

CITY SYSTEMS AND THE CAUSE OF INEQUALITY

A CITY SCIENCE APPROACH

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Causality in City Science

Regularity and Contextuality

Moving to generative value

Talk outline

Causality in City Science

What do we mean by it?

Regularity and Contextuality

Moving to generative value

Talk outline

regularity value

How often is this true?

contextual value

Where/when is this true?

generative value

How is this true?

Three kinds of “value”
for law-like statements

regularity value

How often is this true?

contextual value

Where/when is this true?

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How is this true?

Three kinds of “value”
for law-like statements

Causal reasoning can
play a role in each

regularity value

How often is this true?

contextual value

Where/when is this true?

generative value

How is this true?

City size distributions often follow Zipf's Law...

... in “coherent” urban systems ...

... because of within-city inequality.

Beyond open science: Data, code, and causality

Levi John Wolf

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Indeed, city science is relatively unusual in the social sciences, in that one can still often find work seeking ‘laws’



A COMPUTER MOVIE SIMULATING URBAN GROWTH IN THE DETROIT REGION

W. R. TOBLER

University of Michigan

The LAWS of MIGRATION.

By E. G. RAVENSTEIN, Esq., F.R.G.S.

HUMAN BEHAVIOR

AND

THE PRINCIPLE
OF LEAST EFFORT



An Introduction to Human Ecology

GEORGE KINGSLEY ZIPF, Ph.D.

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Tobler's First Law

Gravity Law (of flows)

Zipf's Law (power law)

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Near things are more similar than distant things

Separation decreases interaction between cities

The sizes of cities in a “coherent” system will decay in a regular way

regularity value

*Statements
we make that
derive their value
from how often
they're true.*

Near things are more similar than distant things

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City scaling as an example

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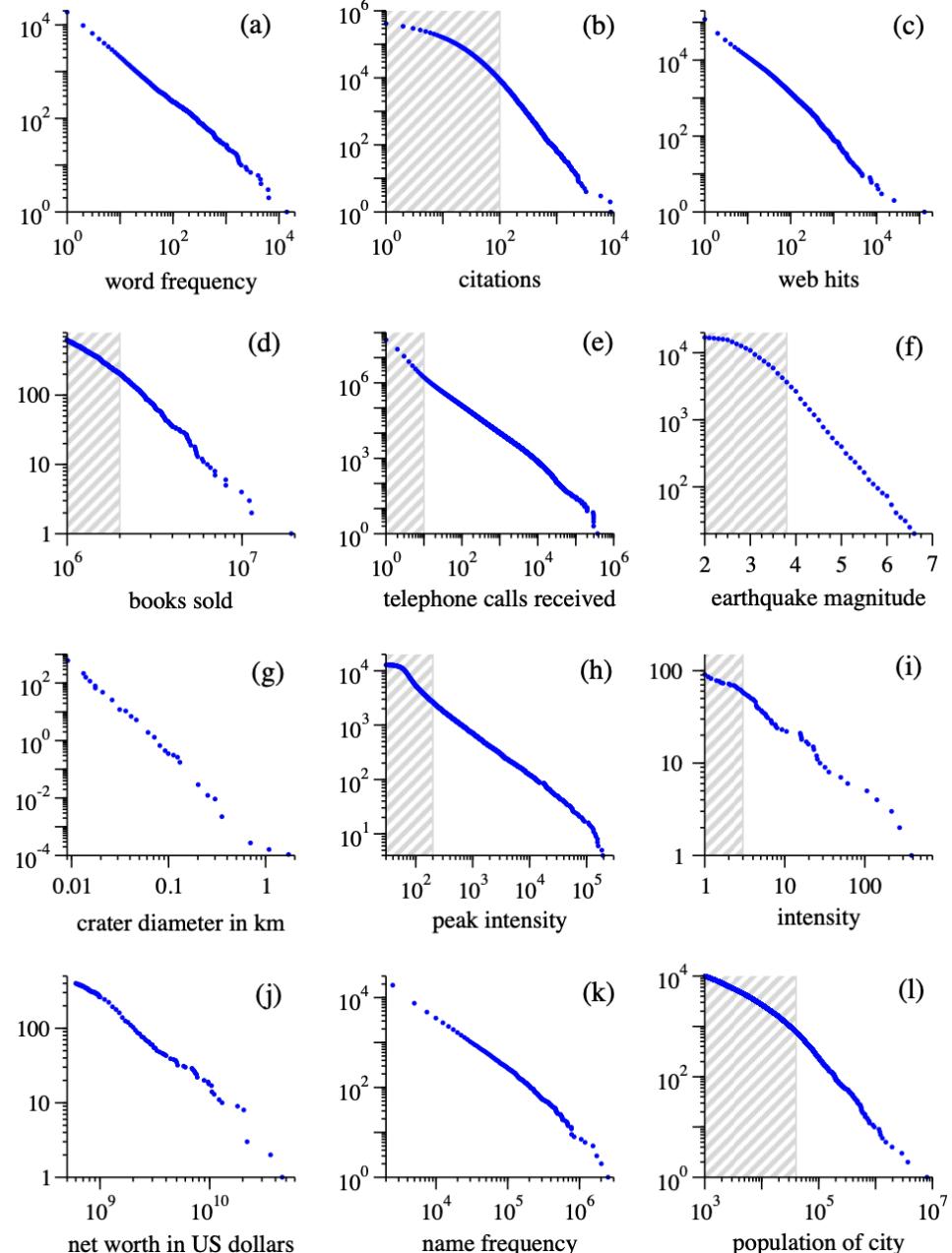
regularity value

Power laws in plain language

Starting from the biggest item, the next item gets smaller at a consistent ratio

$$rank \propto size^{-decay}$$

Newman, (2005)



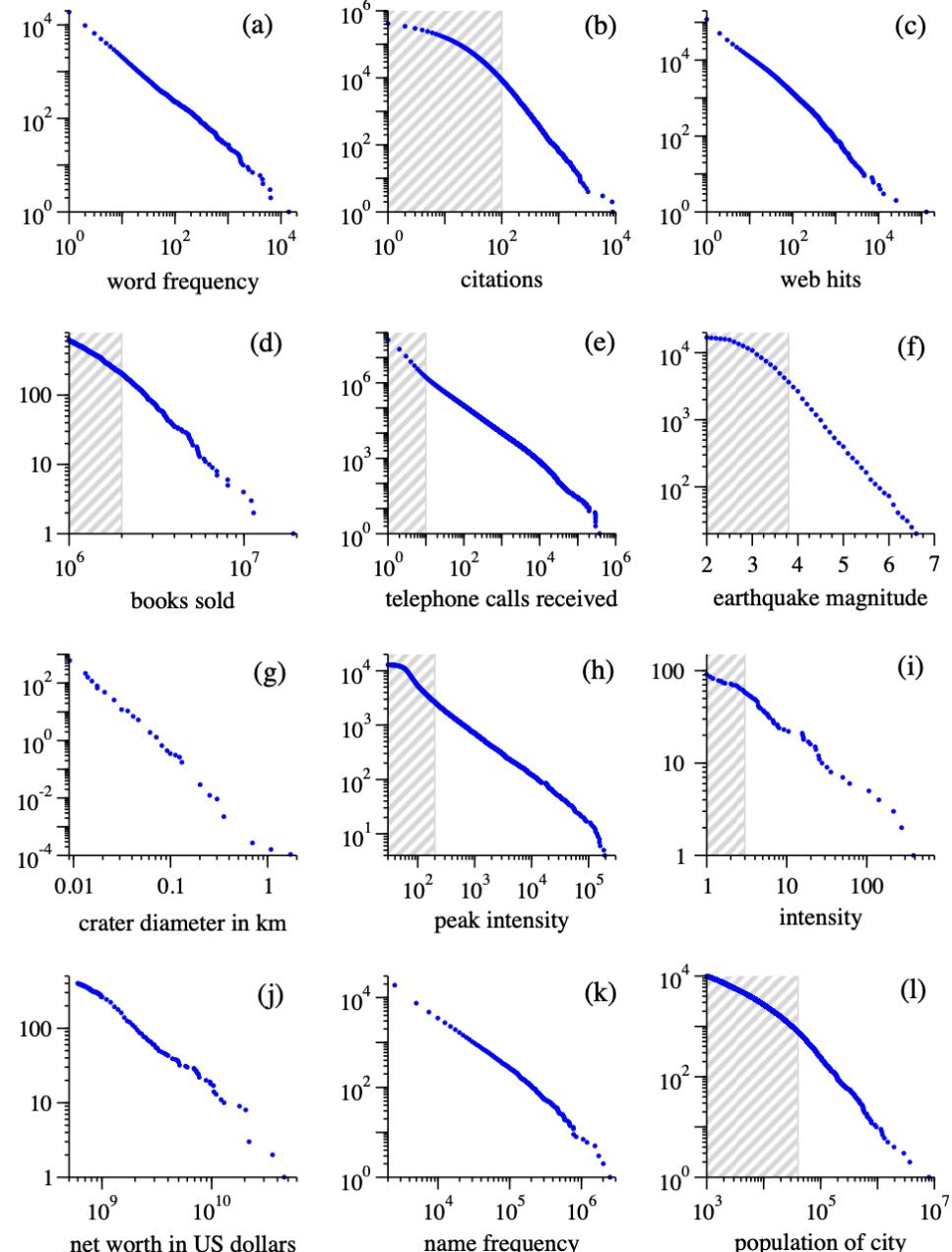
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Starting from the biggest item, the next item gets smaller at a consistent ratio

$$rank \propto size^{-decay} \quad \text{primal}$$

$$size \propto rank^{-decay} \quad \text{dual}$$

Gabaix & Ibragimov (2005)

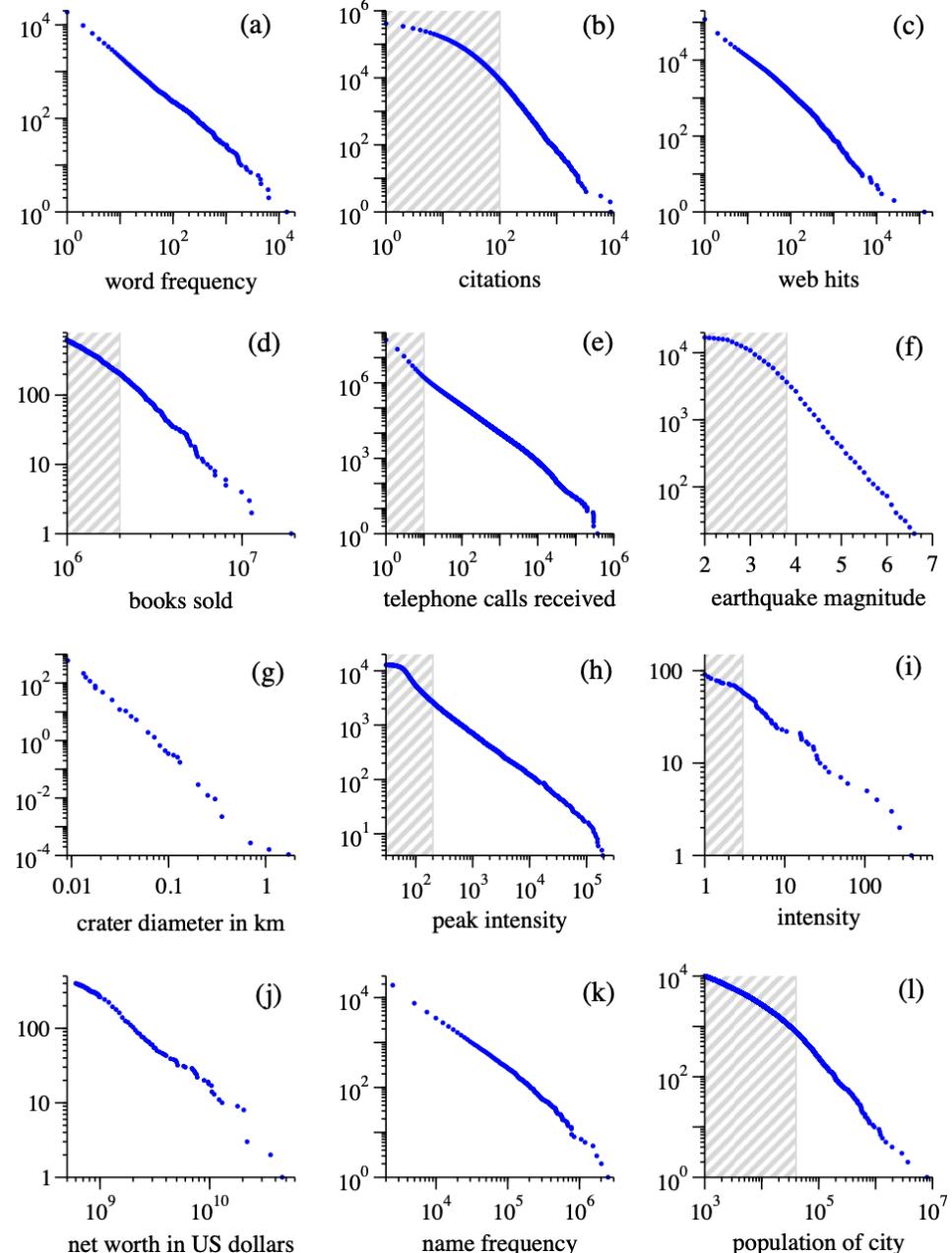


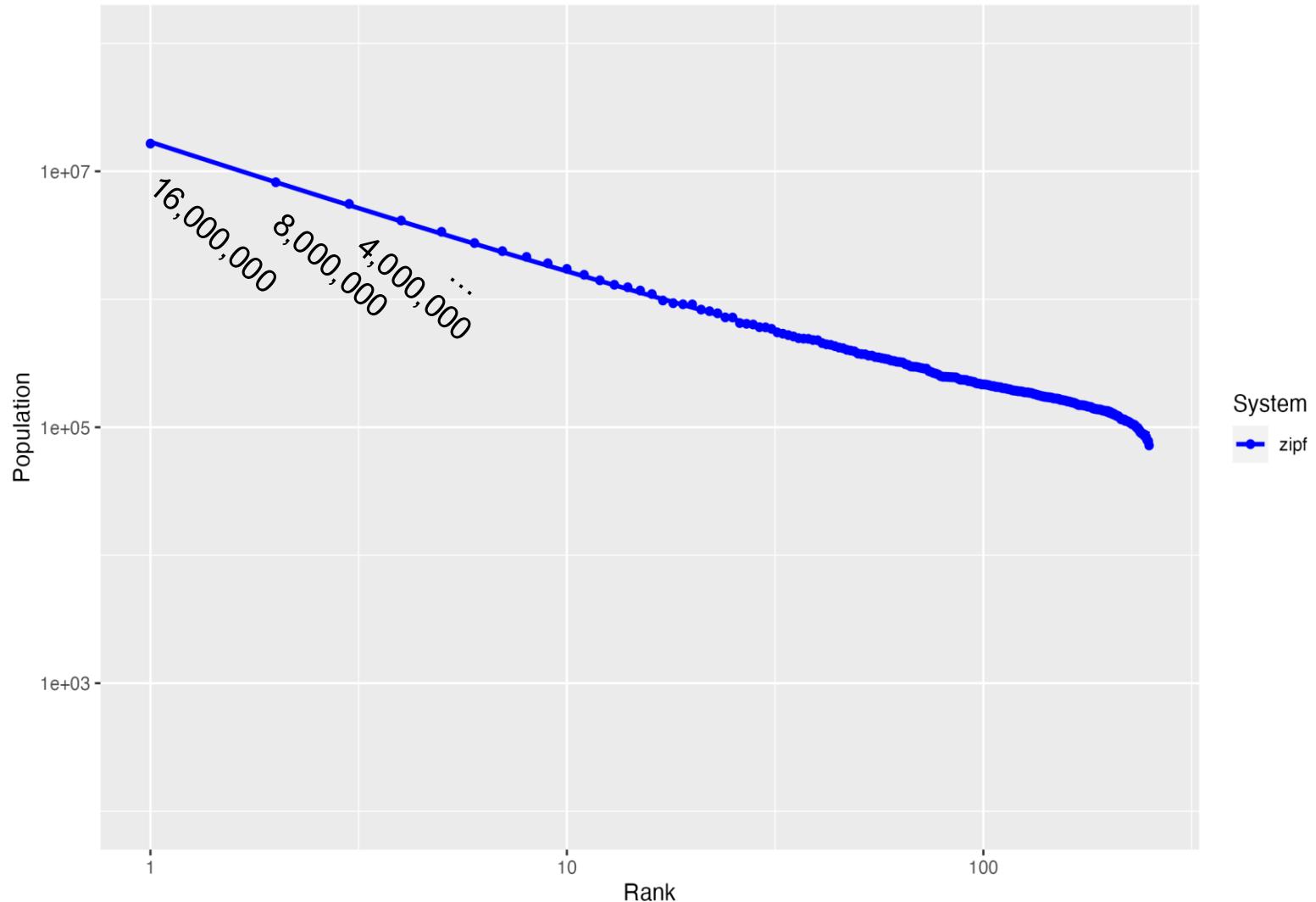
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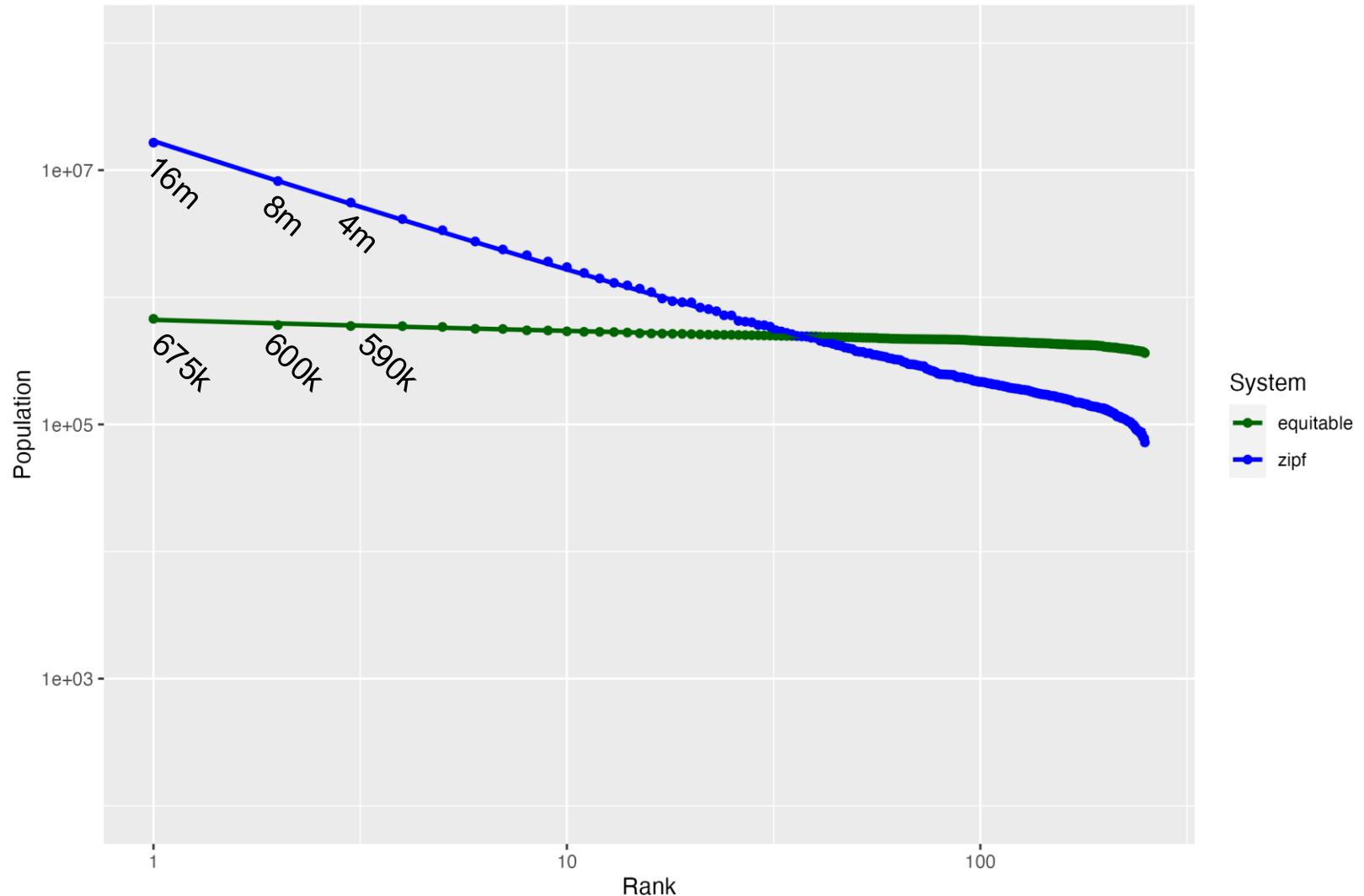
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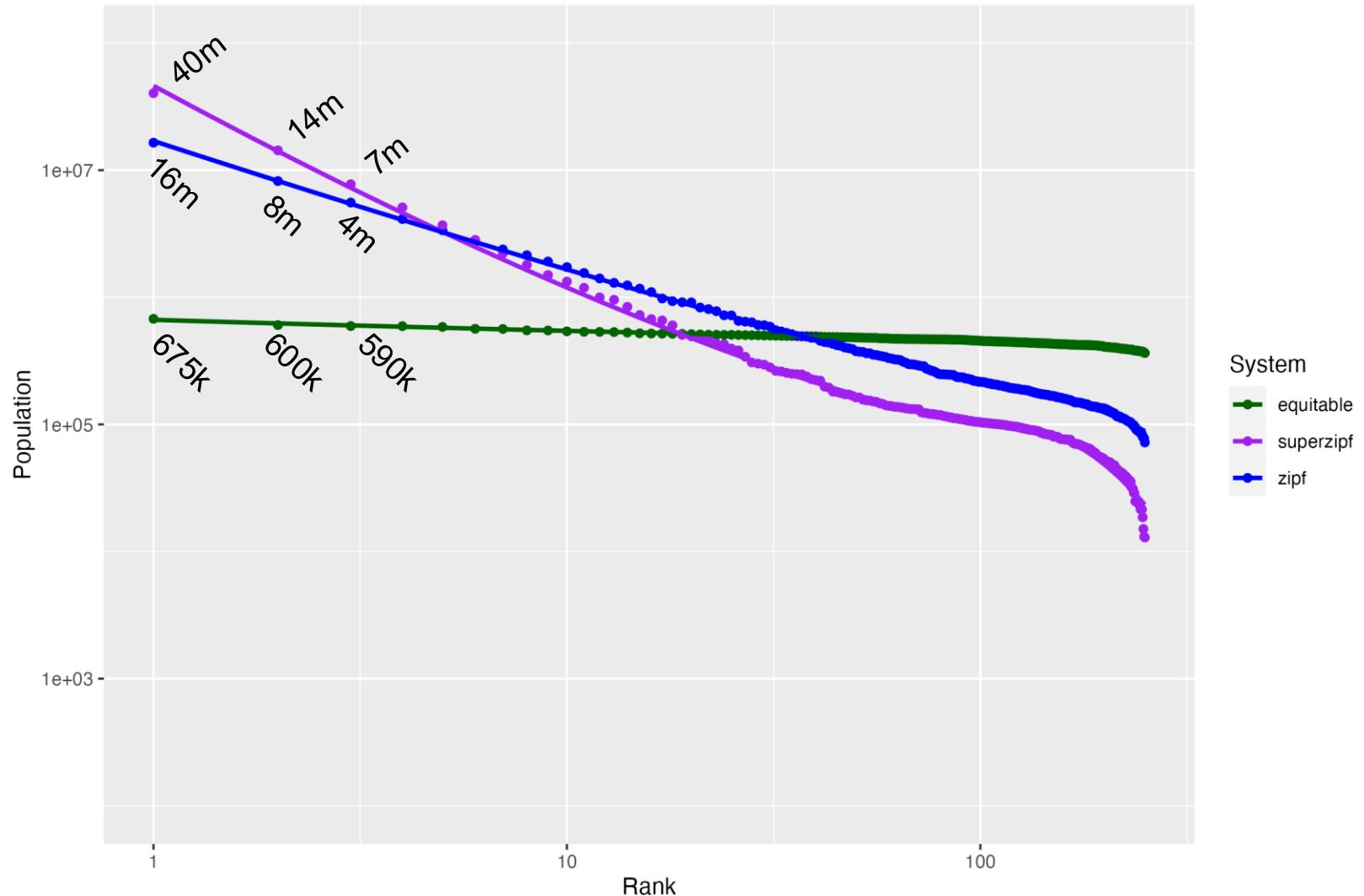
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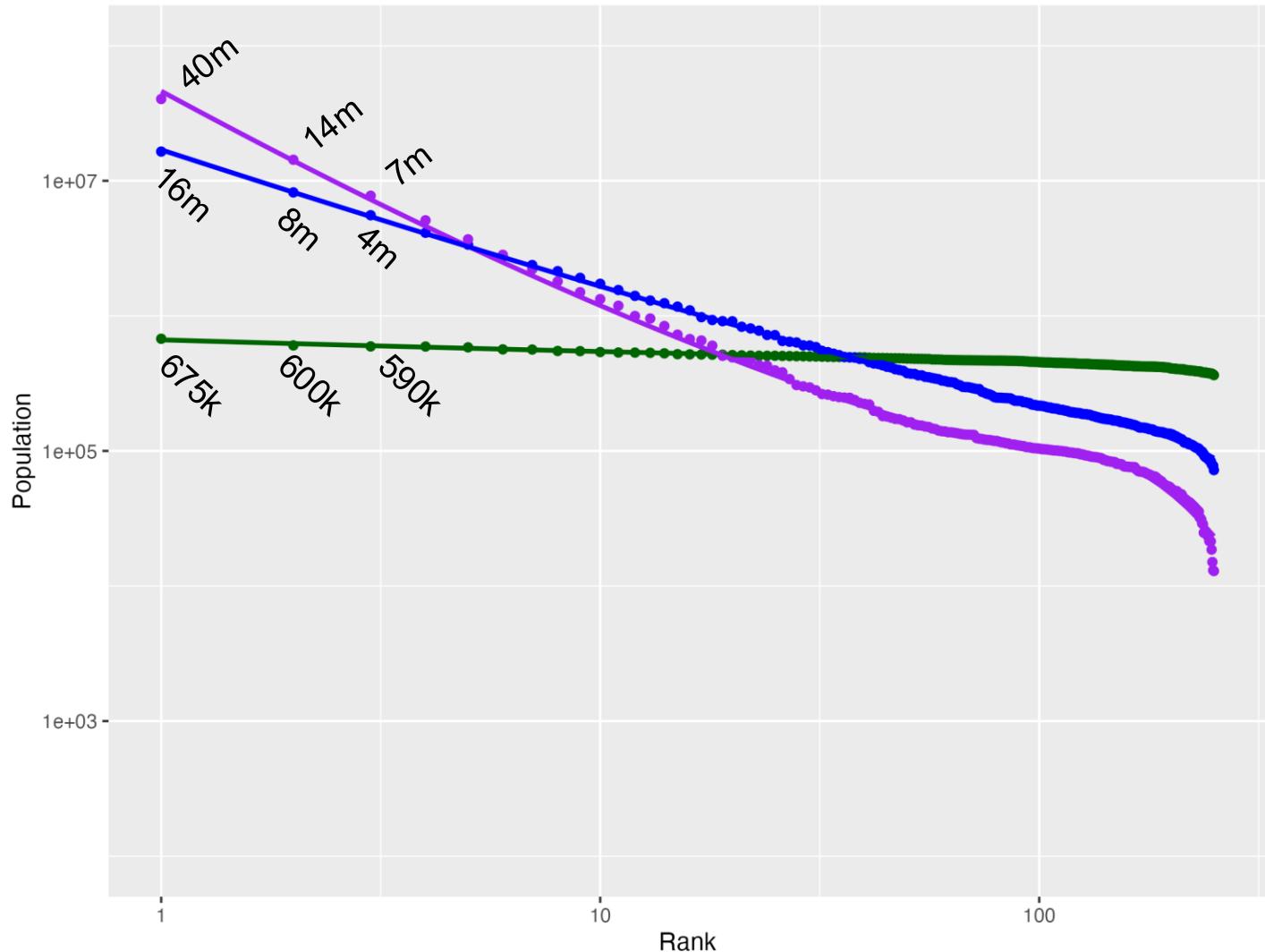
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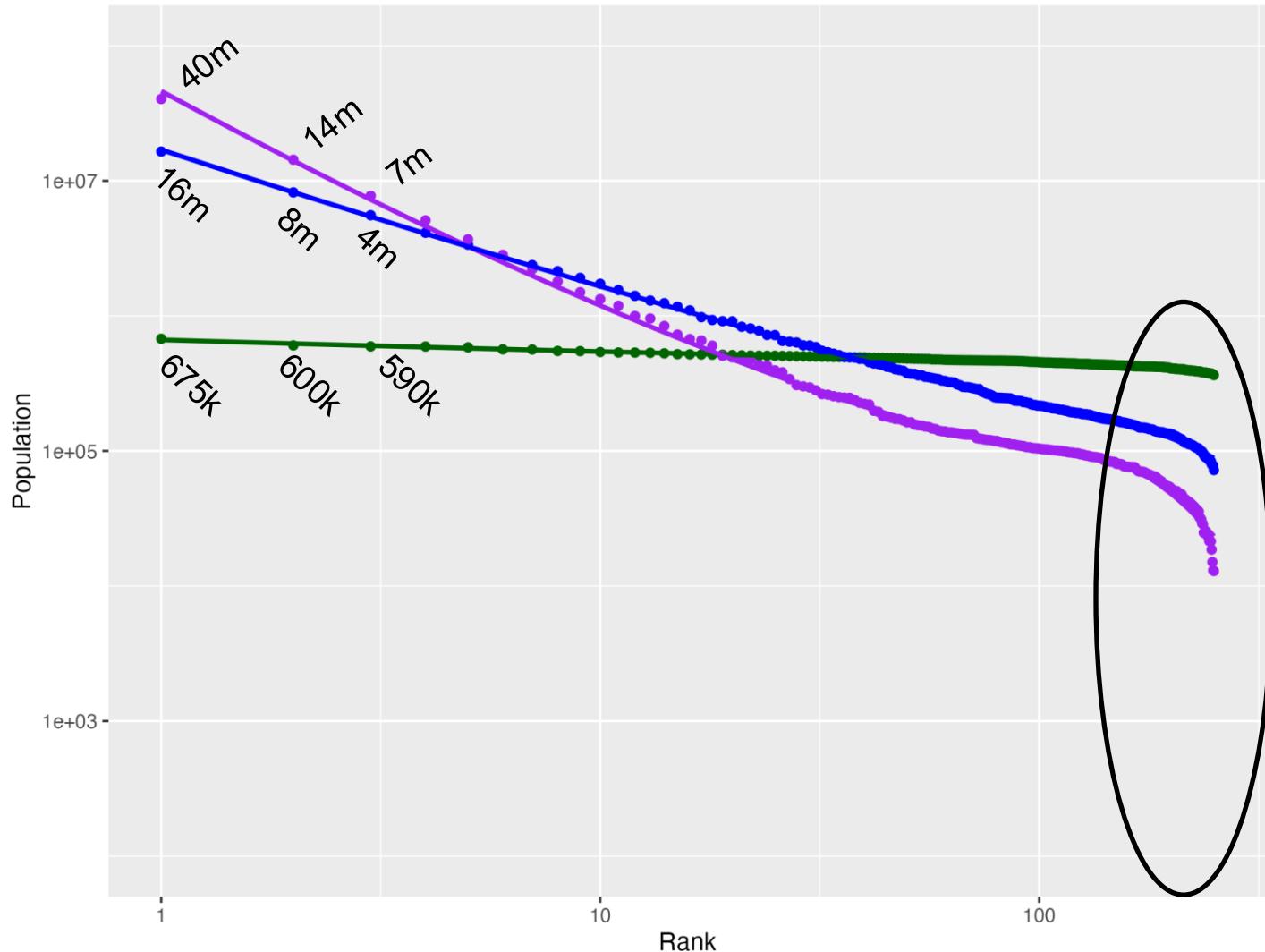




System

- equitable ($\lambda = .1$)
- superzipf ($\lambda = 1.5$)
- zipf ($\lambda = 1$)

$$x \propto r(x)^{-\lambda}$$

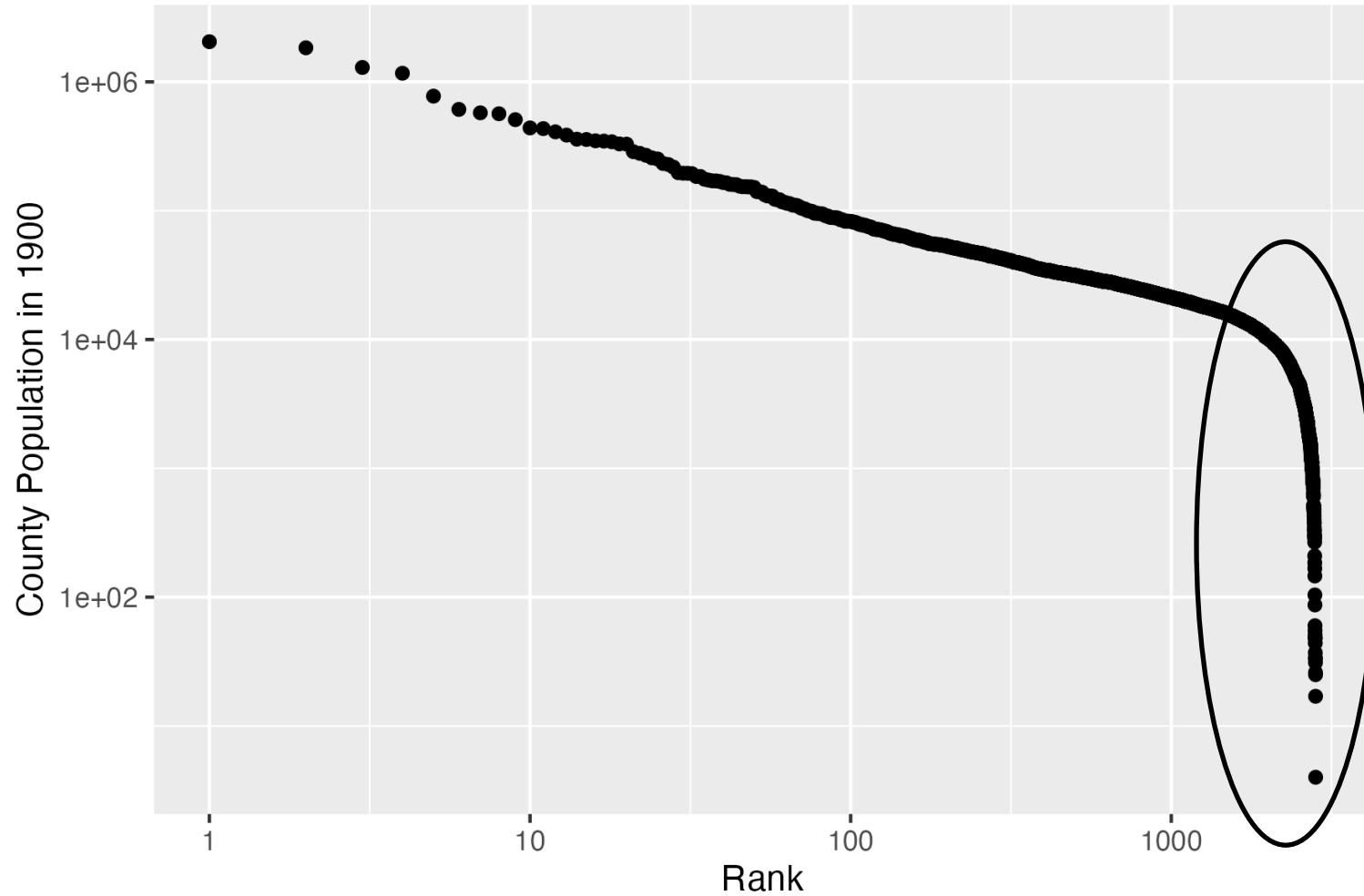


“fall off”
common to many
real-world things with
more small values

System

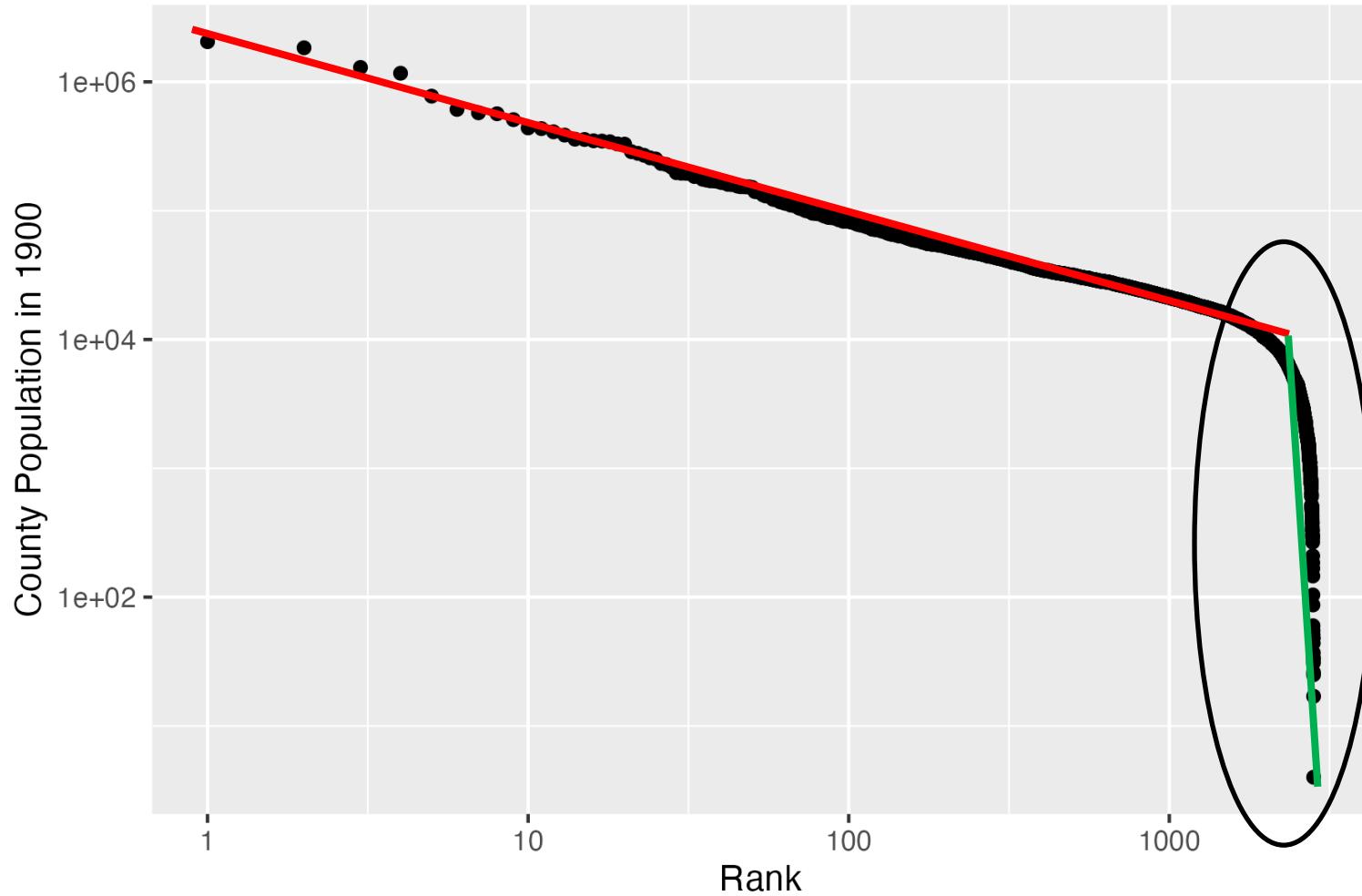
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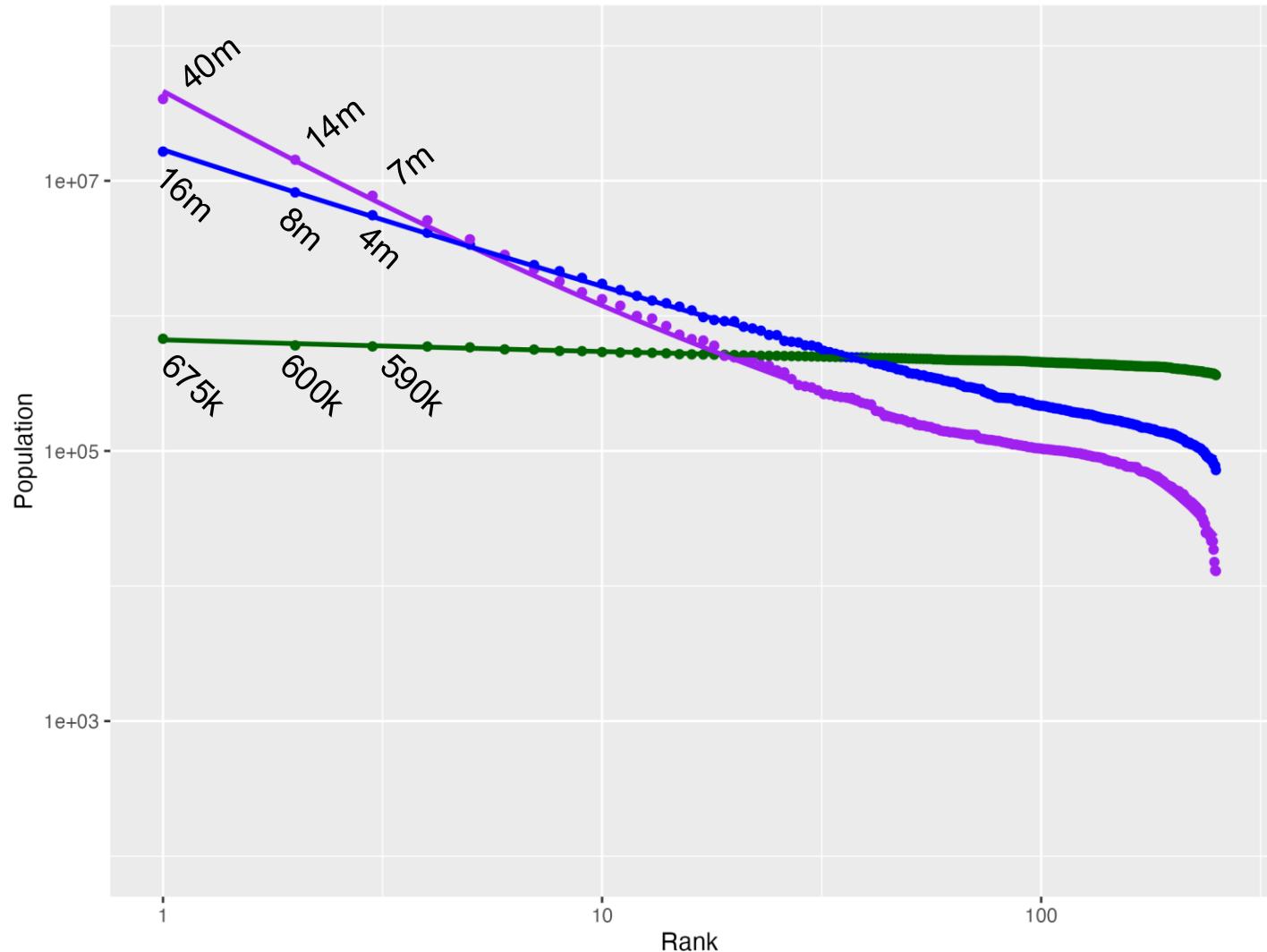
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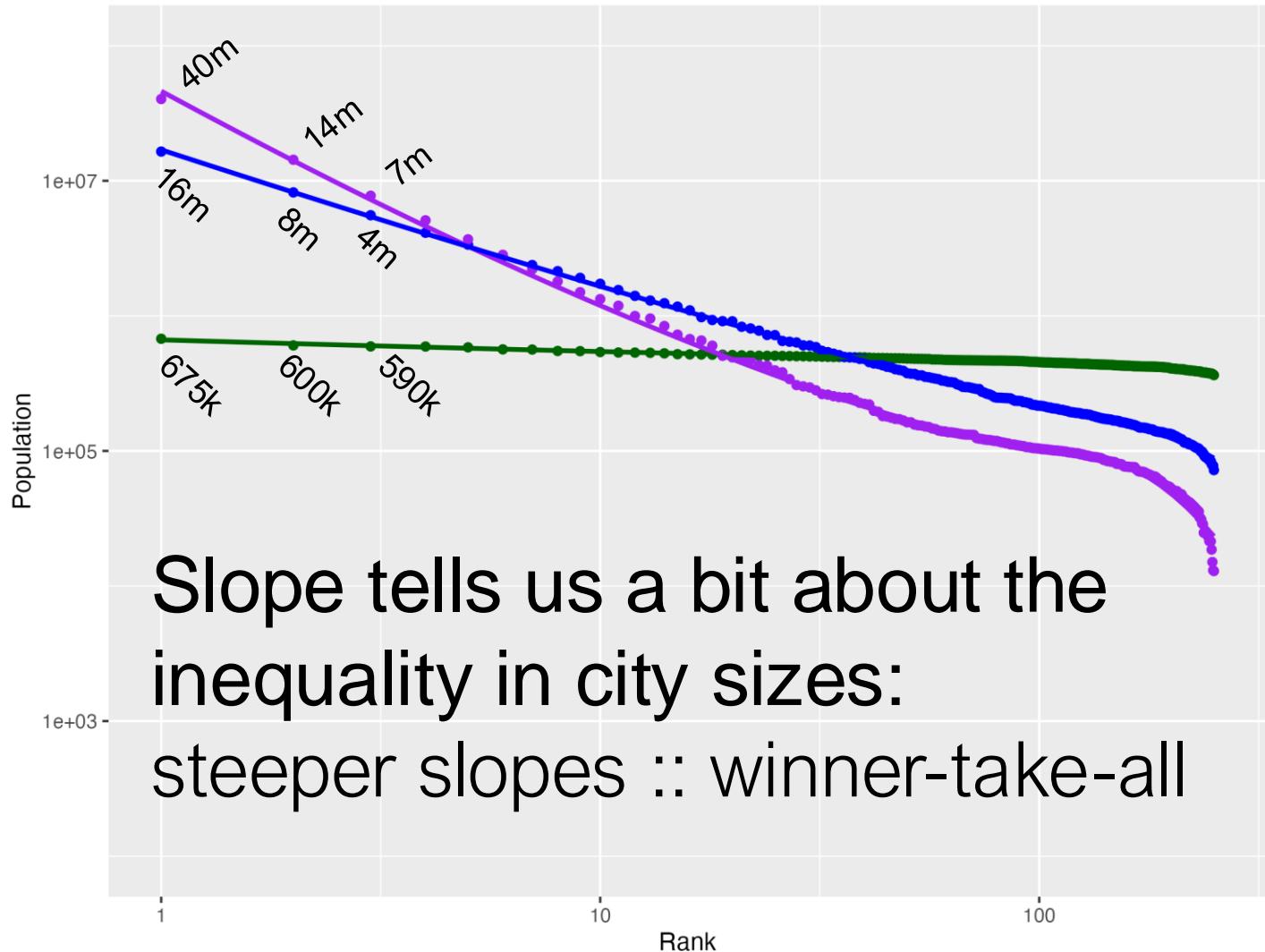
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Critical Truths About Power Laws

Michael P. H. Stumpf¹ and Mason A. Porter²

What genuinely new insights have been gained by having found a robust, mechanistically-supported, and in-all-other-ways superb power law? We believe that such insights are very rare.



Slope tells us a bit about the
inequality in city sizes:
steeper slopes :: winner-take-all

$$x \propto r(x)^{-\lambda}$$

Rethinking Causality in Quantitative Human Geography

Mirah Zhang Levi John Wolf

“Weak replicability” should instead be framed as “strong contextuality”: our specific explanations of why context counts should be sufficient to understand when a given causal mechanism might operate.



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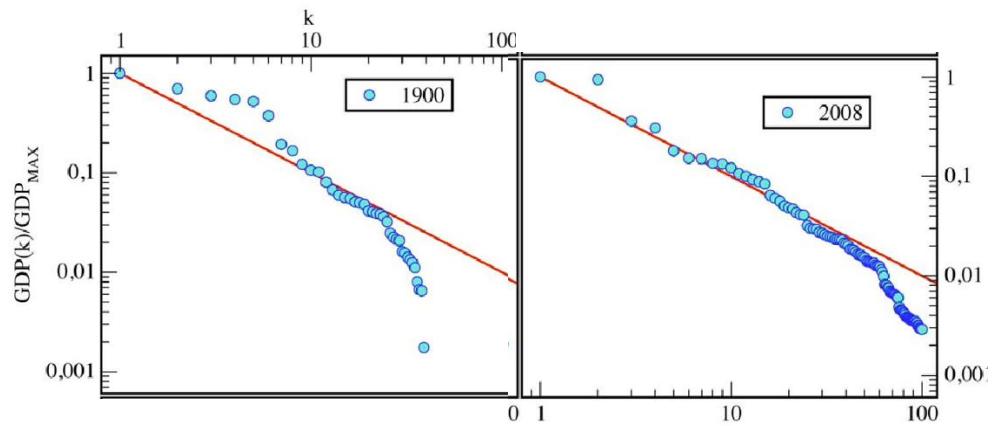
Separation decreases flow between cities

The sizes of cities in a “**coherent**” system will decay in a regular way

While Zipf's Law holds approximately for the city sizes of each European country ... it completely fails in the aggregated sets, that is in the EU.

There is More than a Power Law in Zipf

Matthieu Cristelli^{1,2}, Michael Batty^{3,4} & Luciano Pietronero^{1,2,5}



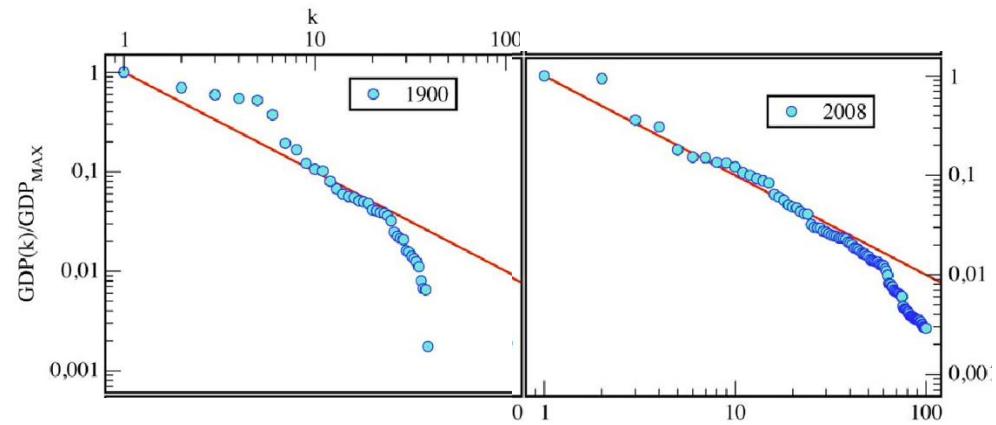
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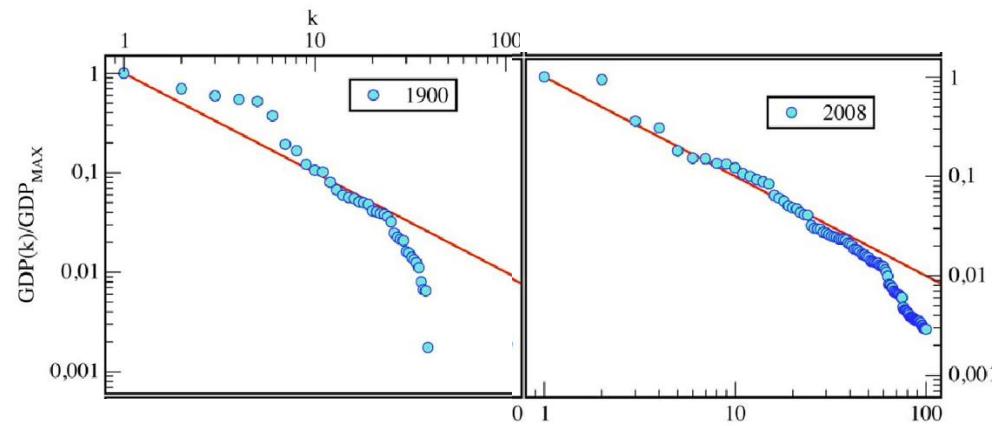
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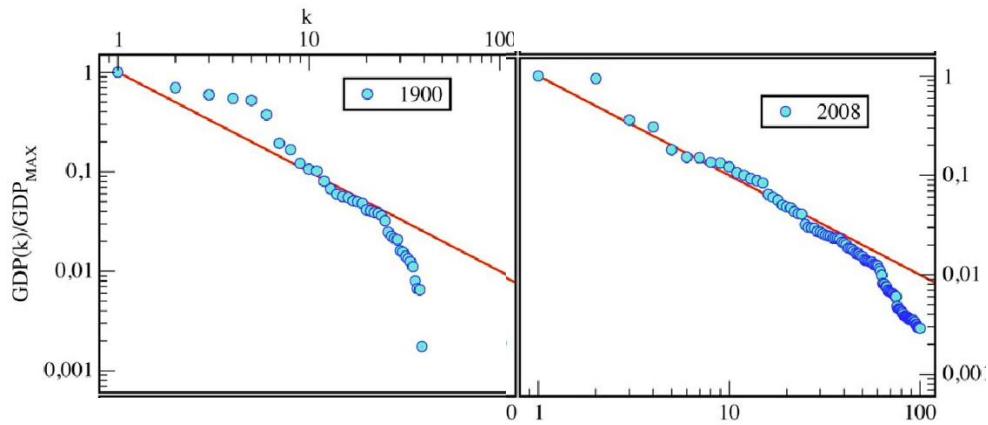
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Contextual value

*Statements
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(or are not!)*

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... in “coherent” urban
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... because of within-city
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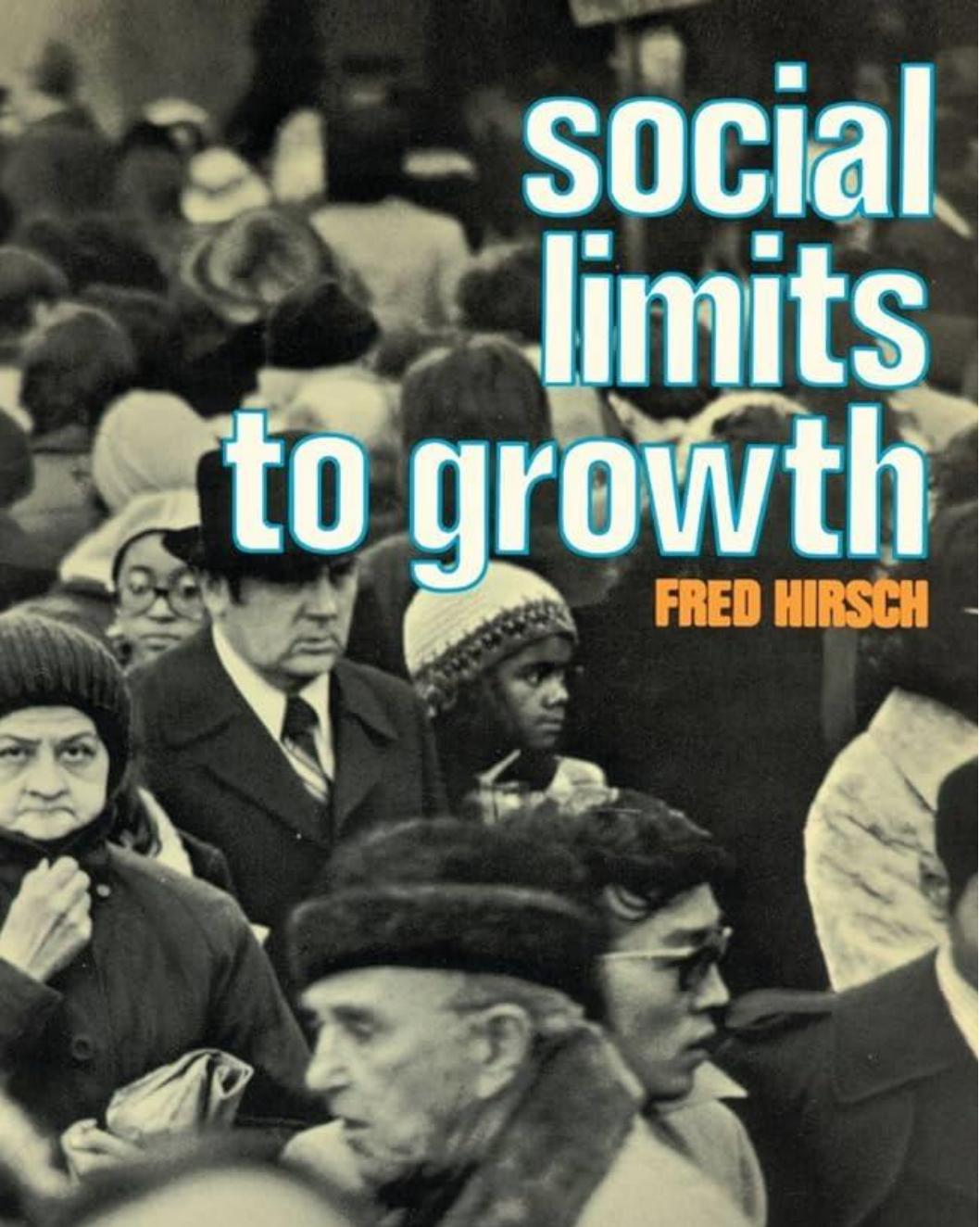
... because of within-city
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Positional goods derive their value from their relation to other consumers' goods.

“What each of us can achieve, all cannot.”

Examples include luxuries, education, and real estate.

Are cities themselves positional?



Winner-take-all Urbanism: Geographic Divisions in the Modern Era

RICHARD FLORIDA
University Professor
University of Toronto

An Interview with Gray Brakke

The first dimension [of the New Urban Crisis] is the growing divide between the winner cities ... and the rest. I call this winner-take-all urbanism.

Urban scaling laws arise from within-city inequalities

Arvidsson et al. (2023)

City size-dependent cumulative advantage

- (1) Cities benefit their inhabitants
- (2) Benefits are unevenly distributed
- (3) In big cities, “winners” win more from more people
- (4) Disparity compounds over time due to generational transfer and migration
- (5) These winners drive migration, increasing city system scaling

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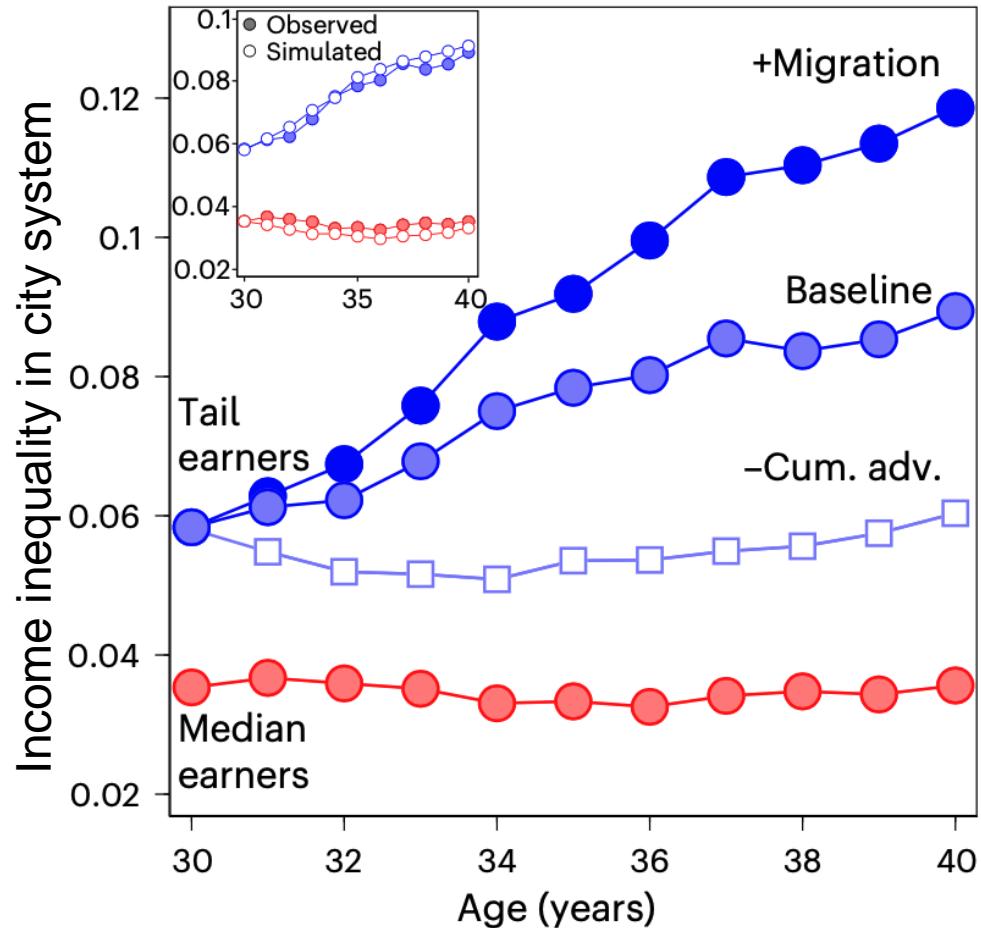
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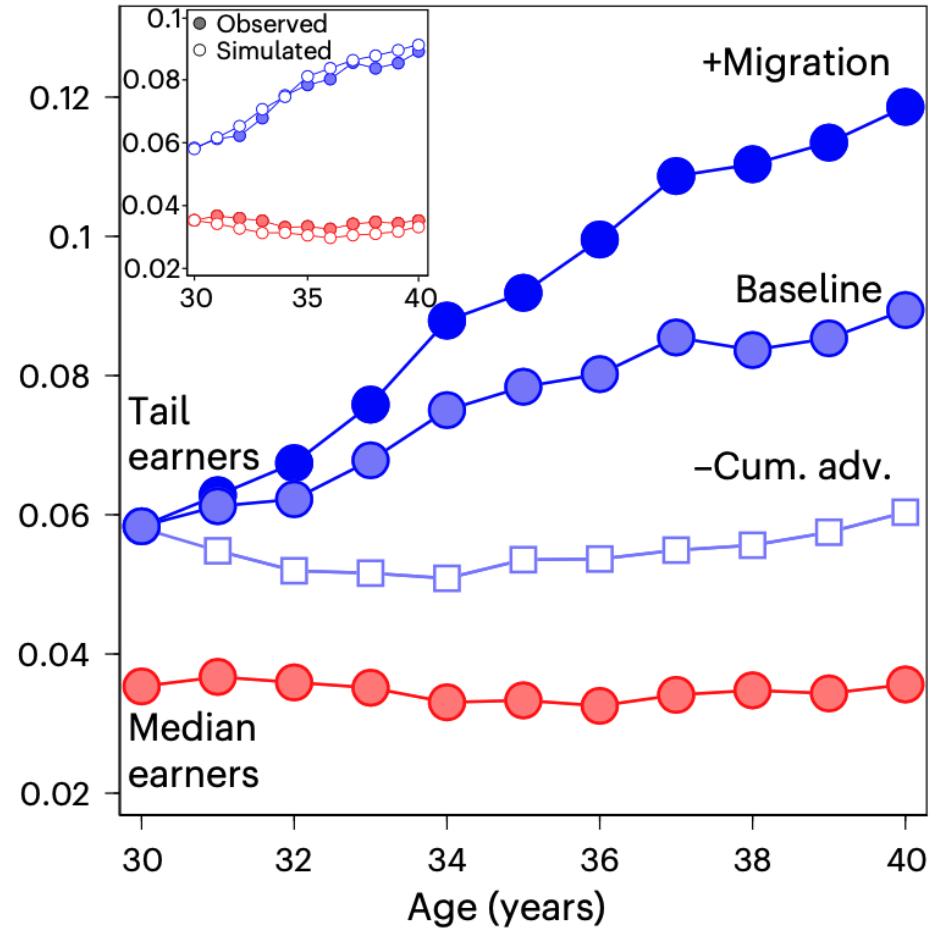
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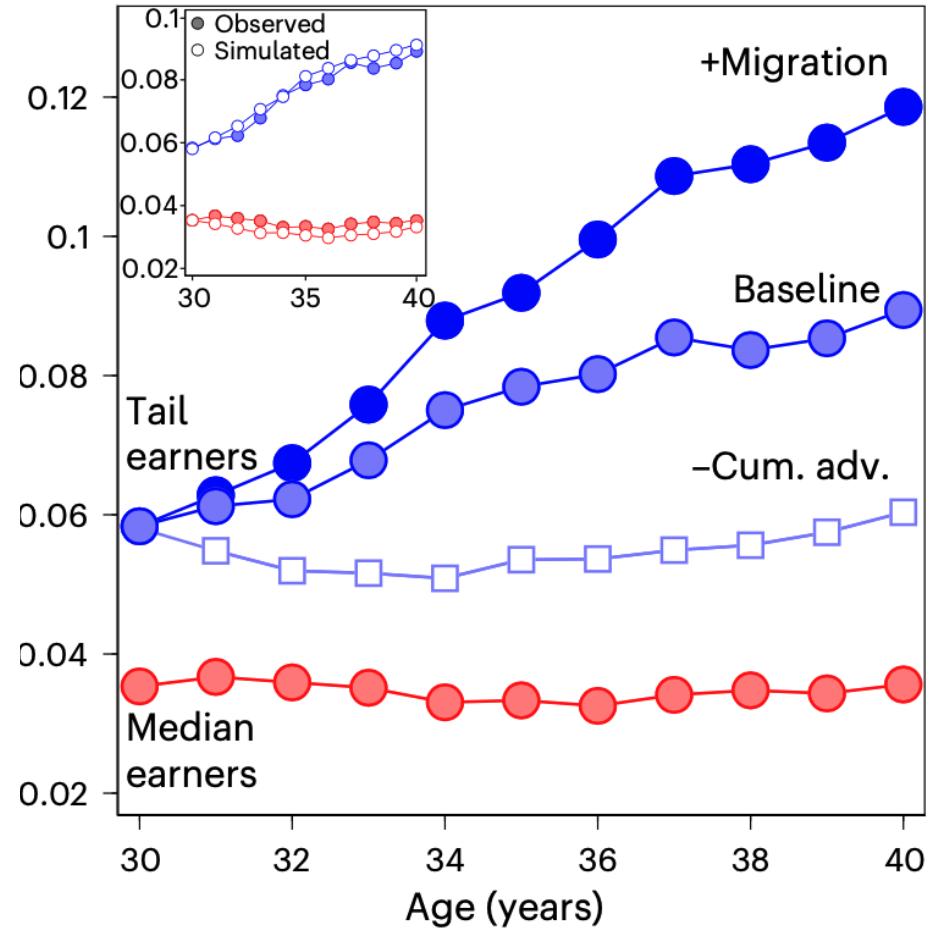
Empirical results show the contribution of each mechanism

- As below, including “move to opportunity” effects
 - As below, *including* inheritance effects over generations
 - Scaling for wealthy incomes, minus inheritance effects
-
- Scaling (inequality) in median wage across the city system



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Wealth scaling in city system
increases as the wealthy inherit, move

Urban scaling laws arise from within-city inequalities

Arvidsson et al. (2023)

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So, if this is true:

Within-city inequality should go hand-in-hand with pop & growth

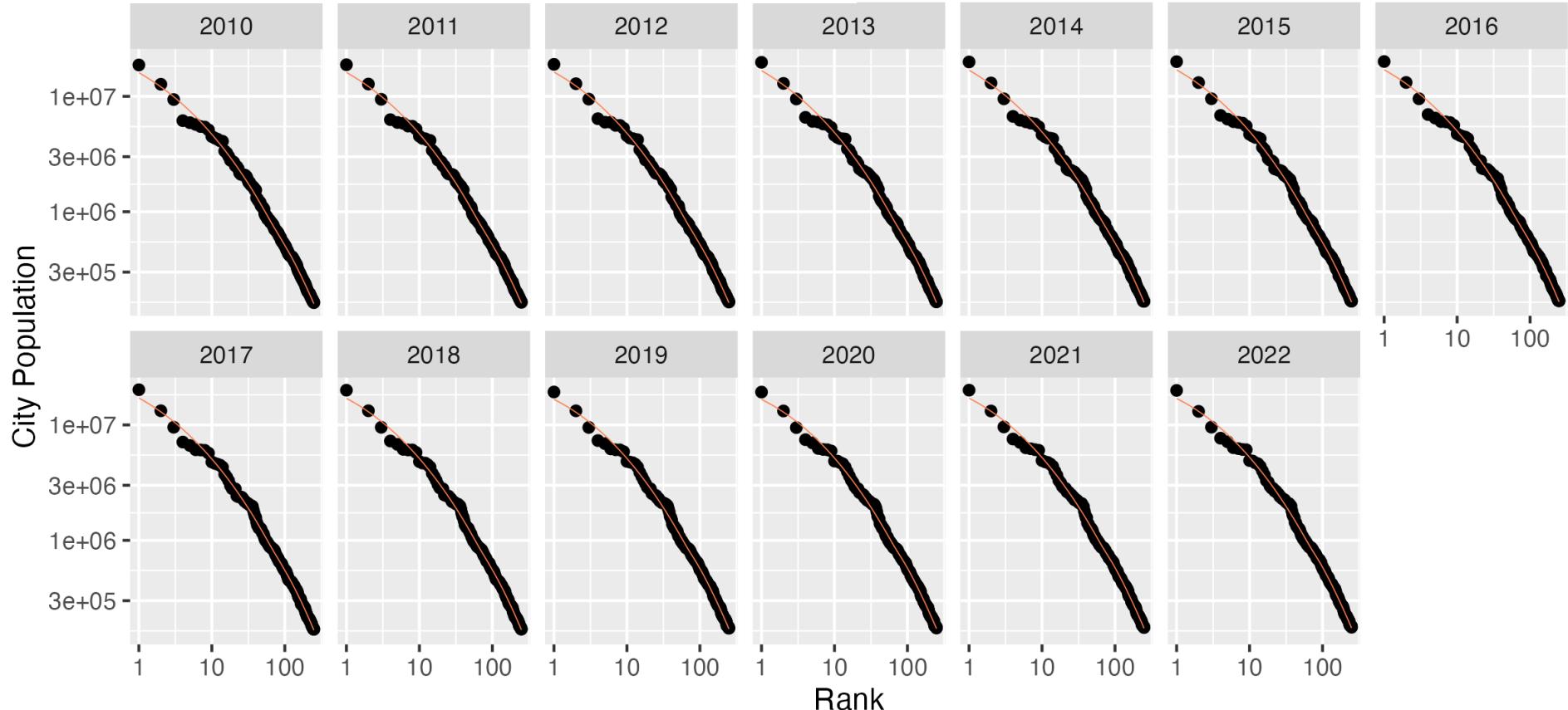
Cities grow by attracting people at all levels of the income distribution

Between-city inequality should rise as within-city inequality rises

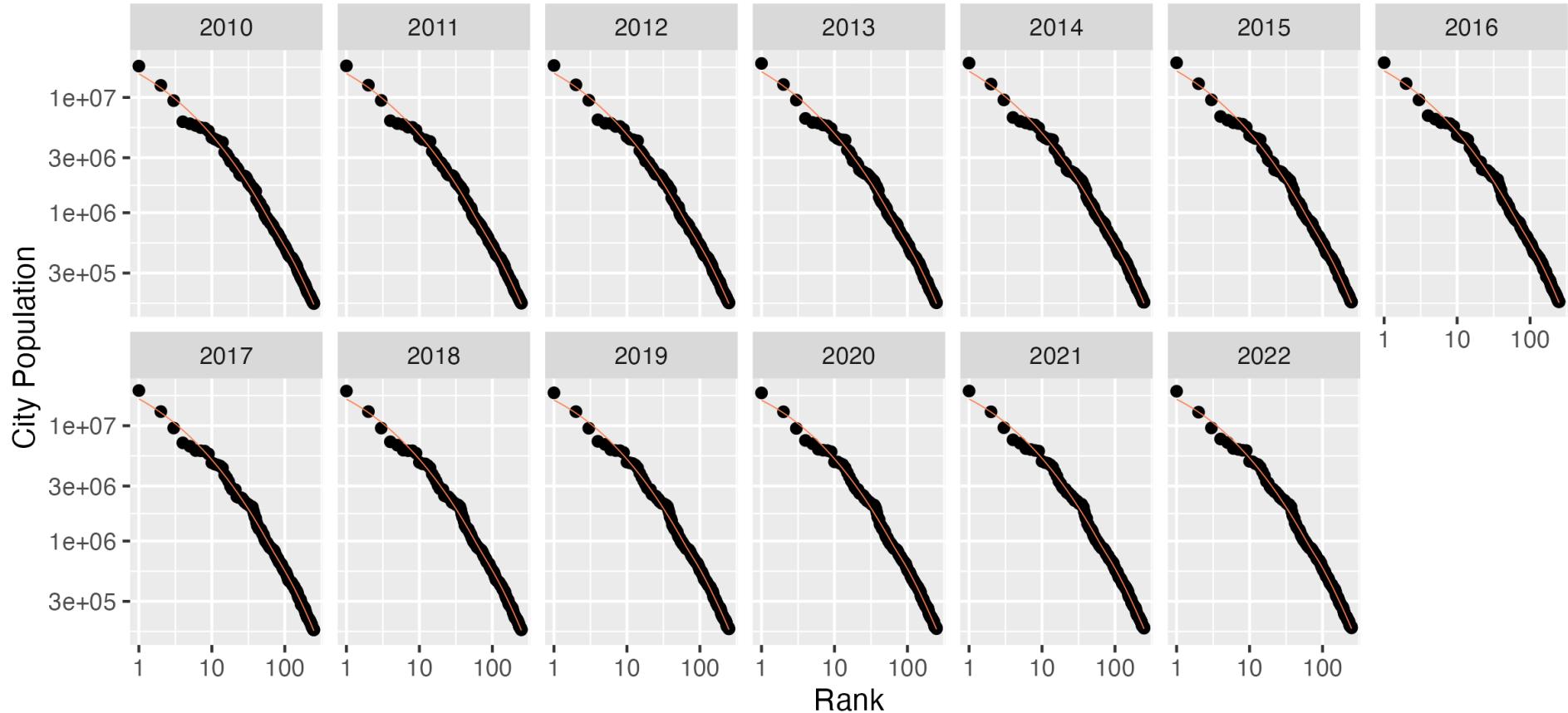
Unequal cities will attract more “winners” with more to “win”

generative value

Size-Rank plot of cities by year (ACS)

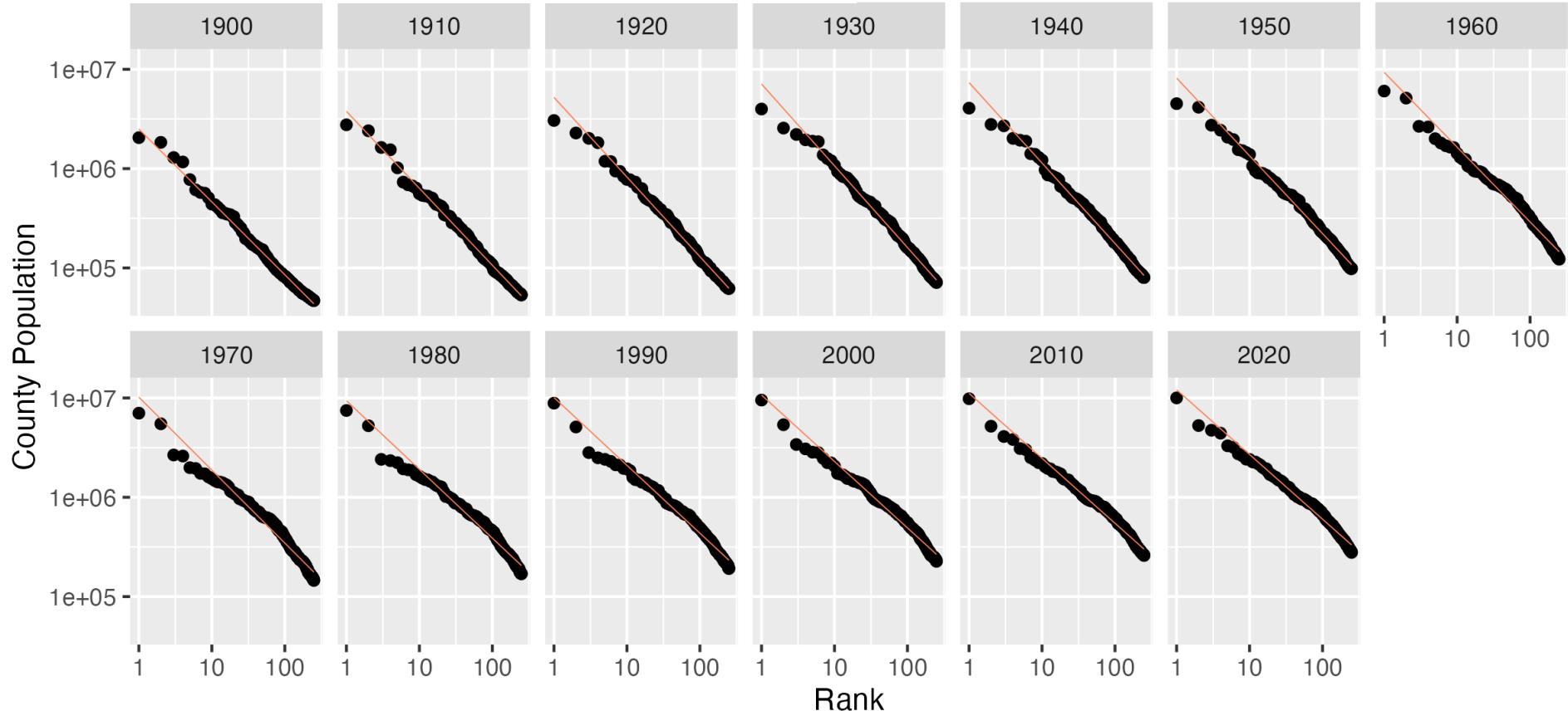


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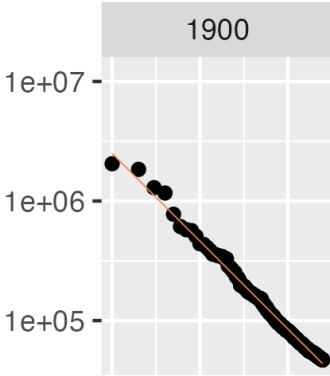
Cities don't really change
substantially on this timescale

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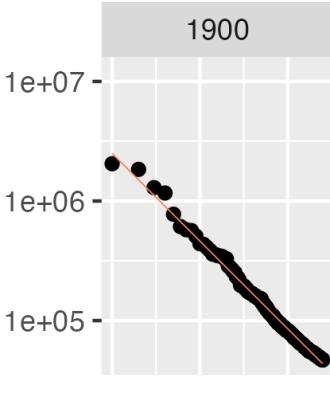
County Population



- NY (Manhattan)
- Cook (Chicago)
- Philadelphia
- Kings (Brooklyn)
- Allagheny (Pittsburgh)
- Suffolk (Central Boston)
- St. Louis
- Middlesex (Boston-Cambridge)
- Baltimore
- Cuyahoga (Cleveland)
- Erie (Buffalo)
- Hamilton (Cincinnati)
- Hudson (Jersey City)
- Essex (Newark)
- Essex (Boston-Salem)
- Wayne (Detroit)
- Worcester
- San Francisco
- Milwaukee

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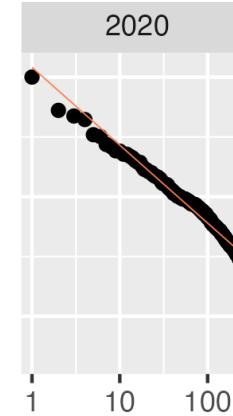


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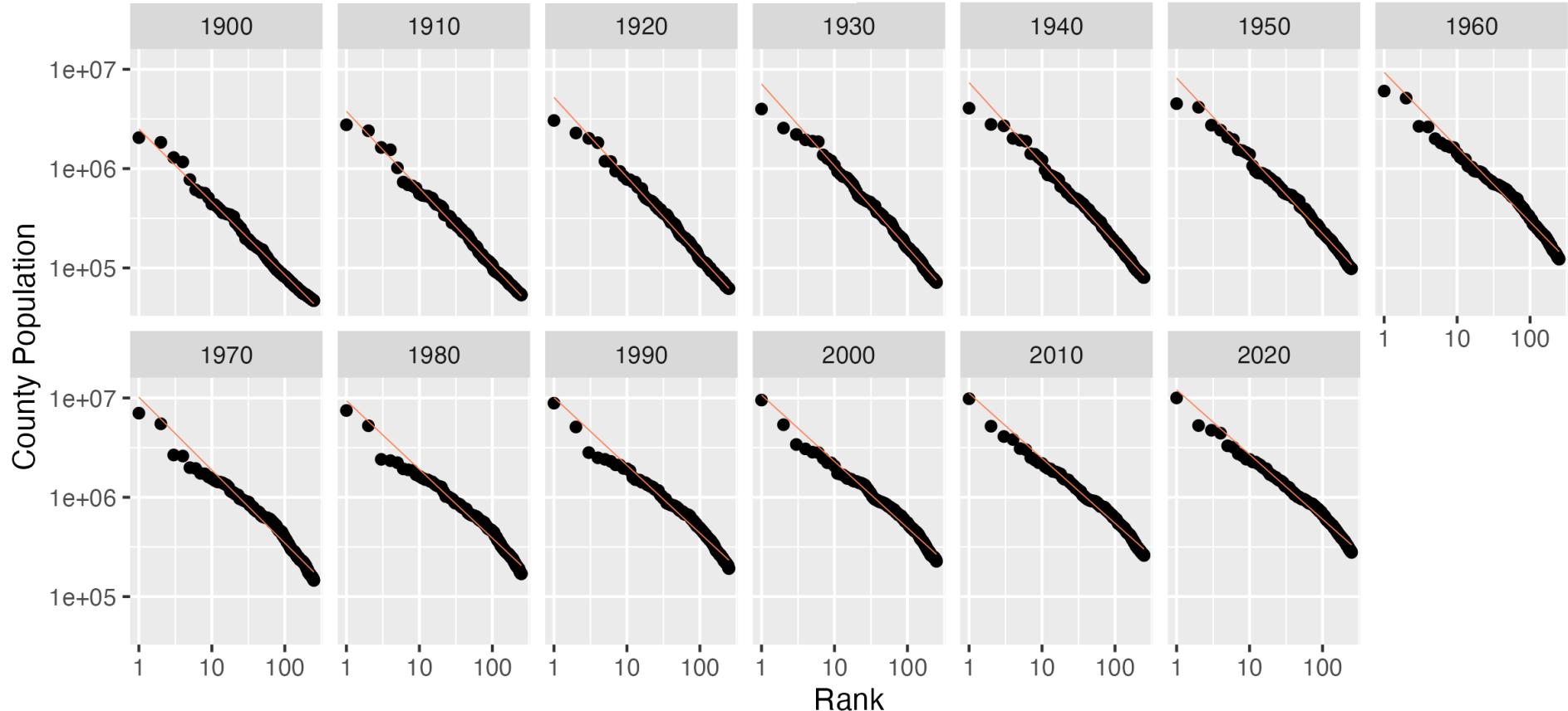
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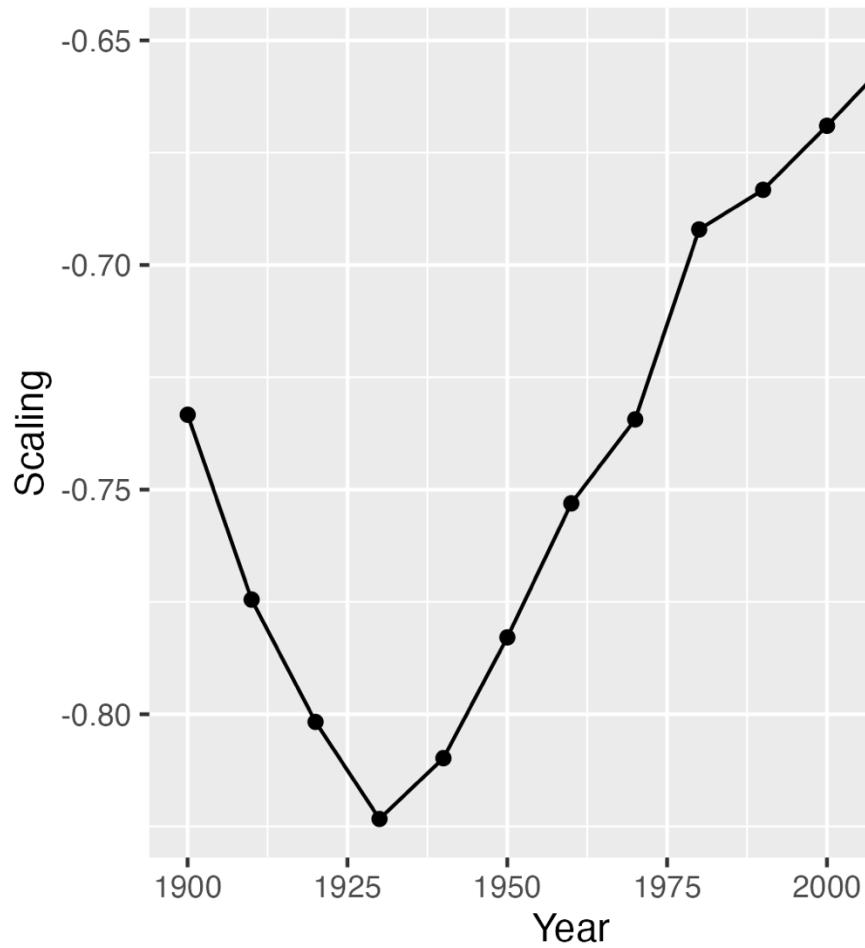
- Los Angeles
- Cook (Chicago)
- Harris (Houston)
- Maricopa (Phoenix)
- San Diego
- Orange (Anaheim/Irvine)
- Kings (Brooklyn)
- Dallas
- Riverside (Inland Empire LA)
- Queens
- King (Seattle)
- Clark (Las Vegas)
- San Bernardino
- Tarrant (Ft. Worth)
- Bexar (San Antonio)
- Broward (Miami)
- Santa Clara (San Jose/South Bay)
- Wayne (Detroit)
- NY (Manhattan)



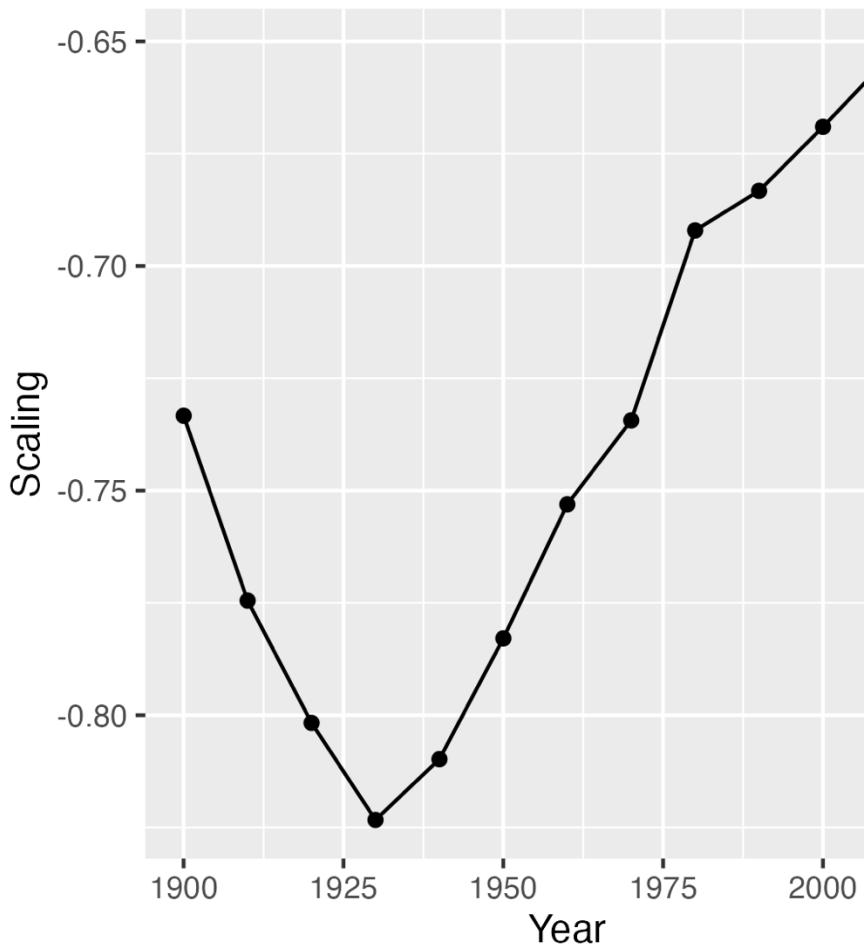
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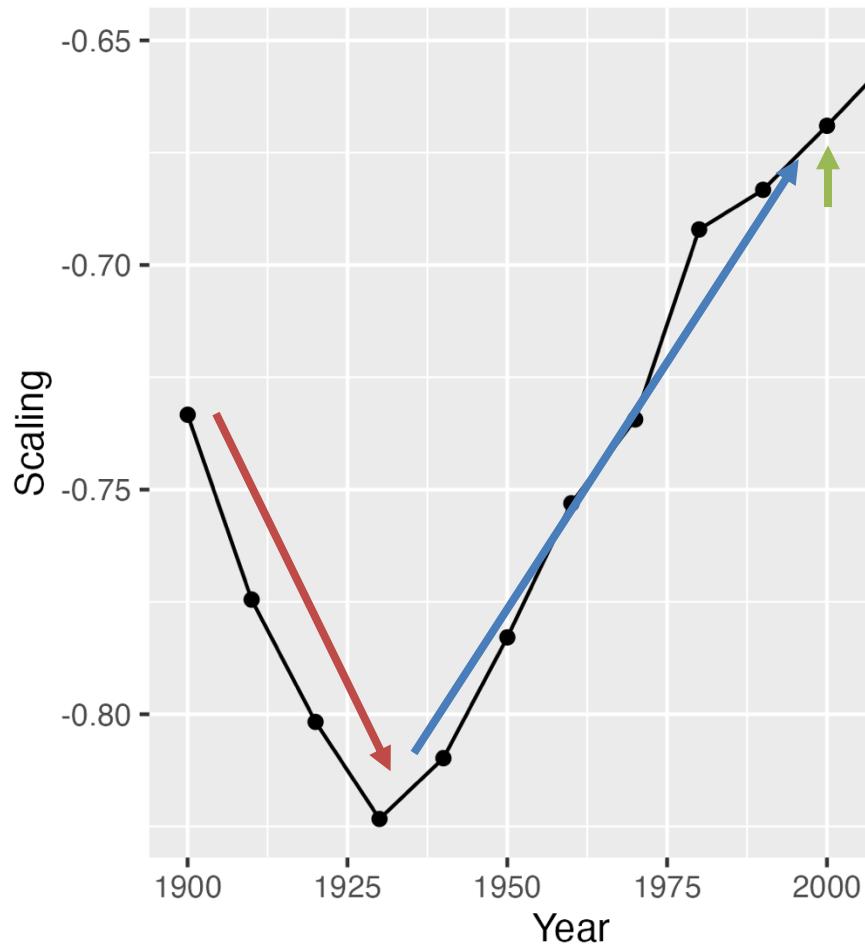


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US city population scaling in the 20th C.

- Increases during the “Gilded Age”
- Rapid reversal during the mid-20th
 - Population transfer west & south
 - Massive growth overall
 - Mass sub-urbanization
- Now, population distribution across cities is more equitable than ever

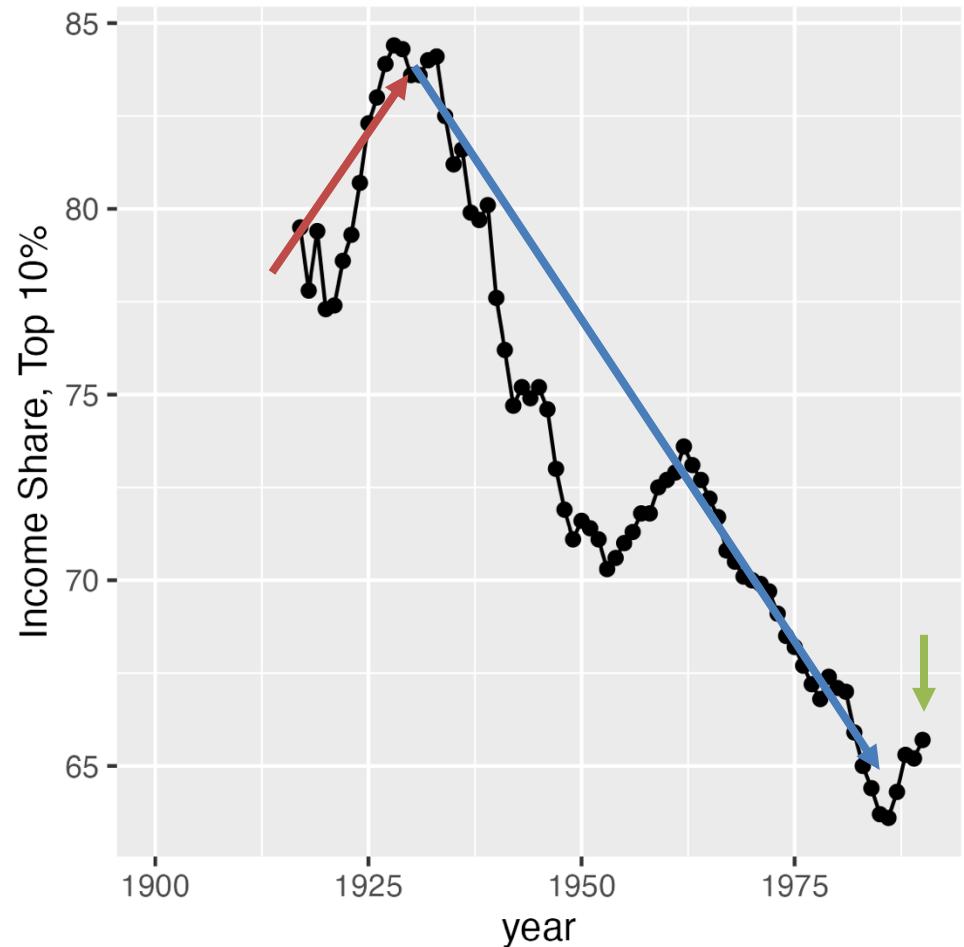


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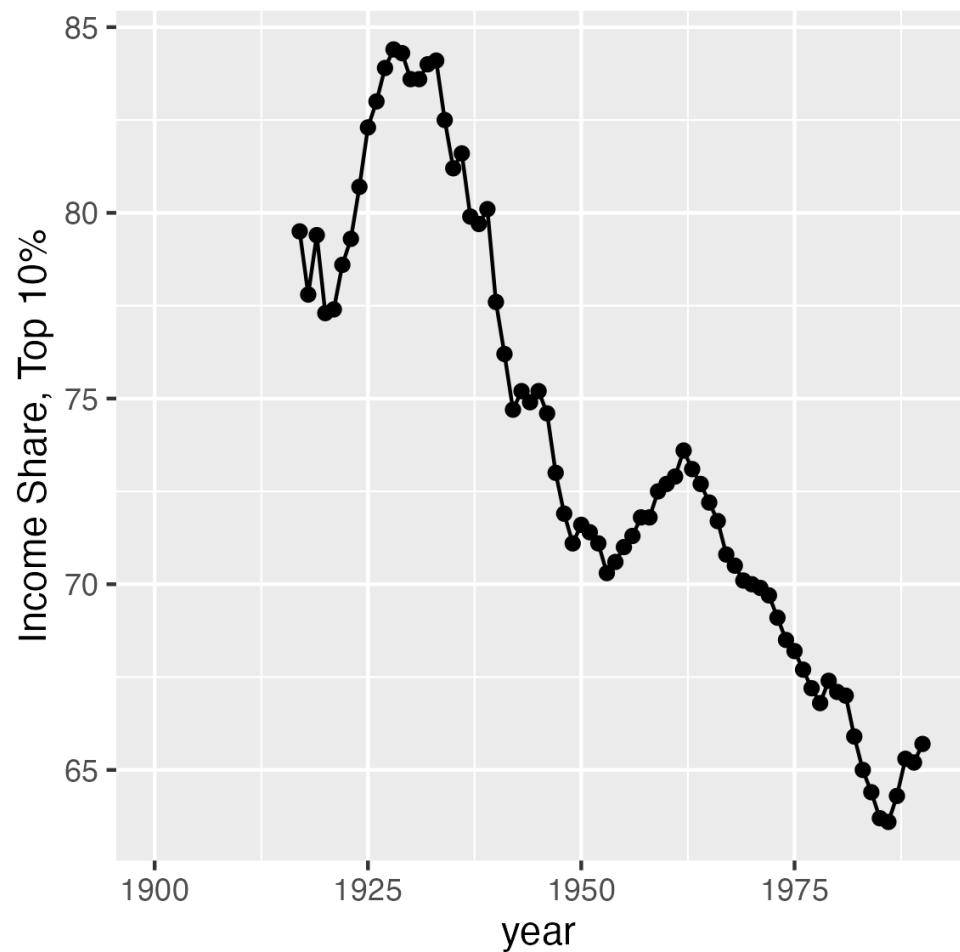
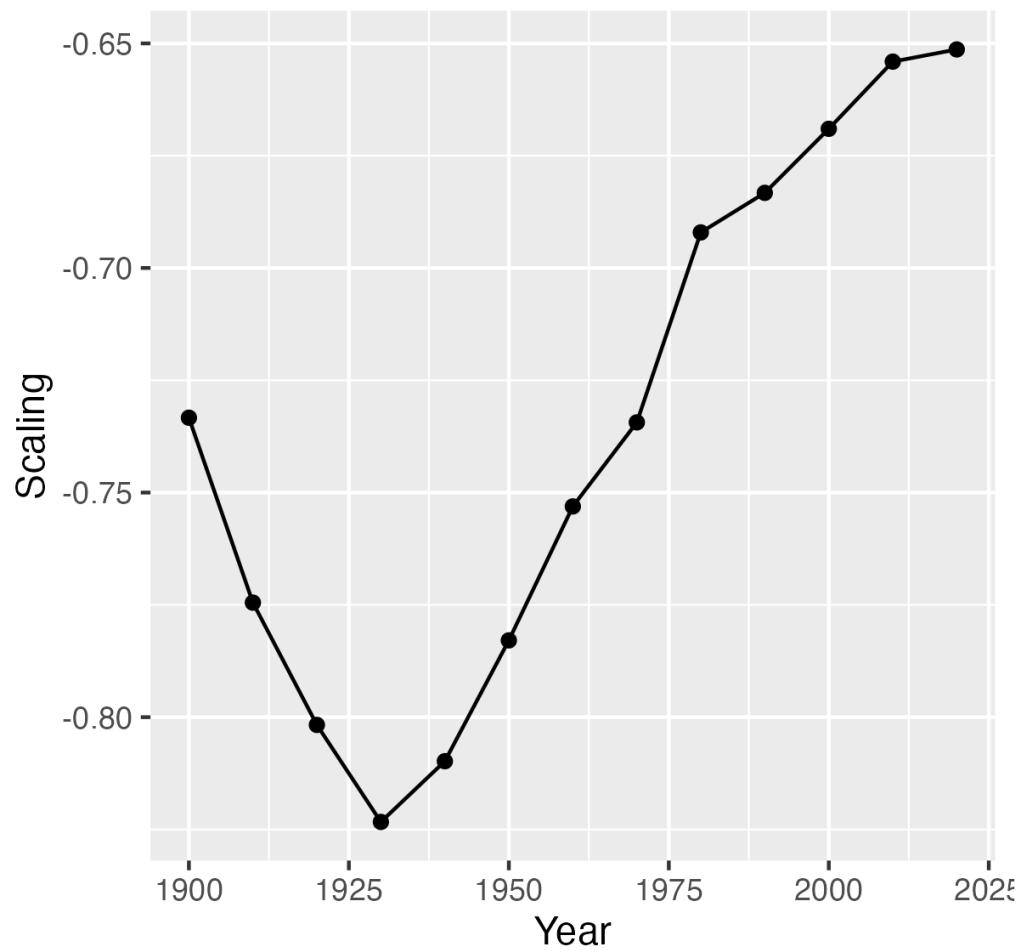
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US Inequality in the 20th Century

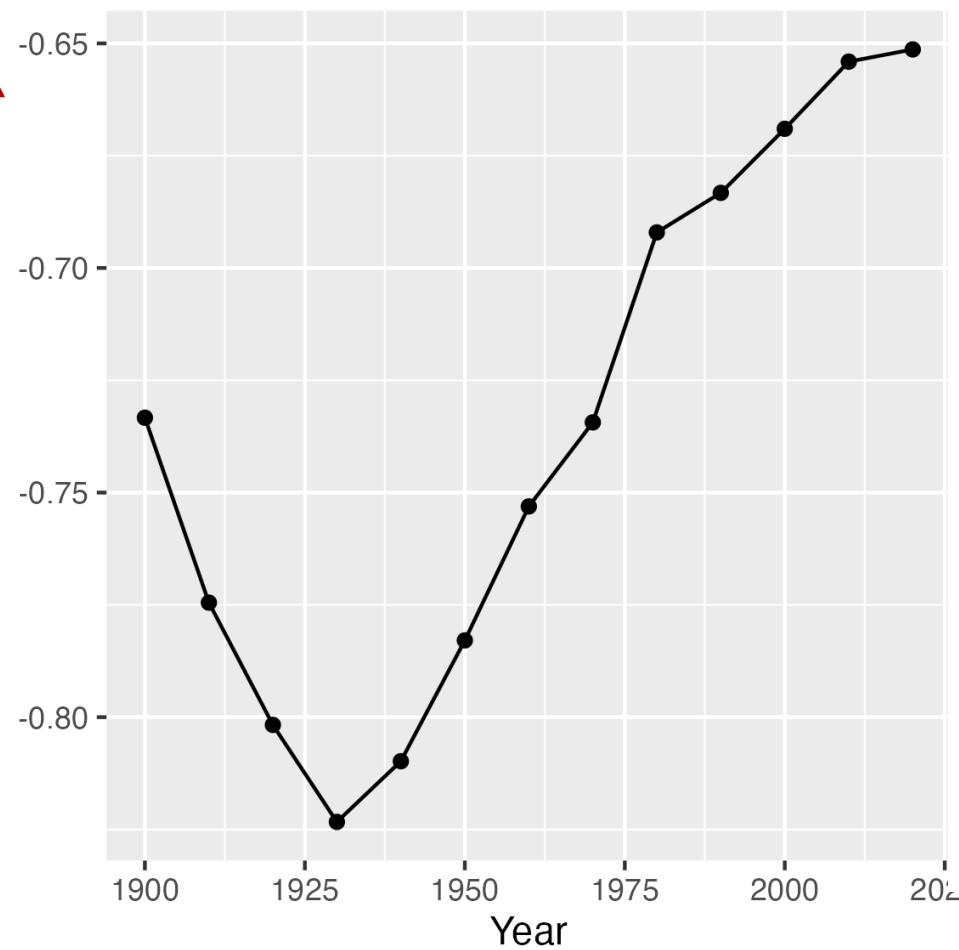
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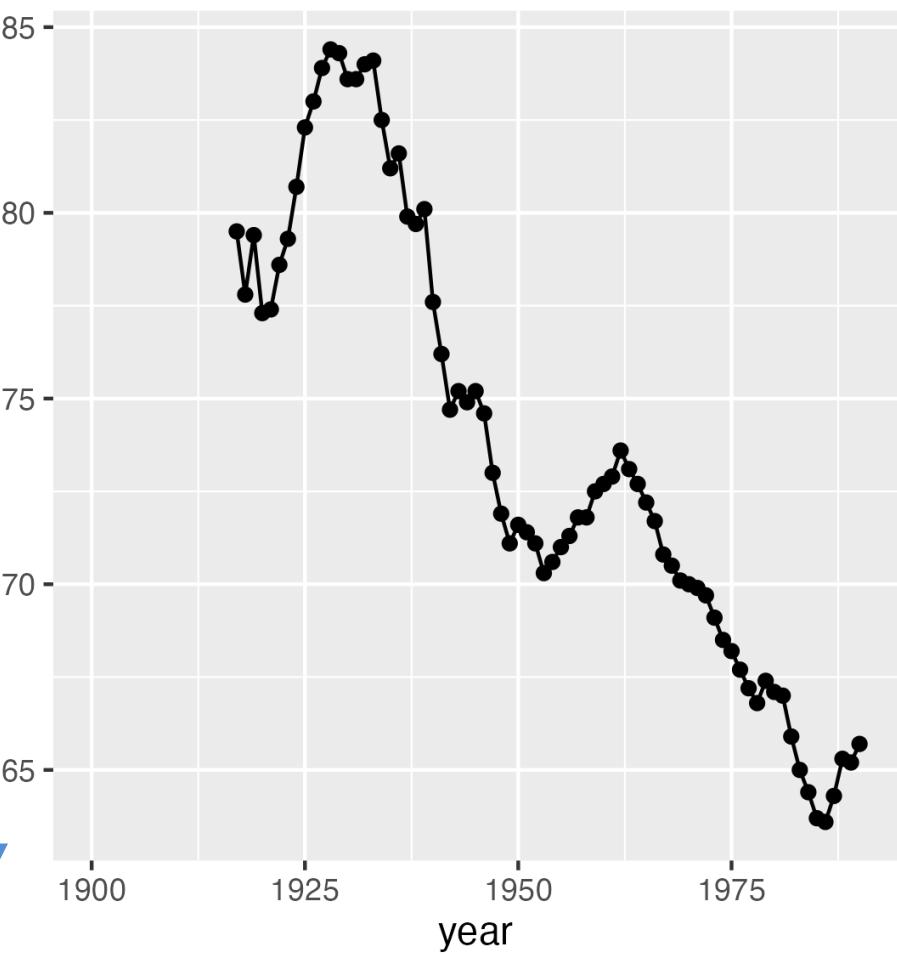
Saez-Zucman (2015)

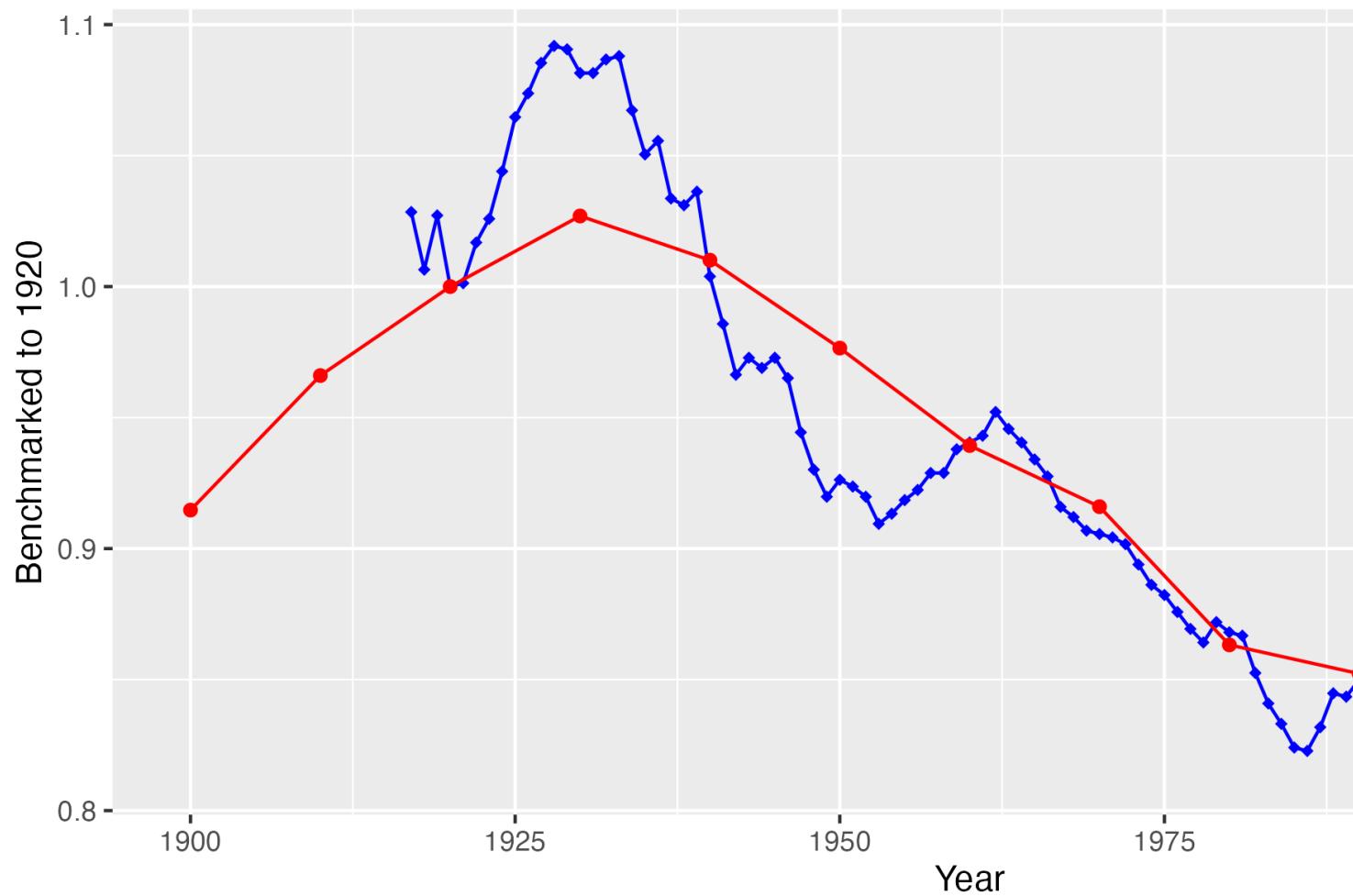


Inequality in city population decreases

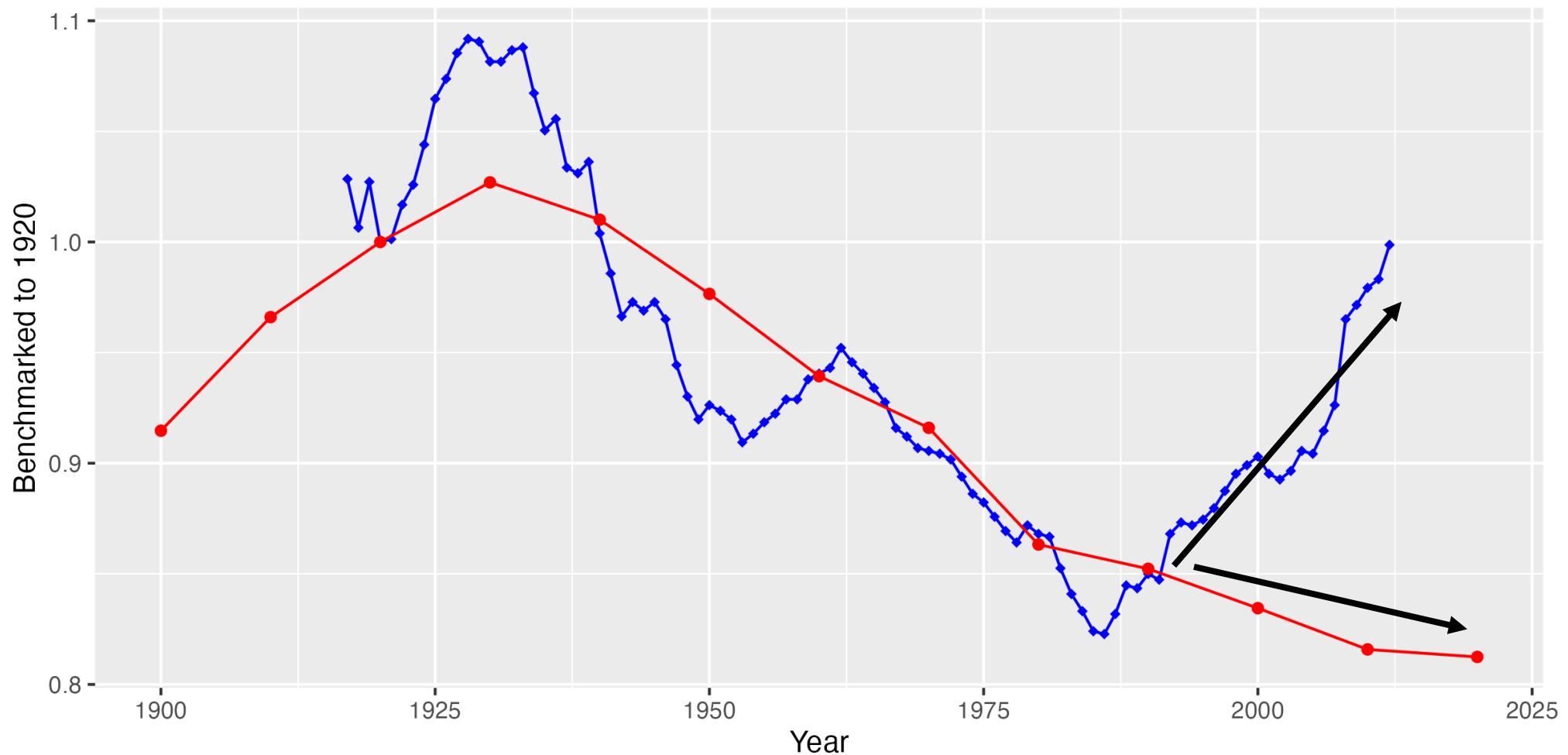


Inequality in population income decreases

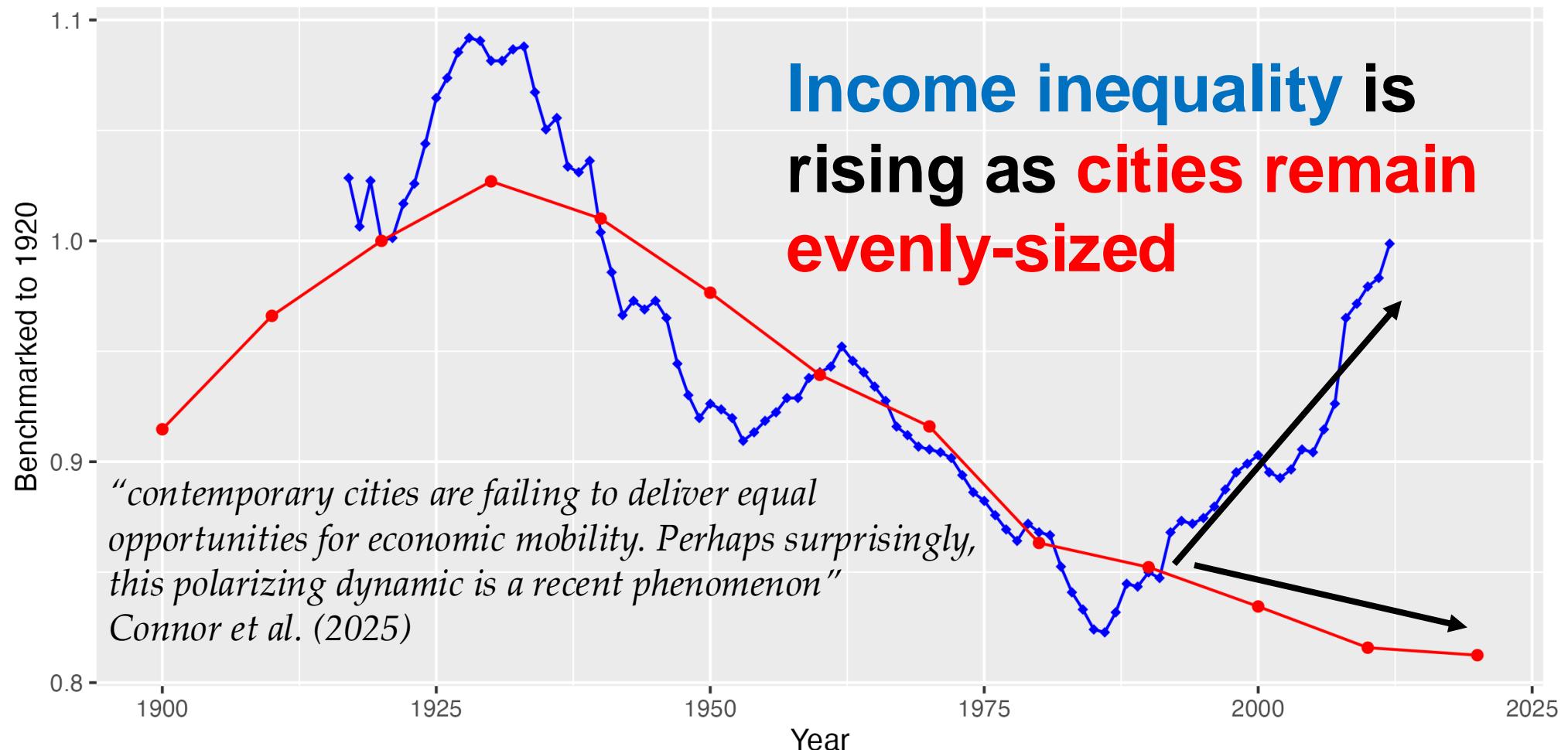




Between-city population inequality moved with macro-level income inequality

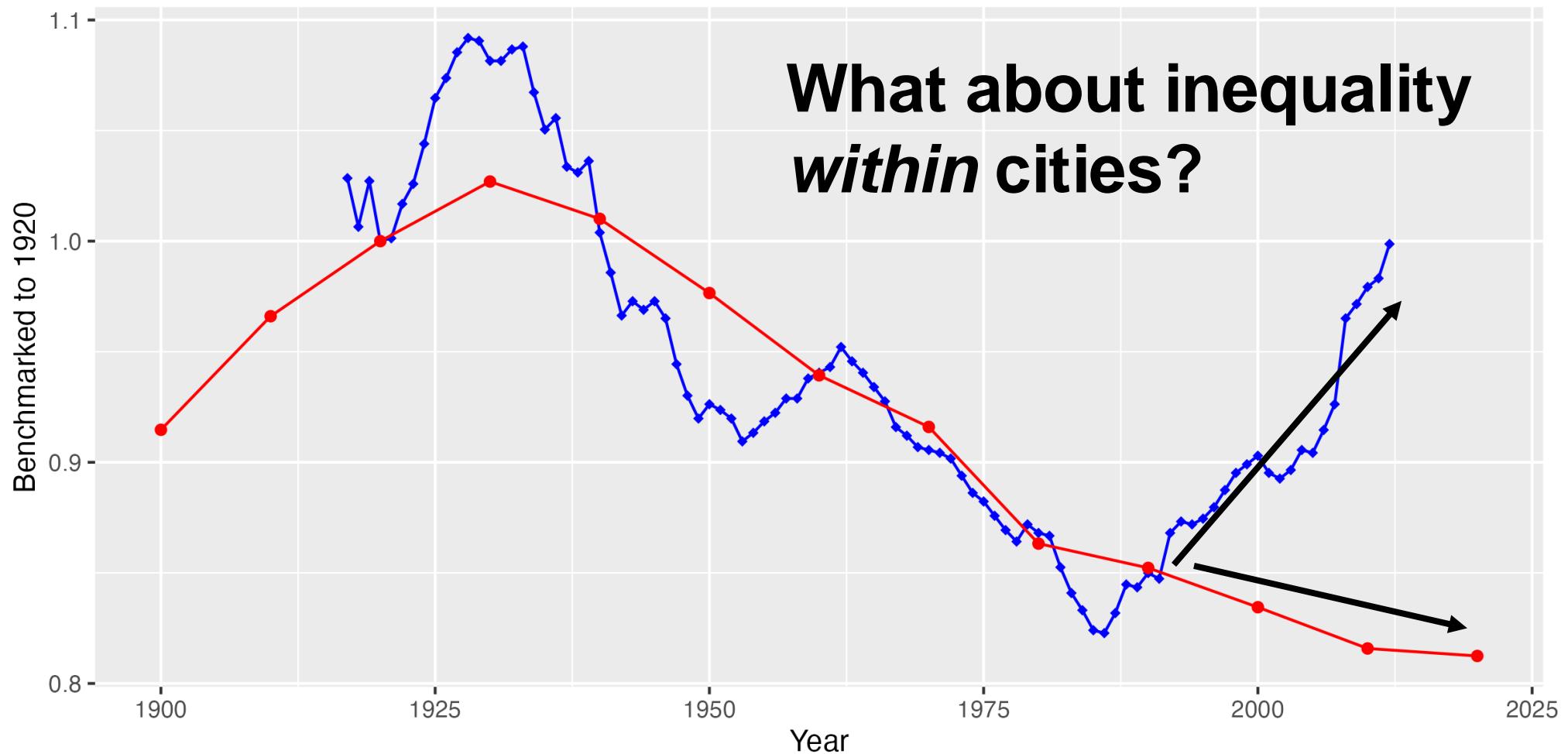


Between-city population inequality moved with macro-level income inequality until the 1990s...

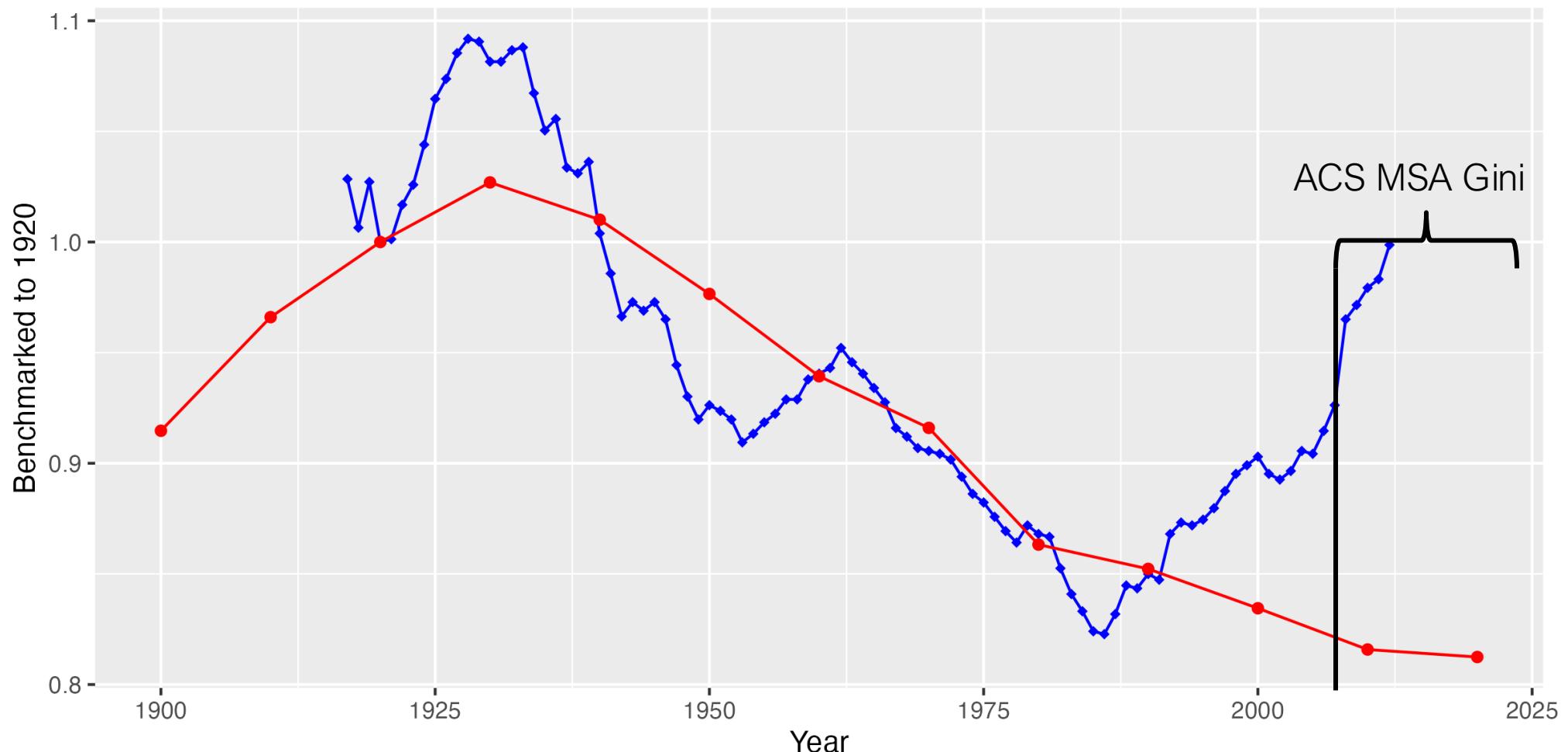


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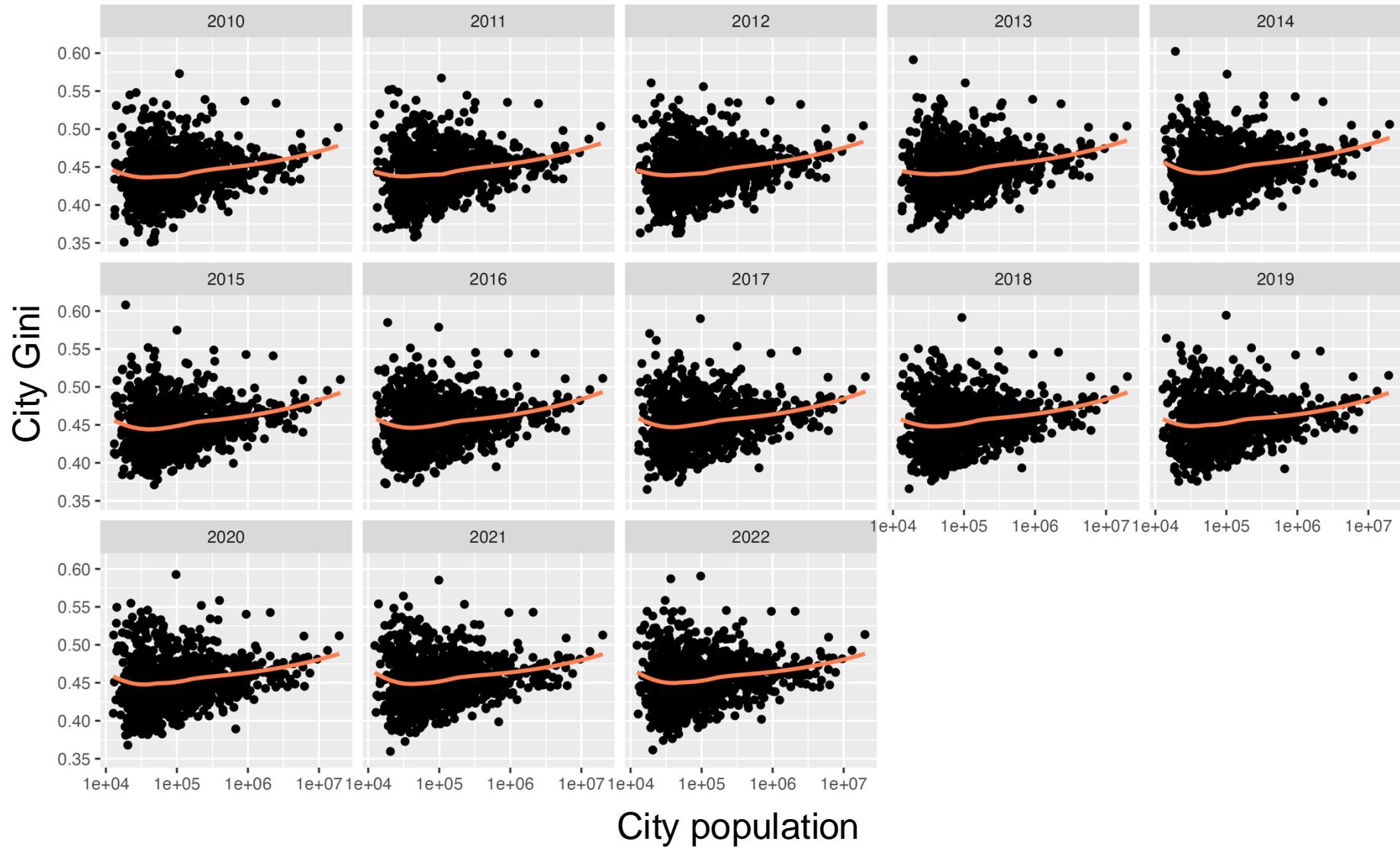
What about inequality *within* cities?

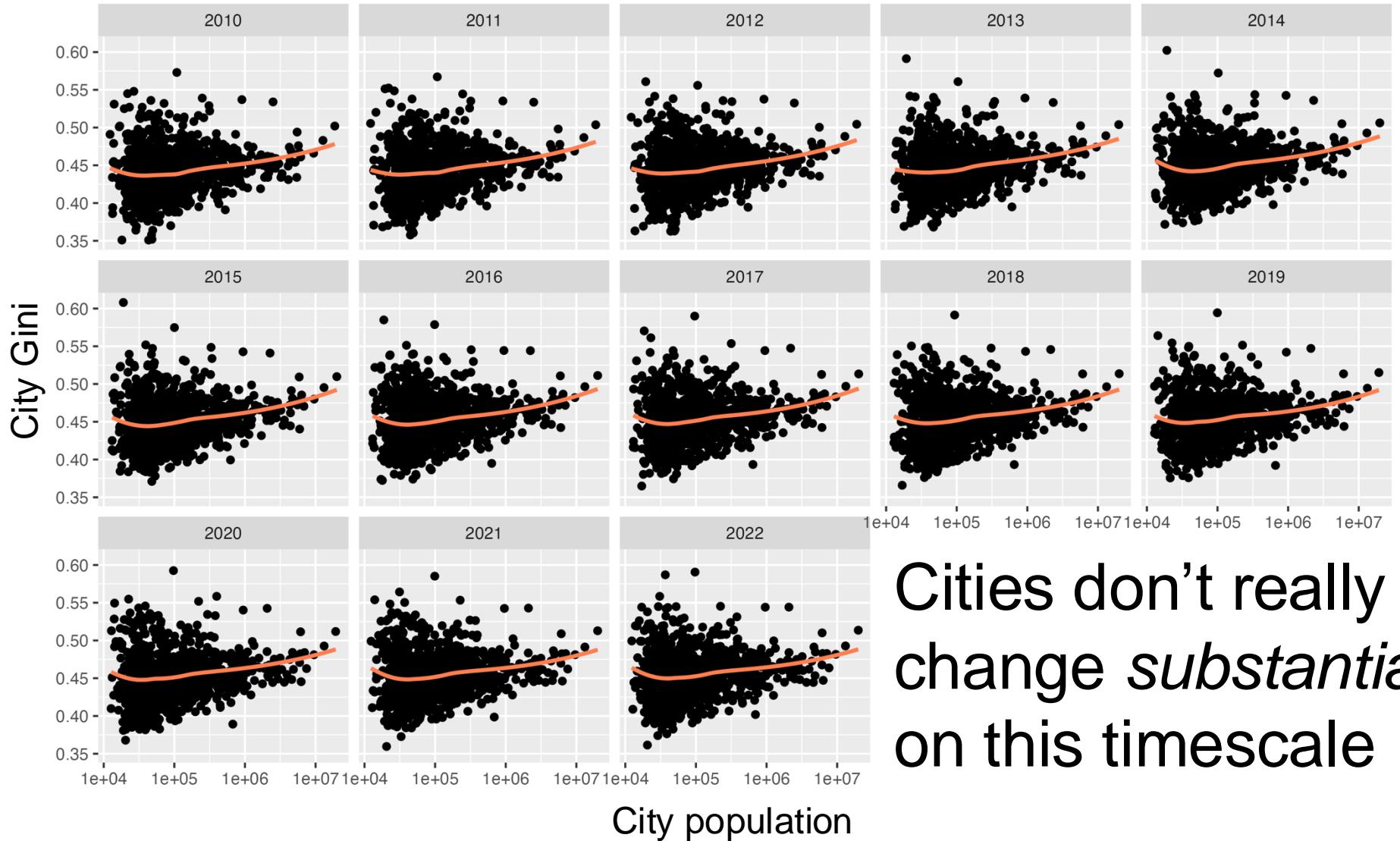


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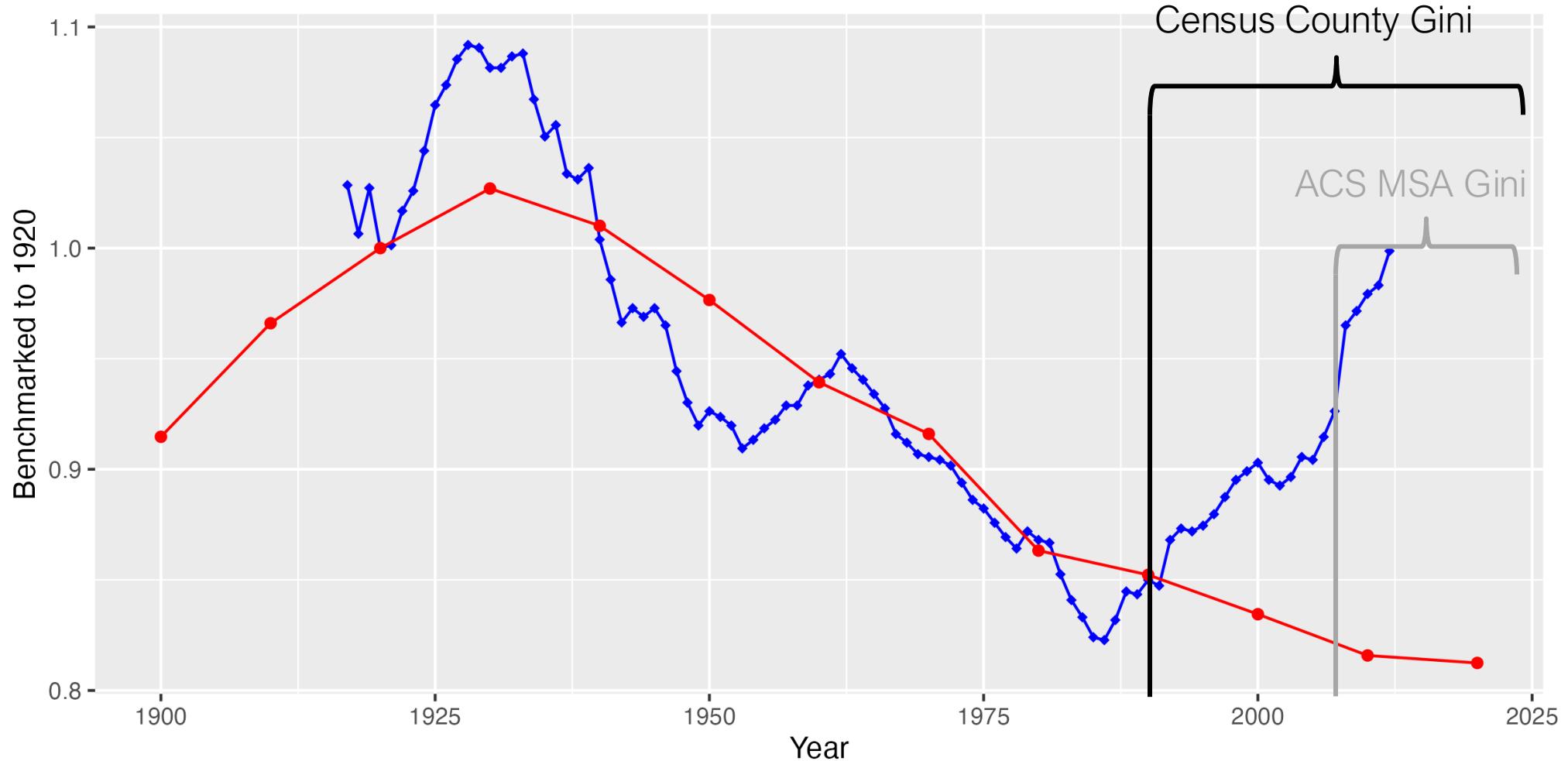


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until the 1990s...

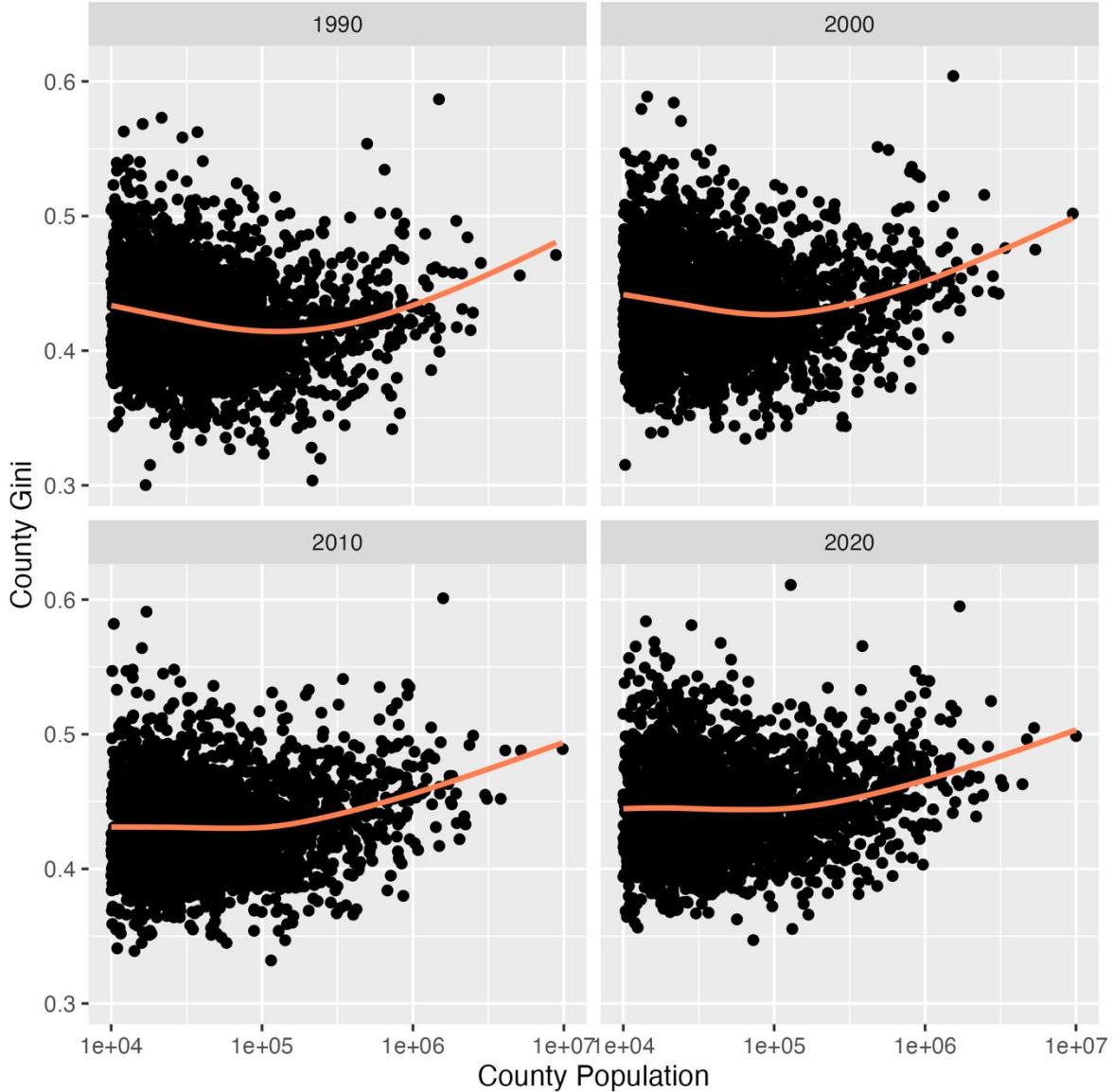


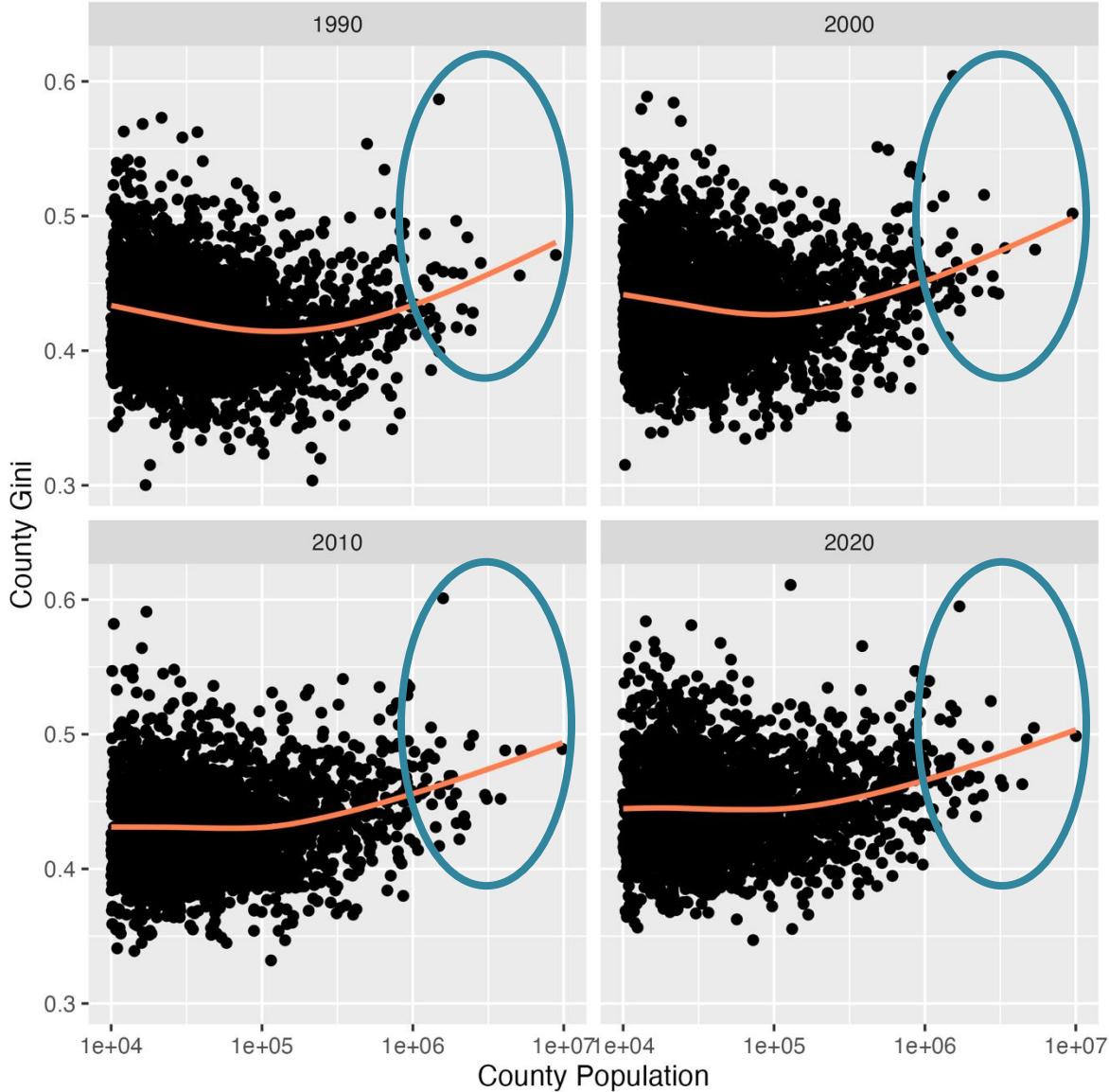


Cities don't really
change substantially
on this timescale

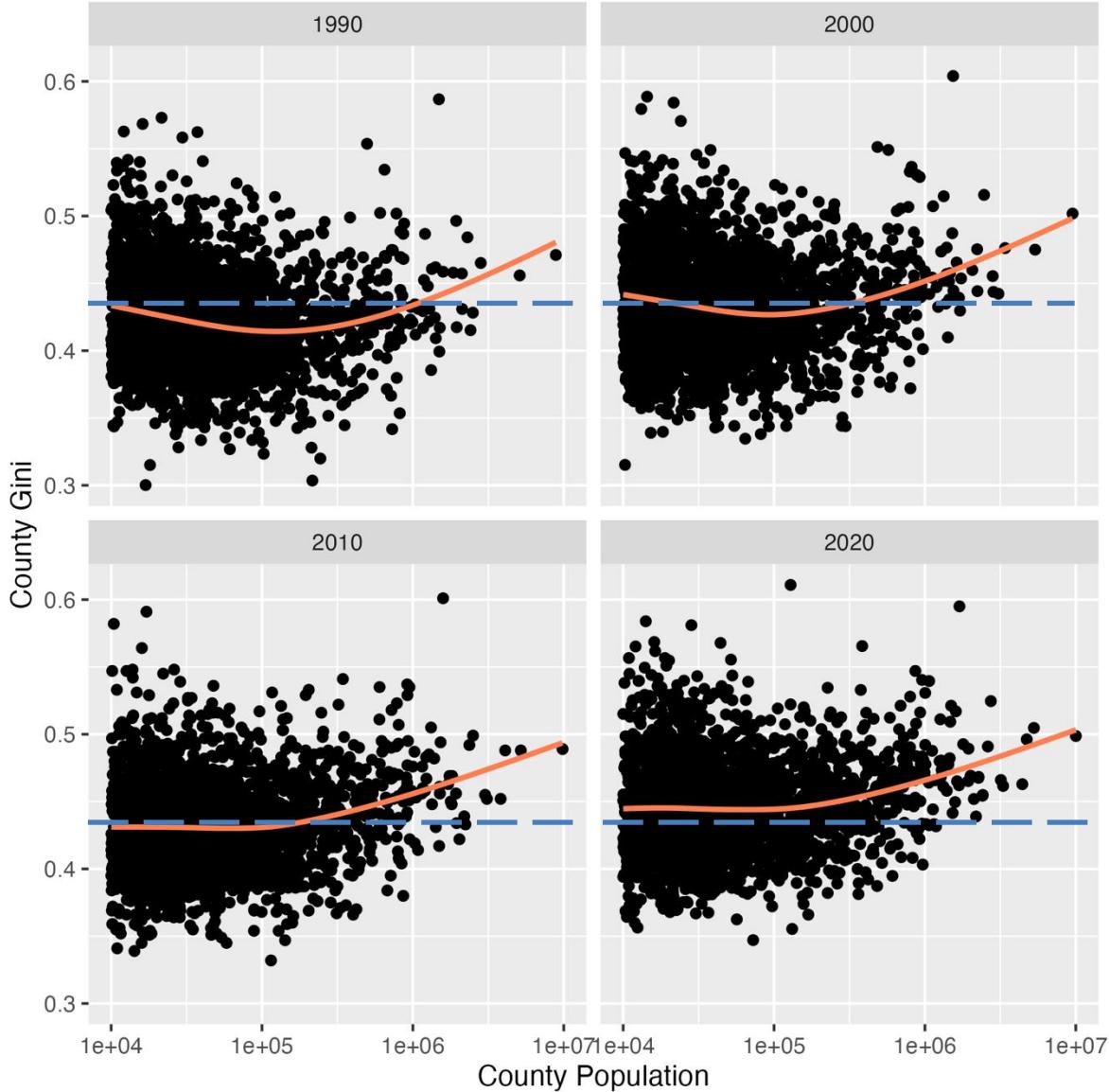


Between-city population inequality moved with macro-level income inequality until the 21st Century...

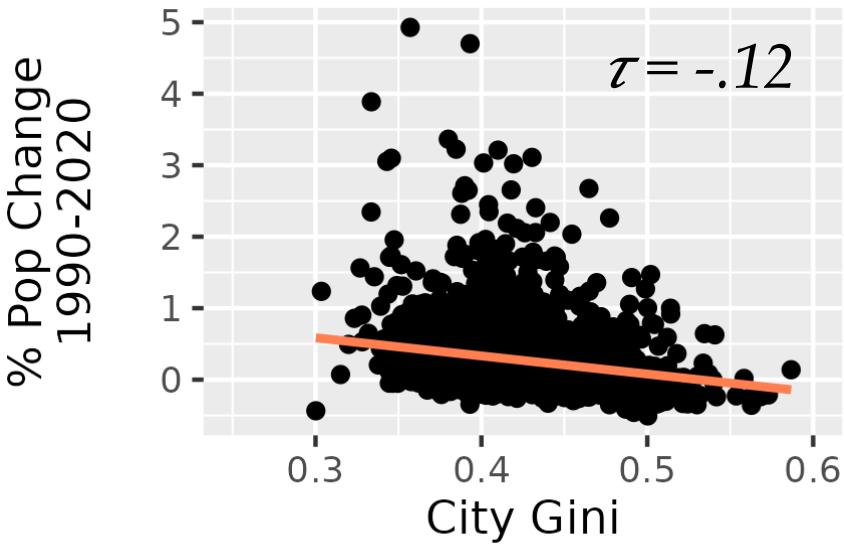
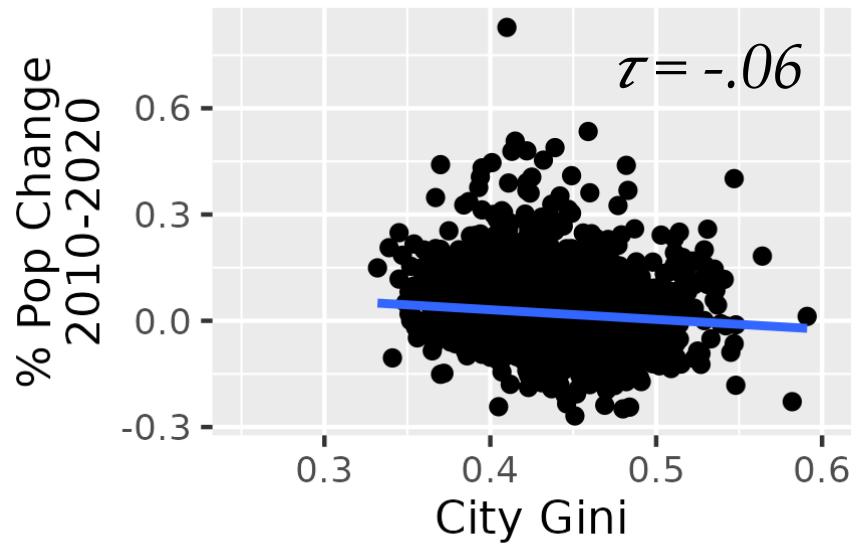
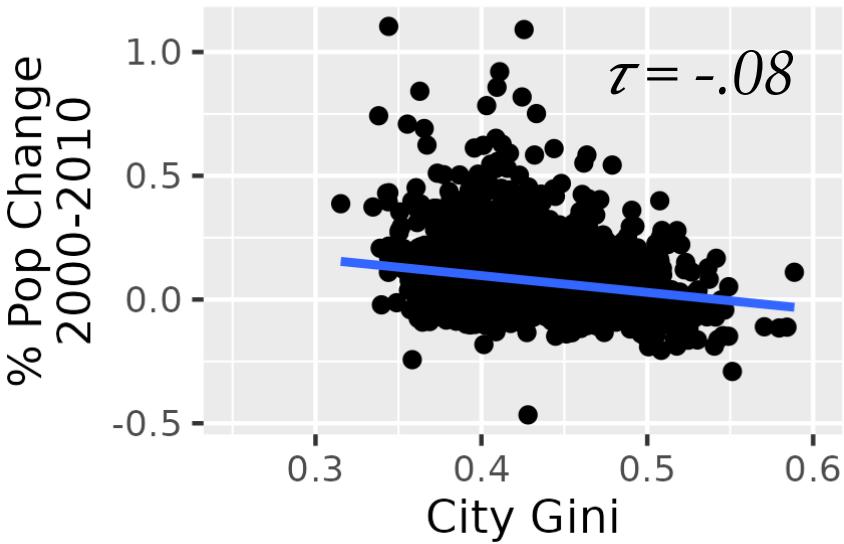
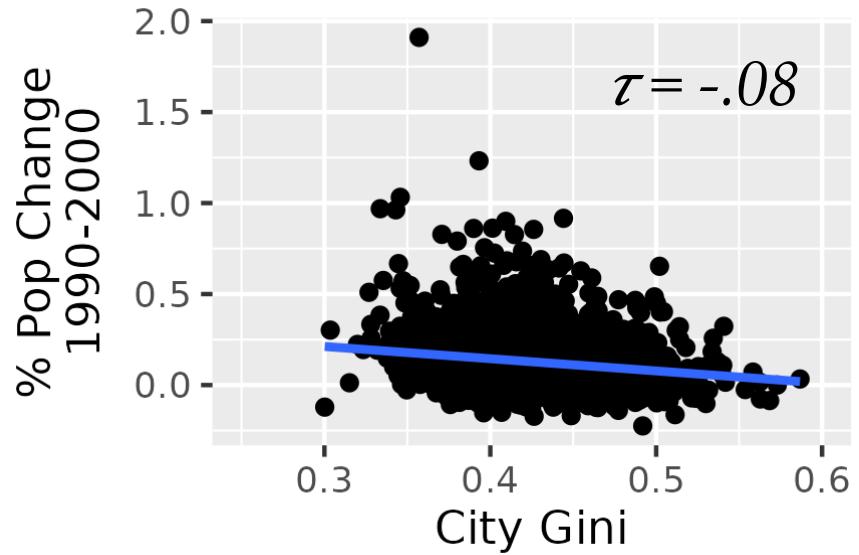




Bigger cities
have tended to
have higher
income
inequality

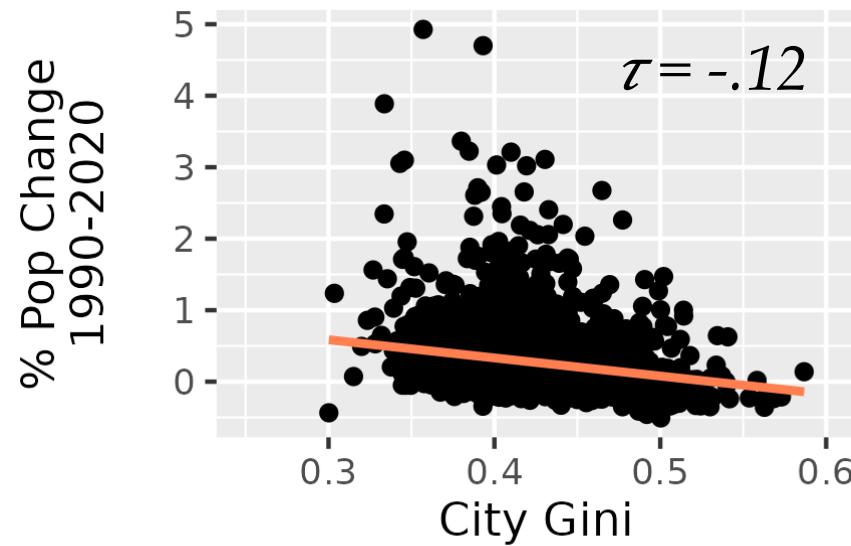
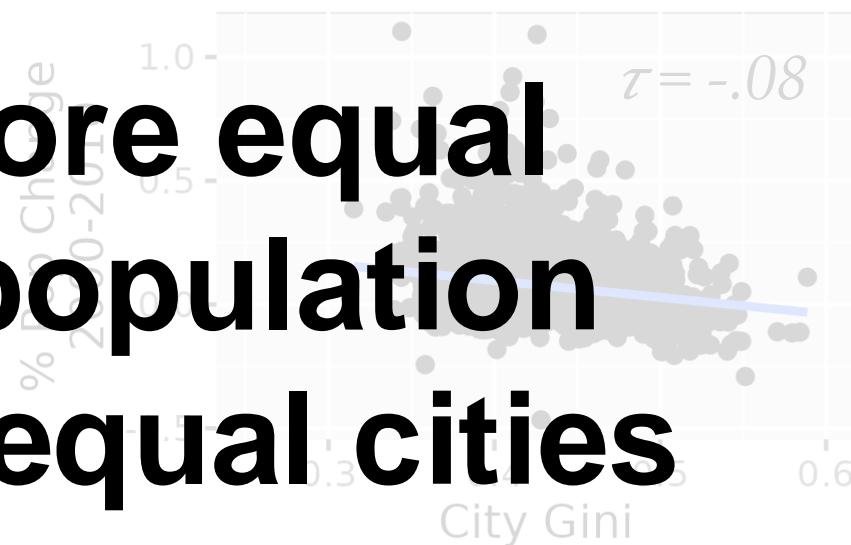
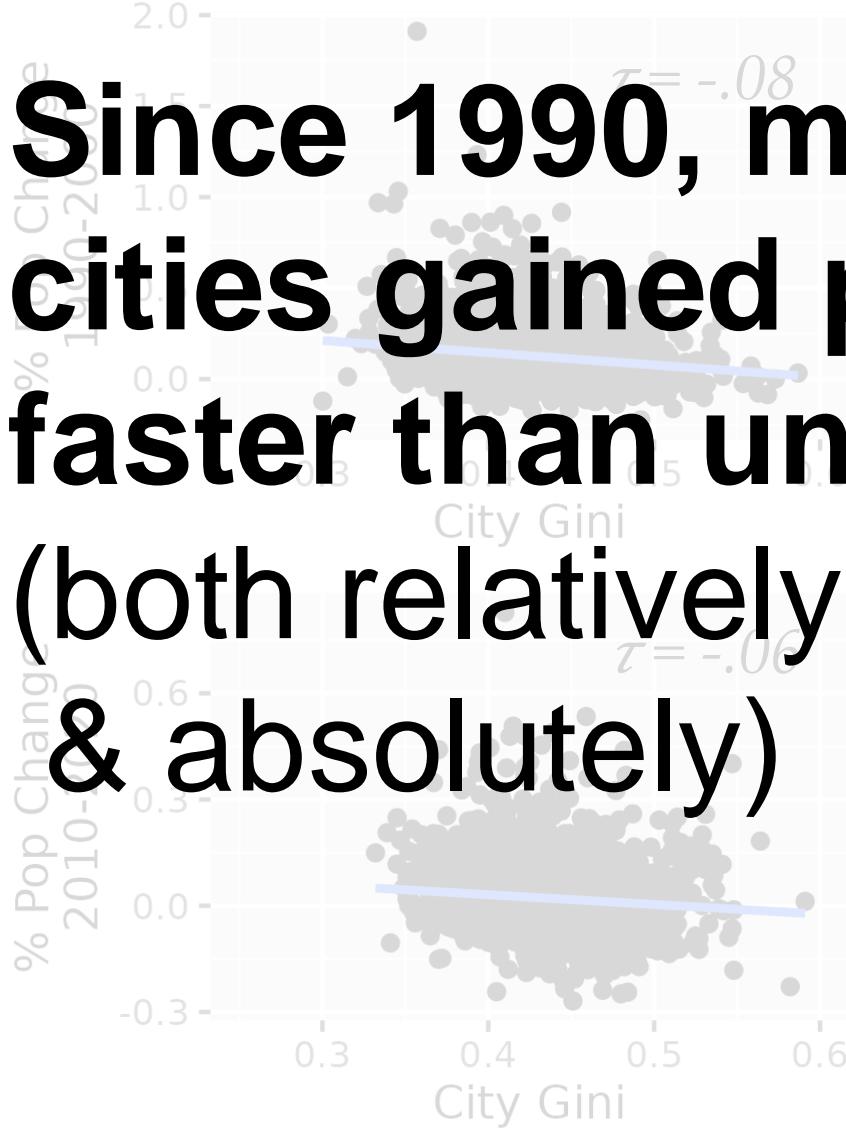


But, mid-sized cities have become more unequal recently

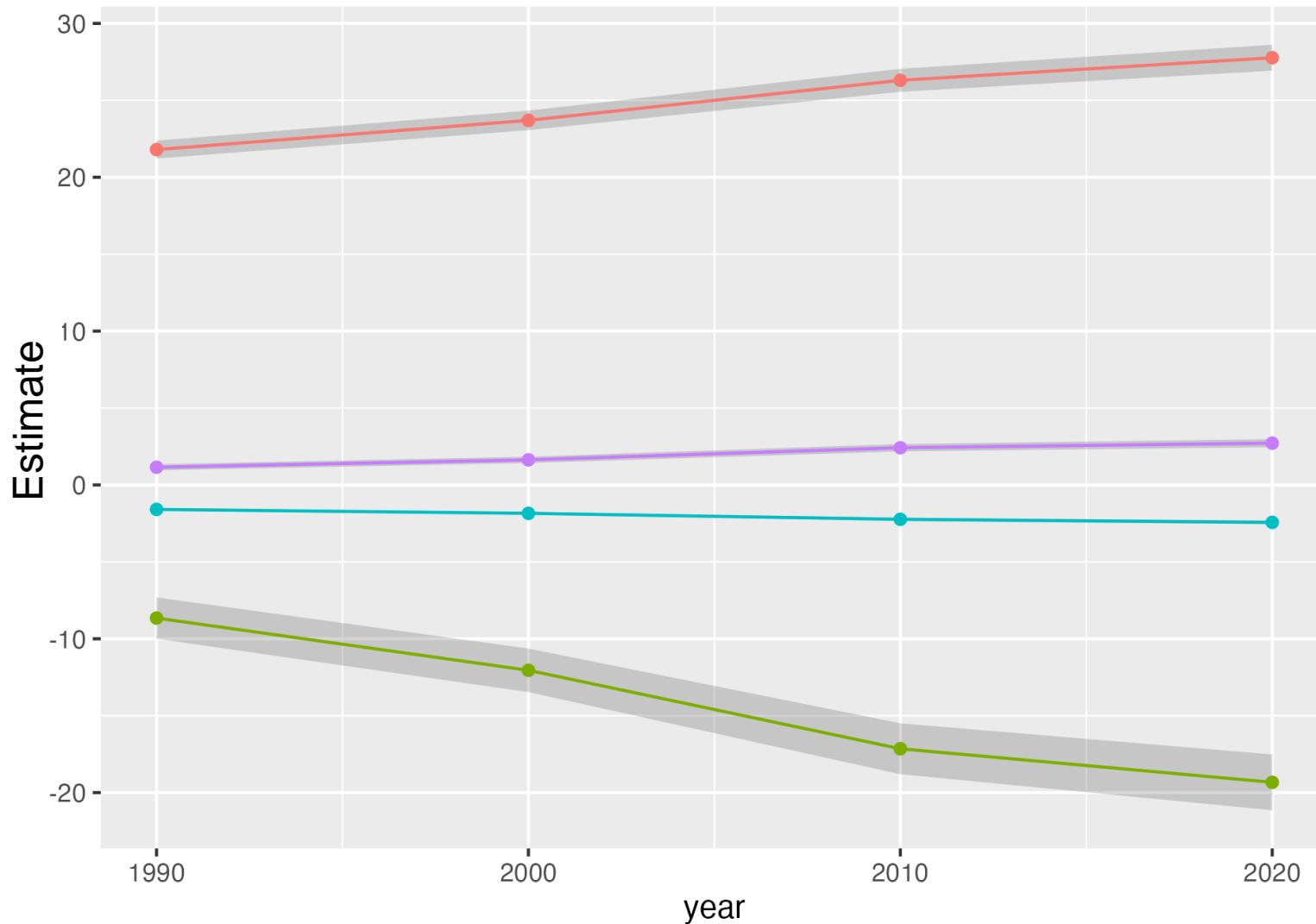


Since 1990, more equal cities gained population faster than unequal cities

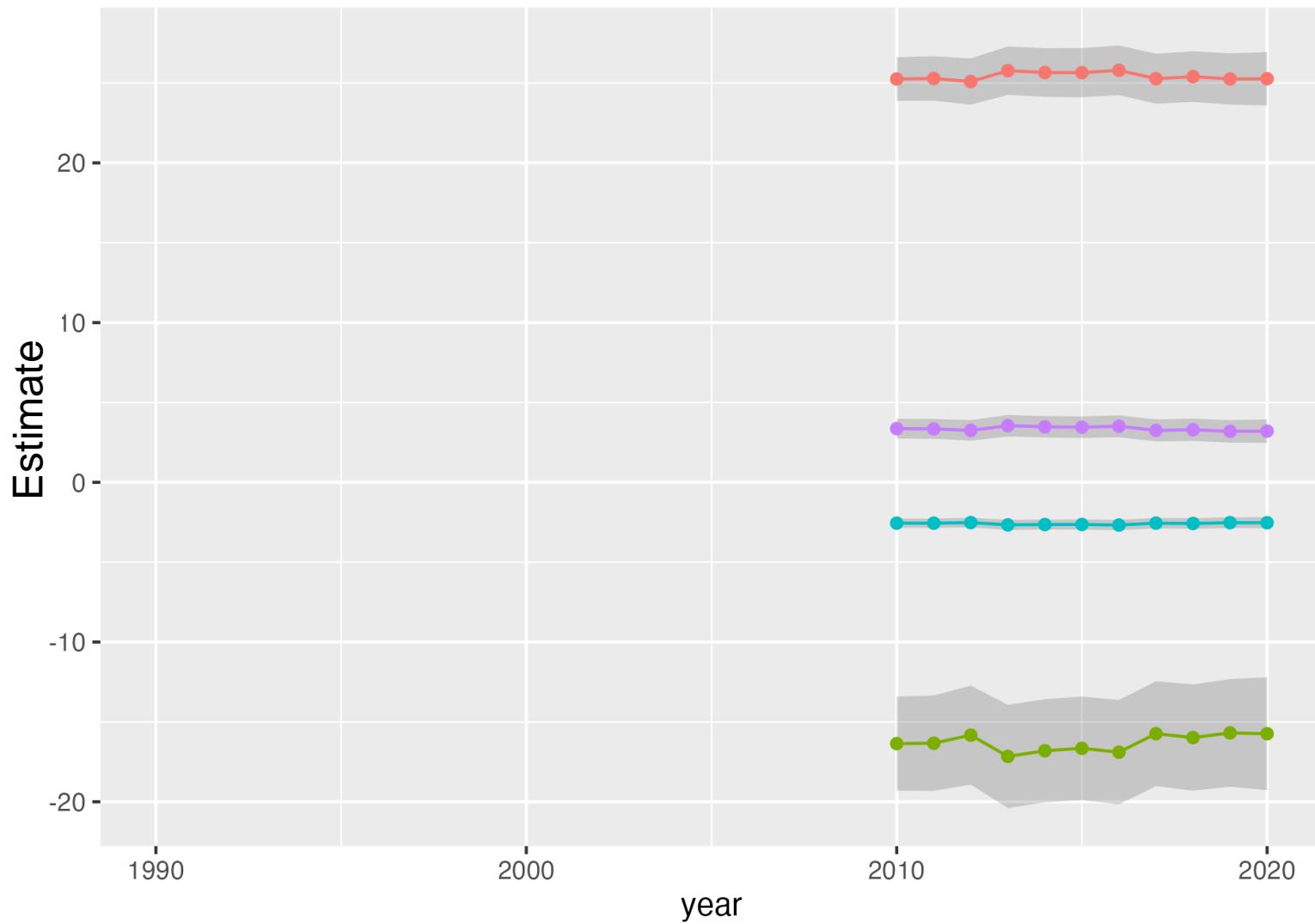
(both relatively & absolutely)



Decadal estimates by county since 1990



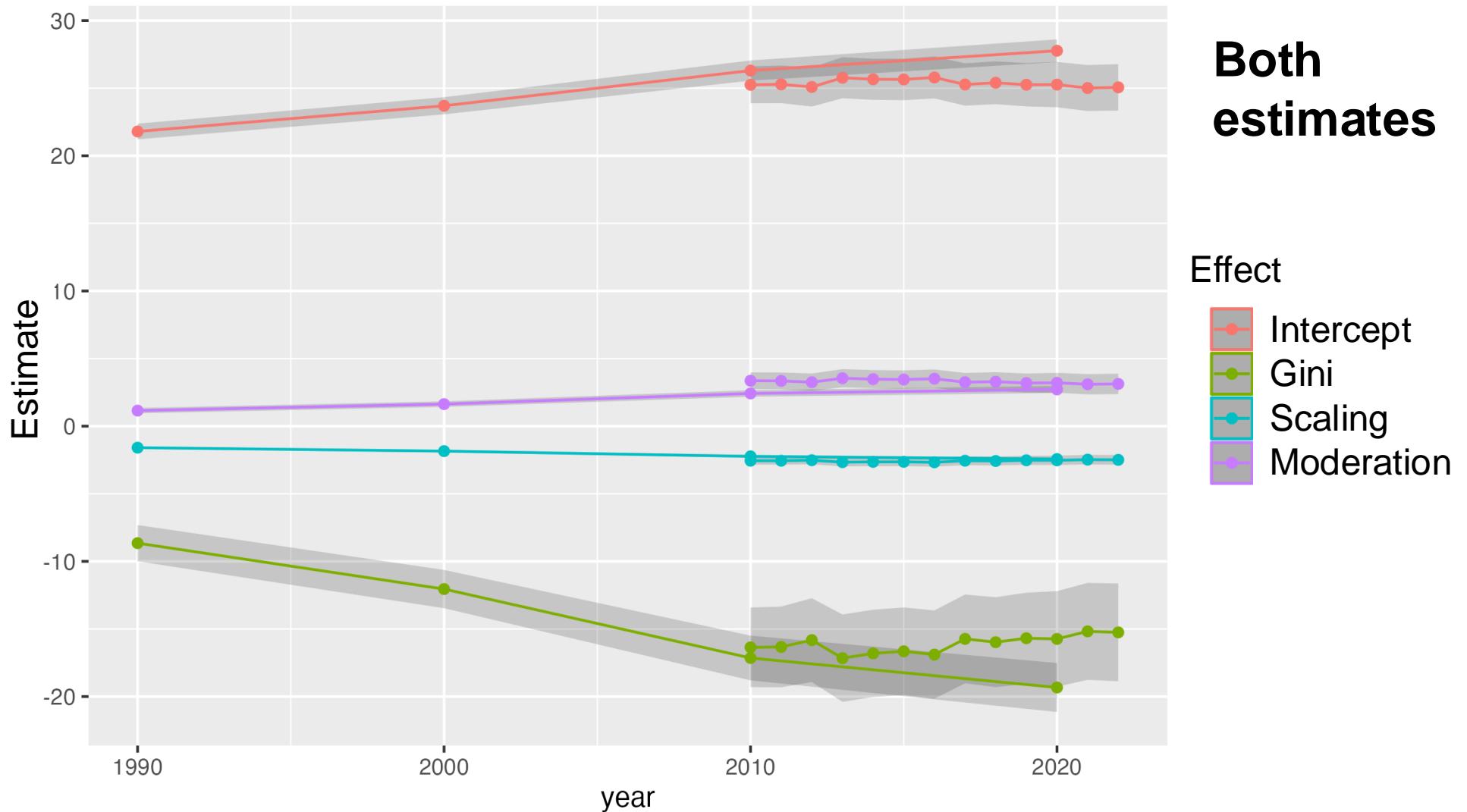
$$\log(\text{pop}) \sim 1 + \log(\text{rank}) + \text{gini} + \log(\text{rank}) * \text{gini}$$



**Yearly
estimates
by city
since 2010**

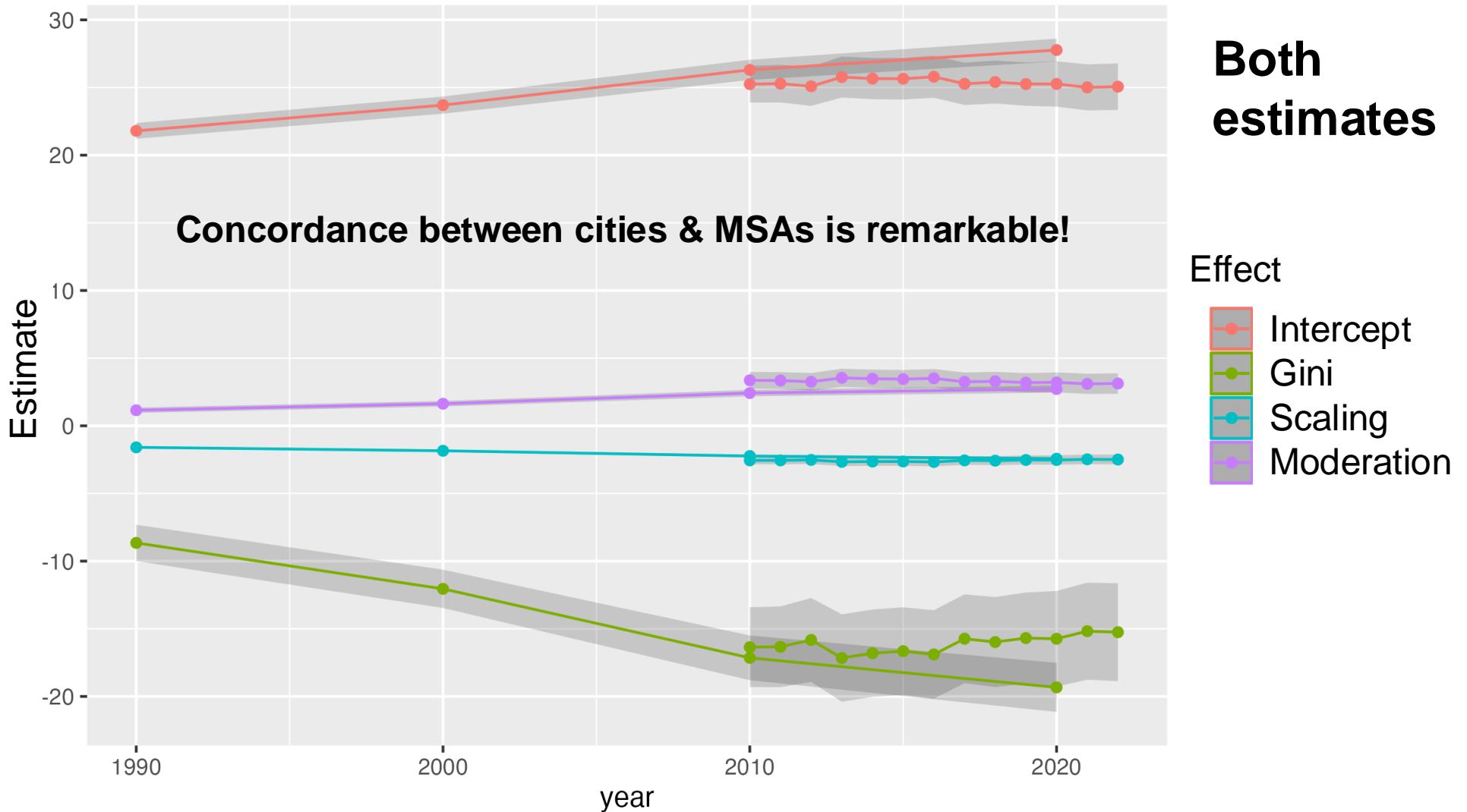
$$\log(\text{pop}) \sim 1 + \log(\text{rank}) + \text{gini} + \log(\text{rank}) * \text{gini}$$

Both estimates

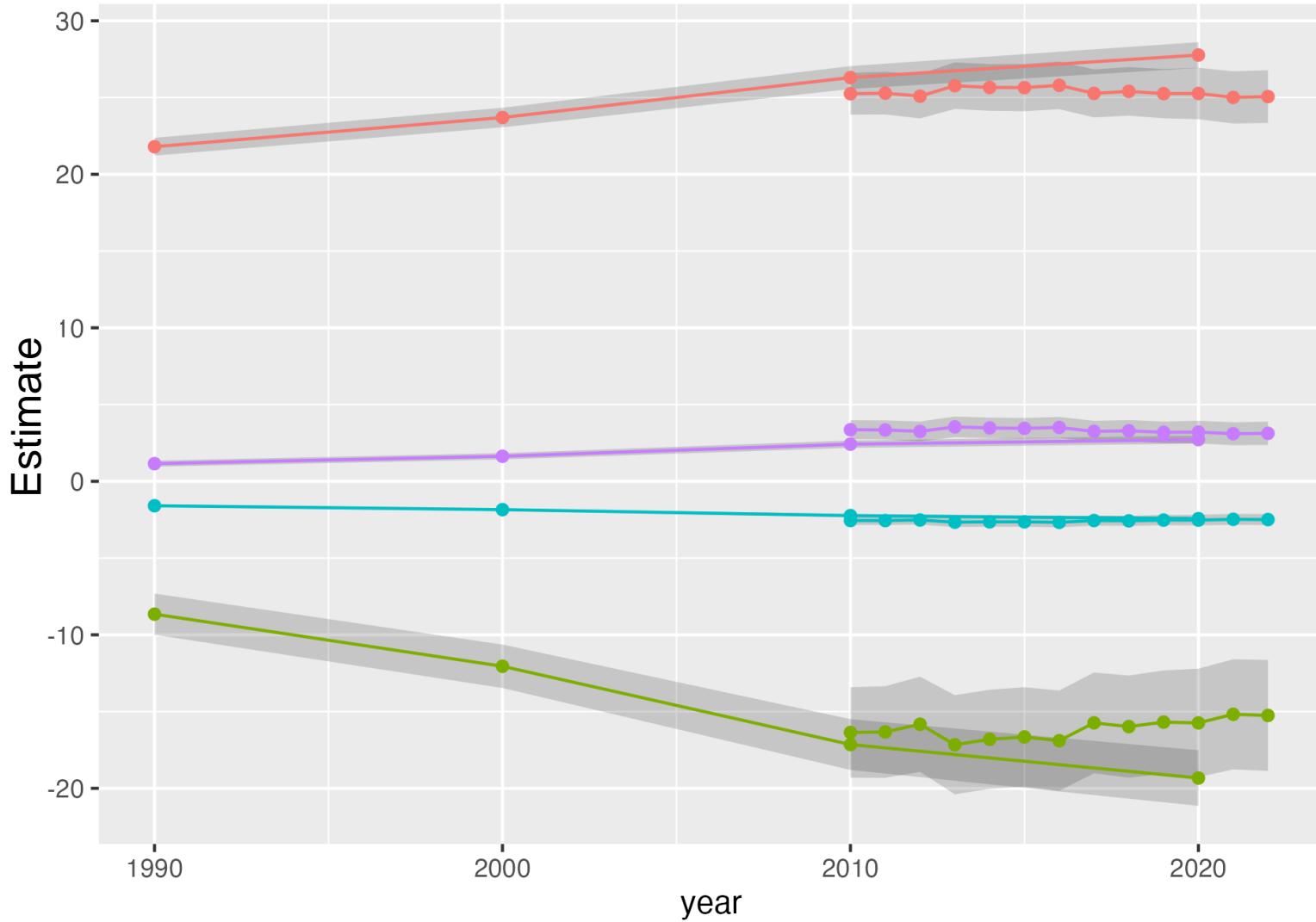


$$\log(\text{pop}) \sim 1 + \log(\text{rank}) + \text{gini} + \log(\text{rank}) * \text{gini}$$

**Both
estimates**



$$\log(\text{pop}) \sim 1 + \log(\text{rank}) + \text{gini} + \log(\text{rank}) * \text{gini}$$



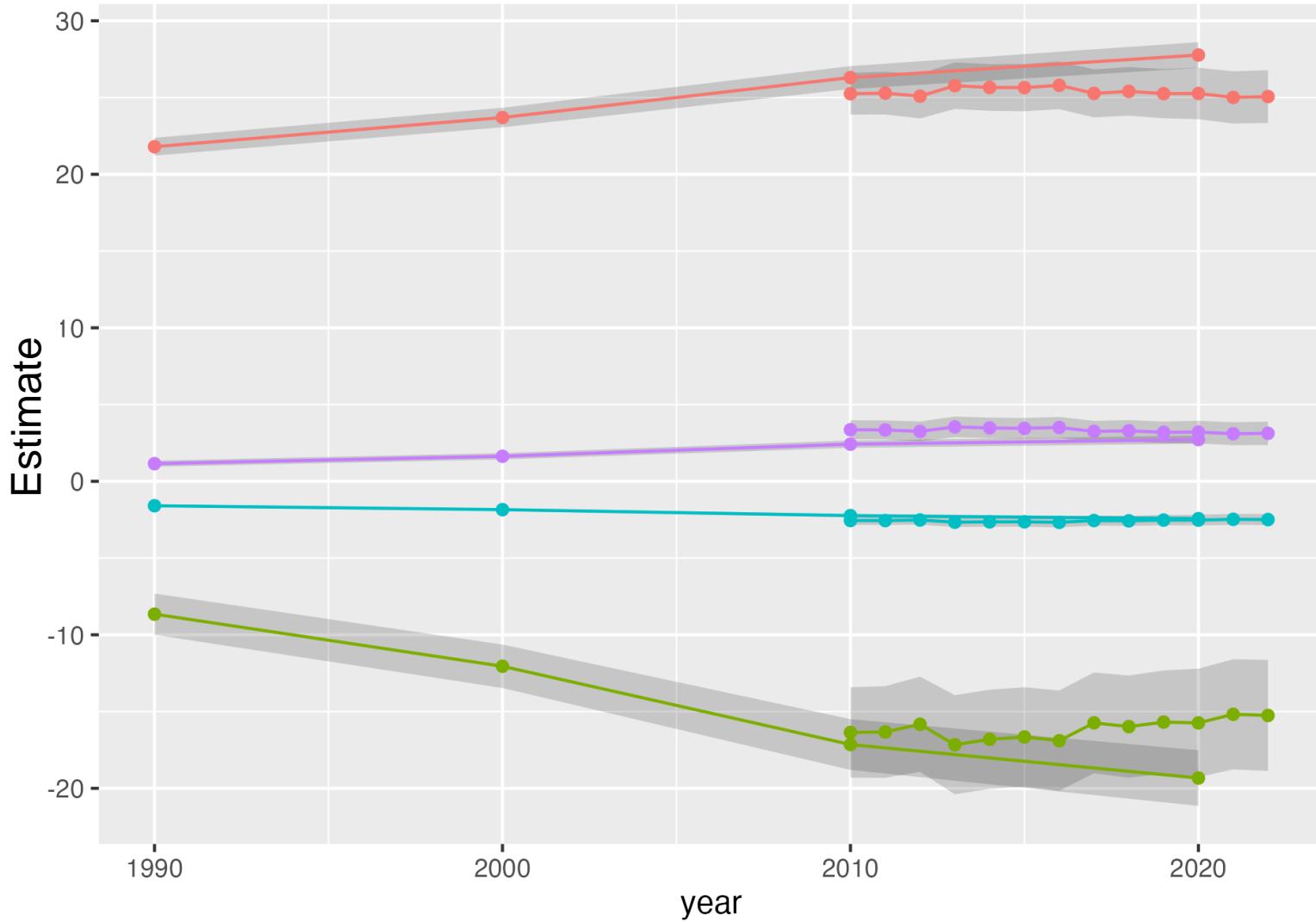
**Both
estimates**

Effect

- Intercept
- Gini
- Scaling
- Moderation

**Increasing city
rank decreases
city population,
holding city
inequality fixed**

$$\log(\text{pop}) \sim 1 + \log(\text{rank}) + \text{gini} + \log(\text{rank}) * \text{gini}$$



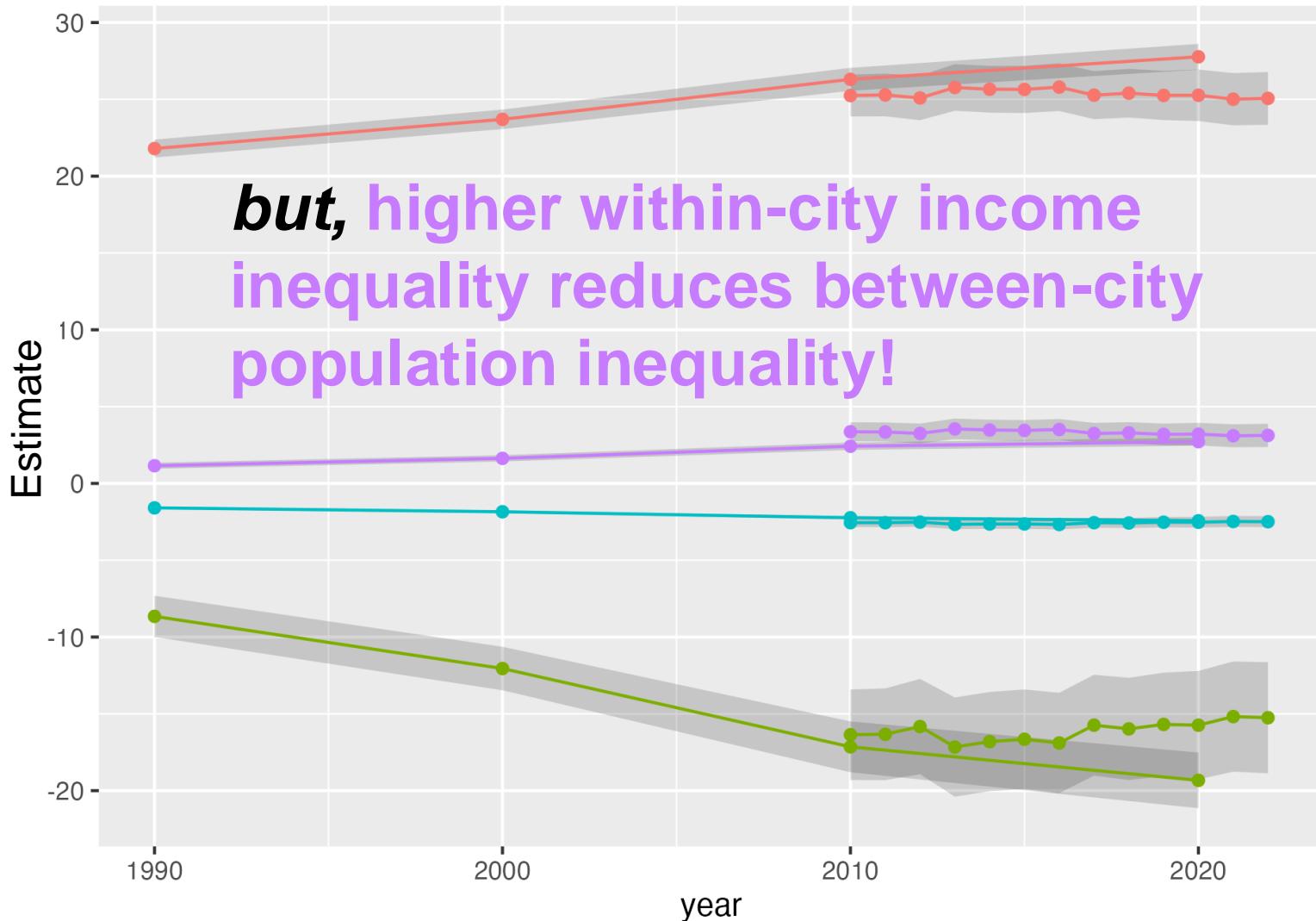
**Both
estimates**

Effect

- Intercept
- Gini
- Scaling
- Moderation

At a fixed rank in
the city system,
unequal cities
will be smaller...

$$\log(\text{pop}) \sim 1 + \log(\text{rank}) + \text{gini} + \log(\text{rank}) * \text{gini}$$



**Both
estimates**

Effect

- Intercept
- Gini
- Scaling
- Moderation

At a fixed rank in
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[nature](#) > [scientific data](#) > [data descriptors](#) > [article](#)

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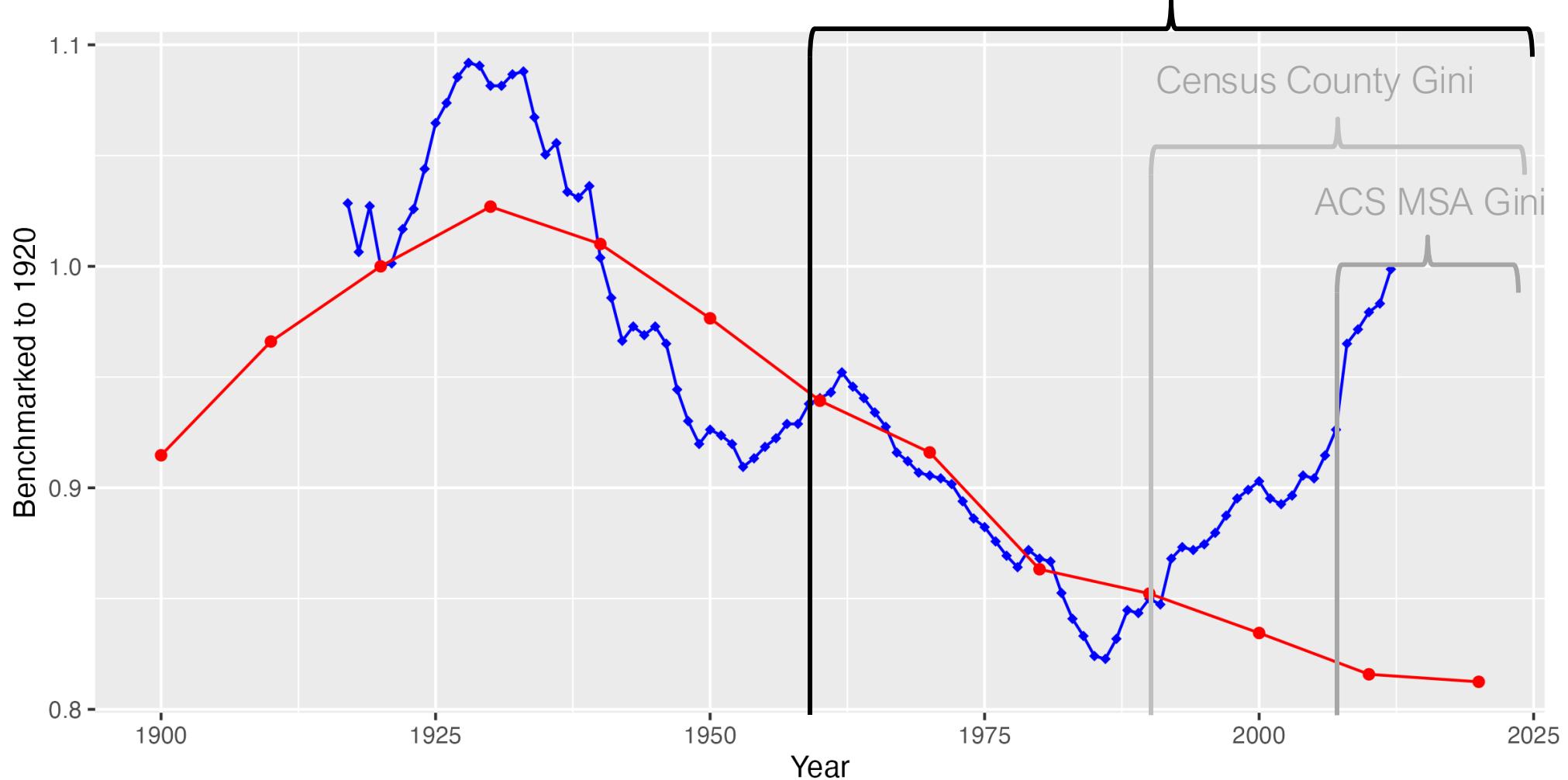
GEOWEALTH-US: Spatial wealth inequality data for the United States, 1960–2020

[Joel Suss](#), [Tom Kemeny](#)  & [Dylan S. Connor](#)

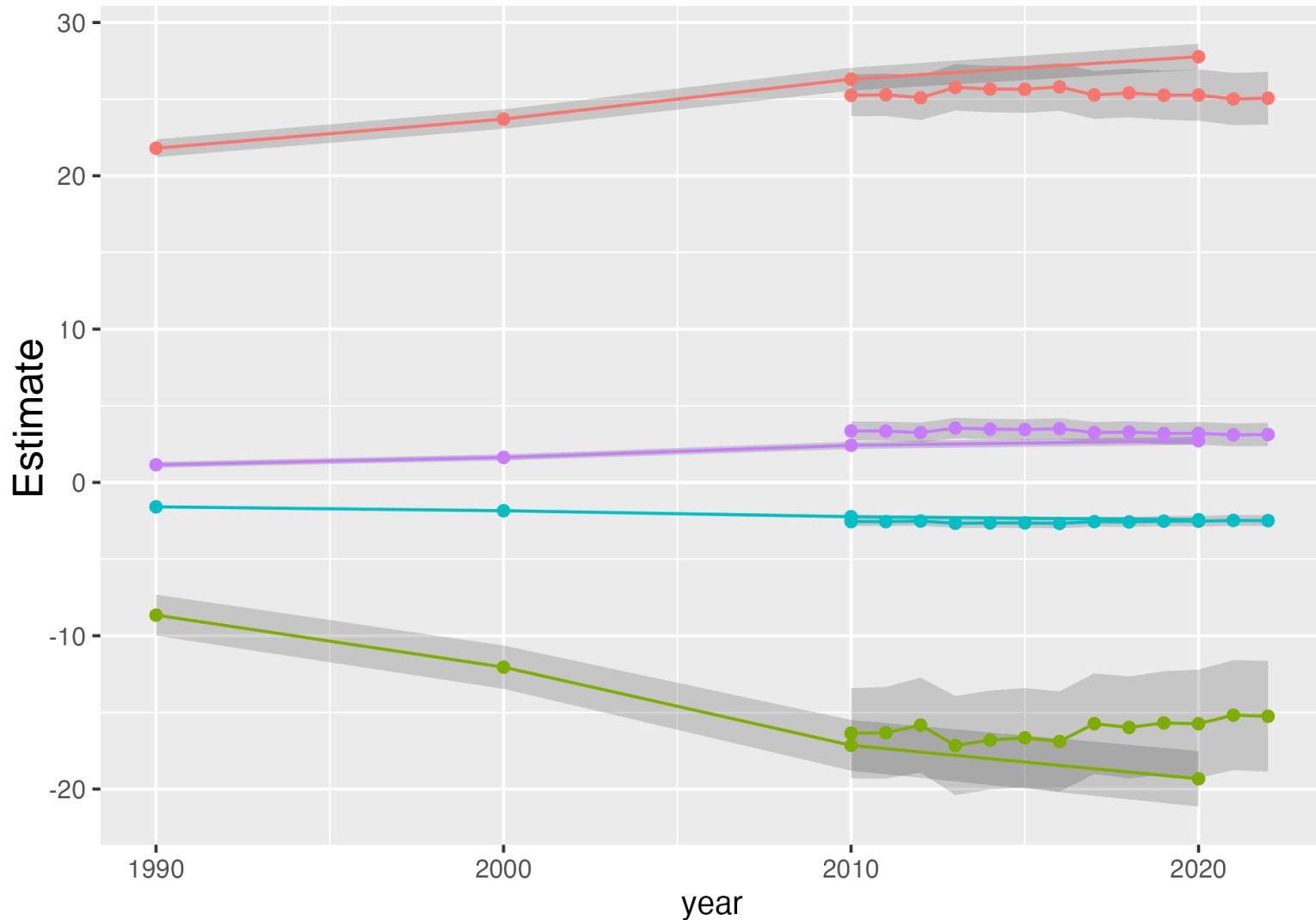
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GEOWEALTH County Gini



Between-city population inequality moved with macro-level income inequality until the 21st Century...



$$\log(\text{pop}) \sim 1 + \log(\text{rank}) + \text{gini} + \log(\text{rank}) * \text{gini}$$

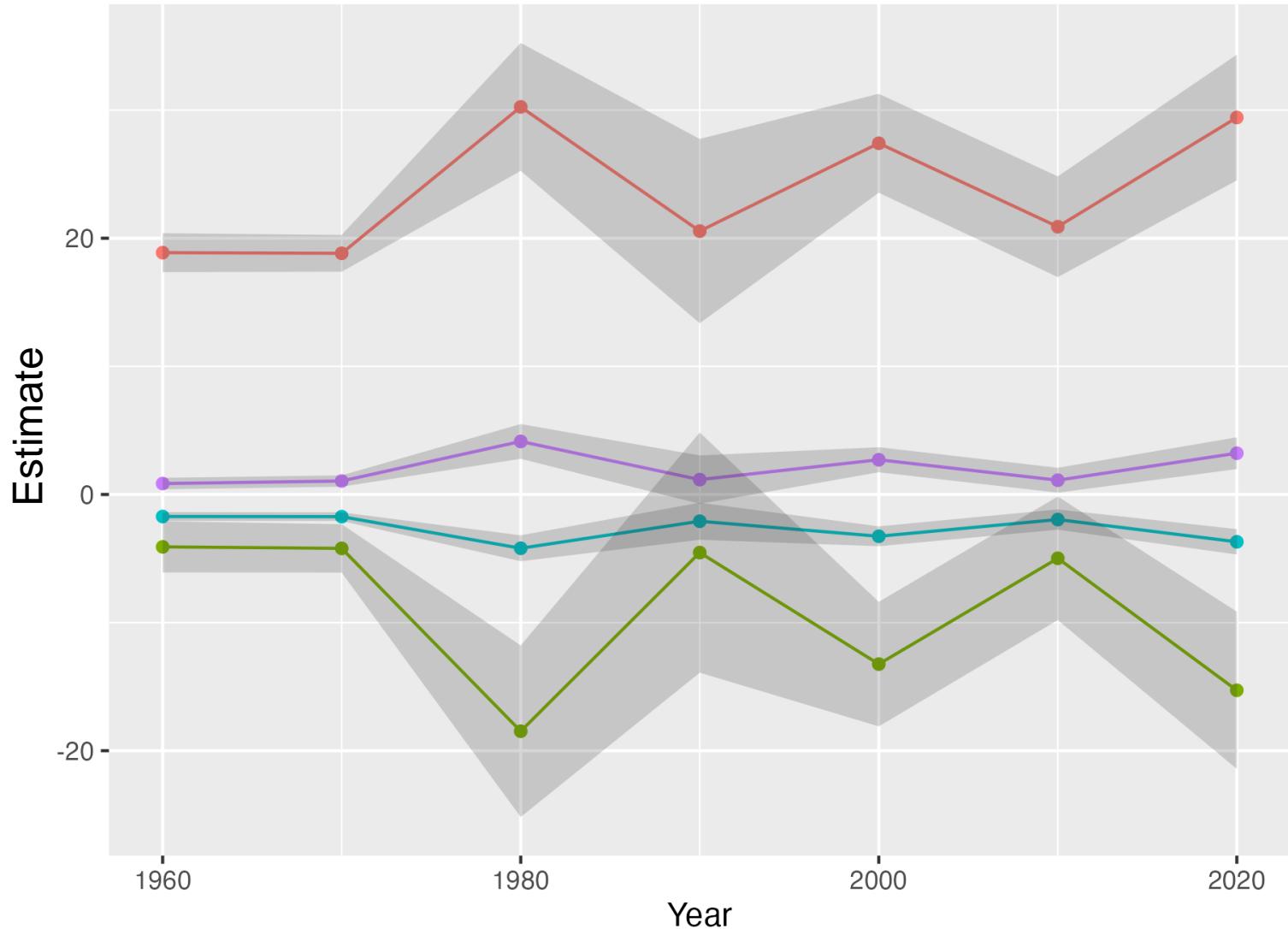
Both estimates

Effect

- Intercept
- Gini
- Scaling
- Moderation

Holding city rank constant, large income inequality is associated with smaller city population

Suss et al. estimates



$$\log(\text{pop}) \sim 1 + \log(\text{rank}) + \text{gini} + \log(\text{rank}) * \text{gini}$$

Effect

- Intercept
- Gini
- Scaling
- Moderation

Holding city rank
constant, large
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population

Suss et al. estimates



$$\log(\text{pop}) \sim 1 + \log(\text{rank}) + \text{gini} + \log(\text{rank}) * \text{gini}$$

Effect

- Intercept
- Gini
- Scaling
- Moderation

Holding city rank constant, large income inequality is associated with smaller city population

regularity value

How often is this true?

contextual value

Where/when is this true?

generative value

How is this true?

City size distributions often
follow Zipf's Law...

... in “coherent” urban
systems ...

... because of within-city
inequality?

regularity value

How often is this true?

contextual value

Where/when is this true?

generative value

How is this true?

Lots of data about the present

Lots of data about the present, disaggregated by geography or time

Lots of data about, disaggregated by geography and time

Urban scaling laws arise from within-city inequalities in the mid 20th C. but no longer

Within-city inequality *doesn't*
go hand-in-hand with pop growth
Between-city inequality *doesn't*
rise as within-city inequality rises

Urban scaling laws arise from within-city inequalities in the mid 20th C. but no longer

nature cities

Perspective

People make places urban

People—not buildings—make places feel urban. Conversely, it is buildings, infrastructure and amenities that make places feel developed. Sometimes urbanness and development go together, but often they do not.

Within-city inequality doesn't go hand-in-hand with pop growth
Between-city inequality doesn't rise as within-city inequality rises



inequality ≠ opportunity
wealth ≠ development
density ≠ concentration

Causal Values in City Science

What do we mean by it?

Regularity and Contextuality

City scaling gives an example

Moving to generative value

Winner-take-all city systems?

Talk outline

CITY SYSTEMS AND THE CAUSE OF INEQUALITY

A CITY SCIENCE APPROACH

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