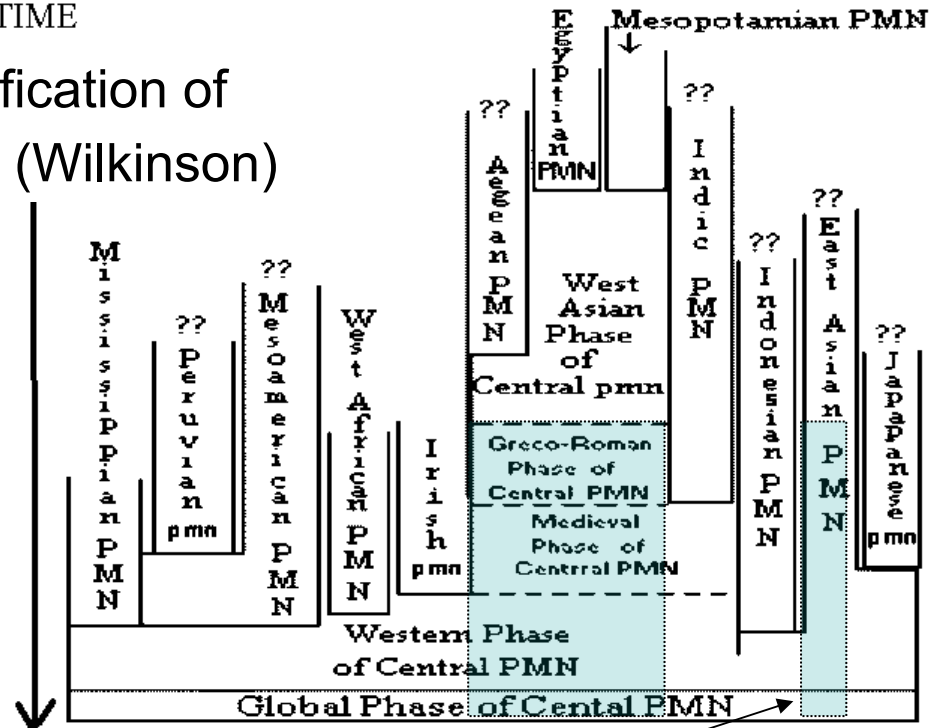


Table 1: Single Factor Variance (PCA) for City-size Distributional Scaling

Test 1	Component	Test 2	Component	Test 3	Component	Component
Q1987_2	.894	Q1987_2	.941	Q1987_2	.940	.907
Q1987_1	.709	Q1987_1	.890	Q1987_1	.869	
Q1974	.529	Q1974	.685	Q1974	.675	
QChina1987	.280	QChinaPlus50	.697	QChinaPlus50	.804	.847
				SPI_VcentralPMN	.670	.770
Variance	61.3%	Variance	65.8%	Variance	63.8%	71.1%
2 nd Eigenvalue	.82	2 nd Eigenvalue	.71	2 nd Eigenvalue	.71	.59
1 st /2 nd EigenRatio	2.45	1 st /2 nd EigenRatio	2.63	1 st /2 nd EigenRatio	3.19	2.13

These are long phases

As evidenced by statistical runs tests
(6 phases, Q1-Q6, in 3 cycles)

PART II

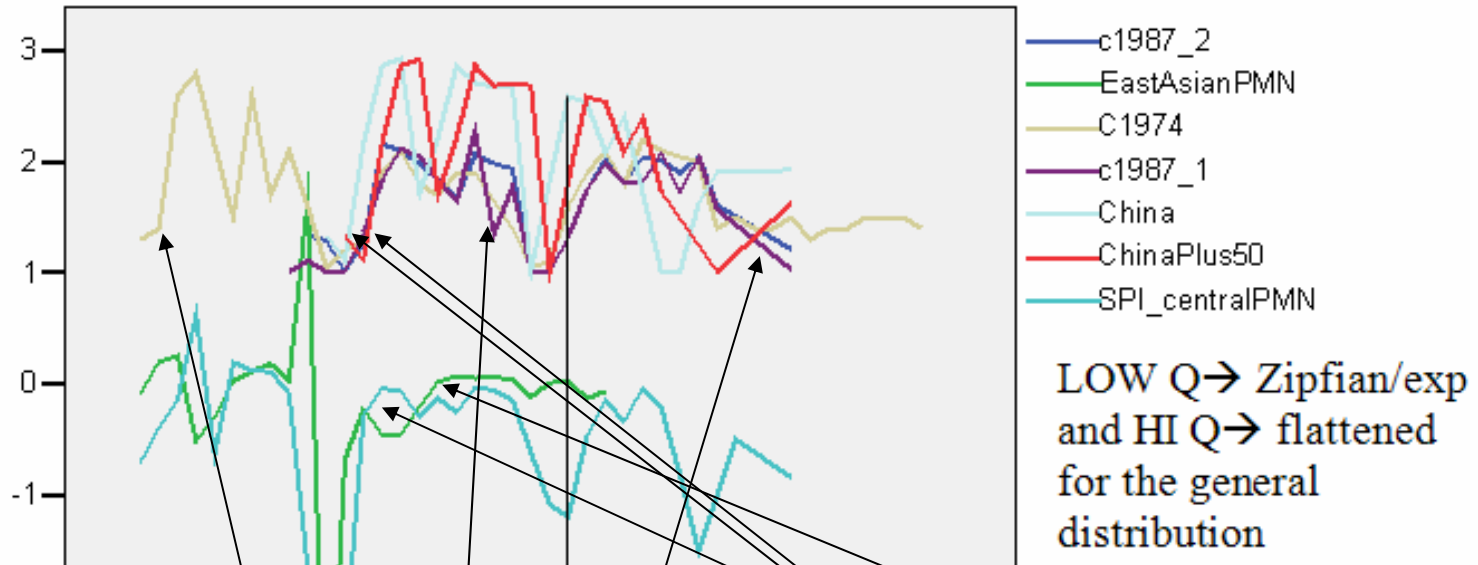
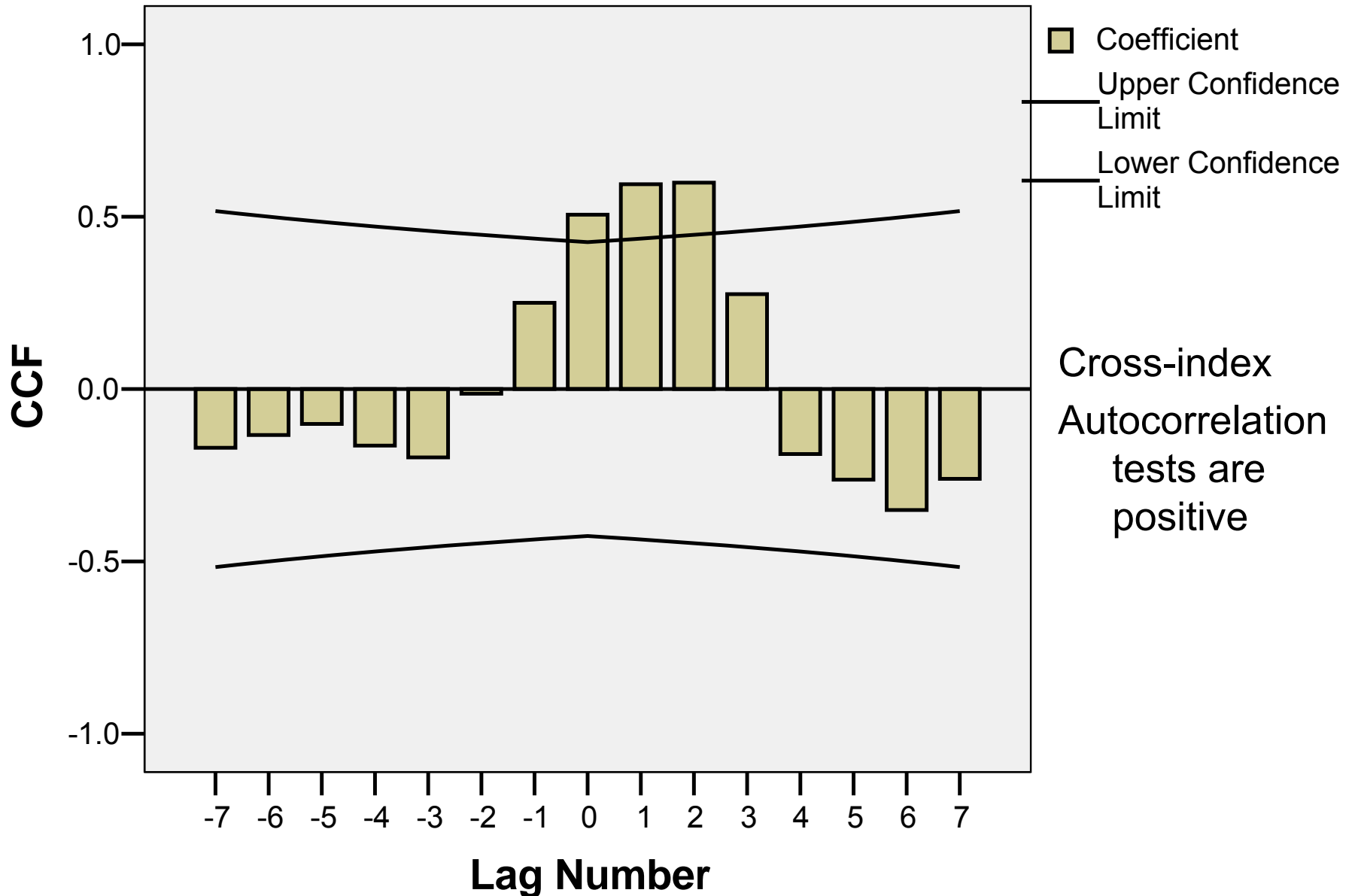


Table 2: Statistical Runs Tests for Number of Historical Periods

Runs Test (Means)	C1974	C1987_1	C1987_2	adj1.02	China	SPI_V	EastAsianPMN
Test Value(a)	1.6725	1.5828	1.6846	1.6854	2.0430	-.3725	-.1712
Cases < Test Value	23	11	10	9	11	15	8
Cases >= Test Value	17	14	14	15	12	19	18
Total Cases	40	25	24	24	23	34	26
Number of Runs	9	7	7	5	7	10	5
Z	-3.624	-2.414	-2.221	-3.015	-2.129	-2.567	-3.113
Asymp. Sig. (2-tailed)	.000	.016	.026	.003	.033	.010	.002

SPI_central with c1987_1



c1987_1

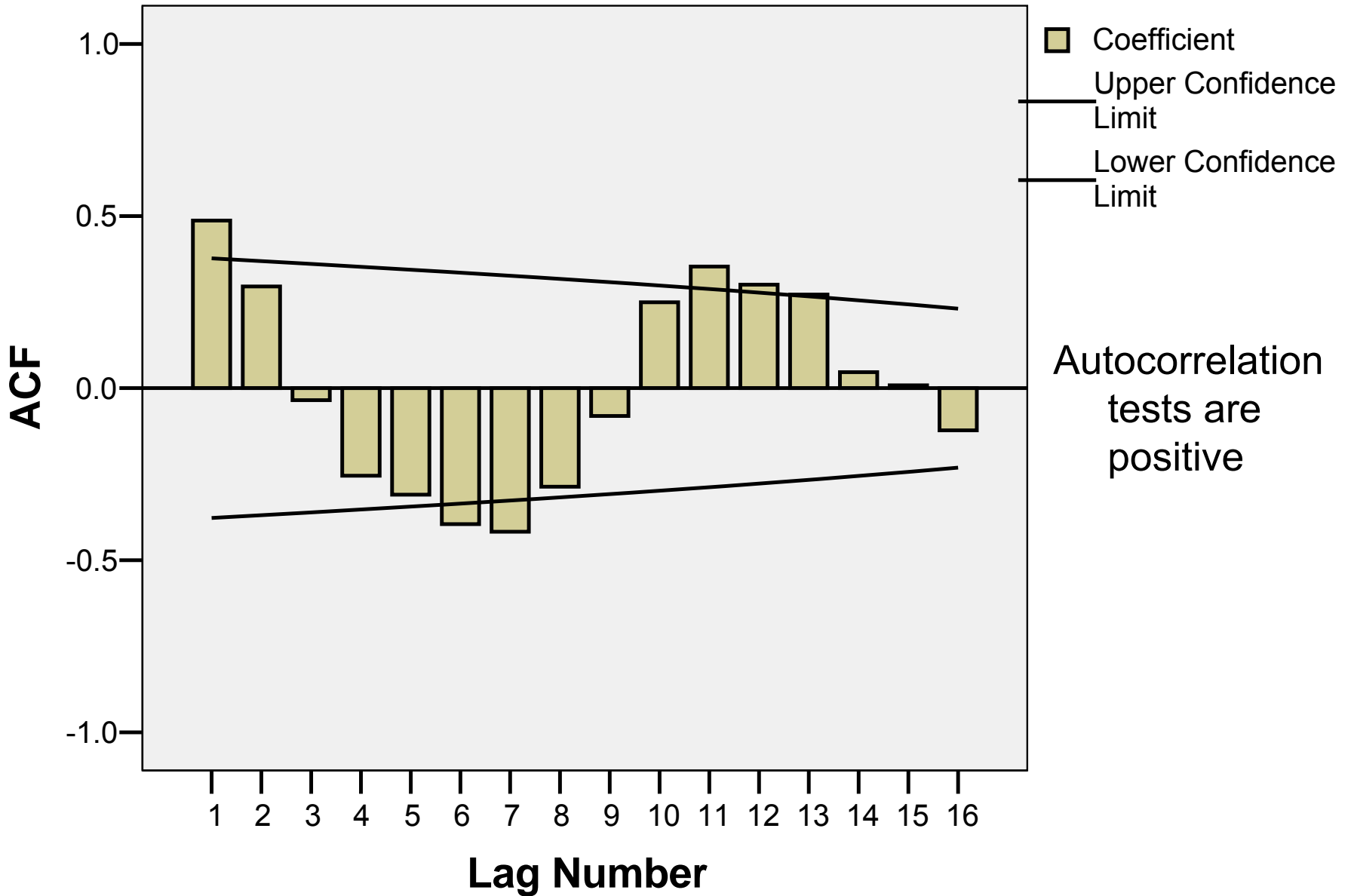
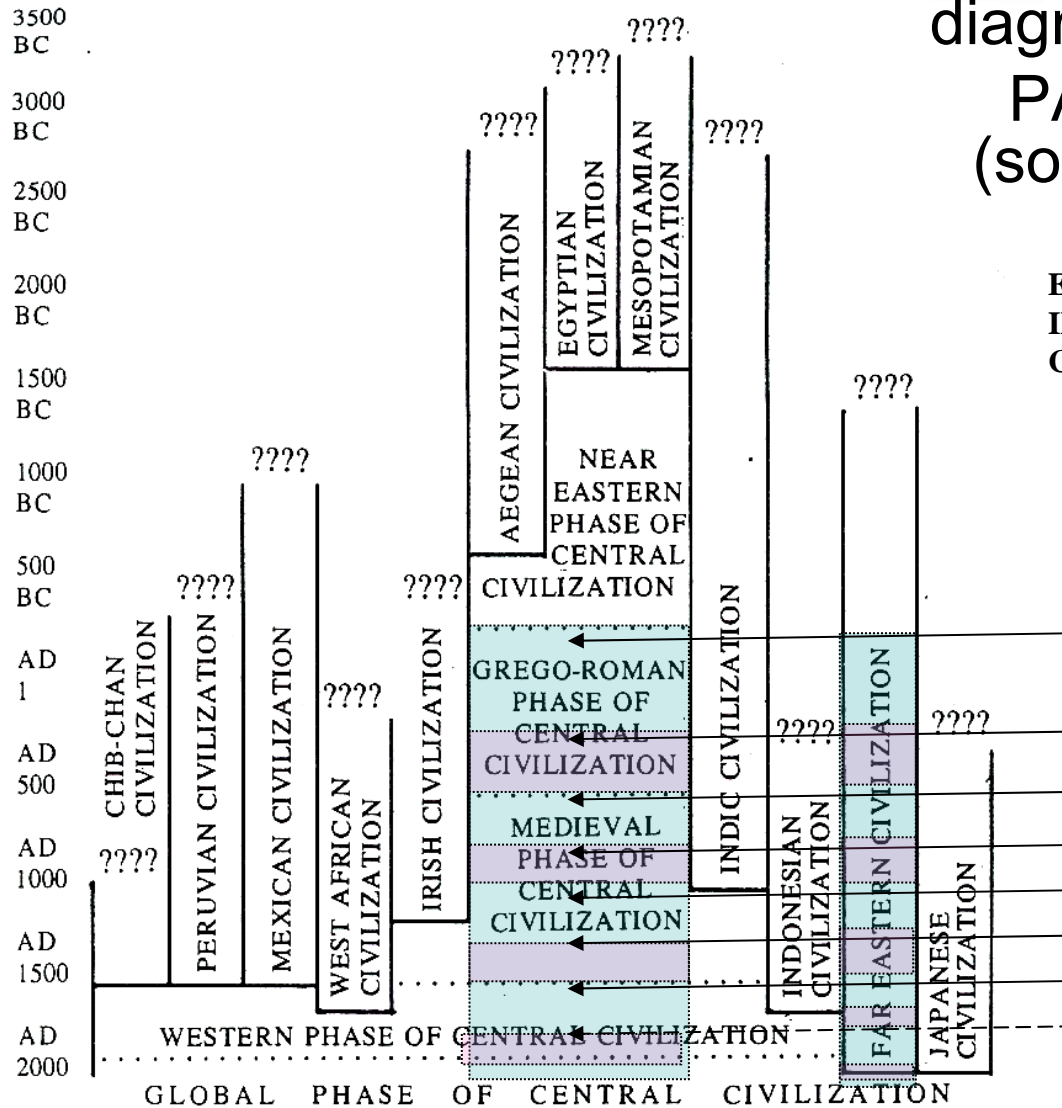
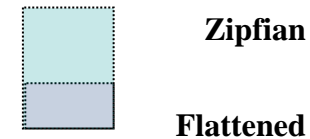


FIGURE 1
THE INCORPORATION OF
TWELVE CIVILIZATIONS INTO ONE



(forget the dates and names here, this diagram is conceptual)
PART II - phases
(some synchronies)

EAST-WEST SYNCHRONIES
IN TRADE AND
CITY SIZE DISTRIBUTIONS:



Q-2 (trade synchrony)

Q-1 (trade synchrony)

Q0 " & city synchrony

Q1 " & city synchrony

Q2 " & city synchrony

Q3 " " " " "

Q4 " " " " "

Q5 (loss of synchrony)

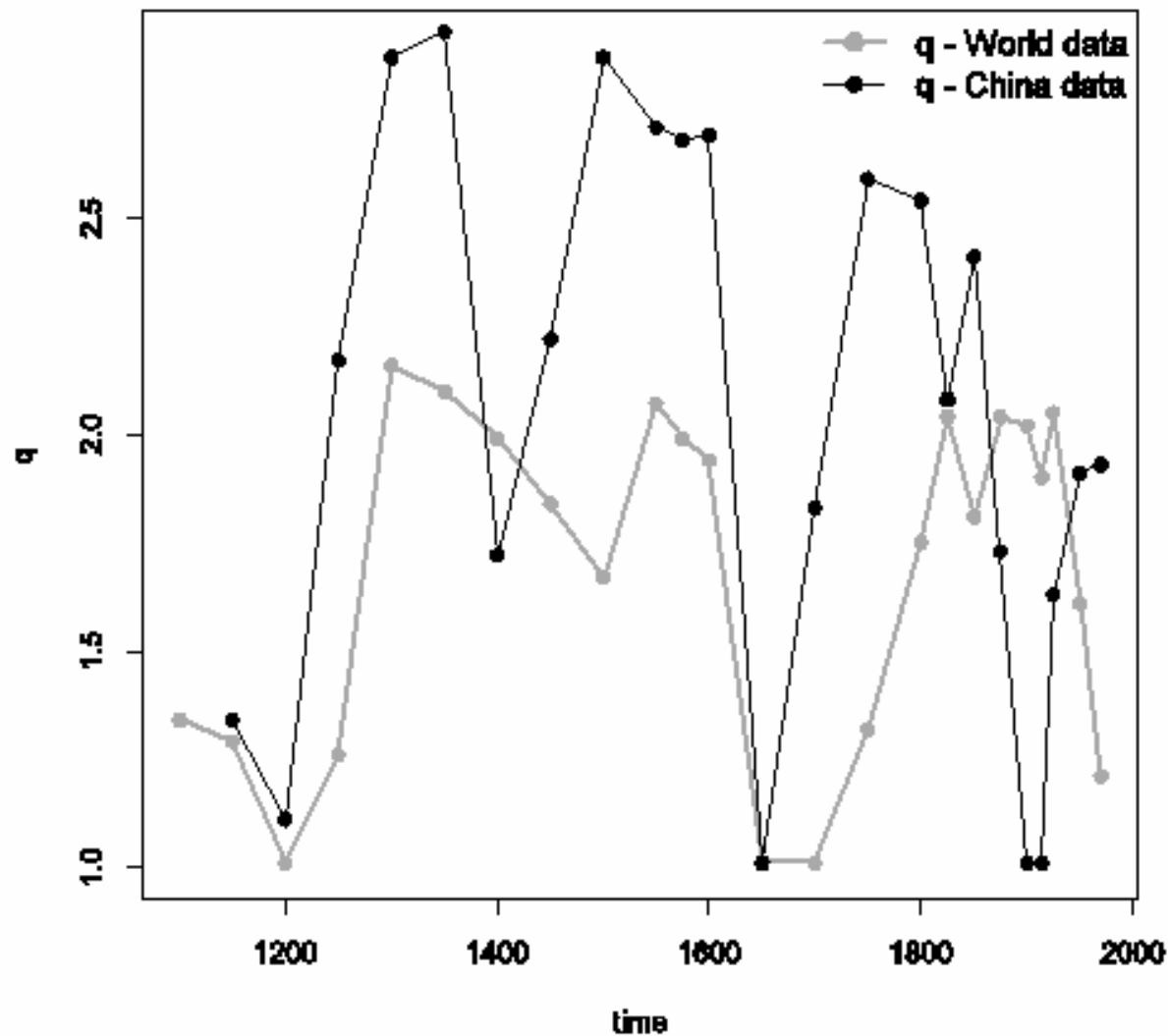
Q6

China leads the world in Q

Up to 1850, by 50 years or so

still PART II - Q varies in long phases

q from China and World dataset over time



(upper estimates may be in error)

Values over 2 are out of range

Flat power-law

Sub-Zipfian
Zipfian bulk
 Hyper-Zipf

Exponential

China leads the World by 50 years \pm 20

Figure 2:

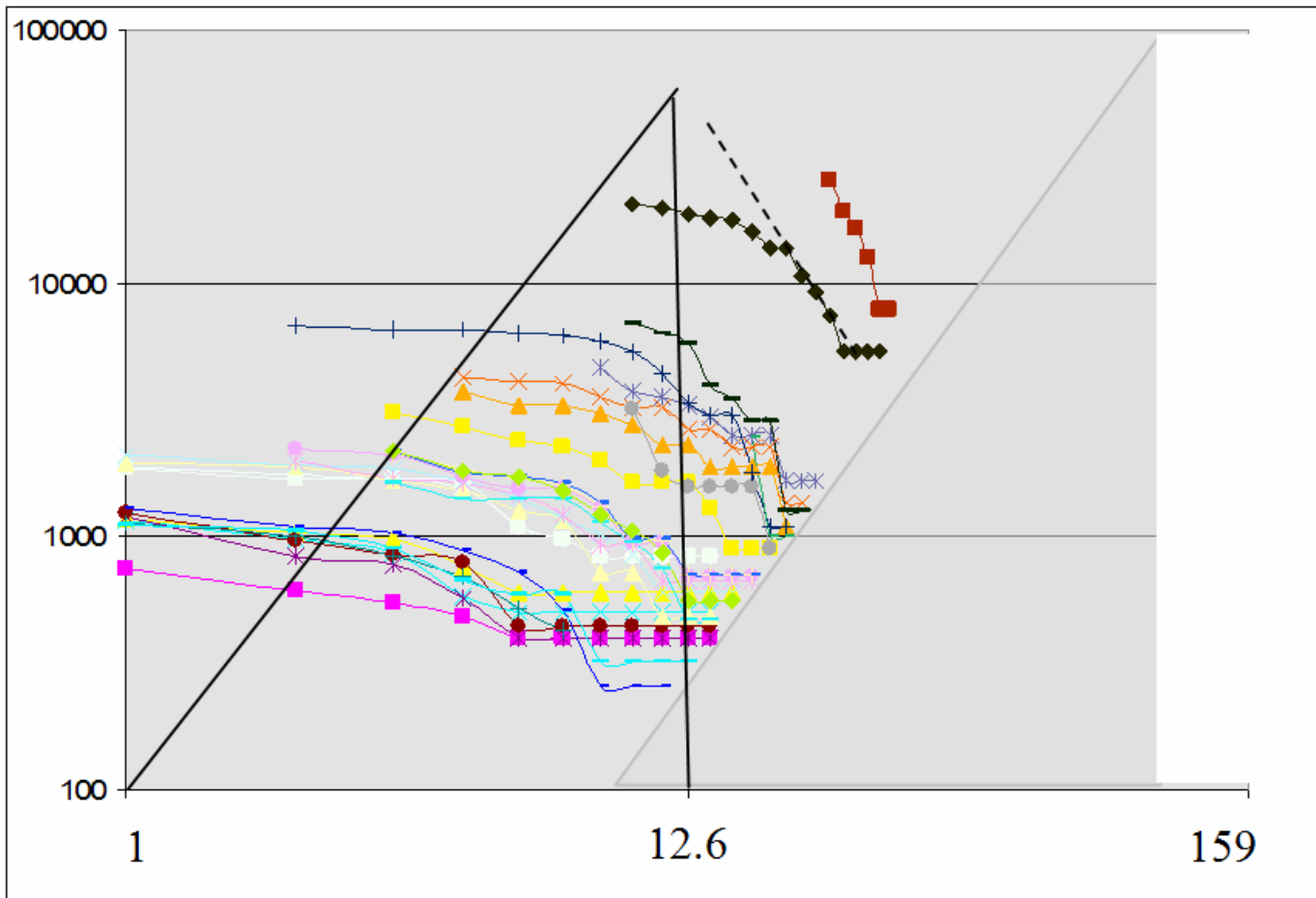
Q scaling: Examples

Examples 1: china

Examples 2: world cities

PART III

We do Q-scaling from Chandler's 1987 data by creating city-size bins as powers of 1.26 times the lowest bin size (e.g., 40,000 people), then constructing a cumulative population distribution in cities at least as large as the bin size.



The slope for the cutoff line
 $159/12.6 = 12.6$,
where the largest population is located, is a function of the bin size multiple, 1.26.

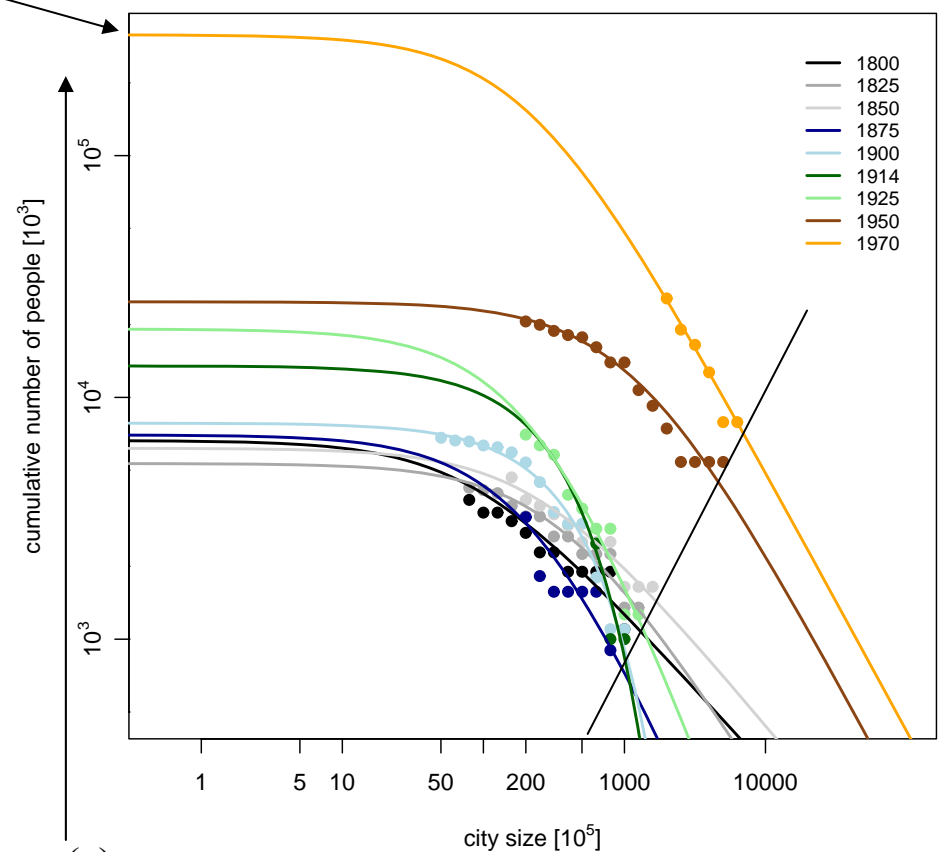
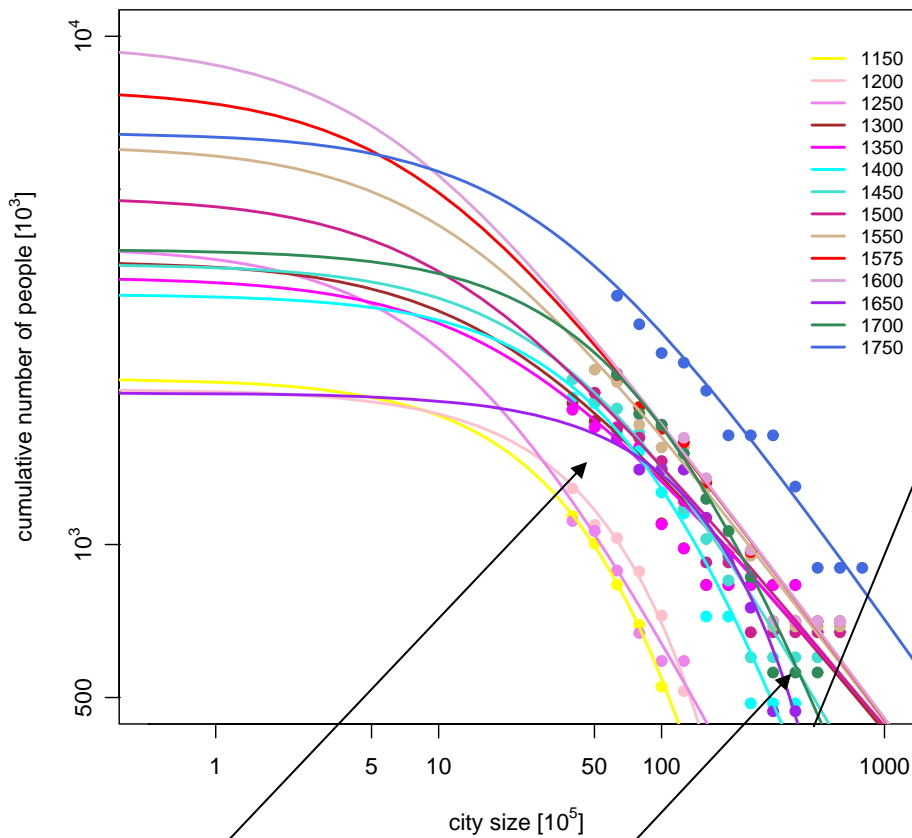
Figure 5: Cumulative Binned City Sizes for 28 Historical Periods in China

Fitting the q -exponential to get the best predictors of actual distributions ($q > 1$)

$$y(s) = y(0) e_q^{-s/\kappa} = y(0) [1 - (1 - q)s/\kappa]^{1/(1-q)} \quad (e_1^x = e^x) \quad (4)$$

Weighted least squares estimation (China): 1150 – 1750

Weighted least squares estimation (China): 1800 – 1970

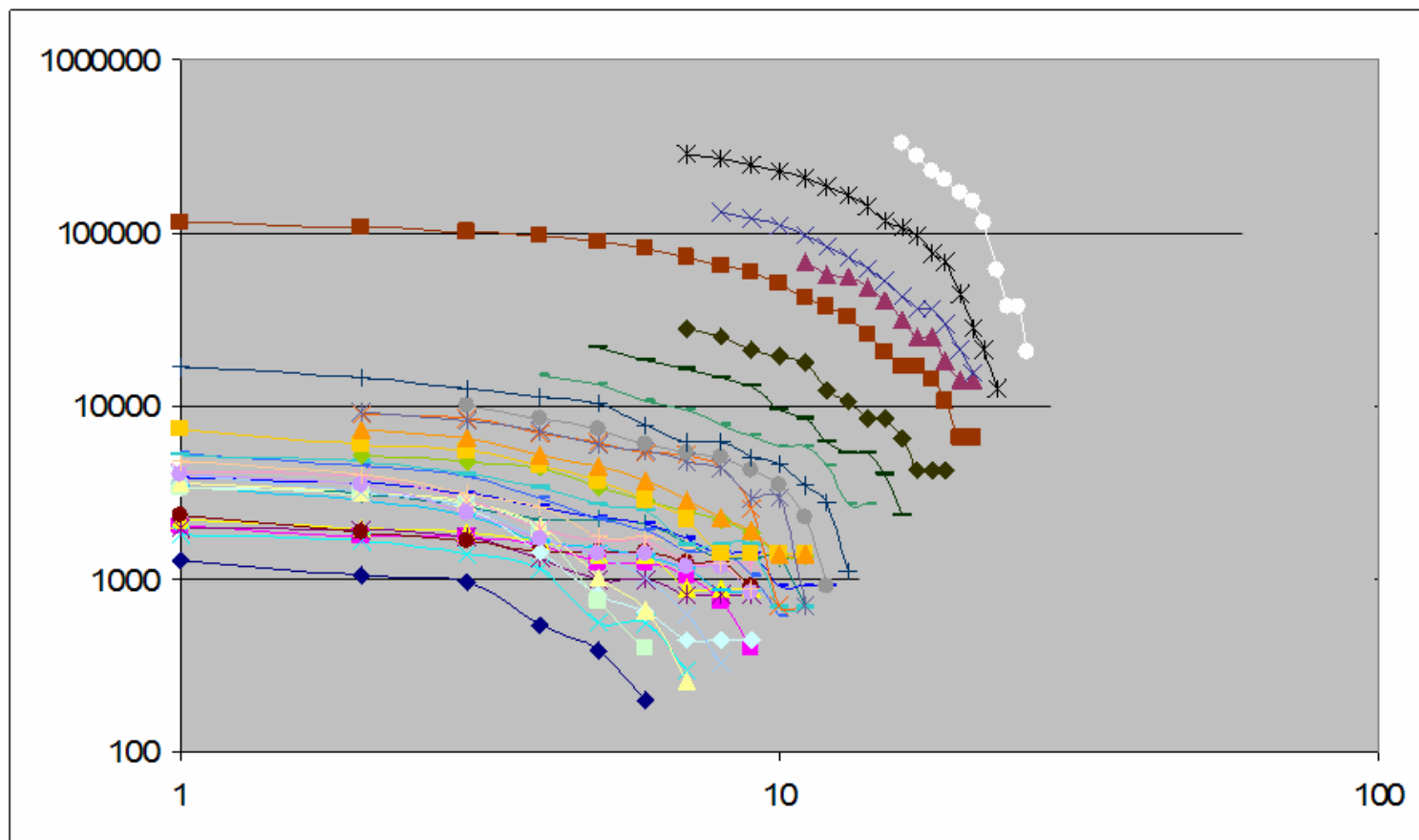


Body and tail of the distributions

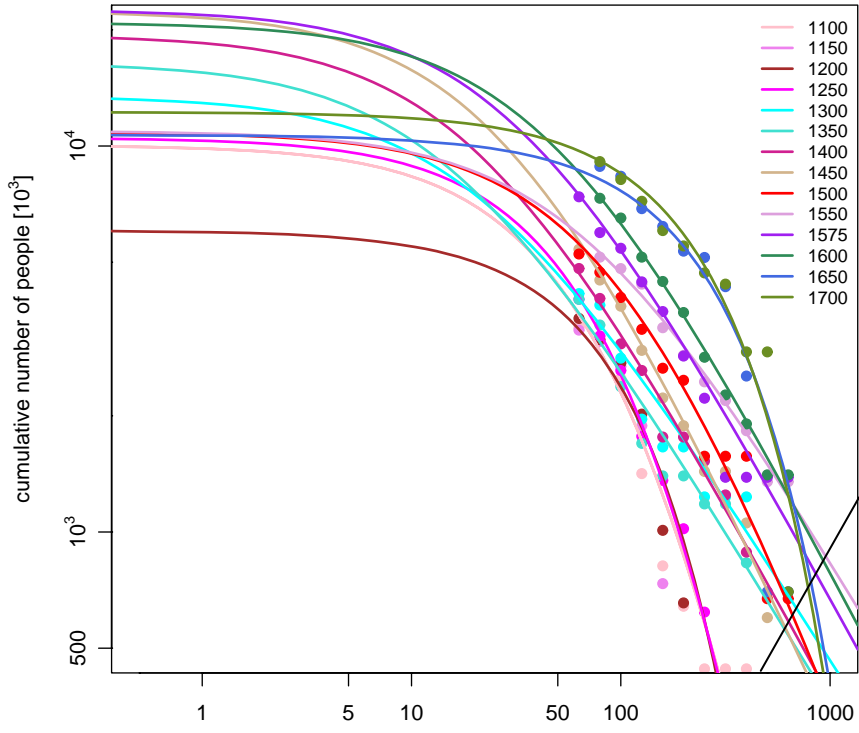
$y(s)$

s

Figure 10: World City Size Distributions, raw cumulative binned data



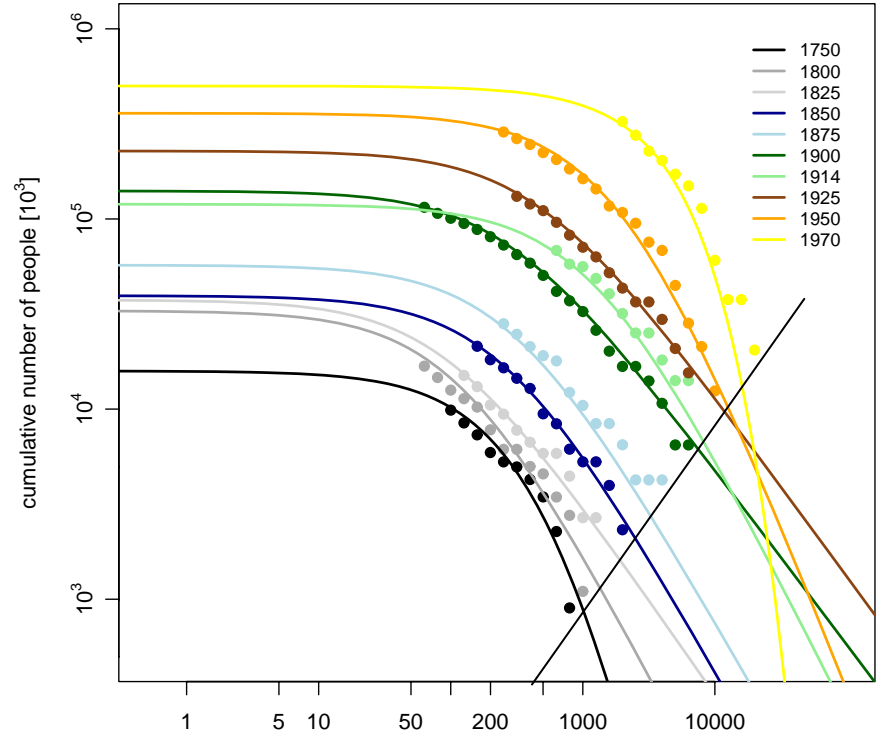
Weighted least squares estimation (world): 1000 – 1700



Early

World Cities

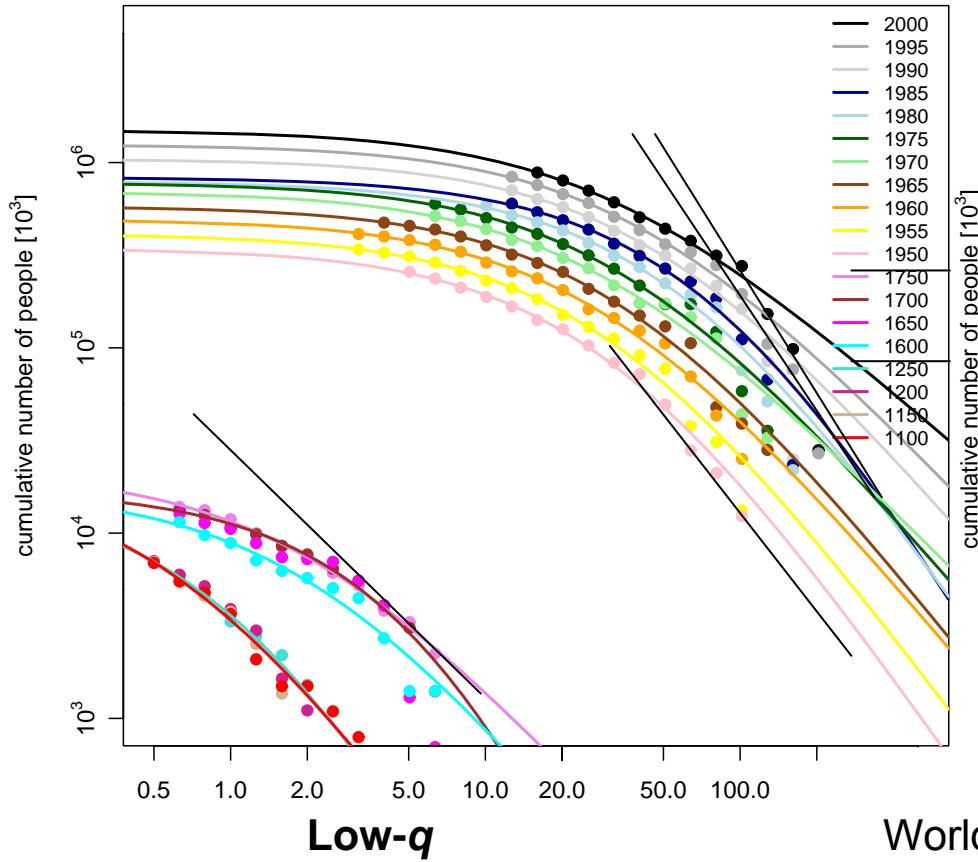
Weighted least squares estimation (world): 1750 – 1970



Late

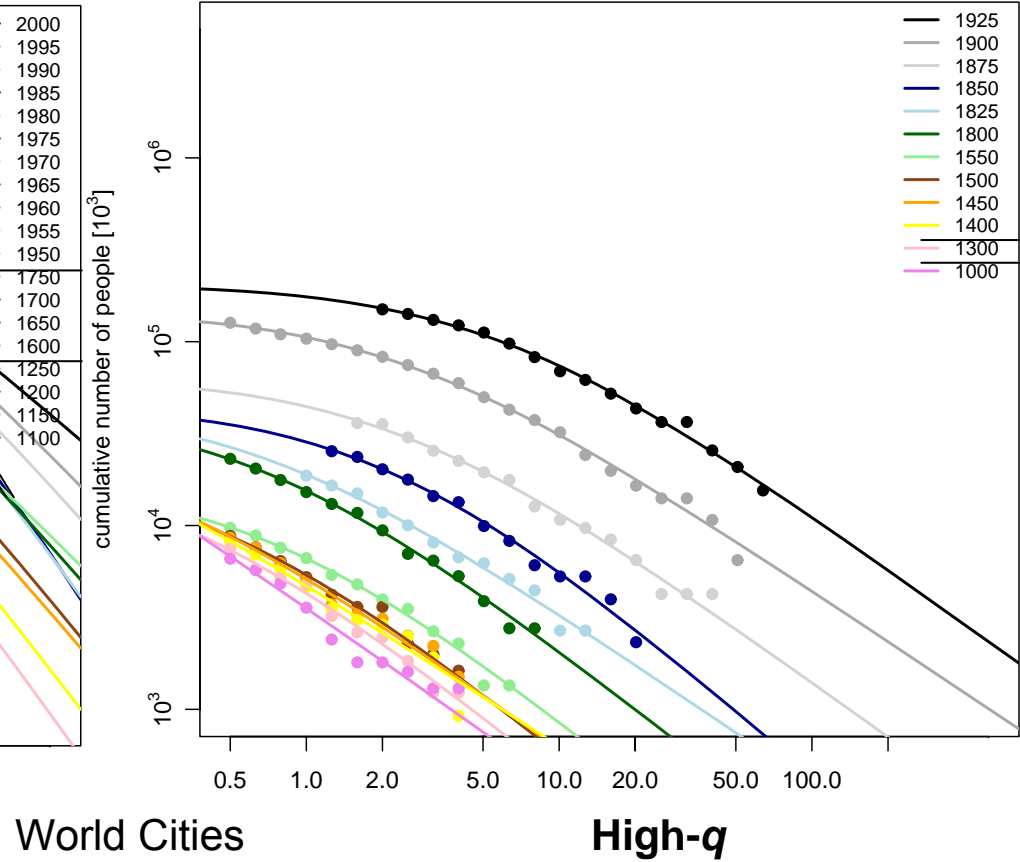
PART III, continued

Low-q fittings for years in 1000 – 2000



(low-q changes in slopes of tails are relevant to the summary of over time Q-phases on slide 32)

High-q fittings for years in 1000 – 2000



(high-q slopes of the large-city tails are constant over time)

4 basic features of Q scaling

- 1 The computation of Q involves fitting a straight line in a plot of size s by the function $\log_q(s)$. That is why Q is called a (stretched) exponential function. It is also easy to do and to get right even without huge # of datapoints.
- 2 Because this line is straight, and through an origin $(0,0) \equiv (s=0, \log Q=0)$, it can be extrapolated from one piece of the distribution to another. This gives comparability to the measure of Q for different historical periods regardless of the # of cities sampled or minimum city size criterion.

PART IV – MAIN ARGUMENT AND RESULTS !

(4 basic features of Q scaling)

3 We weight the fitting of Q more heavily by the greater numbers of cities in the body of the distribution. Then by extrapolation we can compare the expected shape of the tail to the actual shape that is observed (for the fewer larger cities in the tail).

PART IV – MAIN ARGUMENT AND RESULTS !

Finding the asymptotic power-law coefficient in the tail (Zipf=1) from q
(SPI is the Standardized Primacy Index)

$q =$ Qcdf	α for tail	small sizes	SPI	$q =$ Qcdf	α for tail	small sizes	SPI	mixed
2.20	Undef.			1.60	0.67	exp	-0.78	
2.15	Undef.			1.55	0.82	exp	-0.71	
2.10	Undef.			1.50	1.00	exp	-0.64	Exp + power law
2.05	Undef.			1.45	1.22	exp	-0.56	
2.00	$y(0)$			1.40	1.50	exp	-0.47	
1.95	0.05	Fat		1.35	Thin	exp		
1.90	0.11	tail	-0.78	1.30	Tail	exp		
1.85	0.18	exp	-0.71	1.25	Exp	exp		
1.80	0.25	exp	-0.64	1.20	Exp	exp		
1.75	0.33	exp	-0.56	1.15	Exp	exp		
1.70	0.43	exp	-0.47	1.10	Exp	exp		Steeper
1.65	0.54	exp	-0.38	1.05	Exp	exp		Exponential

Table 1: Conversion from q to the power law α (or exponential) and SPI

Next slide shows examples of SPI, the Standardized Primacy Index)

Table 4: Six largest Chinese cities in medieval and recent periods (as per Fig. 5)

SPI=Standardized Primacy Index for cities

The SPI index is computed as 0 or more negative deviation from a Zipfian for the top five cities, e.g., as here for China. Q-scaling uses all the city sizes and weights the lower bins more highly.

Alpha (α) is the slope of the large-city tail entailed by Q.

Date	Top Cites	Size in 1000s	Annual growth	date	Top Cites*	Size in 1000s	Annual growth
1100	Kaifeng*	442	1.000998	1150	Kaifeng	150	0.978387
1100	Hangchow	90	1.001178	1150	Hangchow	145	1.009538
1100	Soochow	88	1.001206	1150	Nanking	130	1.013257
1100	Tsinchow	85	1.000000	1150	Peking	100	1.013863
1100	Ningsin	80		1150	Ningshia	90	
1100	Nanking	67	0.999562	1150	Canton	80	1.007494
1100	Wuchang	61	0.999365	1150	Soochow	72	0.995987
* Primate city		no power law fit α	SPI=-.37	*subZipfian (flat)		$\alpha=.40$	SPI=-.55
Date	Top Cites*	Size in 1000s	Annual growth	date	Top Cites*	Size in 1000s	Annual growth
1950	Shanghai	5406	1.043343	1970	Shanghai	7900	1.018968
1950	Peking	2031	1.018907	1970	Peking	4800	1.043004
1950	Tientsin	1795	1.032326	1970	Tientsin	3800	1.037500
1950	Canton	1495	1.025111	1970	Wuhan	2560	1.040012
1950	Wuhan	1150		1970	Chungking	2300	1.021539
1950	Chungking	1055	1.022045	1970	Canton	2300	1.038968
1950	Nanking	1020	1.037947	1970	Nanking	2000	1.033667
*Zipfian		$\alpha=.82$	SPI=-.10	*Zipfian		$\alpha=.73$	SPI=-.17

(4 basic features of Q scaling: conclusion)

4 The extrapolated prediction about the tail is always in the form of an asymptote to a power law, which may be Zipfian (thin tailed as for Mid- $Q=1.5$) or may not (a thick tail is expected for High Q). But in fact we find that the empirical tail for High Q is Zipfian (discontinuous from the Q body).

PART IV – MAIN ARGUMENT AND RESULTS !

Q-bodies and shapes of tails

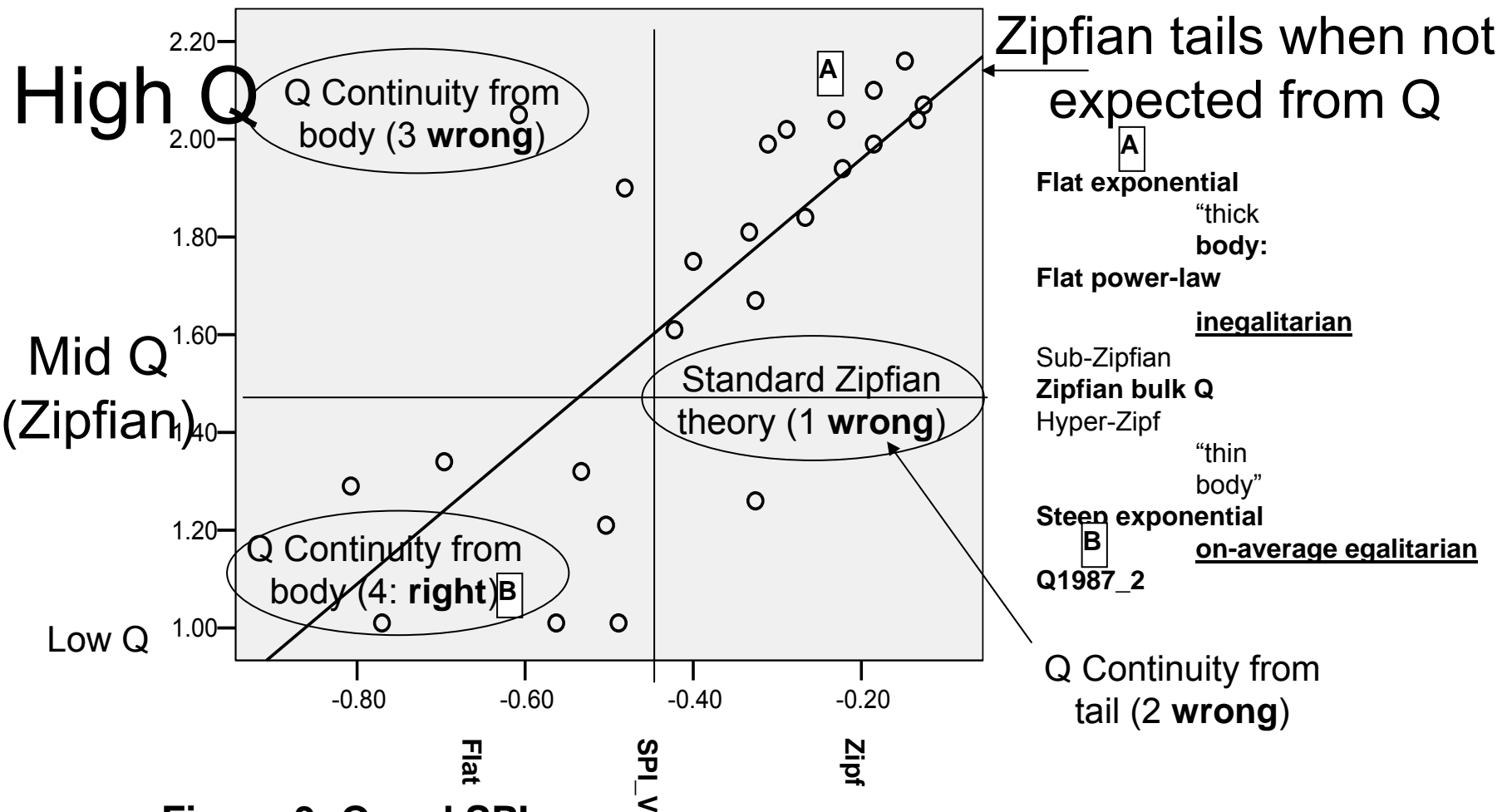


Figure 3: Q and SPI

Q scaling: Results (takeaway)

RE: 4 Basic features of Q scaling
three expectations wrong, one right

Comparing Q bodies of distributions and the hub-city tails. Oddly:

mid-Q-bodies that entail Zipfian hubs (1,2) do not occur; instead:

High-Q bodies that should entail sub-Zipfian (3) hubs are often Zipfian (A)!

Only for Low-Q bodies entailing non-Zipfian hubs (4=B) are the hubs non-Zipfian

PART IV – MAIN ARGUMENT AND RESULTS !

Q and World Historical Systems

1. What do the two Q-phases entail?
2. Cross-correlations of 2:1 phasing cascade

PART V

What do the two Q-phases look like?

- **Low Q (B)** – Early (e.g. 13th C) hubs are non-Zipfian, so: early Qs are as expected from low Zipf! Later hubs, 1960 forward, as seen in slide 21, however, are more Zipfian (thin). This is what gives the ‘Illusion’ of Zipfian theory: Later Qs are more consistent with Zipf! Average pairs of cities are more homogeneous than High Q, with fewer large hubs in a smaller city’s neighborhood – this is called EGALITARIAN, as if Mid-Q (hubs as bigger outliers). Low Qs are typical of more global trade networks.
- **Mid Q** – normally called EGALITARIAN (with Zipfian hub outliers): **do not really occur**, i.e., a historically unstable distribution.
- **High Q (A)** – the bulk of the distribution is unusually heterogeneous (INEGALITARIAN) but there is a discontinuity with the unusually thin tails. This is typical of more regional trade networks, disrupted perhaps by conflicts at the boundaries of regions. These urban hierarchies are regionally hub-navigable from city to city.

PART V

Note the enormous (dynamical) complexity in these patterns.

the remaining slides:

- Deal with how Q periods cross-correlate with
 - Secular cycles (1/2 cycle)
 - Political cycles(1/2 cycle)
 - Economic innovation cycles (1/2 cycle) –K-waves
- Deal with how and why these cross-correlated cycles embed as nested half cycles
 - Secular within Q
 - Political within Secular
 - Economic innovation within Political

PART V

take-home message

- Within each city cycle (Q1/2, Q3/4, Q5/6), there are two secular cycles, within each secular cycle two political cycles, within each political cycle there are two economic innovation cycles.
- HOW and WHY? The midpoint of a city cycle is the disintegrative phase of a secular cycle; more global trade networks contract through conflict to regional segments, but the disintegrative phase of the next secular cycle undermines the very conflicts that restrict trade and free trade networks to expand again more globally.
- The 1:2 embedded phasings may be explained by conflicts (**“its conflict turtles”**) **“all the way down.”**

PART V

Silk road multiconnectivities in the more global trading periods synchronize regions, and when these are interrupted the respective trading networks break apart

Table 3: Evolution of the Silk Roads 100 BCE to 1500 CE

Period	Major linkages	Anchor cities	K-waves
IV: Silk Roads			
-100 – 250	Silk via Parthia	Rome, Luoyang	
200 – 500	Red Sea Route to India	Alexandria, Guangdong	
500 – 650	Byzantium develops the northern route	Constantinople, Changan	
750 – 1000	Abbasids develop Persian Gulf route	Baghdad, Changan	
V. Market Systems			
930 – 1125	Northern Song via Central Asia	Constantinople, Kaifeng	K1-2
1125-1150	[northern route broken]		
1150-1250	Southern Song	Cairo, -Hangzhou	K3-4
1250-1350	Mongols restore northern route	Genoa, Peking	K5-6
1350 - 1500	Mamluks, Venice work Red Sea route	Venice, Cairo, Calicut, Malacca, Hangzhou	K7-8

Source: Modelski, G. 2000. <http://faculty.washington.edu/modelski/Evoweconomy.html>

(good point to end if no time:
you could peruse the rest off the website)

- The rest of the slides detail cross-correlations of timings for
- 5 pre-Q Trade Expansion/Contraction periods before 900 CE (somewhat hypothetical) and:
 - Secular Cycles
- the 6 Q periods studied after 900 CE and:
 - Secular Cycles
 - Leadership Cycles
 - Economic Innovation Cycles.

PART V

Table 5: European Secular Cycles according to Turchin and Nefedov (2006) and Cross-Correlation of Trade Network Cycles and Secular Cycles, 600 BCE-900 CE

Trade Network (~ Q-period)	From about	Secular cycle	Cohesion and Crisis
(trade startup) N1	700BCE	Expanding - More Global “Outgoing”	market economy ca.700 Axial Age
(flat startup)	600BCE	First Roman Cycle	600BCE-375BCE
N2	375BCE – <145BCE	Contracting Trade Net “Implanting”	- Regional Colonization (including Hellenic)
	375BCE	Second Roman Cycle	375BCE-27BCE
N3 Flatter again	<145 27 BCE 285	Expanding Trade Net “Outgoing” Principate Cycle	- More Global Empire, ending in turmoil 180-285 27BCE-285, followed by Dioclitian
N4 (flat)	<<285 285	Contracting Trade Net “Reimplanting” E. Roman Empire/ Merovingian Cycle	- Regional Shift to Constantinople 285-600
N5	<<550 650	Expanding Trade Net “Outgoing” Carolingian Cycle	- More Global state management & succession crisis 0650-0900

2:1 Cycles:600 BCE-900 CE

Secular cycles follow – Network Size cycles

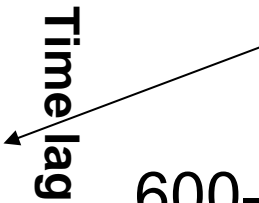
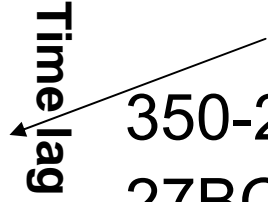
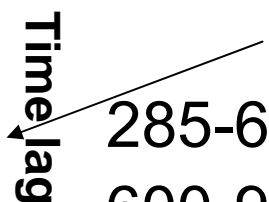
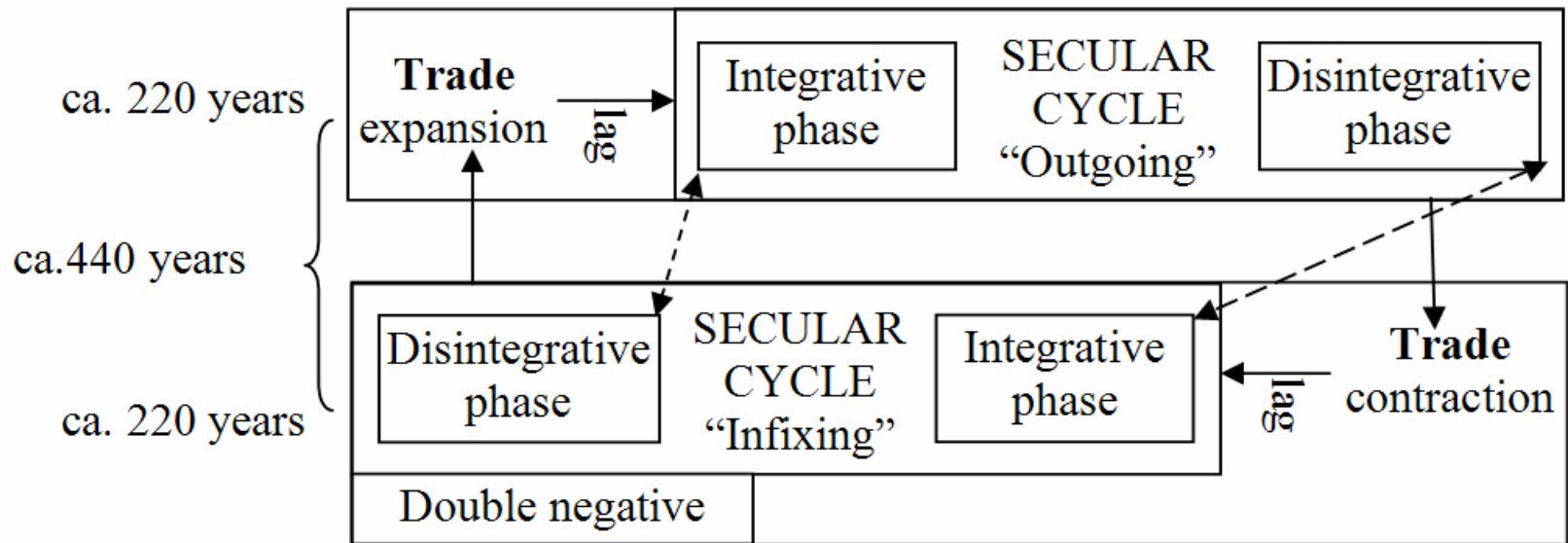
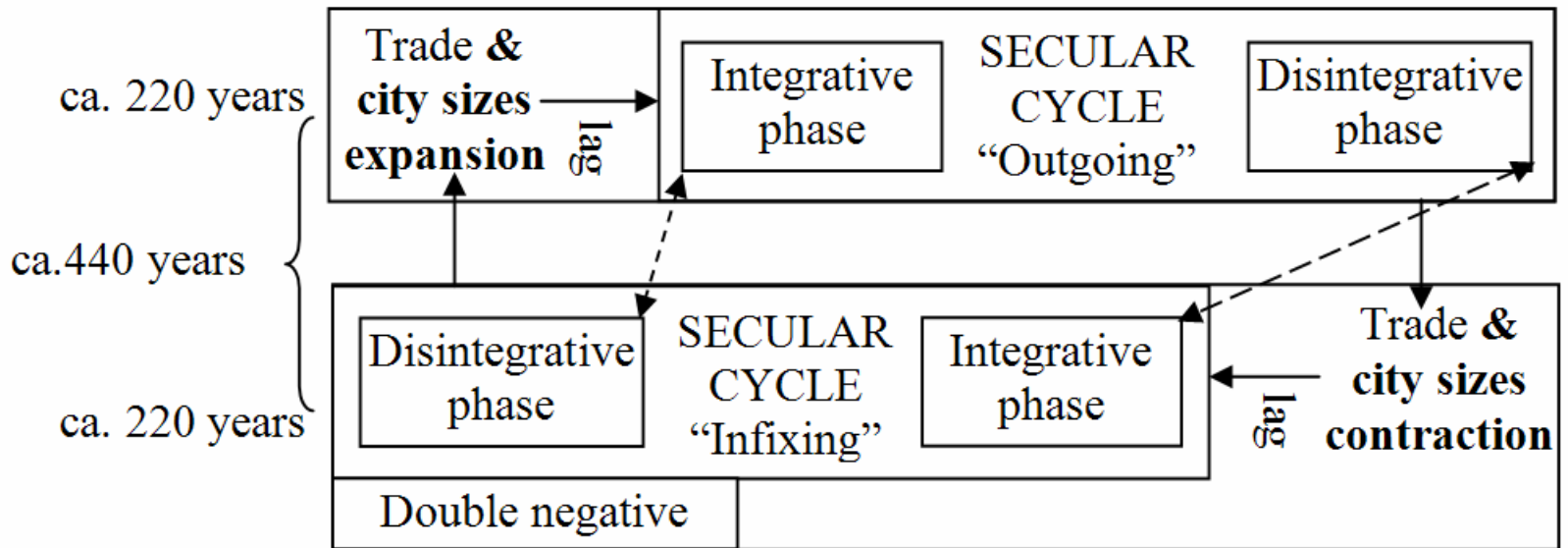
<ul style="list-style-type: none">• (earlier cycle)• 1st Roman Cycle	 <p>Time lag</p>	<ul style="list-style-type: none">• Network Size Cycle Global• 600-350BCE Regional
<ul style="list-style-type: none">• 2nd Roman Cycle• 3rd (Principate)	 <p>Time lag</p>	<ul style="list-style-type: none">• Network Size Cycle Global• 350-27BCE Global• 27BCE-285 Regional
<ul style="list-style-type: none">• E. Roman Empire• Carolingian Cycle	 <p>Time lag</p>	<ul style="list-style-type: none">• Network Size Cycle Global• 285-600 Global• 600-900 Regional

Figure 11: Operation of the Double Negative as key to 2:1 Phasing Secular/Trade Cycles



Here we show trade expansion/contraction leading secular cycle phasing prior to 930 CE when there are few cities in trade networks so there are insufficient data to measure city size pulsations, if any, in the first millennium and such pulsations would apply mostly to capital or primate cities

Figure 14: Operation of the Double Negative as the key to 2:1 Phasing



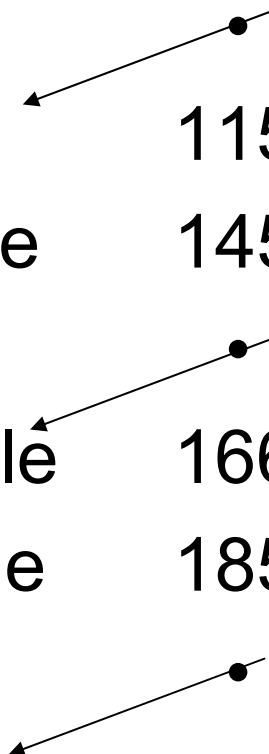
Here we show trade expansion/contraction leading secular cycle phasing after 930 CE when there are many cities in trade networks and city size pulsations accompany those of trade.

Table 6: Cross-Correlation of City-size Cycles and European Secular Cycles

Q-period (Trade Network)	From about	Secular cycle	Crisis
Trade Network Urban Size Q1 Regional CNH	900	Contracting “Infixing” early 12 th C. collapse German Empire Cycle	<i>ca. 870? - 1120</i> Norman & German collapse 900-1150
Trade Network Urban Size Q2 Global RLE	1150	Expanding “Outgoing” Medieval Cycle-High Middle Ages	<i>ca. 1120 - 1350</i> crisis starting in the 14 th century 1150-1450
Trade Network Urban Size Q3 Regional CNH	1450	Contracting “Infixing” First Modern Cycle	<i>ca. 1350 – 1560</i> crisis of the 17 th century 1450-1660
Trade Network Urban Size Q4 Global RLE	1660	Expanding “Outgoing” Second Modern Cycle	<i>ca. 1560 – 1850</i> ending in revolutionary crisis 1660-1850
Trade Network Urban Size Q5 Regional CNH	1850	Industrial Economy “Infixing” Third Modern Cycle	Colonialism 1850-1965
Trade Network Urban Size Q6 Global RLE	1945	Postcolonial Globalization “Outgoing” not yet ending Fourth Modern Cycle	in the “troubles of our times” 1945-2050?

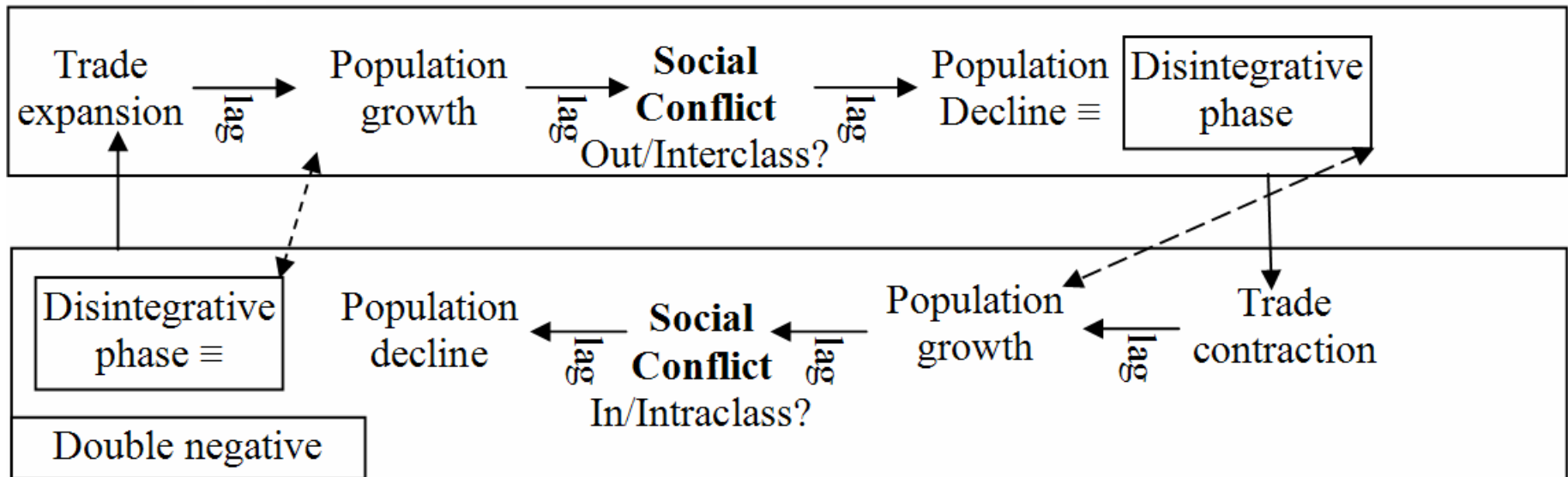
2:1 Cycles: 900-2000

Secular follows – Network Size leads
along with city size distributions

- German Emp. Cycle 900-1150 Regional
 - Medieval Cycle 1150-1450 Global
 - 1st Modern Cycle 1450-1660 Regional
 - 2nd Modern Cycle 1660-1850 Global
 - 3rd Modern Cycle 1850-2006+ Regional
- Network/City Size Cycle
- Network/City Size Cycle
- Network/City Size Cycle
- 

Conflict disruptive to expanded trade networks is key to city network cycling
 Conflict produced by pop growth is key to secular cycling
 Conflict within secular cycles could be key to political cycling

Figure 15: Lag times in 2:1 Phasing for Secular and Trade Cycles (ca. 220/440 years)

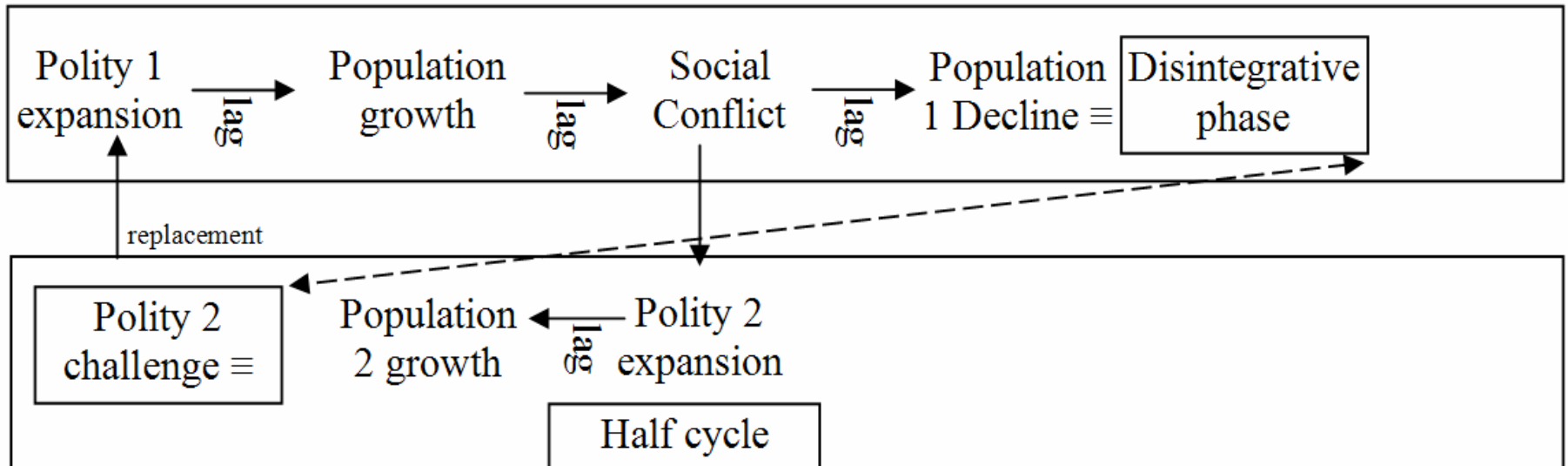


Secular Cycle ca. 220 years: nadir → pop growth → max → decline → nadir

Full Trade Network expansion/contraction ca. 440 years

Conflict disruptive to expanded trade networks is key to city network cycling
 Conflict produced by pop growth is key to secular cycling
 Conflict within secular cycles -- is it key to political cycling?

Figure 16: Lag times in 2:1 Phasing for Political within Secular Cycles (ca. 110/220 years)



Conflict between polities and competition between cities -- is it key to the cycling of economic innovations (K-waves)?

Table 7: K-waves: the sequence of global leading sectors

About	K-waves (global leading sectors)	Long cycles (world powers after 1500)	Secular cycles Trade & City Cycles
900 ?	credit mechanisms?	Chinese	900 SC1 Q1≡
930	K1 Printing and paper	LC1 Northern Sung	Regional/sub- Zipfian
990	K2 National market		
1060	K3 Fiscal framework	LC2 Southern Sung	Q2≡1000
1120	K4 Maritime trade		1150 SC2
1190	K5 Champagne Fair	LC3 Genoa→France	Global / Zipfian
1250	K6 Black Sea trade		
1300	K7 Galley fleets	LC4 Venice	Q3≡1290
1360	K8 Pepper		Regional/sub- Zipfian
1430	K9 Guinea gold	LC5 Portugal →Spain	1450 SC3
1492	K10 Indian spices		
1540	K11 Atlantic, Baltic	LC6 Dutch Republic	
1580	K12 Asian trade (VOC)		
1640	K13 Amerasian trade-tobacco	LC8 Britain I→France	1660 SC4 Q4≡1600
1688	K14 Amerasian trade-coffee		Global / Zipfian
1740	K15 Cotton, iron	LC9 Britain II→	
1792	K16 Steam, rail		Q5≡1785
1850	K17 Electrics, chemicals, steel	LC10 United States →Britain	1850 SC5 Regional /sub- Zipfian
1914	K18 Autos, air, electronics	United States	
1972	K19 Information industries		Q6≡1920
2026?	K20 ?		Global / Zipfian

Source of the three leftmost columns: Modelski, G. 2000.
<http://faculty.washington.edu/modelski/Evoweconomy.html>

Table 8: K-waves: the sequence of global leading sectors

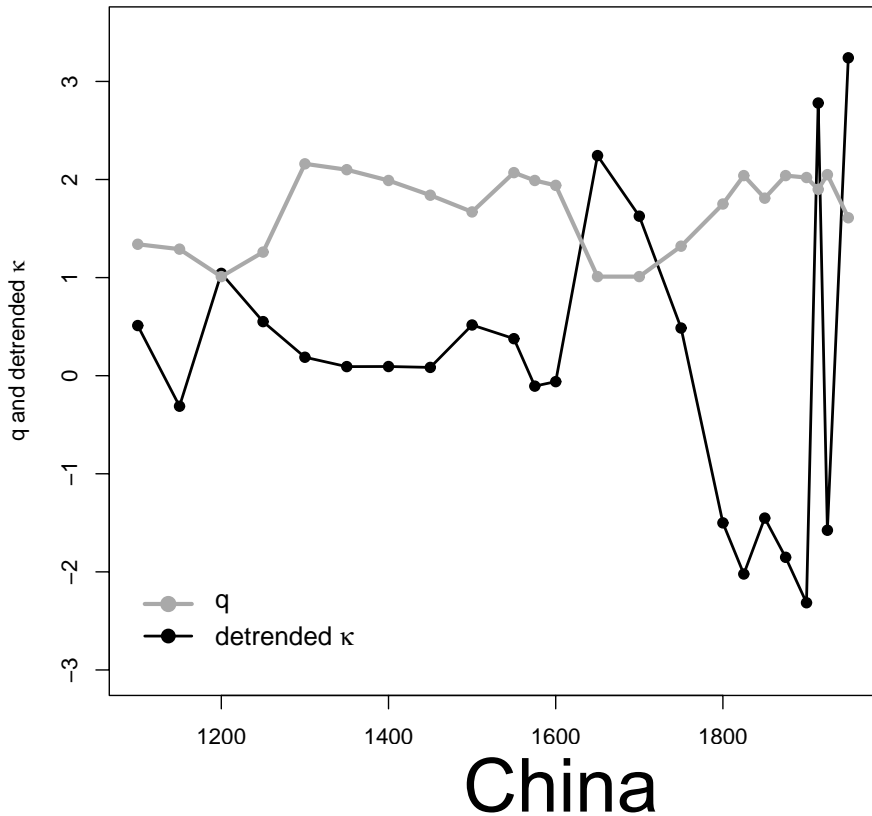
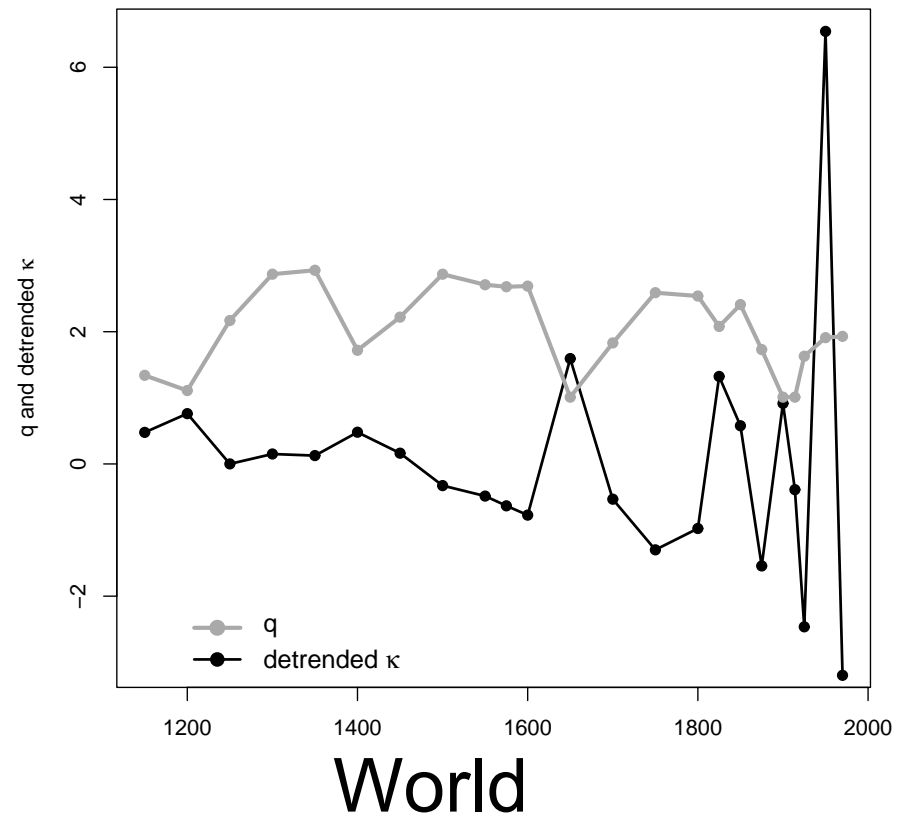
K-wave	From about	Leading sector	Major innovation
K1	930	Printing, paper	Learning society, book printing
K2	990	National market formation	North-south market unification
K3 Q2	1060	Fiscal/administrative framework	Monetization , paper money
K4	1120	Maritime trade expansion	Compass, large junks
K5	1190	Champagne fairs	European market organized
K6	1250	Black Sea trade	Innovations from East Asia
K7 Q3	1310	Venetian galley fleets	New markets in North Europe
K8	1350	Pepper trade	Alexandria-connection institutionalized
K9	1430	Guinea gold	“Discovery” of African trade
K10	1494	Indian spices	Operating oceanic route
K11 Q4	1540	Atlantic, Baltic trades	American silver
K12 Q4	1580	Asian trade	Dutch East Indies Co. VOC
K13	1640	Amerasian trade	Plantations
K14	1688	Amerasian trade	Tobacco
K15	1740	Cotton, iron	Factory production
K16 Q5	1792	Steam, rail	New forms of transport
K17	1850	Electrics, chemicals, steel	Invention of invention
K18	1914	Electronics, autos, aerospace	New products
K19 Q6	1972	Information industries	Computers / Electronic transfers
K-20	2026		

Source: Modelski, G. 2000. <http://faculty.washington.edu/modelski/Evoweconomy.html>

Table 9: Organizational evolution in the global economy

From about	Phases	Centered on	
V. Breakthrough to market systems 930	Song move to national market	China	Experiments
1190	Nautical-Commercial revolution	Italy	Clusters
1430	Oceanic trading	Atlantic Europe	Critical mass
1640	Industrial take-off	Britain	Pay-off
VI. World Market 1850	Information Economy	United States	Experiments
2080			Clusters

Source: Modelski, G. 2000. <http://faculty.washington.edu/modelski/Evoweconomy.html>

q and detrended κ over timeq and detrended κ over time

Afterword: The anomaly of the distribution shape parameter q varying inversely to the scaling parameter kappa (κ), when detrended. This helps to identify breaks in the historical dating but may explain why low- q for the body of the distribution (which should imply Zipfian tails) in fact varies inversely with the direct SPI measure of the Zipfian 5-city upper tail.

conclusions

- Given the conclusion on slide 32 that: Within each city cycle (Q1/2, Q3/4, Q5/6), there are two secular cycles, within each secular cycle 2 political cycles, within each political cycle there are 2 economic innovation cycles.
- City size distribution (Q-) cycles and their two (Q-) periods are real, reliable, long term, and both phased and sometimes synchronized in ways that depend on actual trade networks (expansion and contraction)
- Conflict variables have dynamical connections to the build-up of (1) demographic pressure on resources in secular cycles, (2) competition of polities within these cycles, and (3) competition of economic sectors within those cycles.
- There is ample cross-correlation evidence to substantiate that Q-periods and cycles have demonstrable effects.

(more about network dynamics)

At the foundation of a rethinking in a network perspective of long and convoluted world historical systems change is a compelling need to study dynamics in terms of specific interactions, the ebbs and flows of differential network histories that nonetheless can be seen to operate in large part under some set of generalizable processes. Network theory can clarify basic concepts that can be used to test specific interactional hypotheses derived from principles that are both very general, but also specifically tailored to the phenomena at hand.

If the reasoning of this paper is correct, then a speculative hypothesis is that a network approach to world historical systems, coupled with other theoretical frameworks, offers a series of supplemental hypotheses and potential explanations for historical change that are very specific regarding the channeling of change and that take different network contexts into account. The speculation is that with additional understanding of network predictions and explanations of network and historical dynamics, we should find that what have been taken as idiosyncratic “path dependencies” will to a large extent turn out to be network independencies, subject partly to the role of agency, but much more predictable than previously thought possible.

Footnotes re: networks

After 900 CE, the shapes of Chandler's city size distributions begin to differentiate by historical period

These differentiations by historical period relate to trading network expansion/contraction

Low- q fittings for years in 1000 – 2000

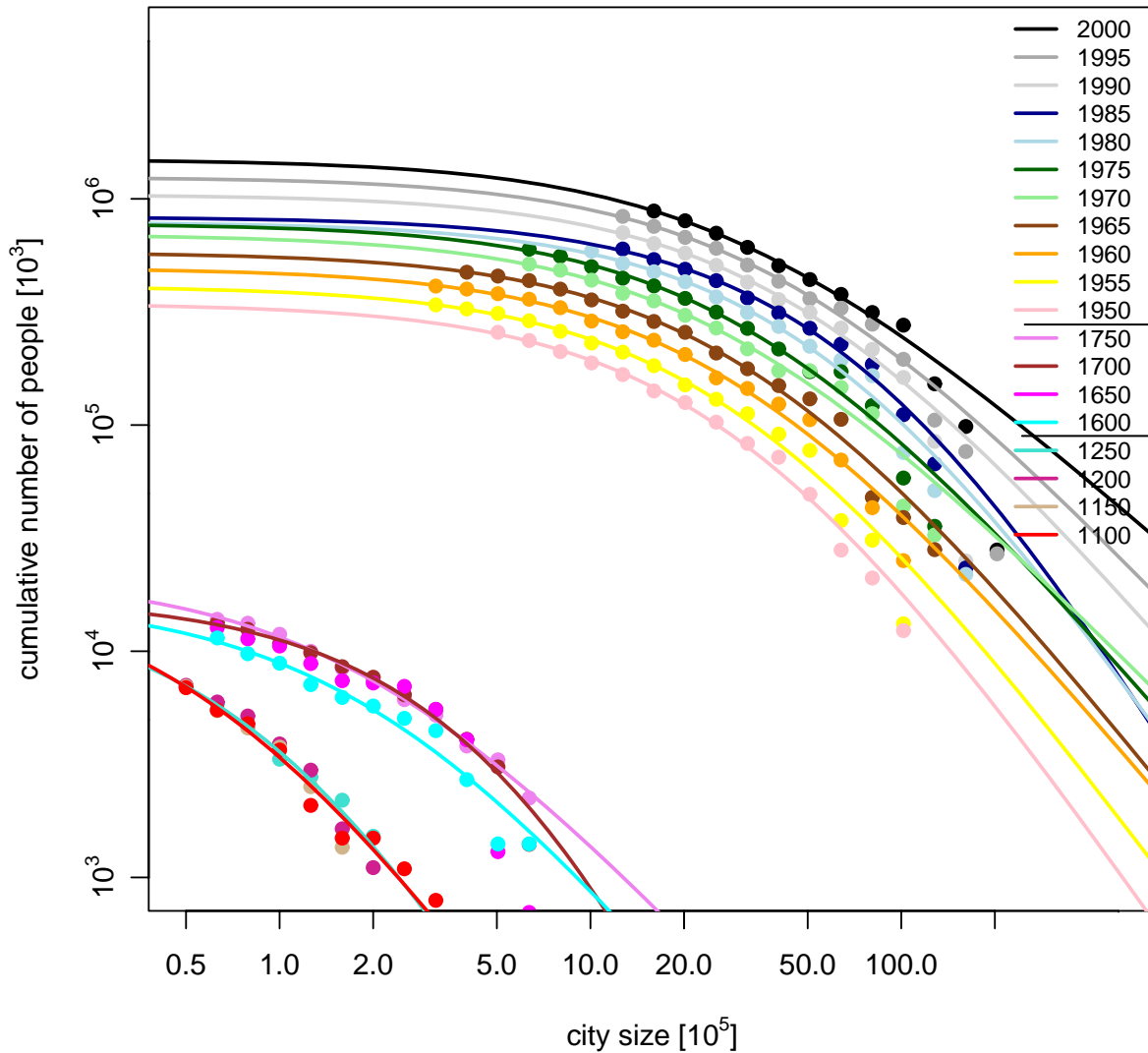


Figure 2: City Size Scaling: Zipfian in the upper city size bins

Extreme global hubs, lesser hubs in the neighborhood of most cities are absent.

q -scaling is stretched exponential scaling that models the entire size distribution, including the power-law slope of the upper sized bins. (cumulative binned, CDF)

In these periods, highest profits are accrued by cities with the highest global flow centralities

High-q fittings for years in 1000 – 2000

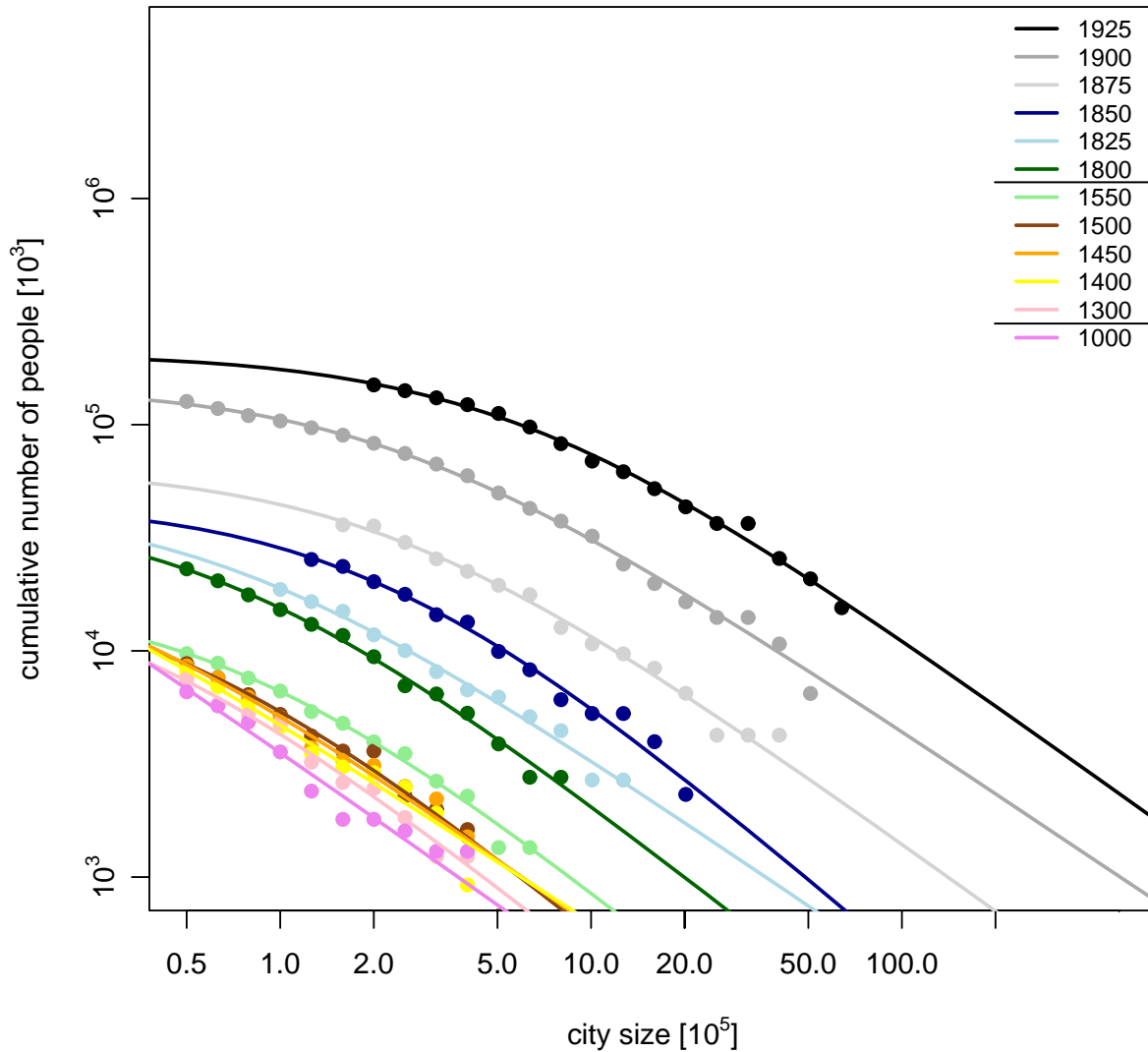
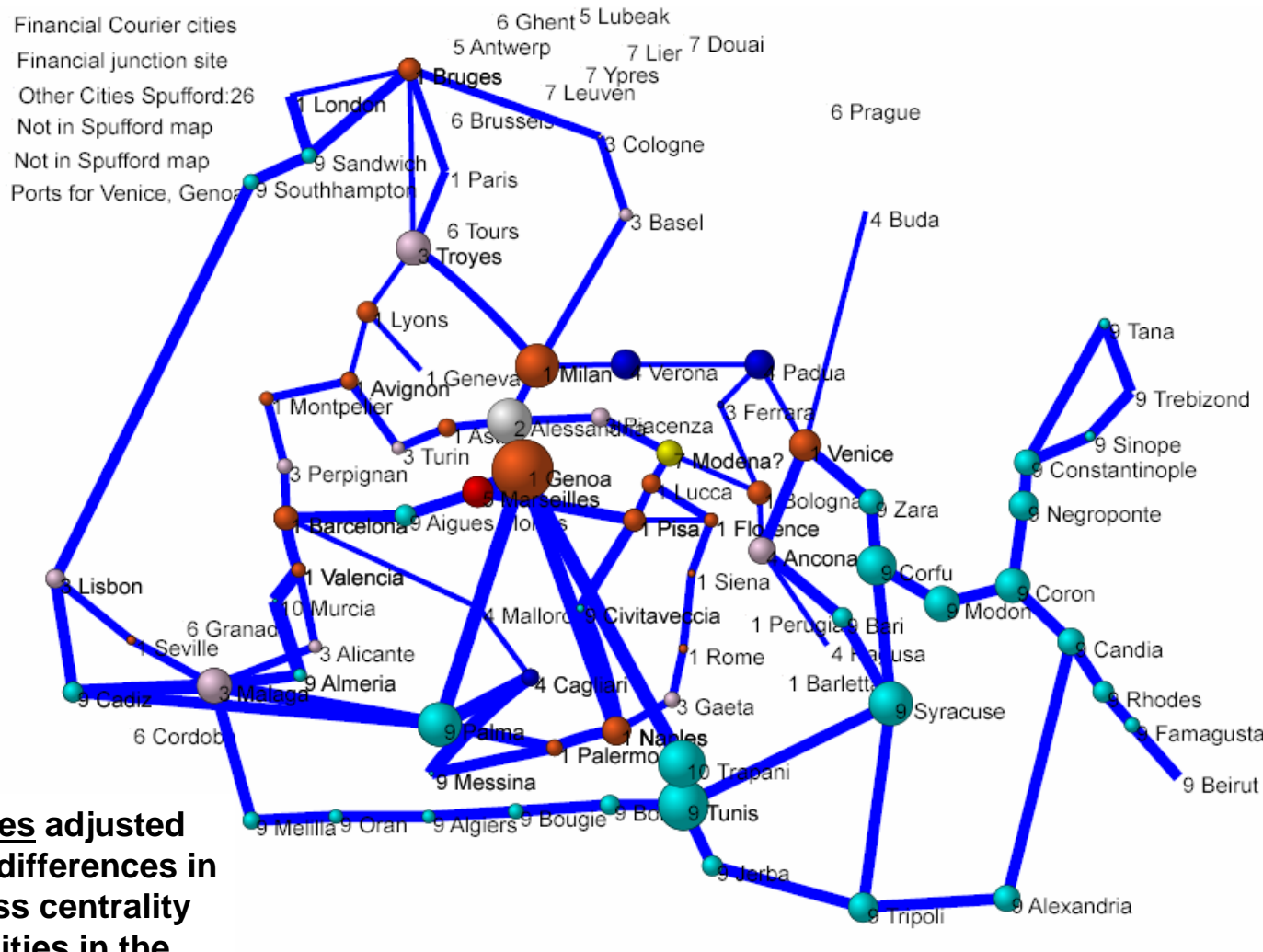


Figure 3: City Size Scaling:
sub-Zipfian in the upper city size bins

*Global hubs less differentiated,
but lesser hubs in the neighborhood
of most cities are present.*

*In these periods, highest wealth
is accrued by cities with the
highest betweenness centralities*

Betweenness centrality in the trade network predicts accumulation of mercantile wealth and emergence of commercial hegemons. e.g., in the 13th century, **Genoa** has greatest betweenness, greatest wealth, as predicted. Later developments in the north shift the network **betweenness center to England**.



Episodically, in 1298, **Genoa** defeated the **Venetians** at sea.

Repeating the pattern, **England** later defeats the **Dutch** at sea

Size of nodes adjusted to indicate differences in betweenness centrality of trading cities in the banking network

Betweenness Centralities in the banking network

Given its 13th C betweenness centrality, Genoa generated the most wealth

discards

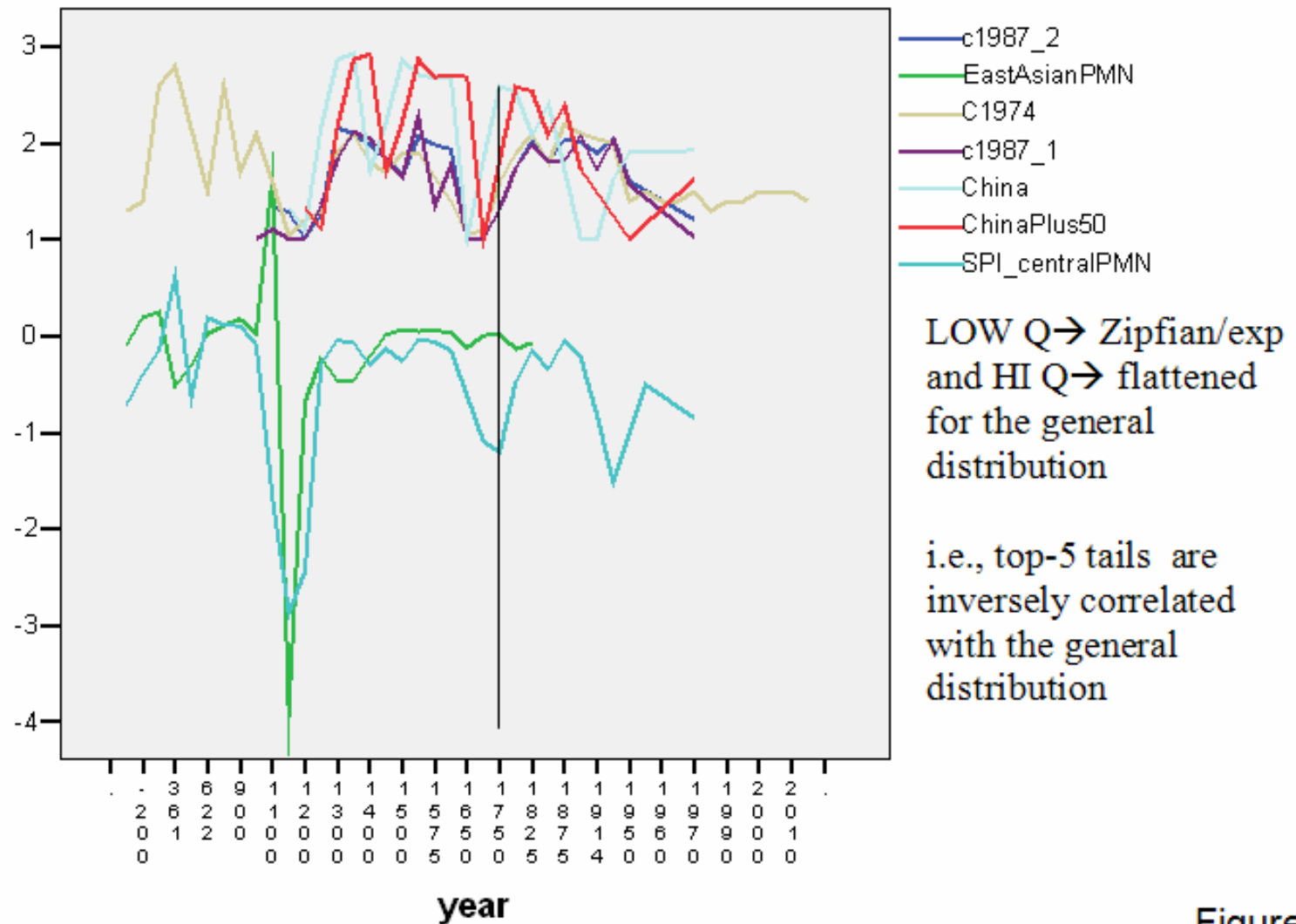


Figure 3:
Largely co-varying oscillations for central and East Asian PMNs, China, and world cities

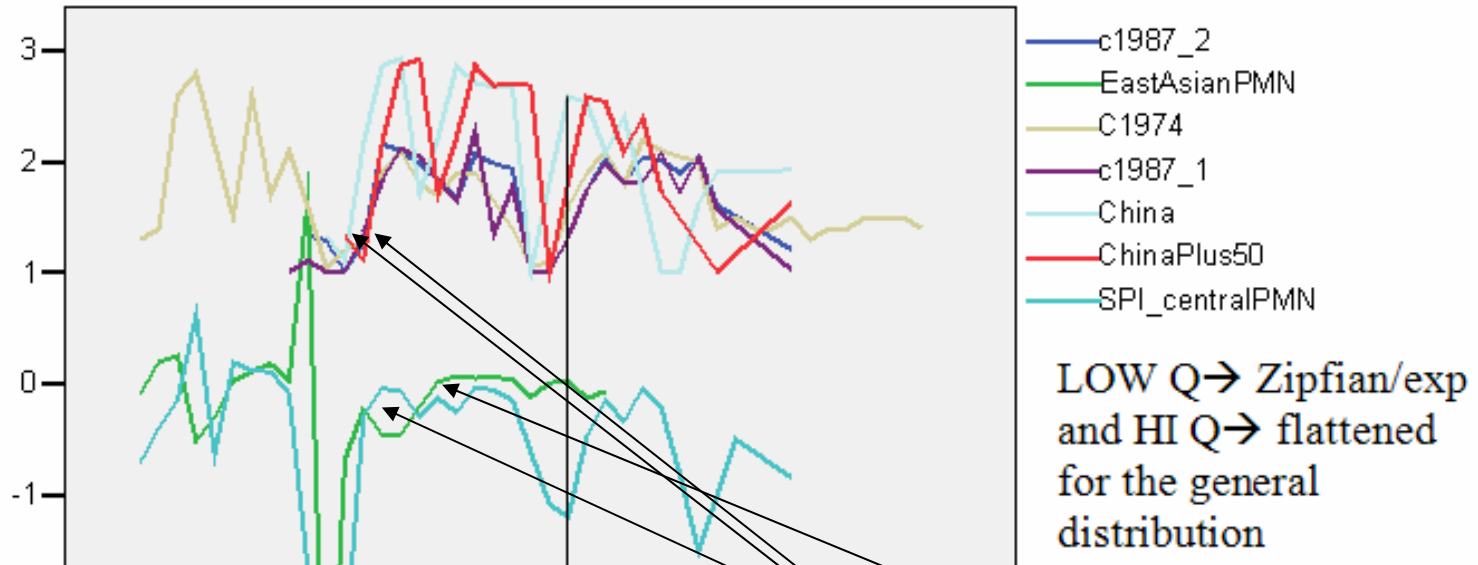


Table 2: Statistical Runs Tests for Number of Historical Periods

Runs Test (Means)	C1974	C1987_1	C1987_2	adj1.02	China	SPI_V	EastAsianPMN
Test Value(a)	1.6725	1.5828	1.6846	1.6854	2.0430	-.3725	-.1712
Cases < Test Value	23	11	10	9	11	15	8
Cases >= Test Value	17	14	14	15	12	19	18
Total Cases	40	25	24	24	23	34	26
Number of Runs	9	7	7	5	7	10	5
Z	-3.624	-2.414	-2.221	-3.015	-2.129	-2.567	-3.113
Asymp. Sig. (2-tailed)	.000	.016	.026	.003	.033	.010	.002