

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?

Three kinds of “value”
for law-like statements

contextual value

Where/when is this true?

generative value

How is this true?

regularity value

How often is this true?

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Where/when is this true?

generative value

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?

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

contextual value

Where/when is this true?

... in “coherent” urban systems ...

generative value

How is this true?

... 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

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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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Causal Values in GIScience

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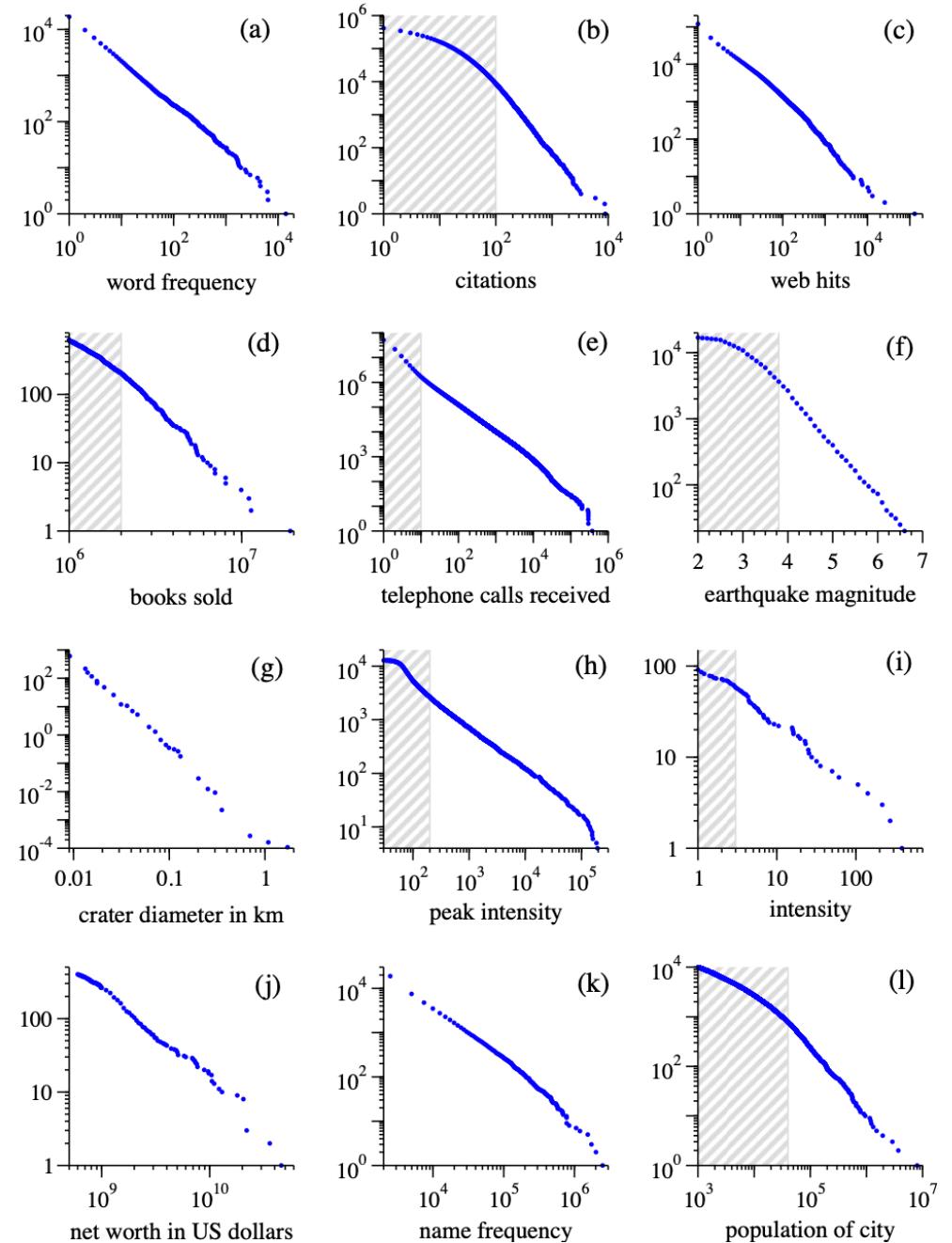
regularity value

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)



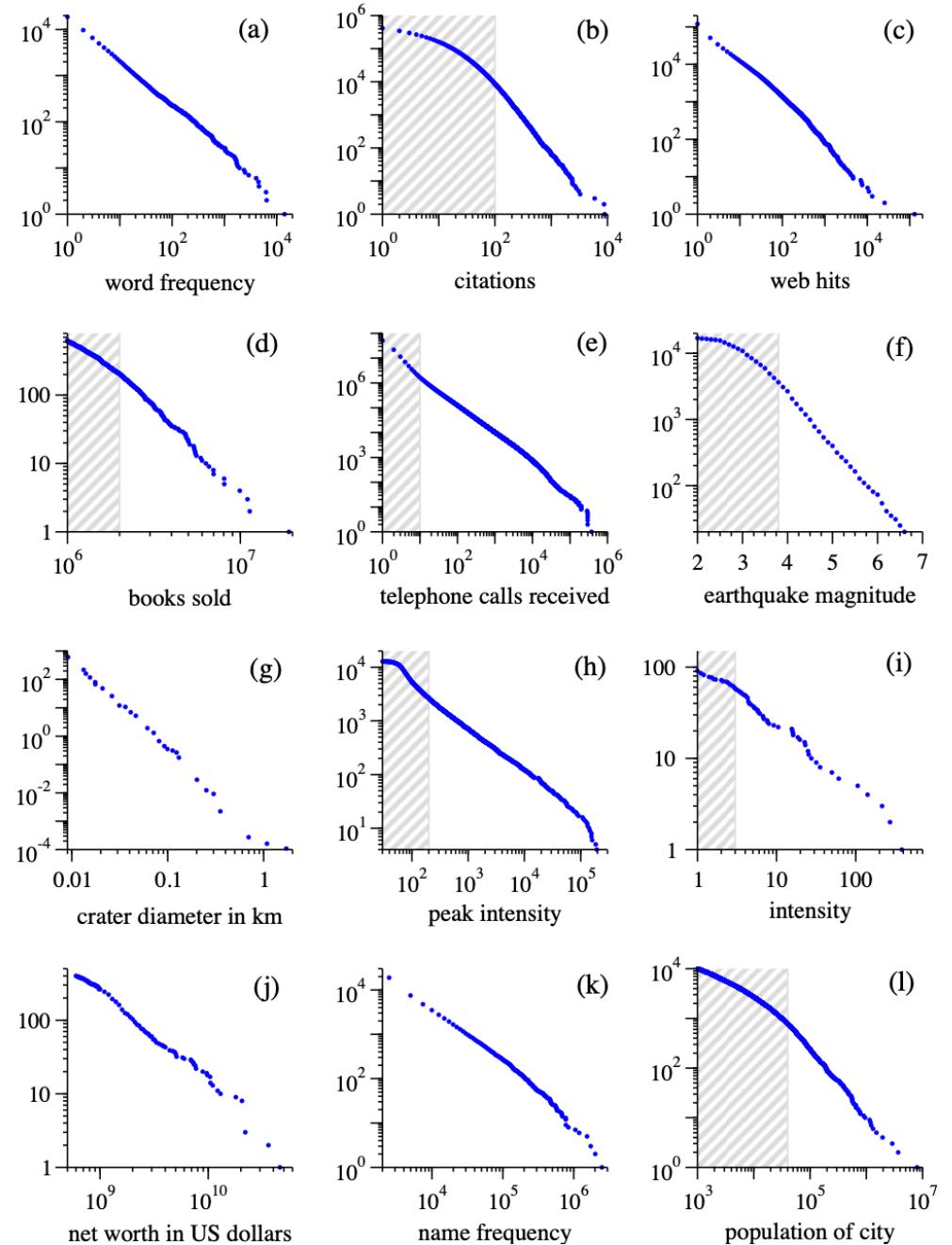
Power laws in plain language

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)

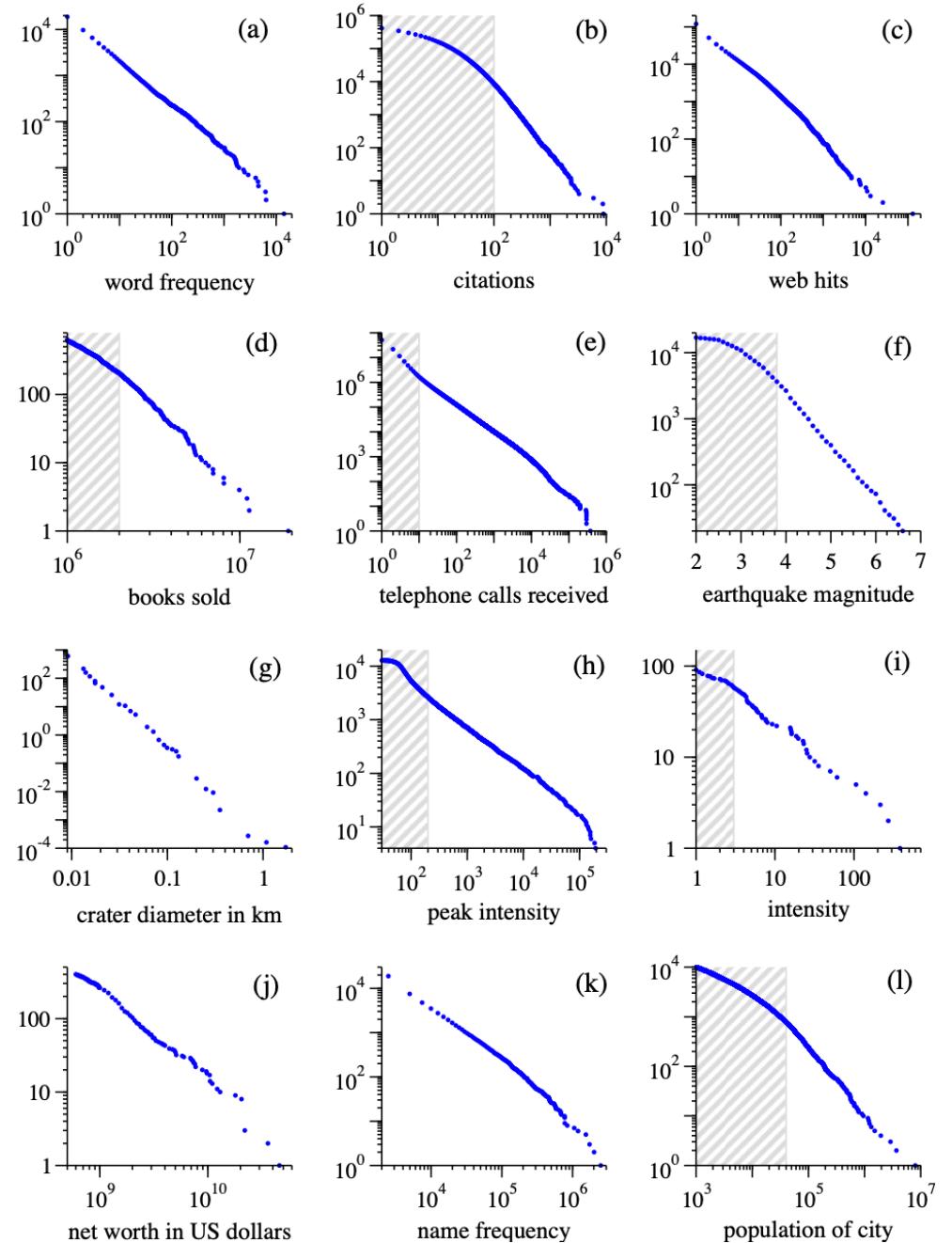


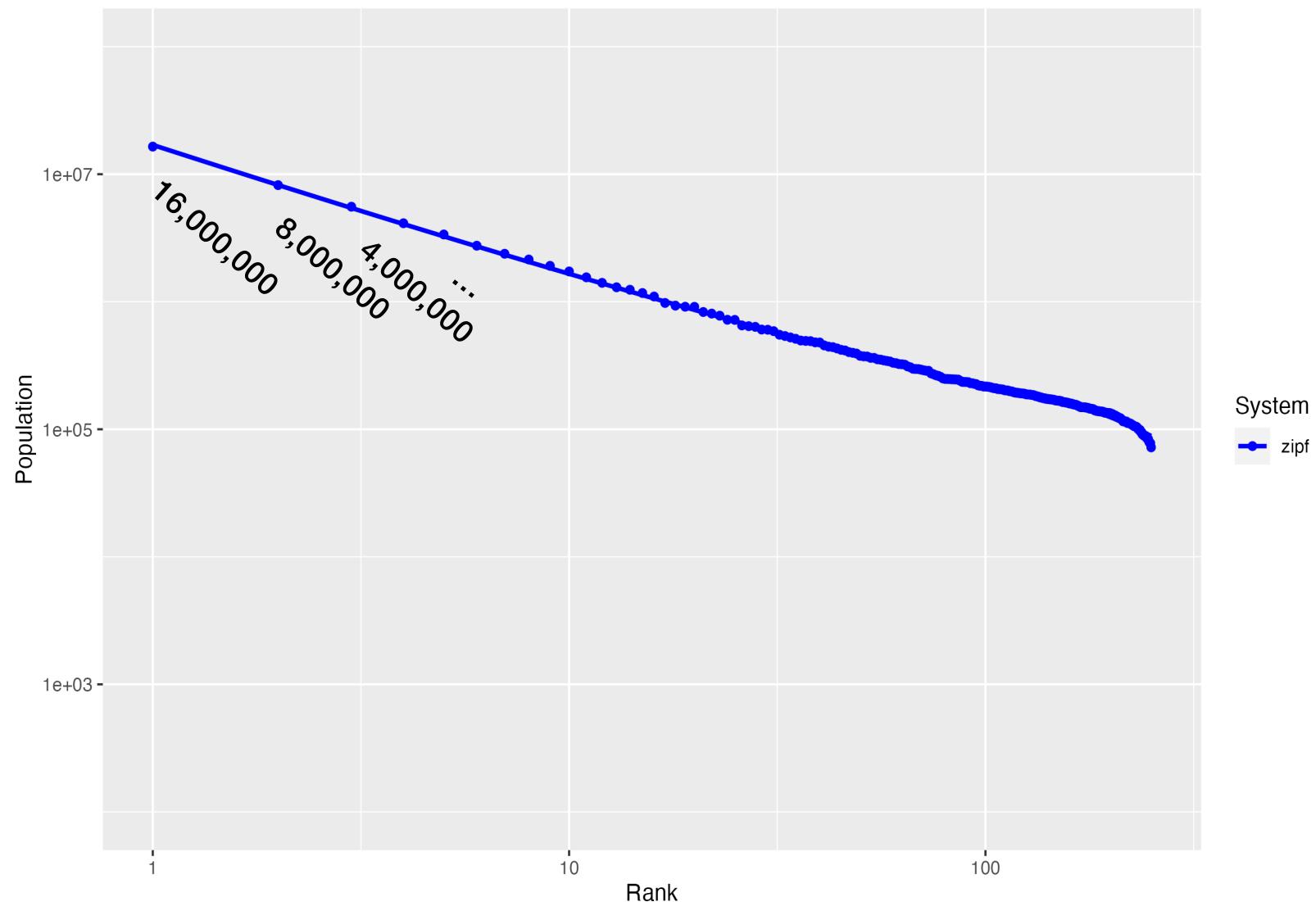
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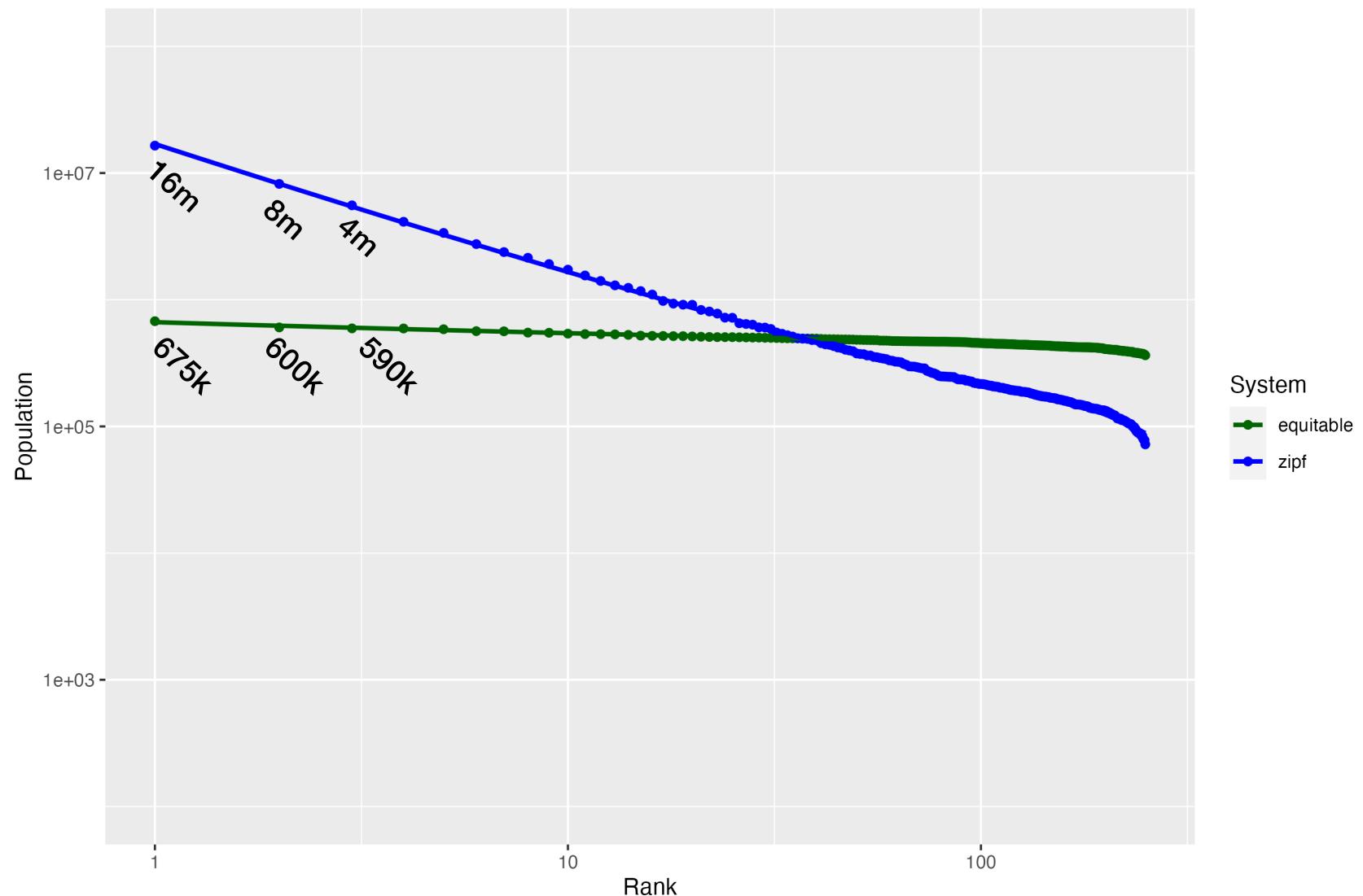
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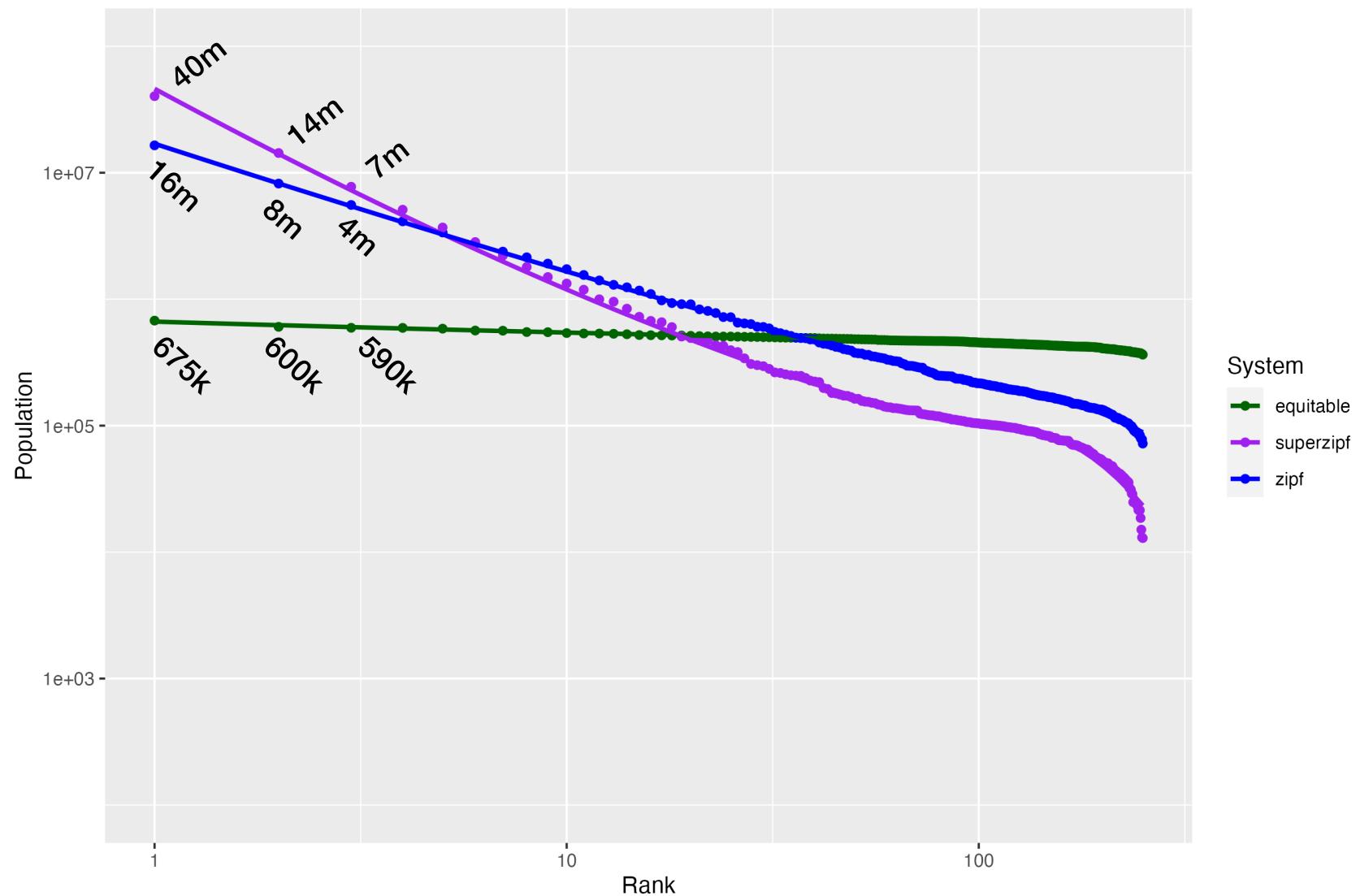
$$\begin{aligned} \text{rank} &\propto \text{size}^{-\text{decay}} & \text{primal} \\ \text{size} &\propto \text{rank}^{-\text{decay}} & \text{dual} \end{aligned}$$

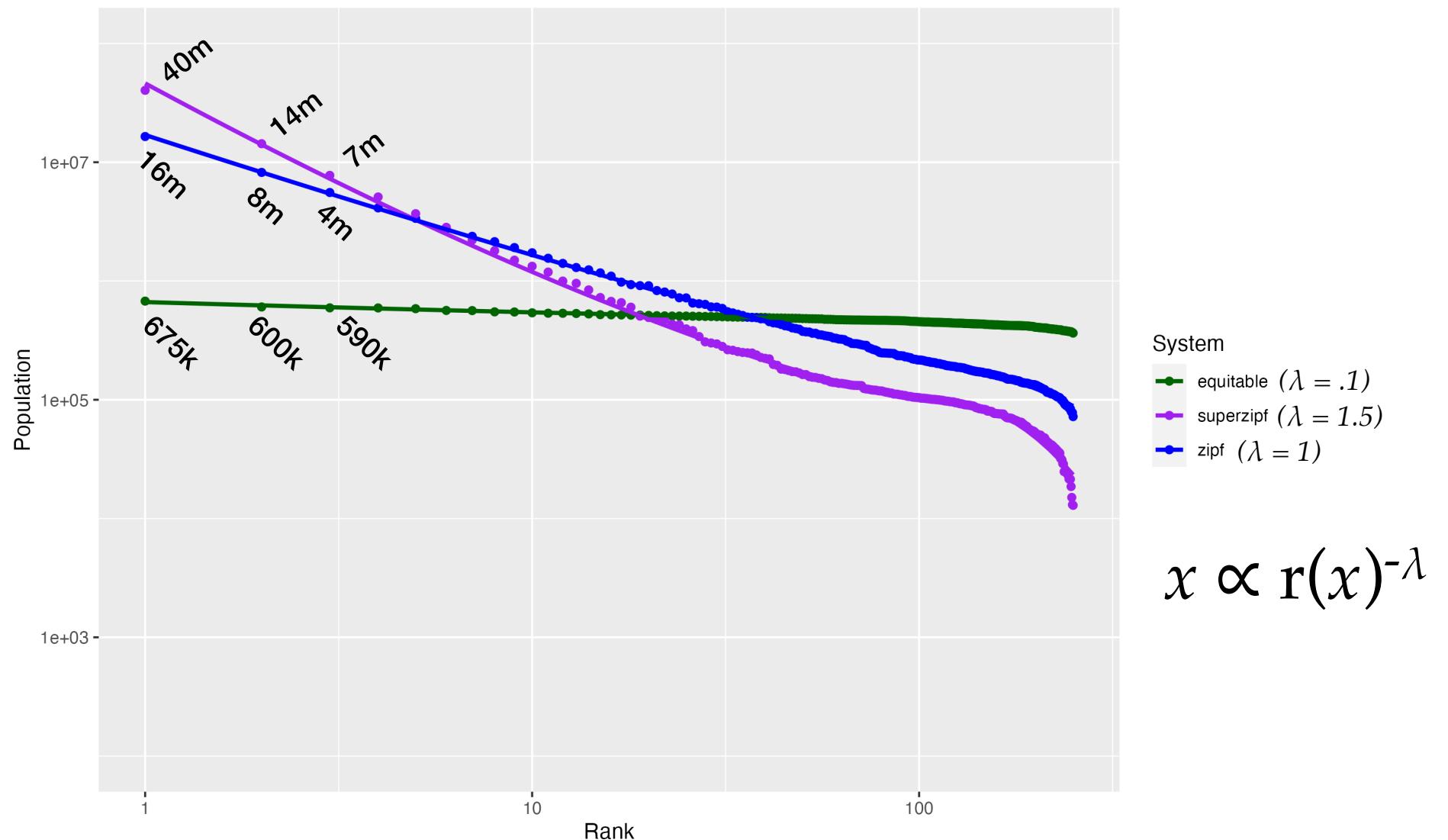
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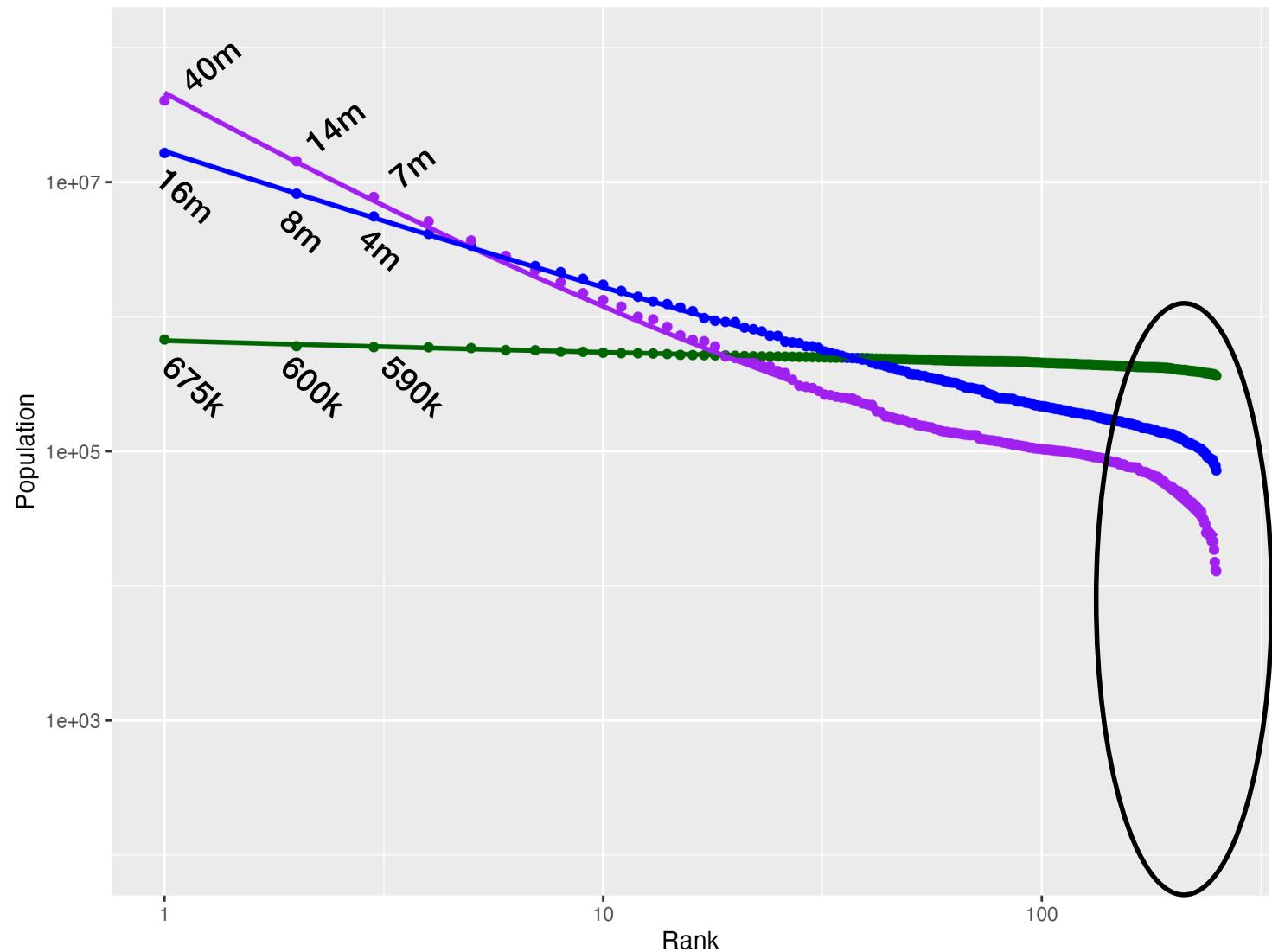










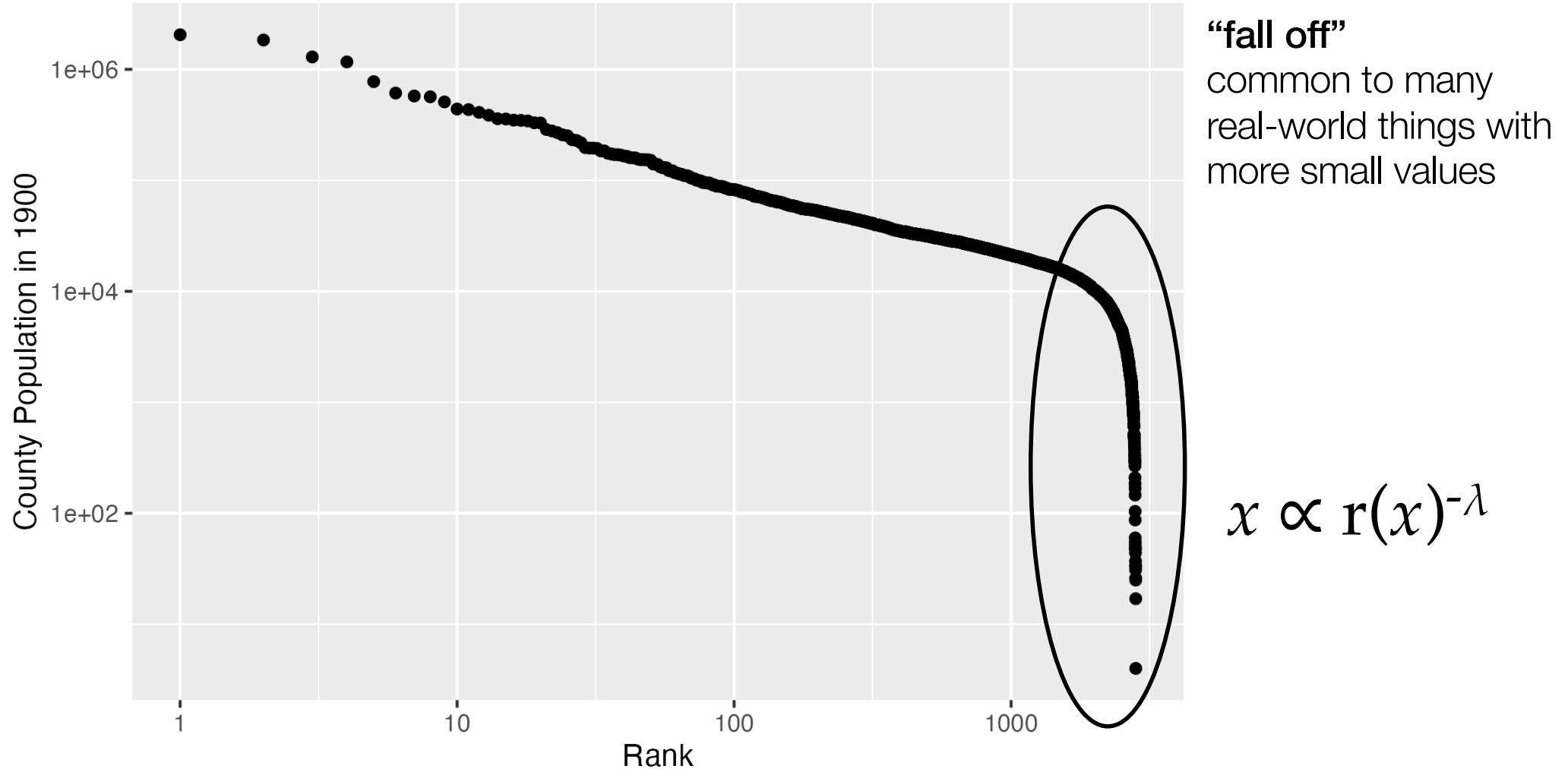


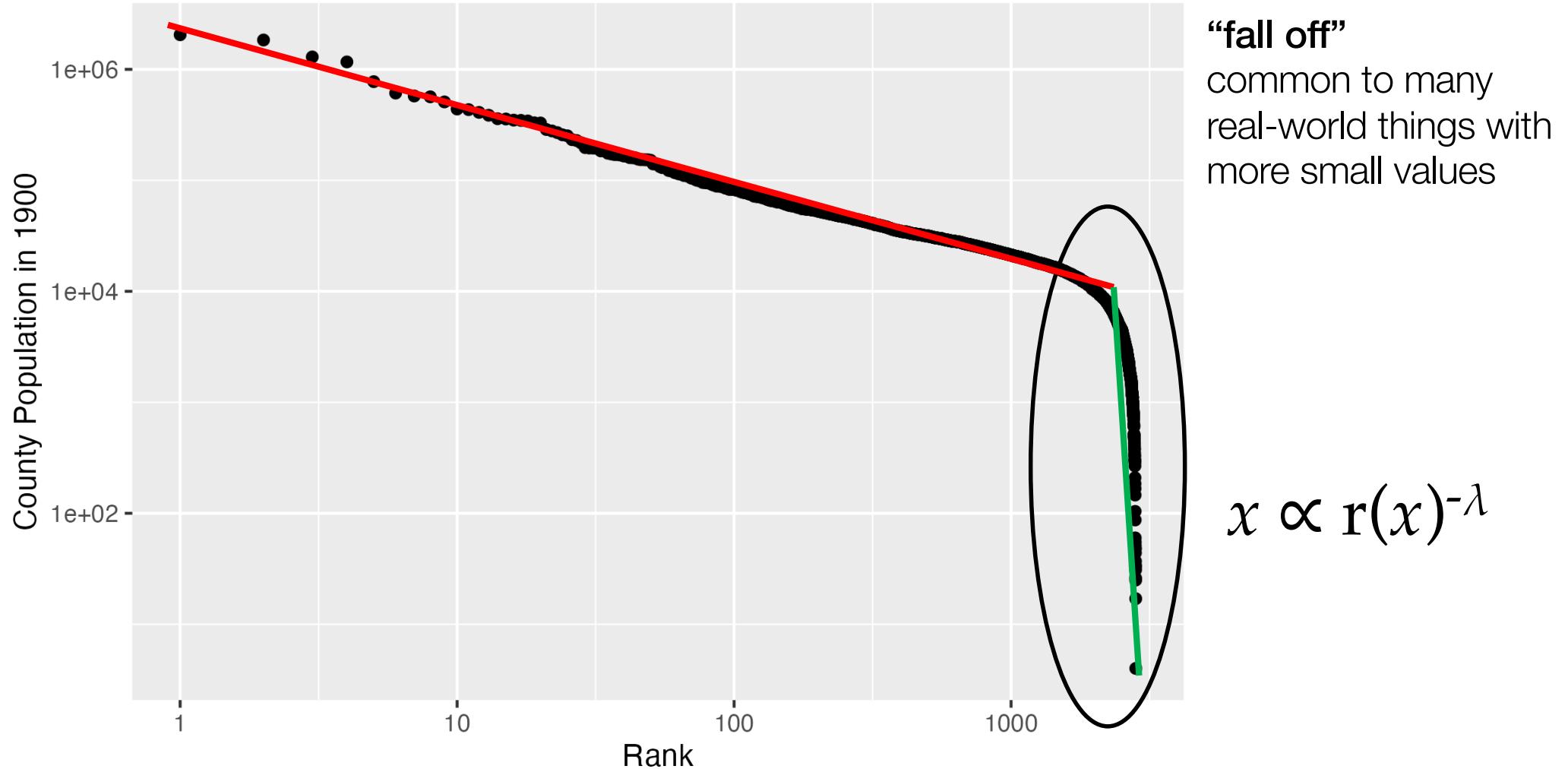
“fall off”
common to many
real-world things with
more small values

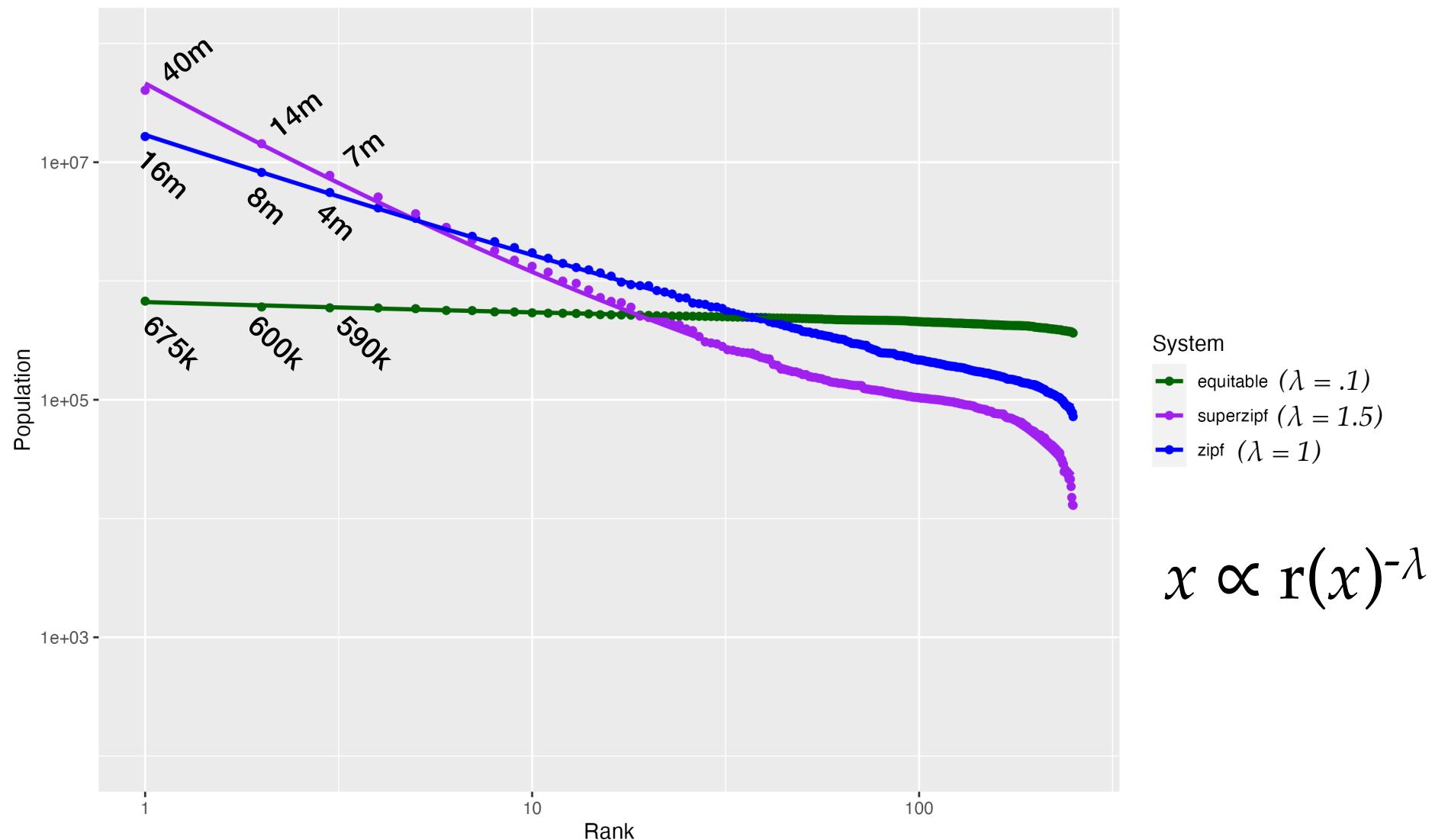
System

- equitable
- superzipf
- zipf

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





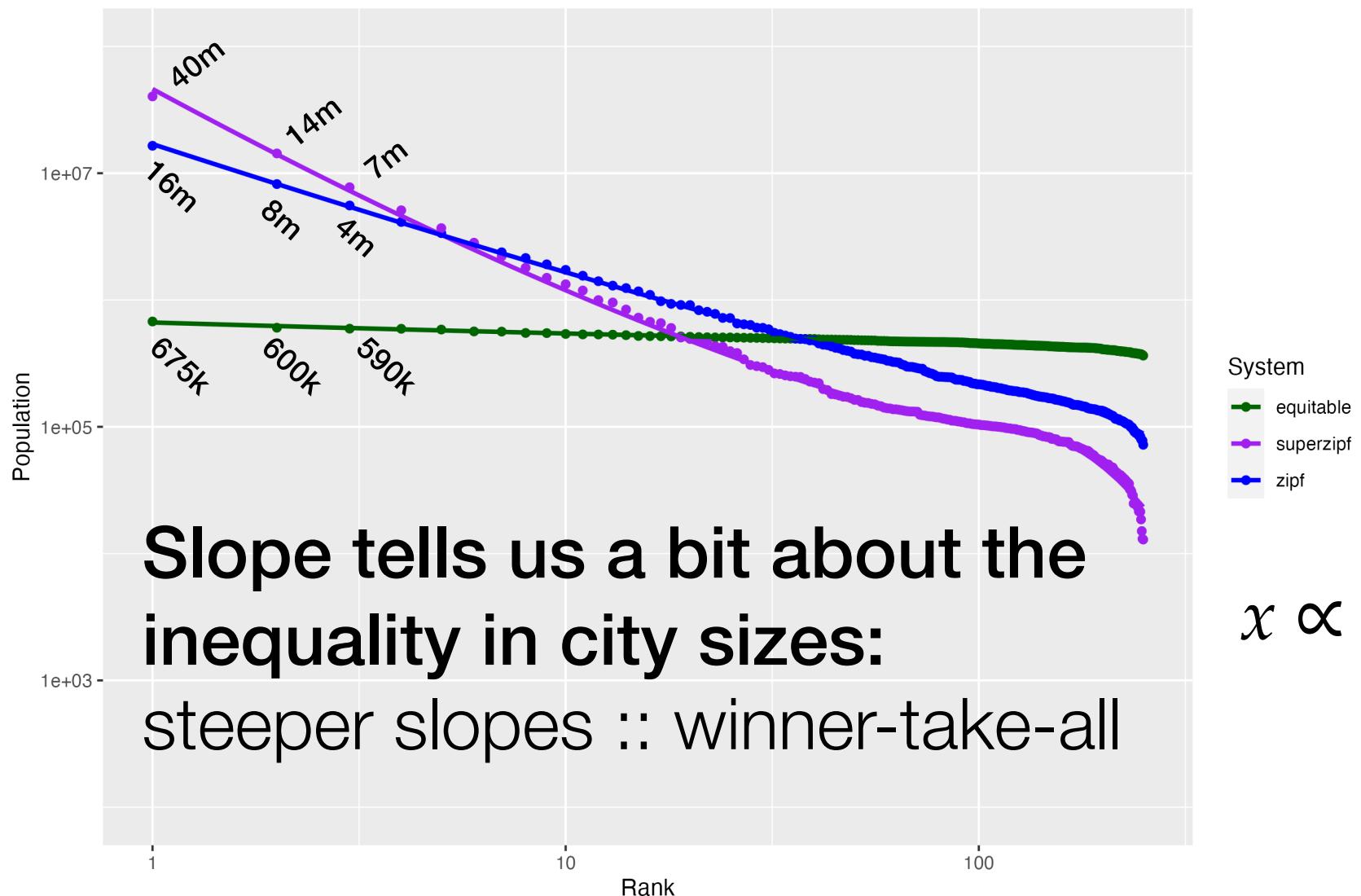


MATHEMATICS

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.



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



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.



preprint

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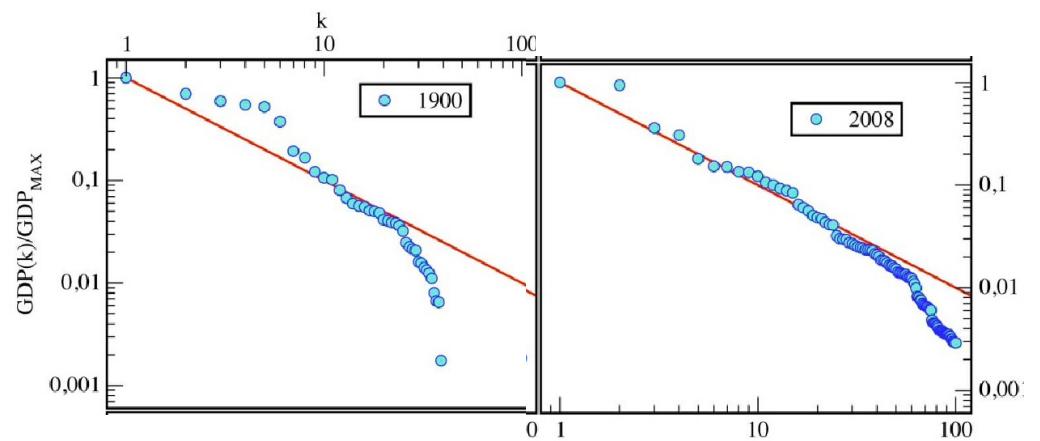
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The sizes of cities in a
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While Zipf's Law holds approximately for the city sizes of each European country ... it completely fails in the aggregated sets, that is in the EU.

There is More than a Power Law in Zipf

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



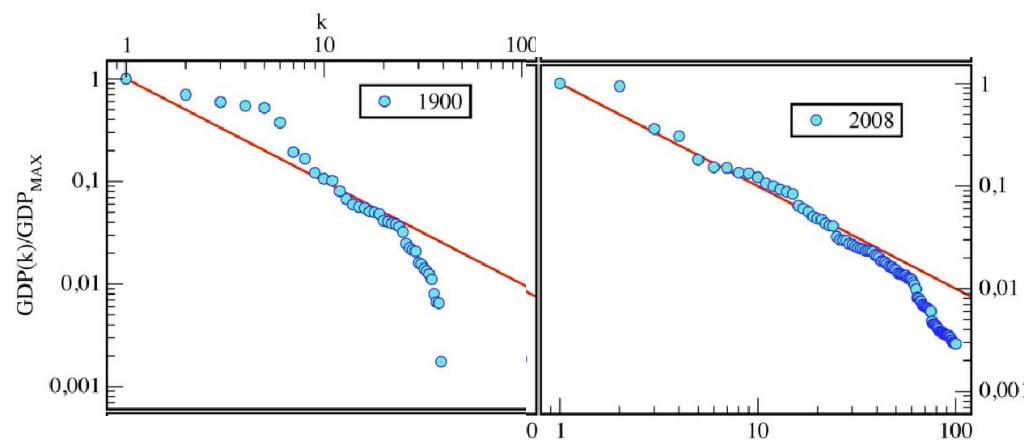
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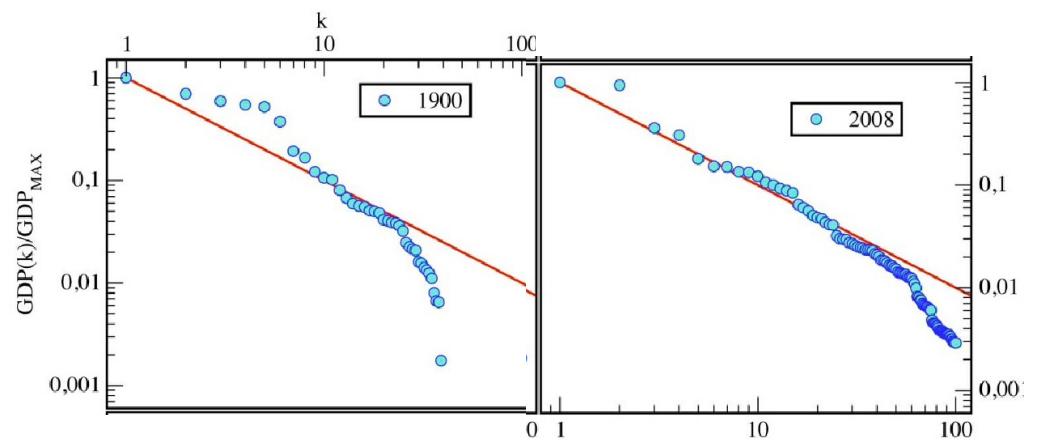
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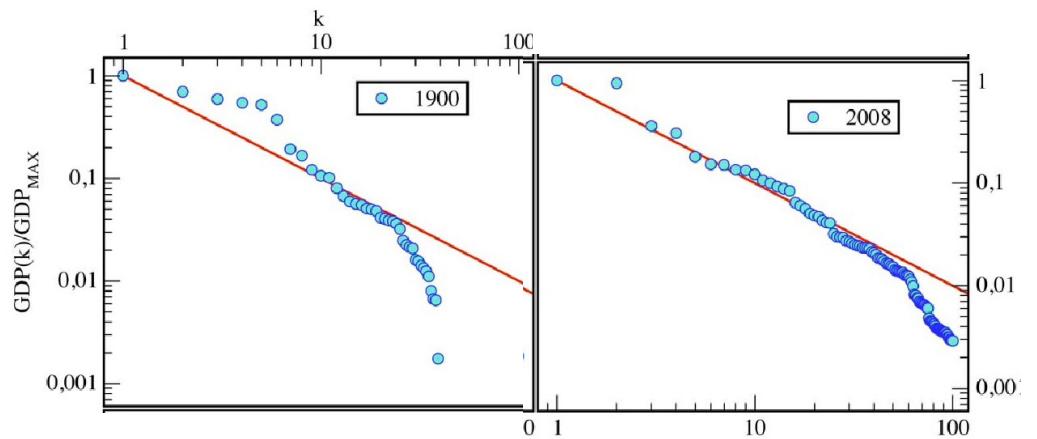
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Contextual value

*Statements
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(or are not!)*

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... because of within-city
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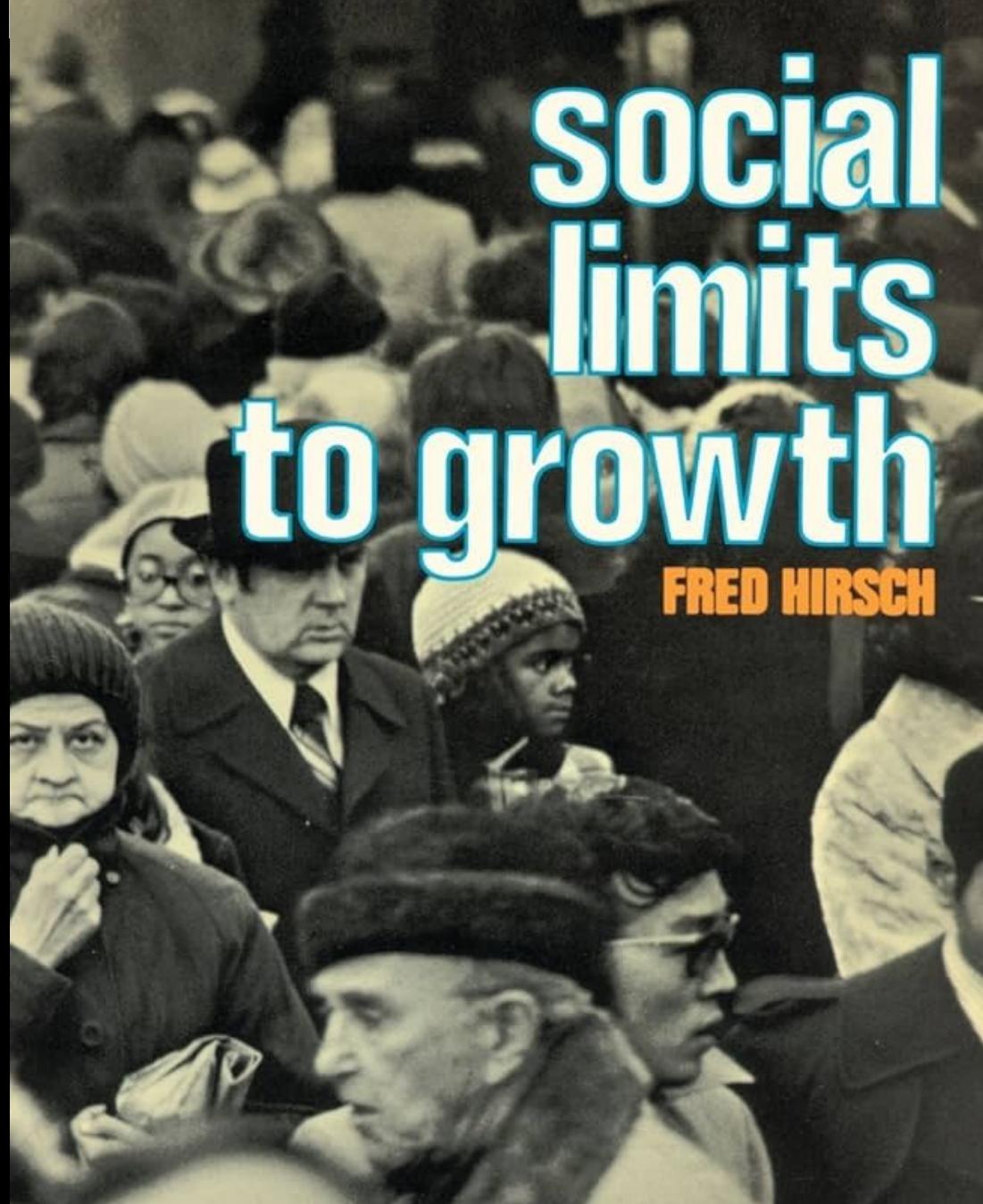
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Positional goods derive their value from their relation to other consumers' goods.

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

Examples include luxuries, education, and real estate.

Are cities themselves positional?



Social limits to growth

FRED HIRSCH

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)

<https://doi.org/10.1038/s41562-022-01609-1>

8

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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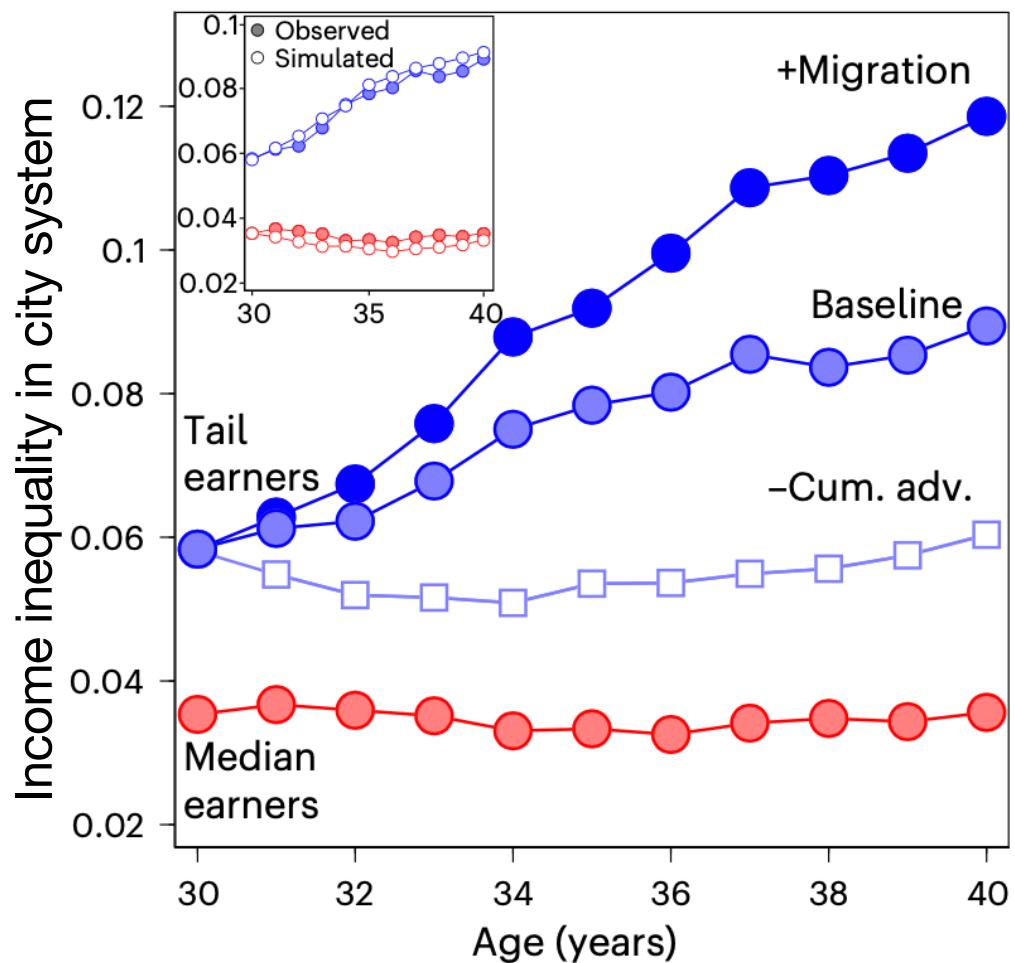
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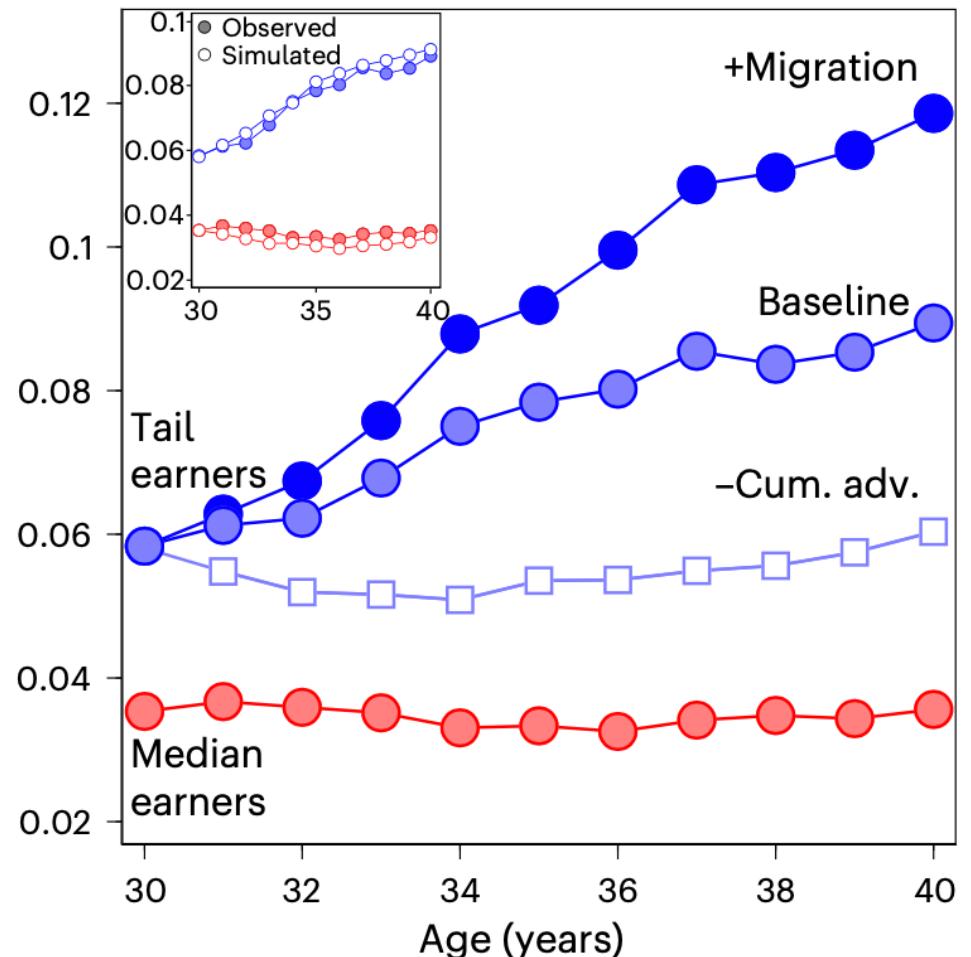
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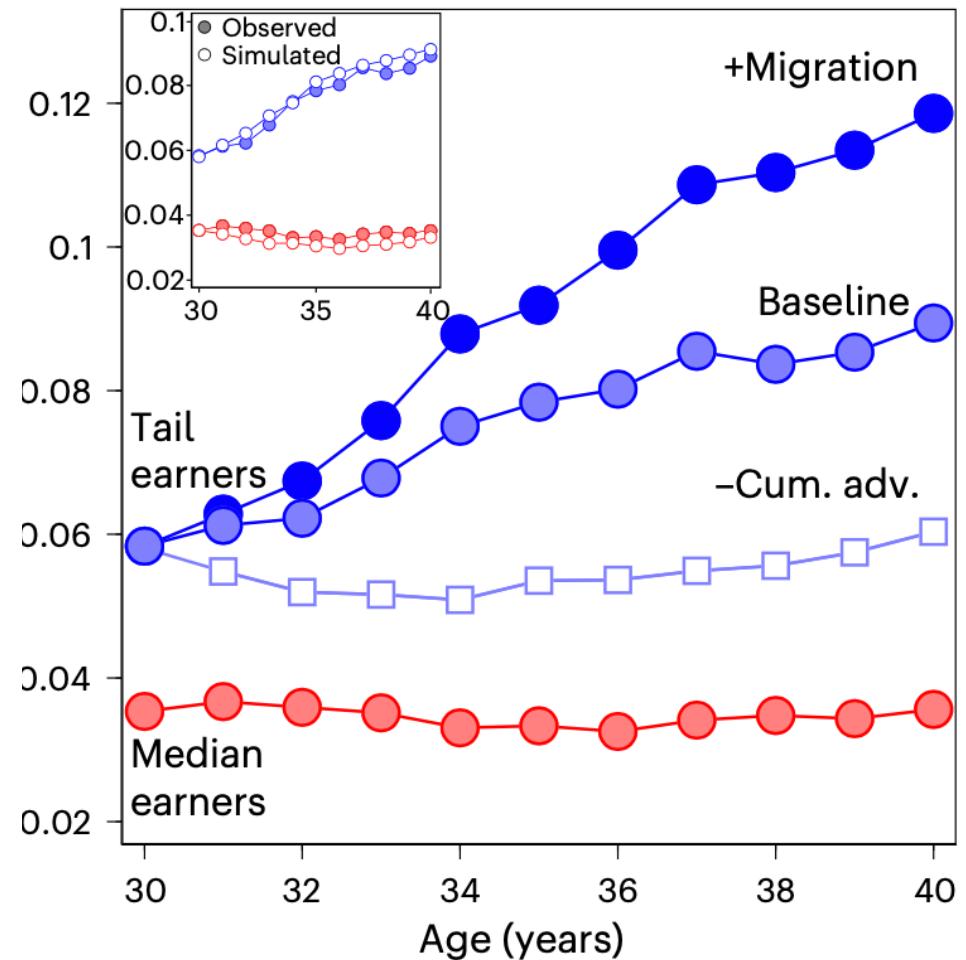
Empirical results show the contribution of each mechanism

- 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

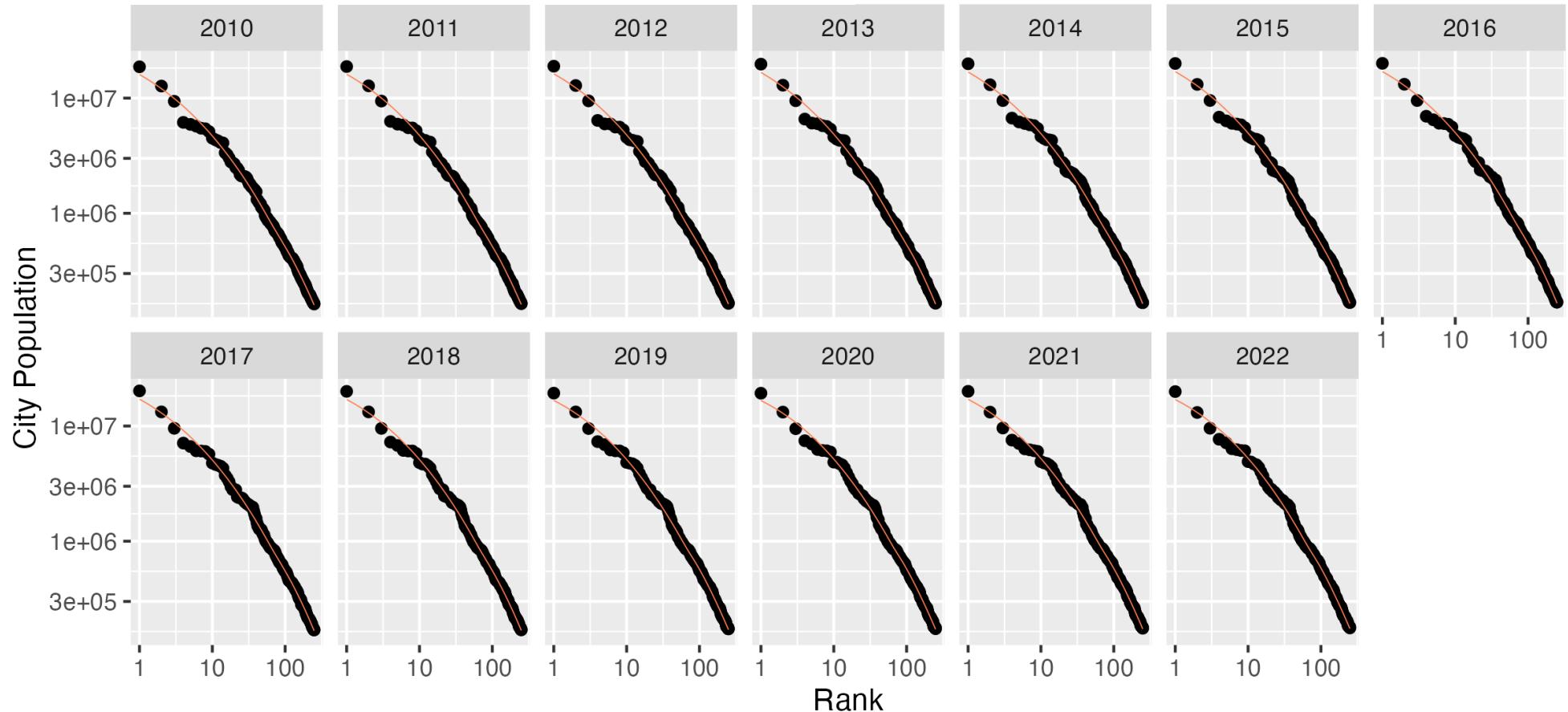
Cities grow by attracting people at all levels of the income distribution

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

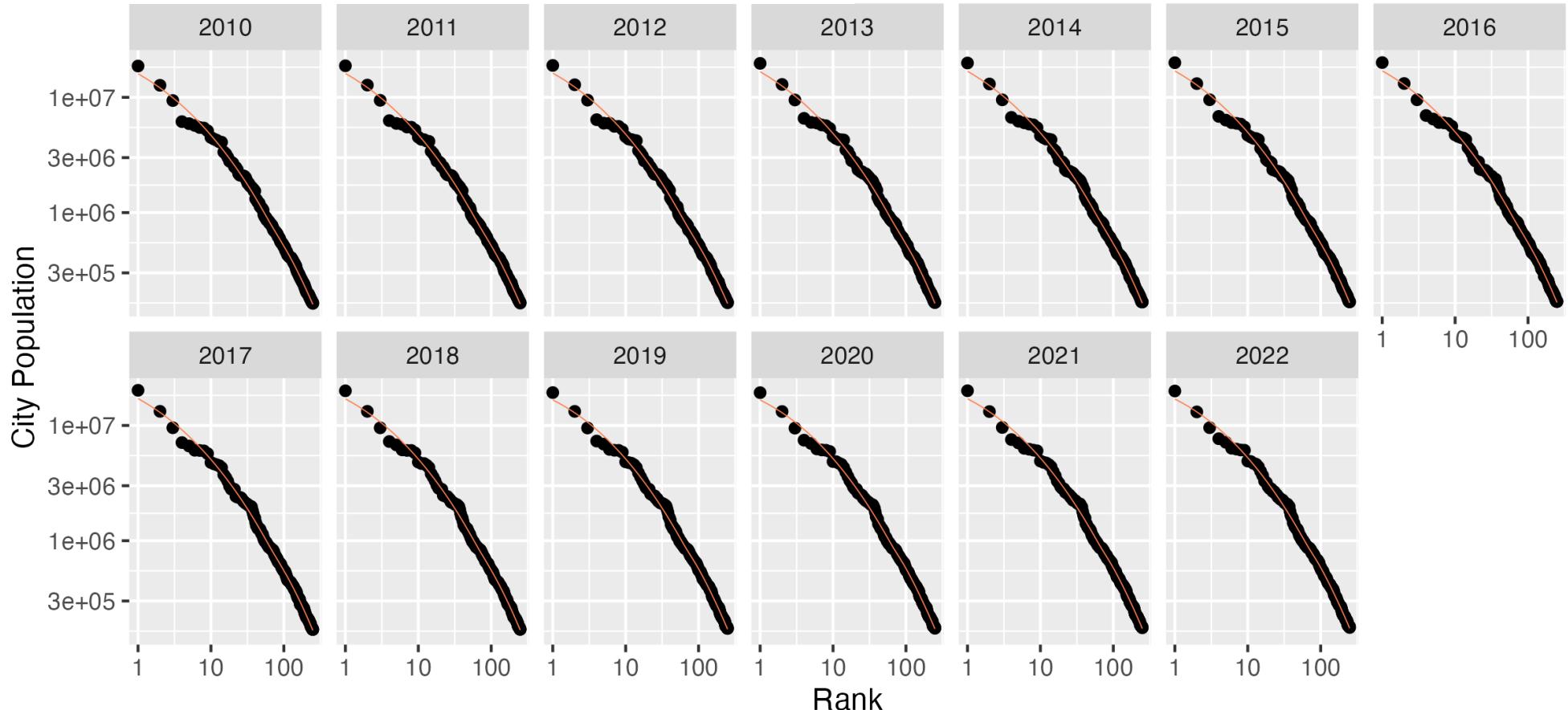
Unequal cities will attract more “winners” with more to “win”

generative value

Size-Rank plot of cities by year (ACS)

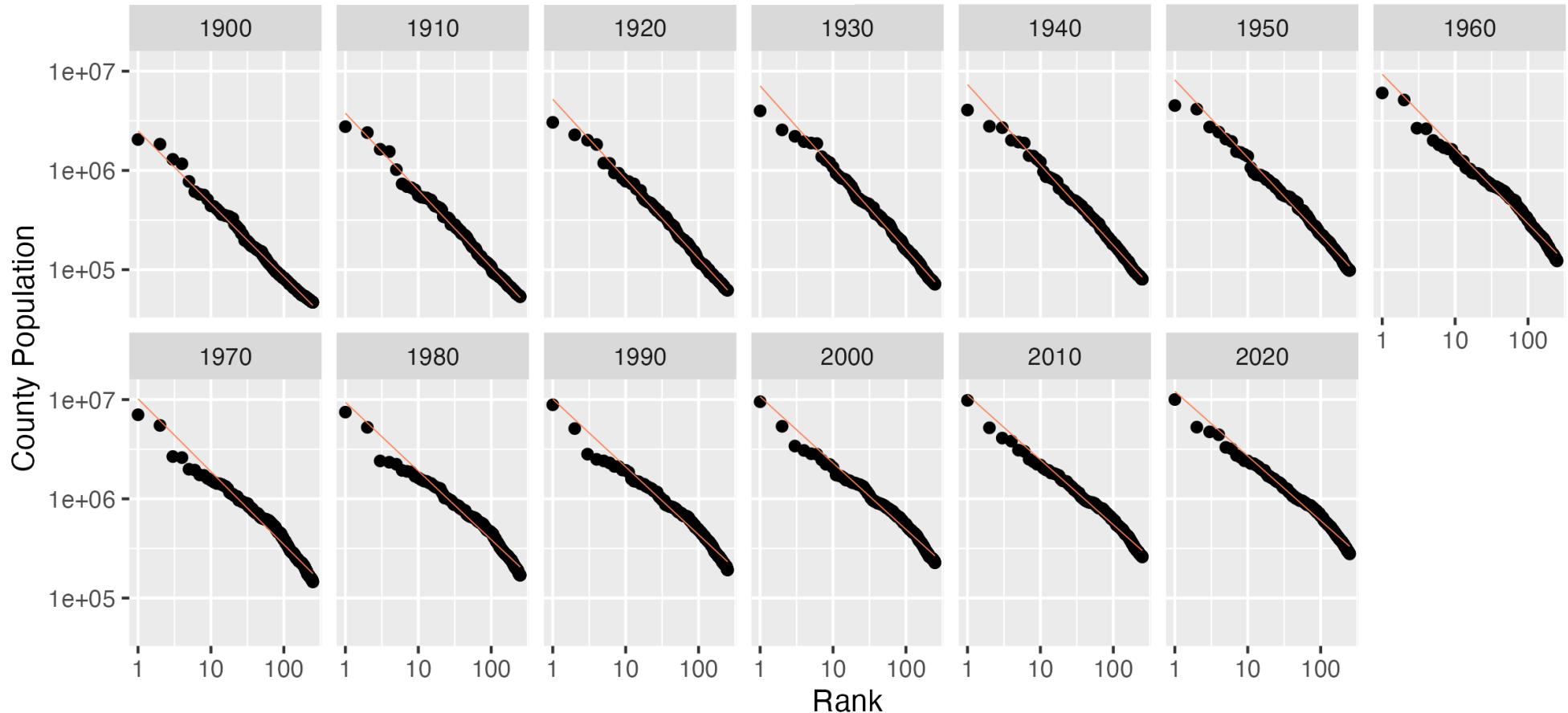


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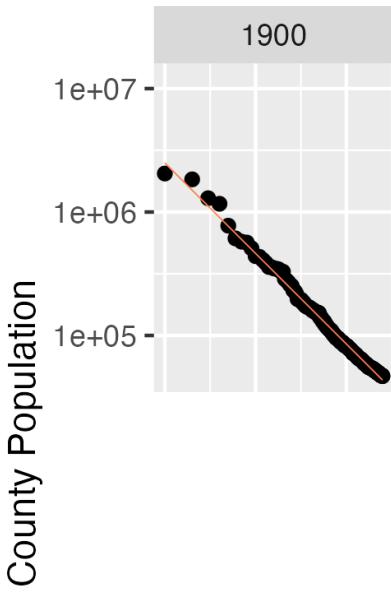


Cities don't really change
substantially on this timescale

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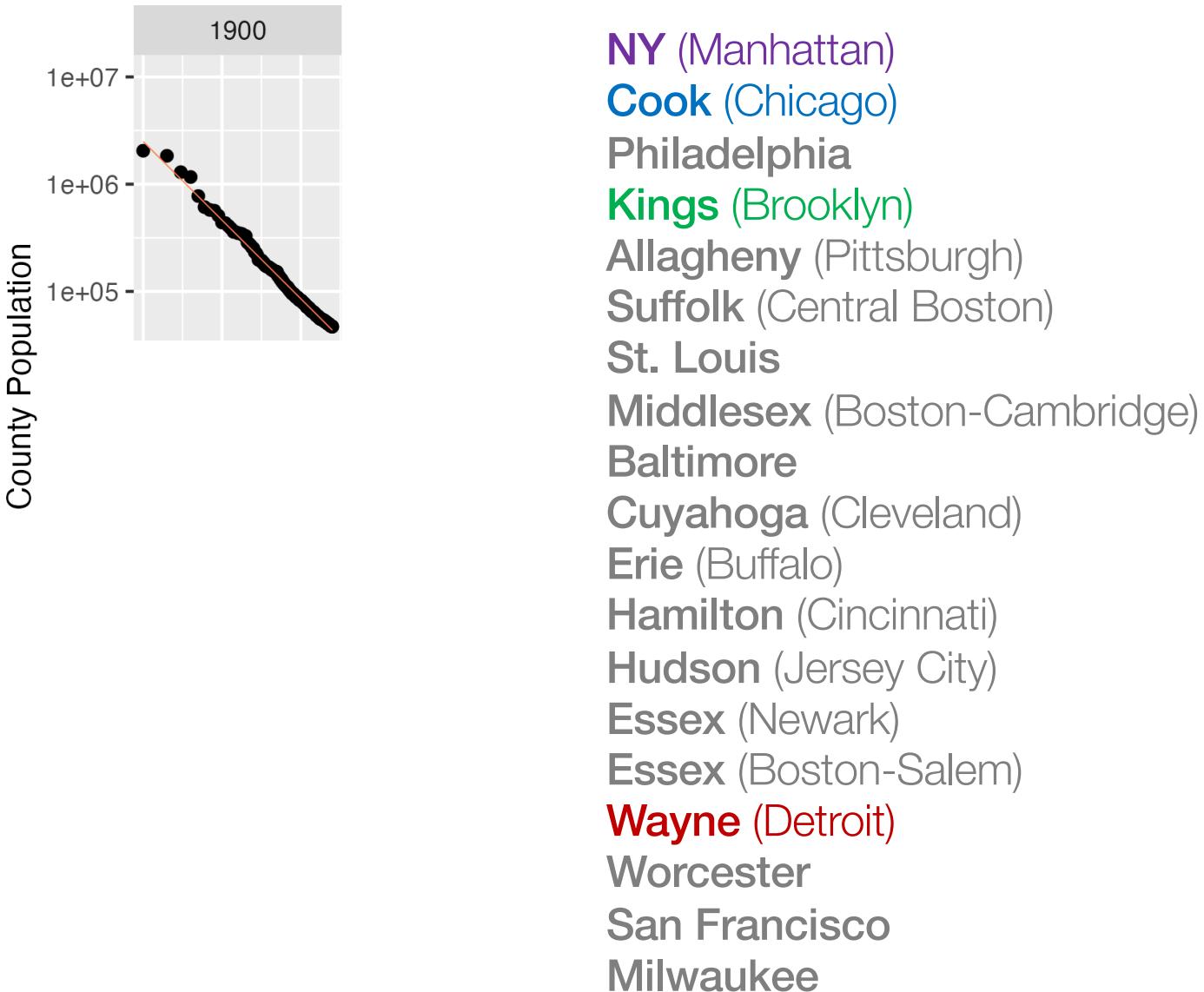


Size-Rank plot of cities by year (ACS)



- 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**

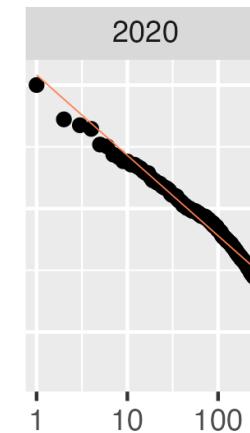
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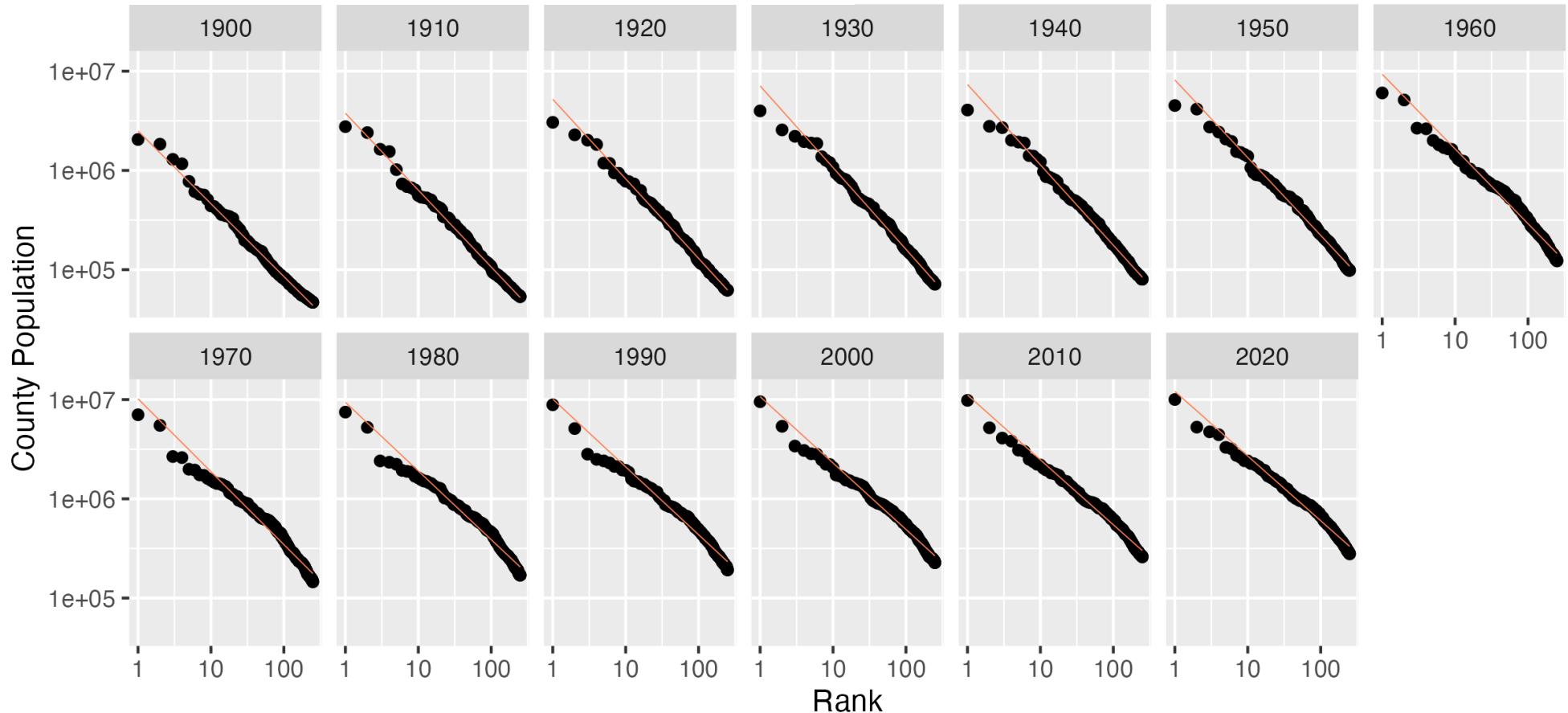
County Population

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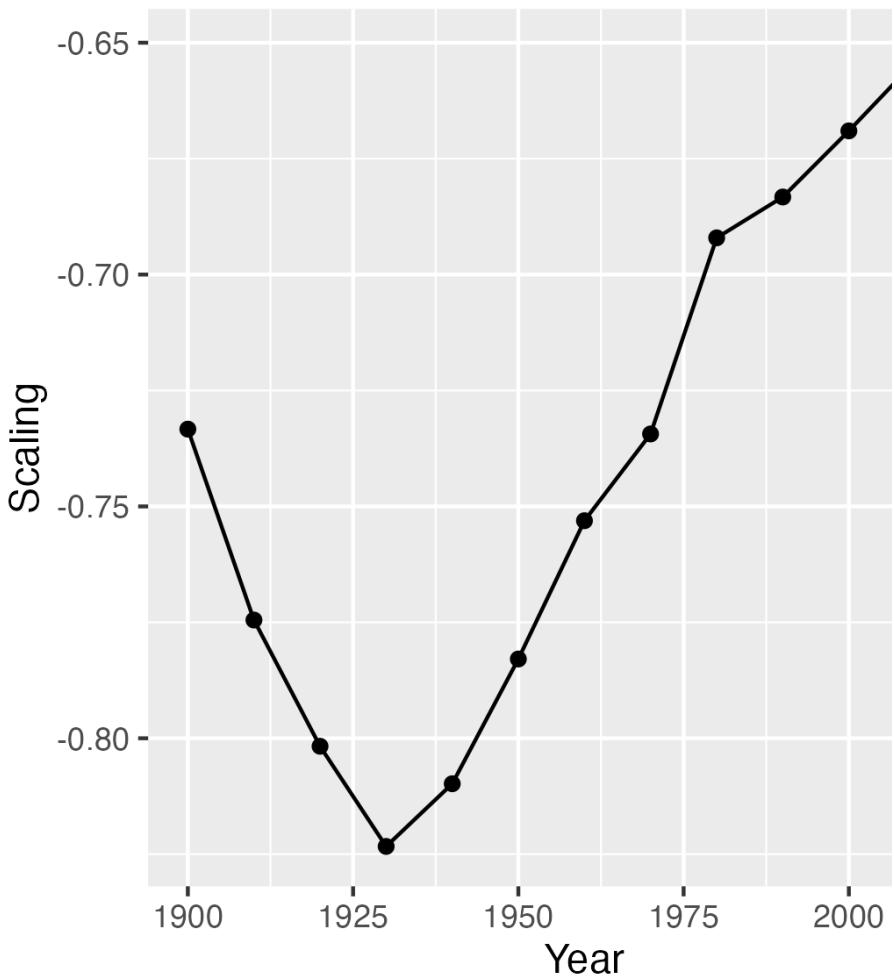
- Los Angeles**
- Cook (Chicago)**
- Harris (Houston)**
- Maricopa (Phoenix)**
- San Diego**
- Orange (Anaheim/Irvine)**
- Kings (Brooklyn)**
- Dallas**
- Riverside (Inland Empire LA)**
- Queens**
- King (Seattle)**
- Clark (Las Vegas)**
- San Bernardino**
- Tarrant (Ft. Worth)**
- Bexar (San Antonio)**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



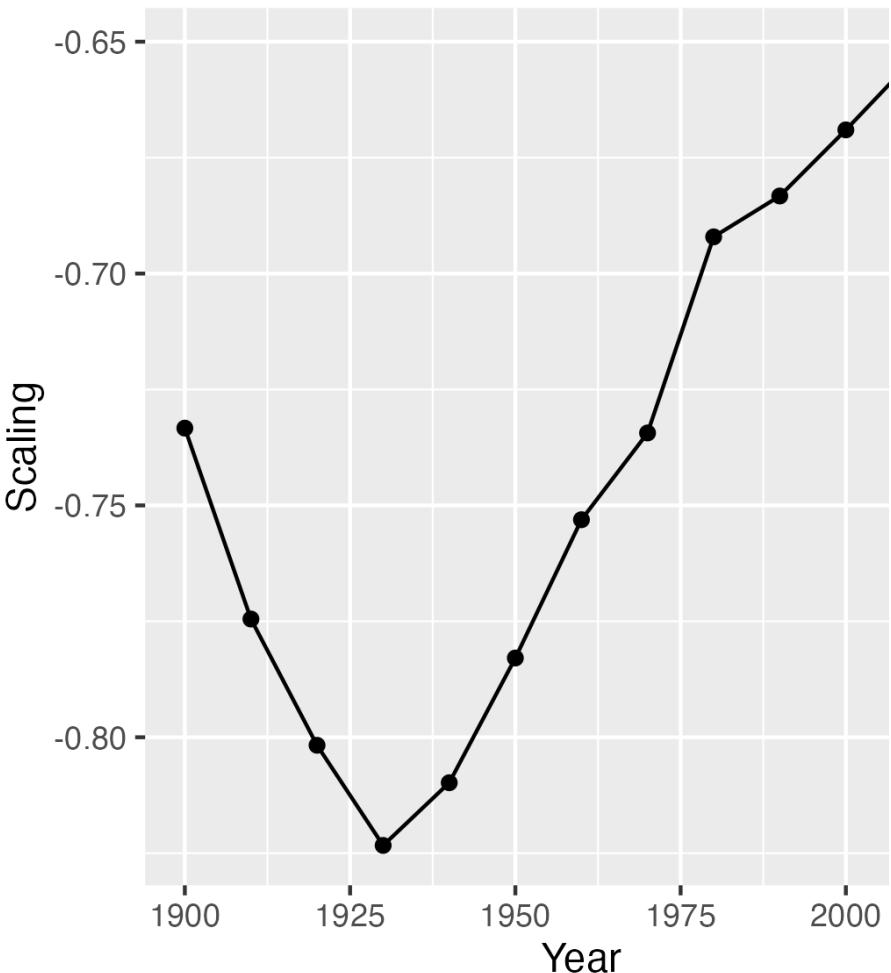
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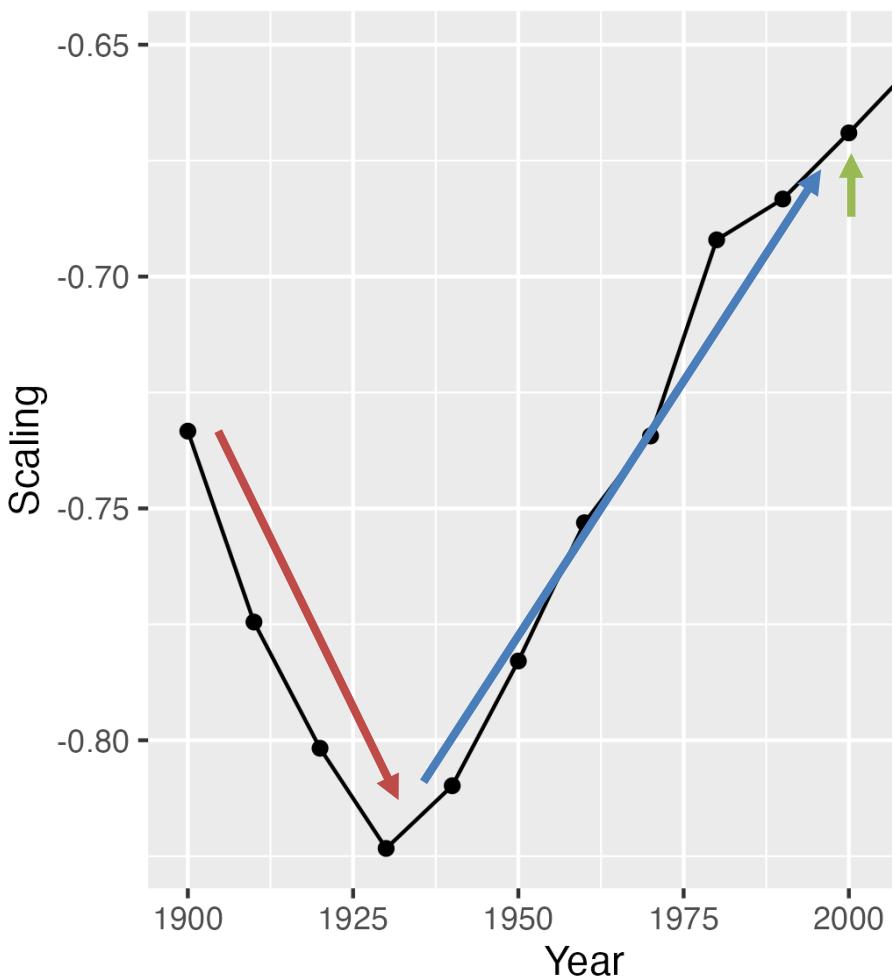


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US city population scaling in the 20th C.

- 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

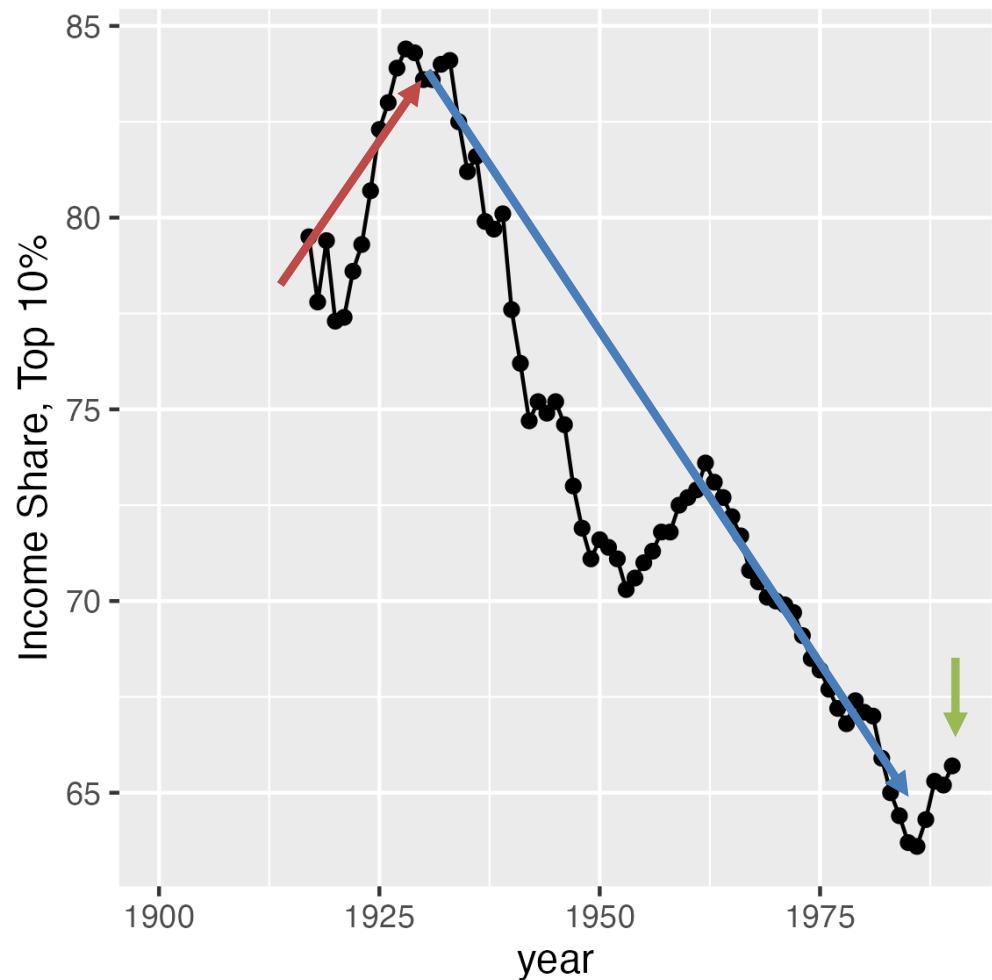


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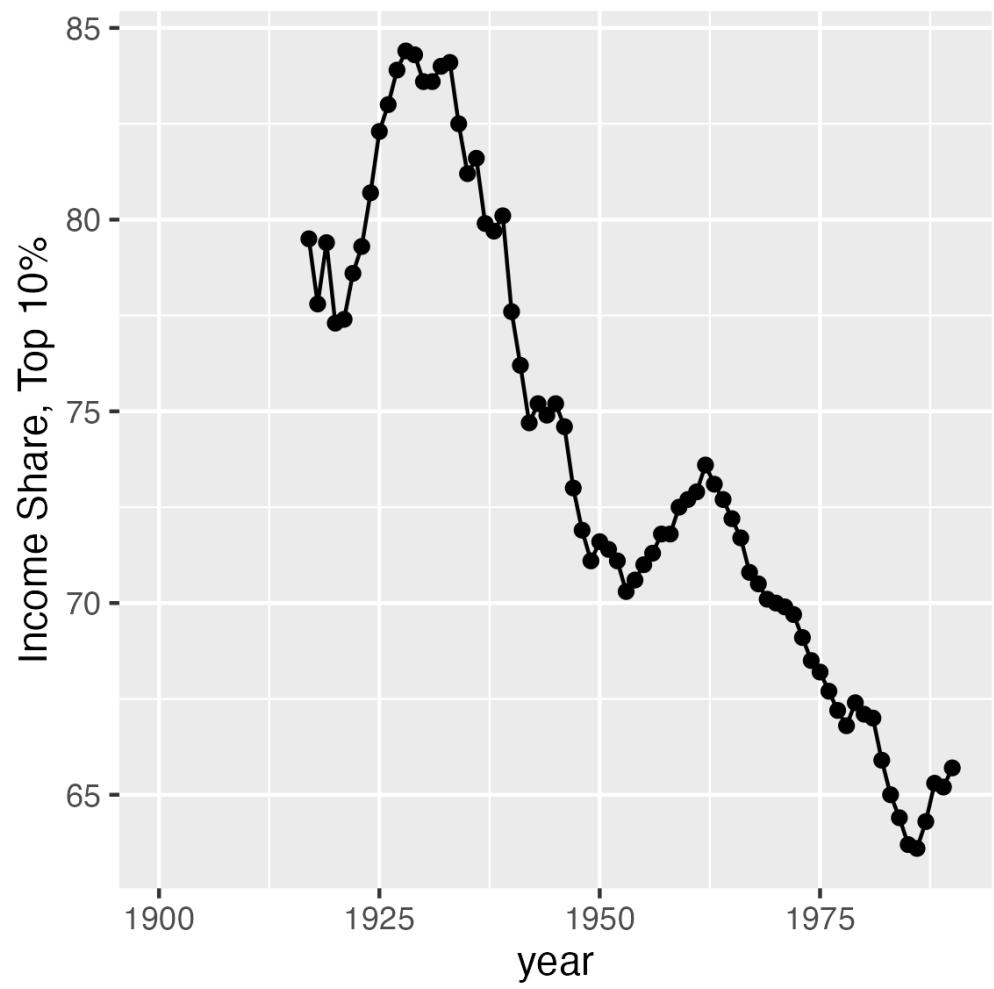
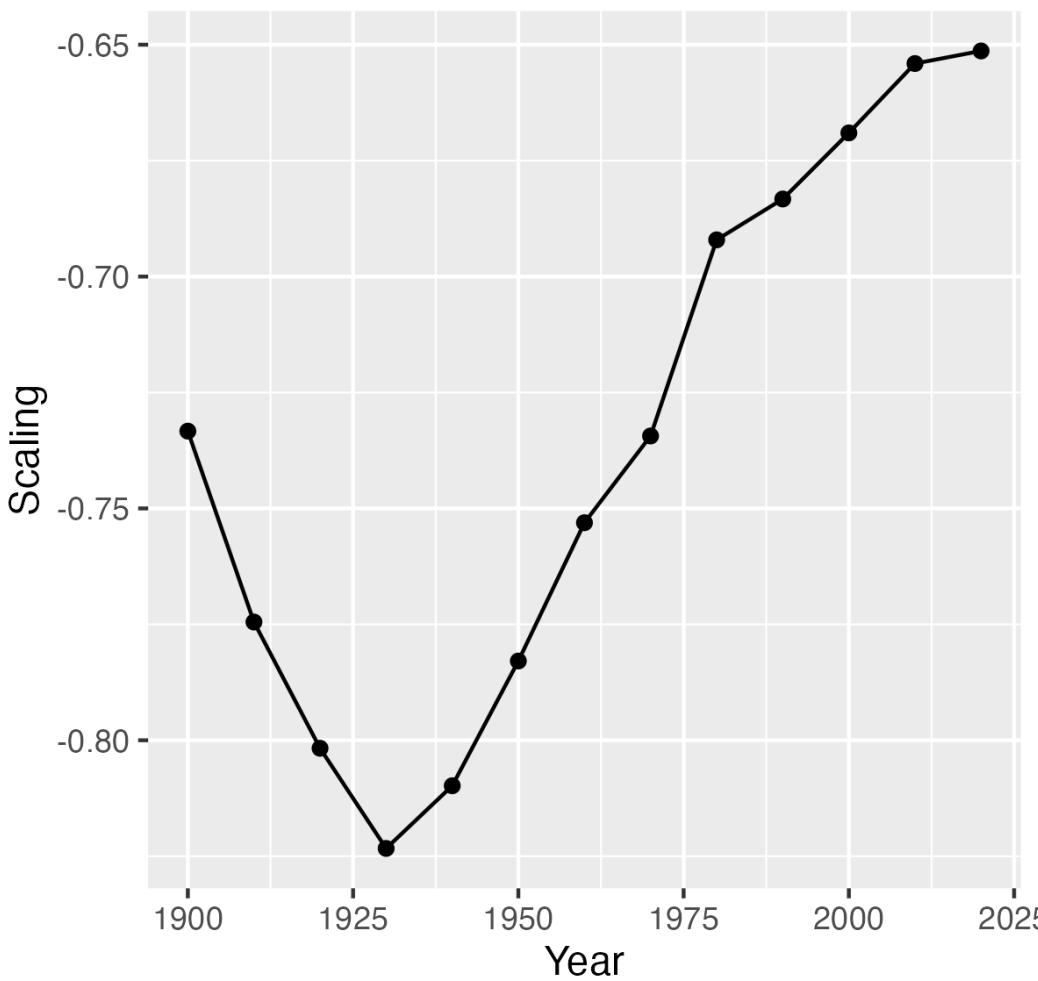
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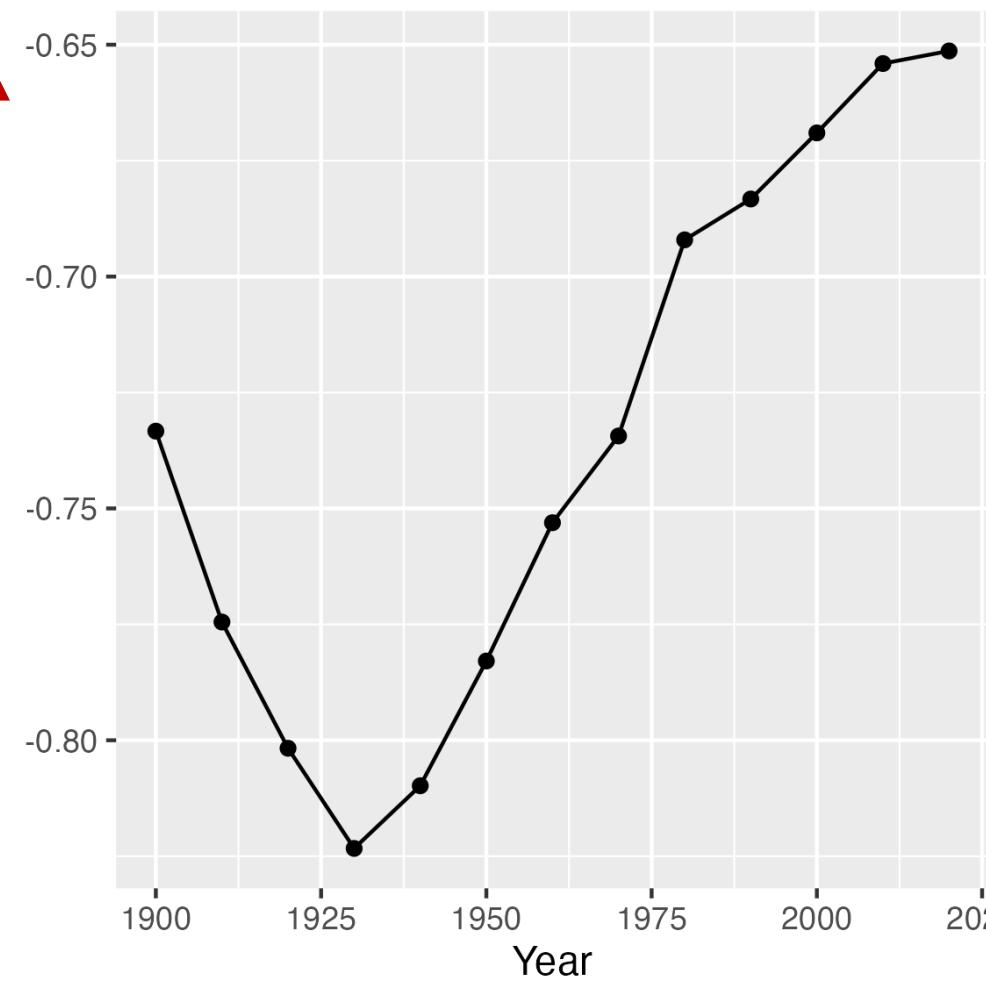
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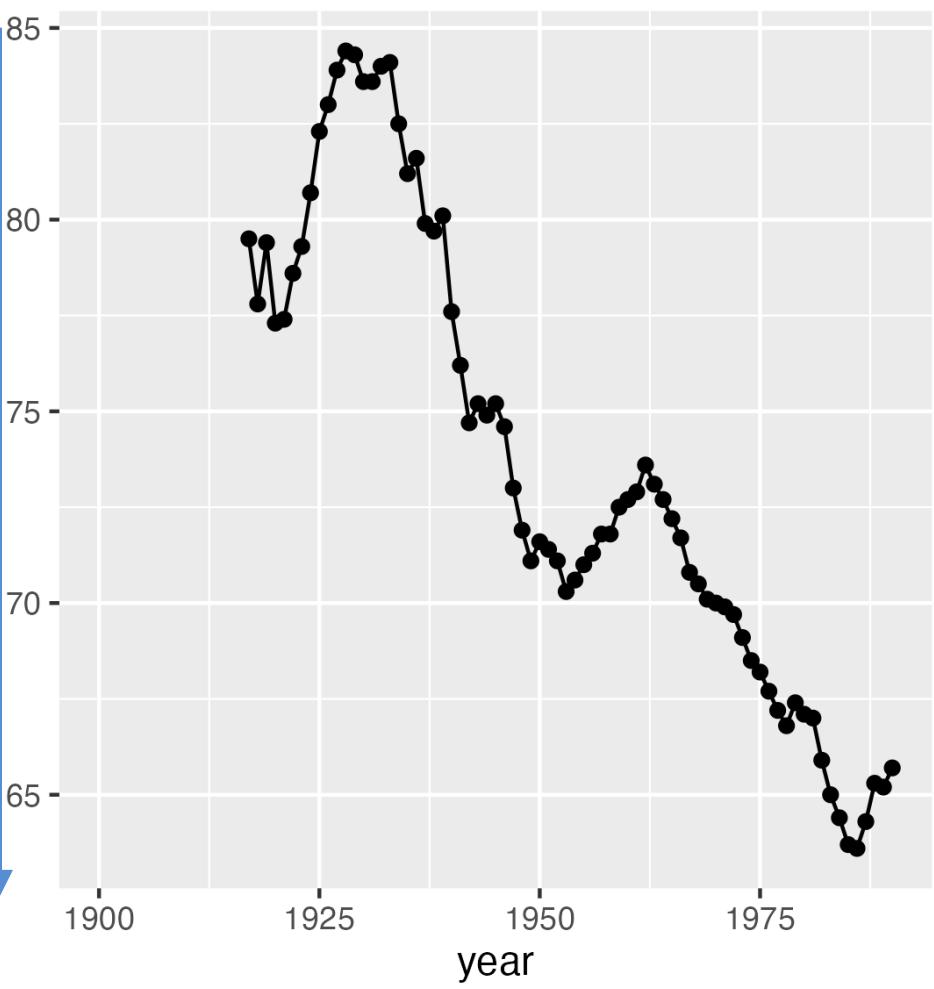
Saez-Zucman (2015)

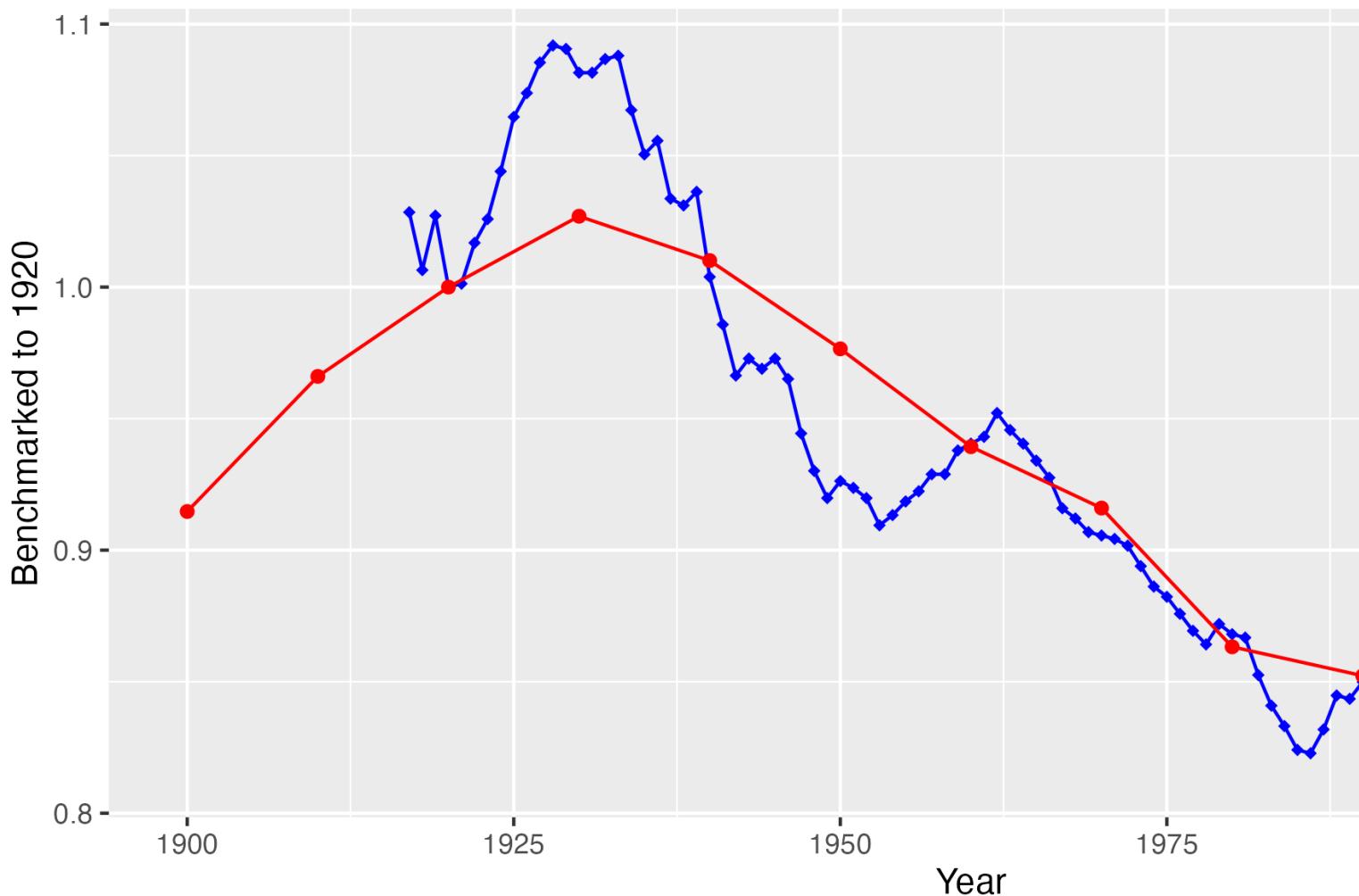


Inequality in city population decreases

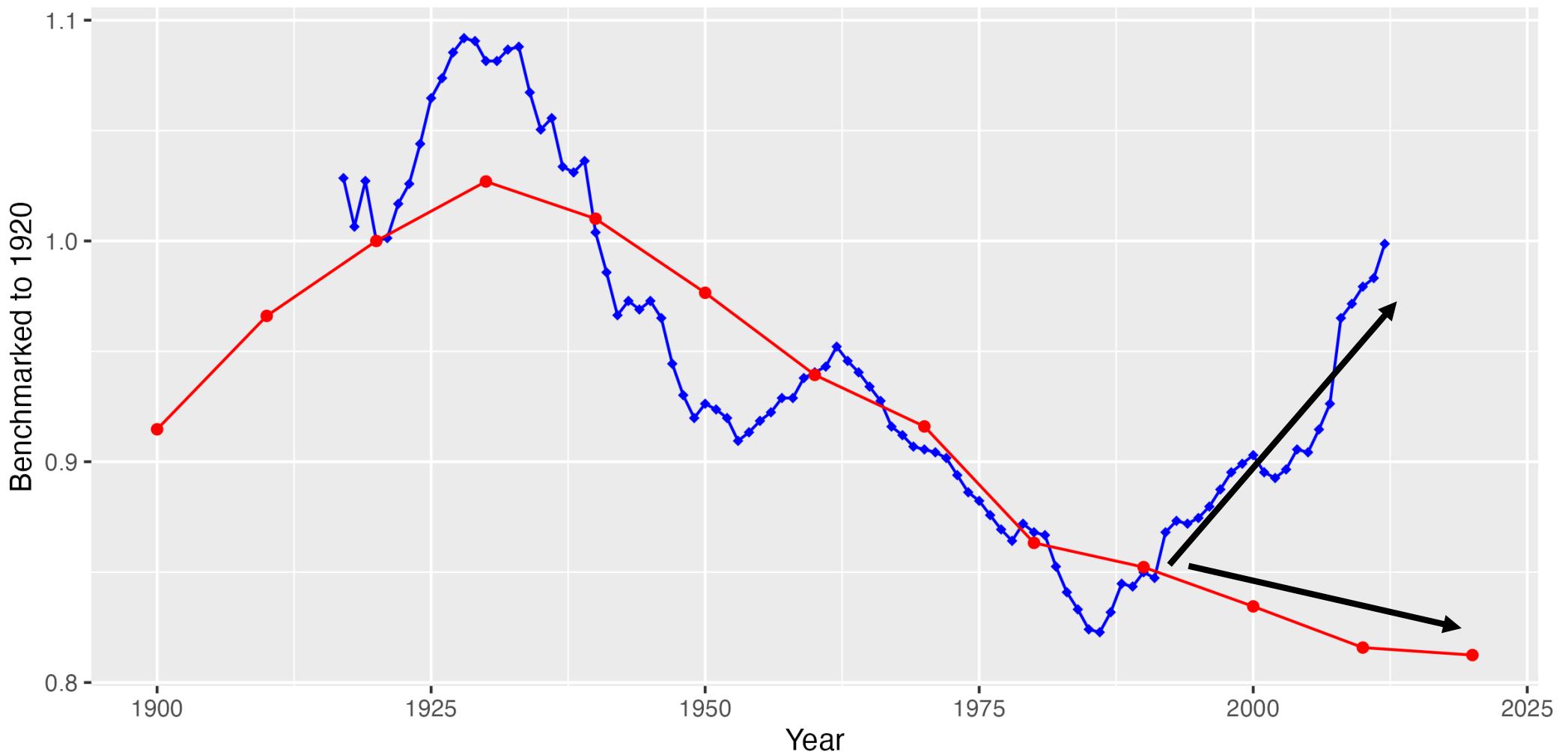


Inequality in population income decreases

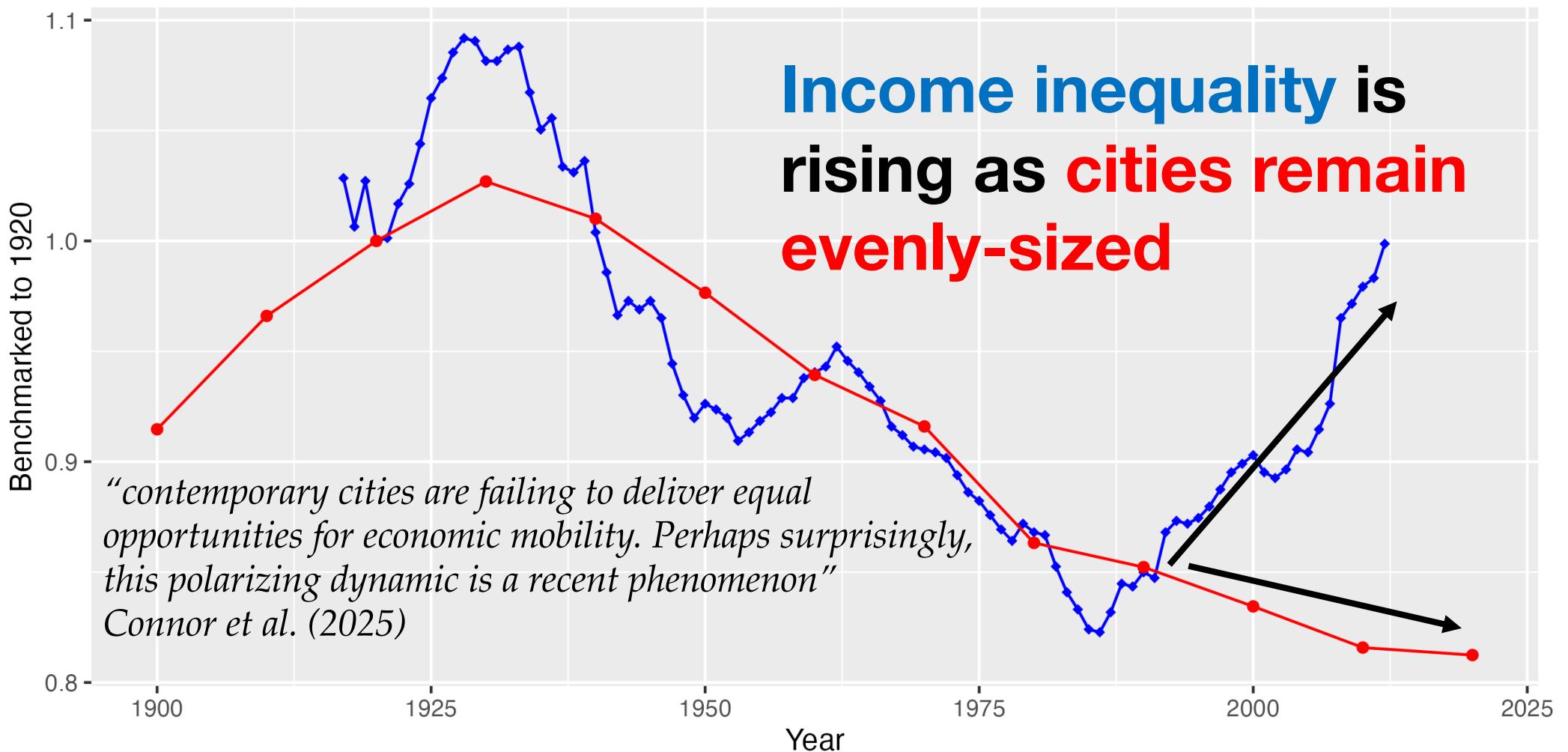




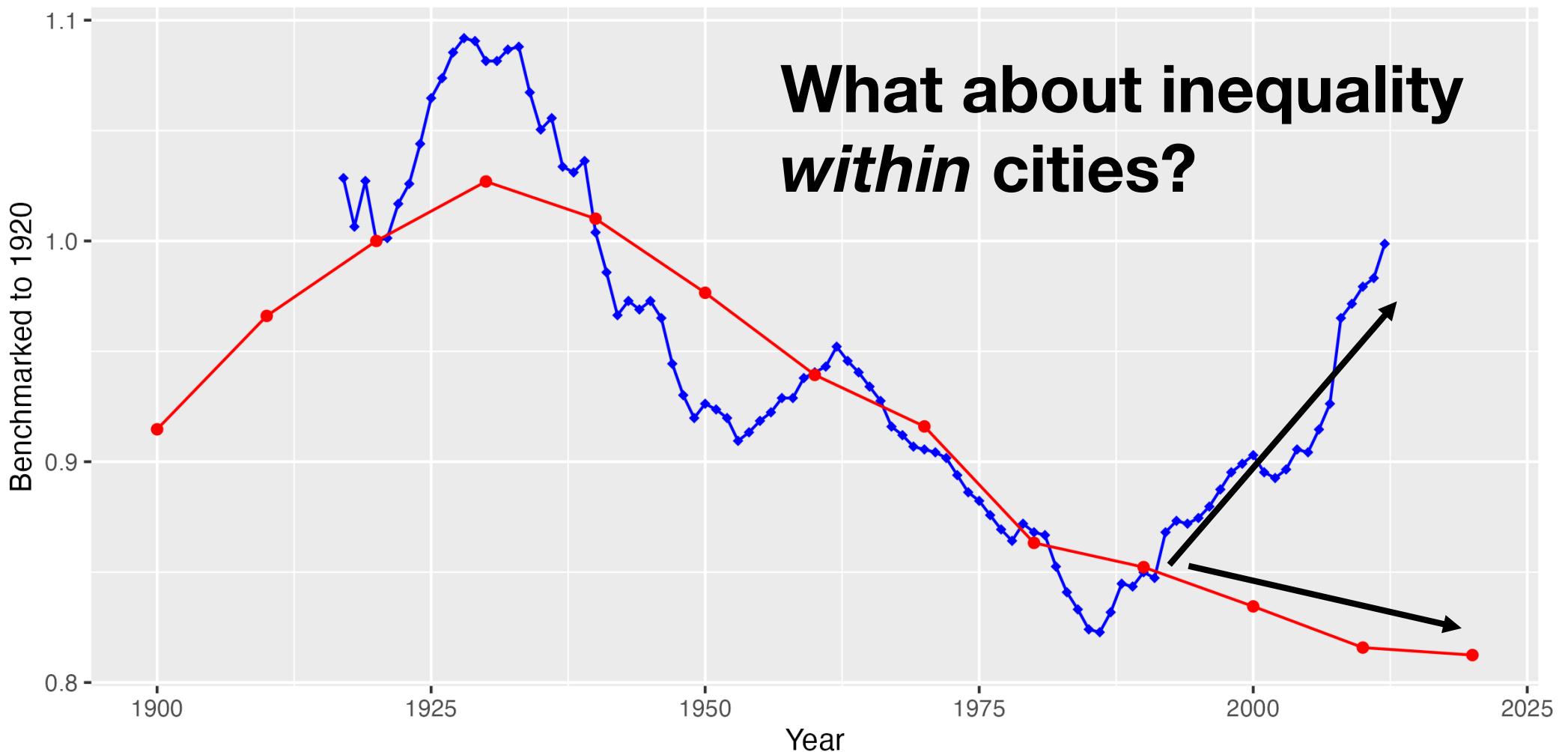
Between-city population inequality moved with macro-level income inequality



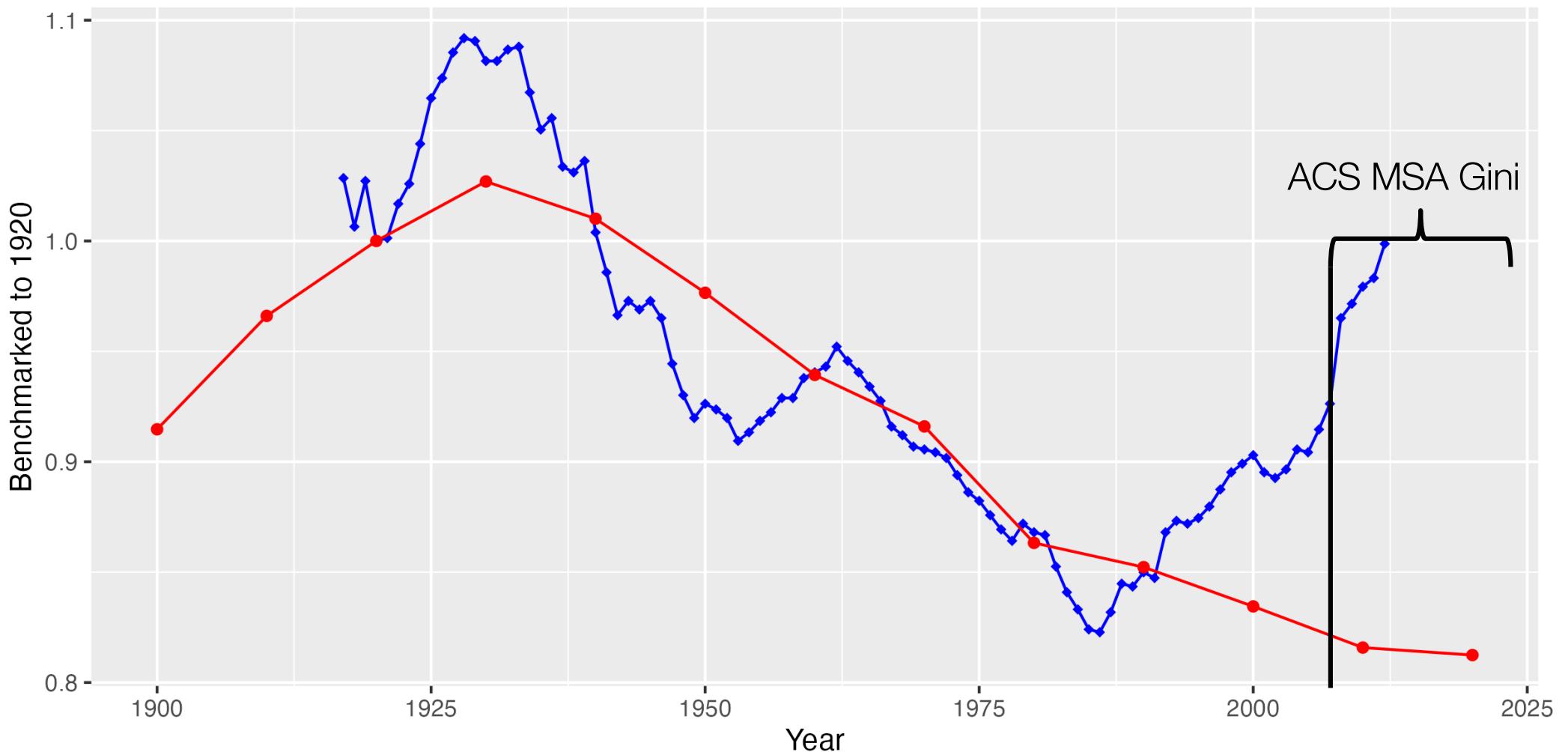
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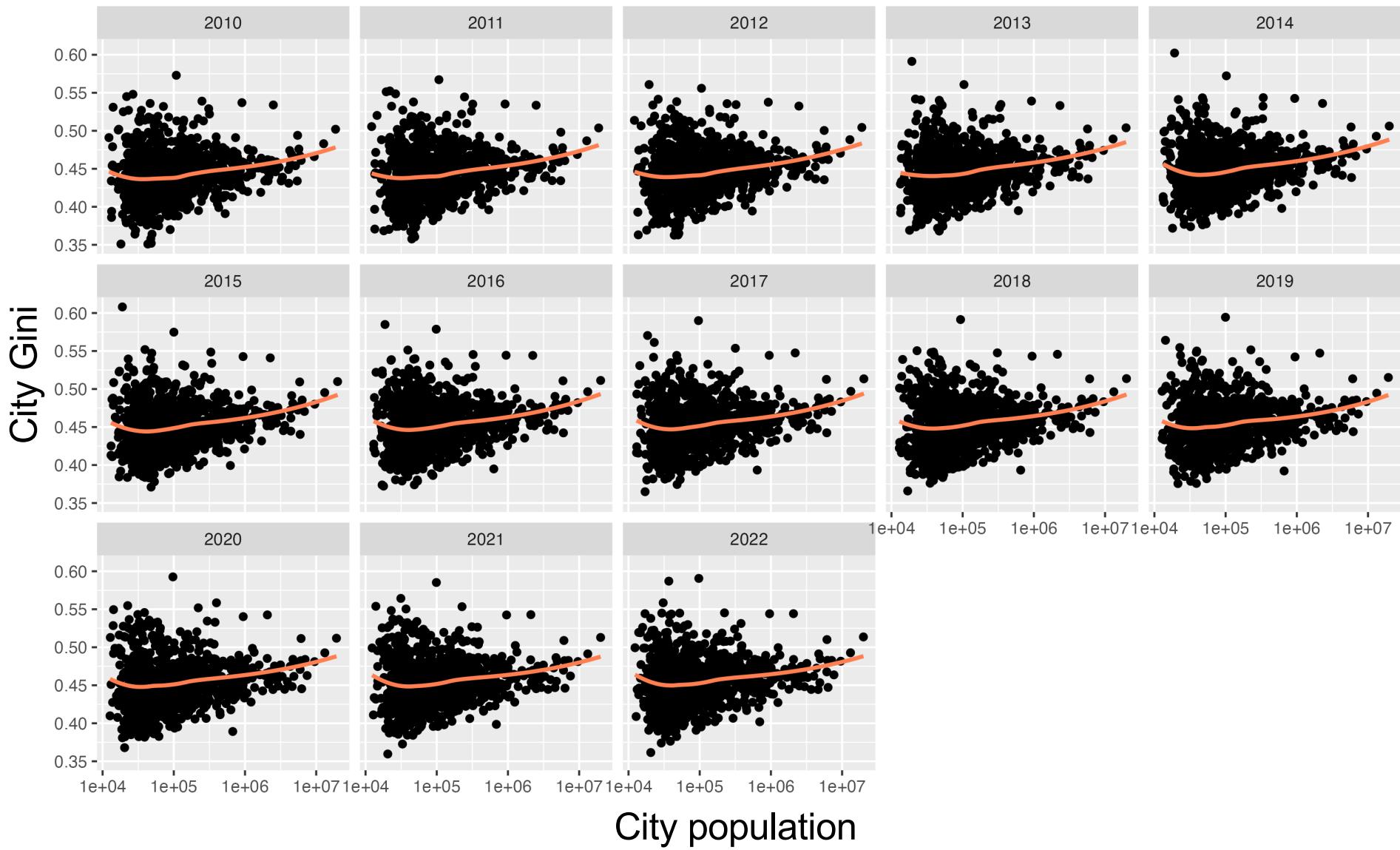
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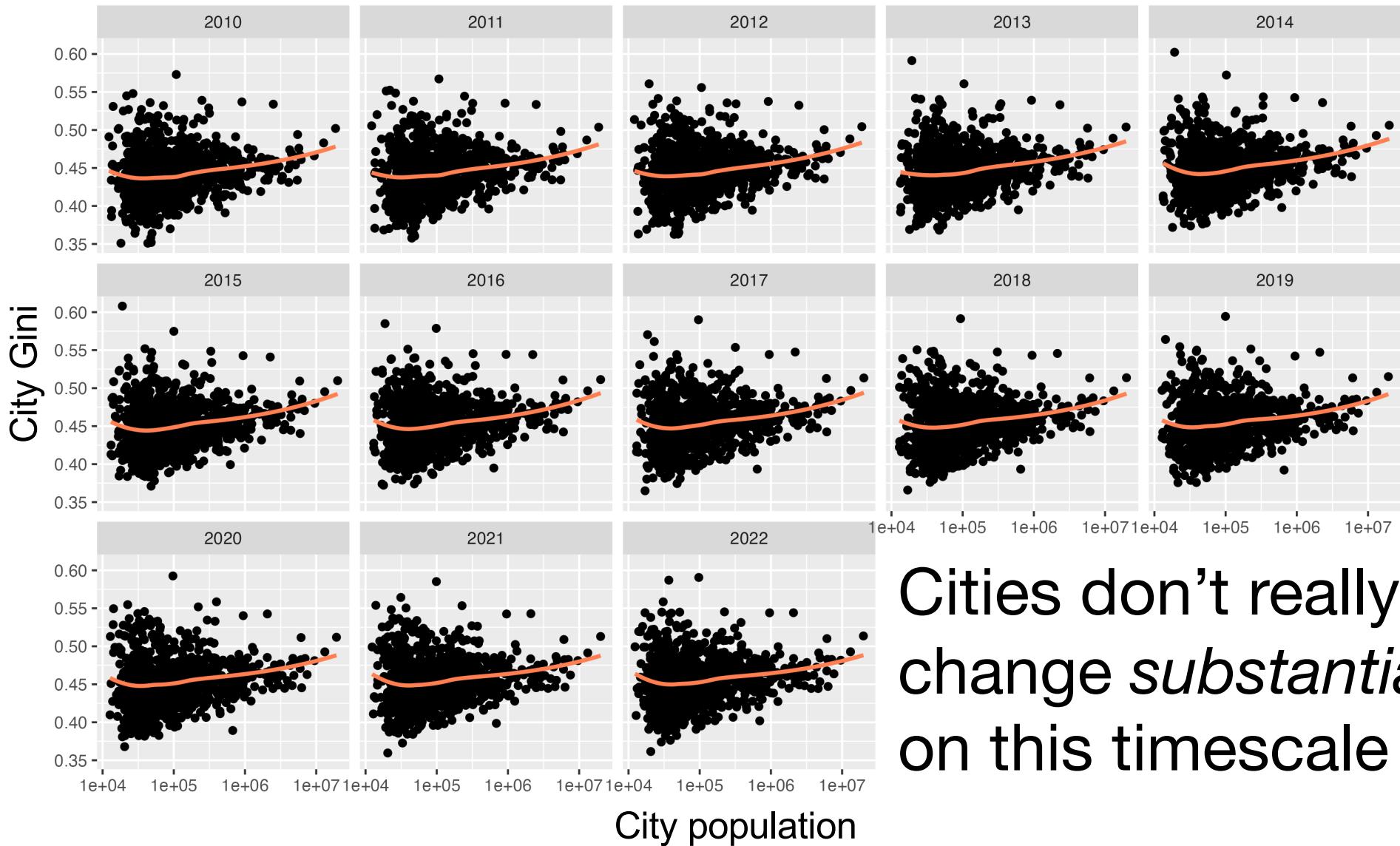


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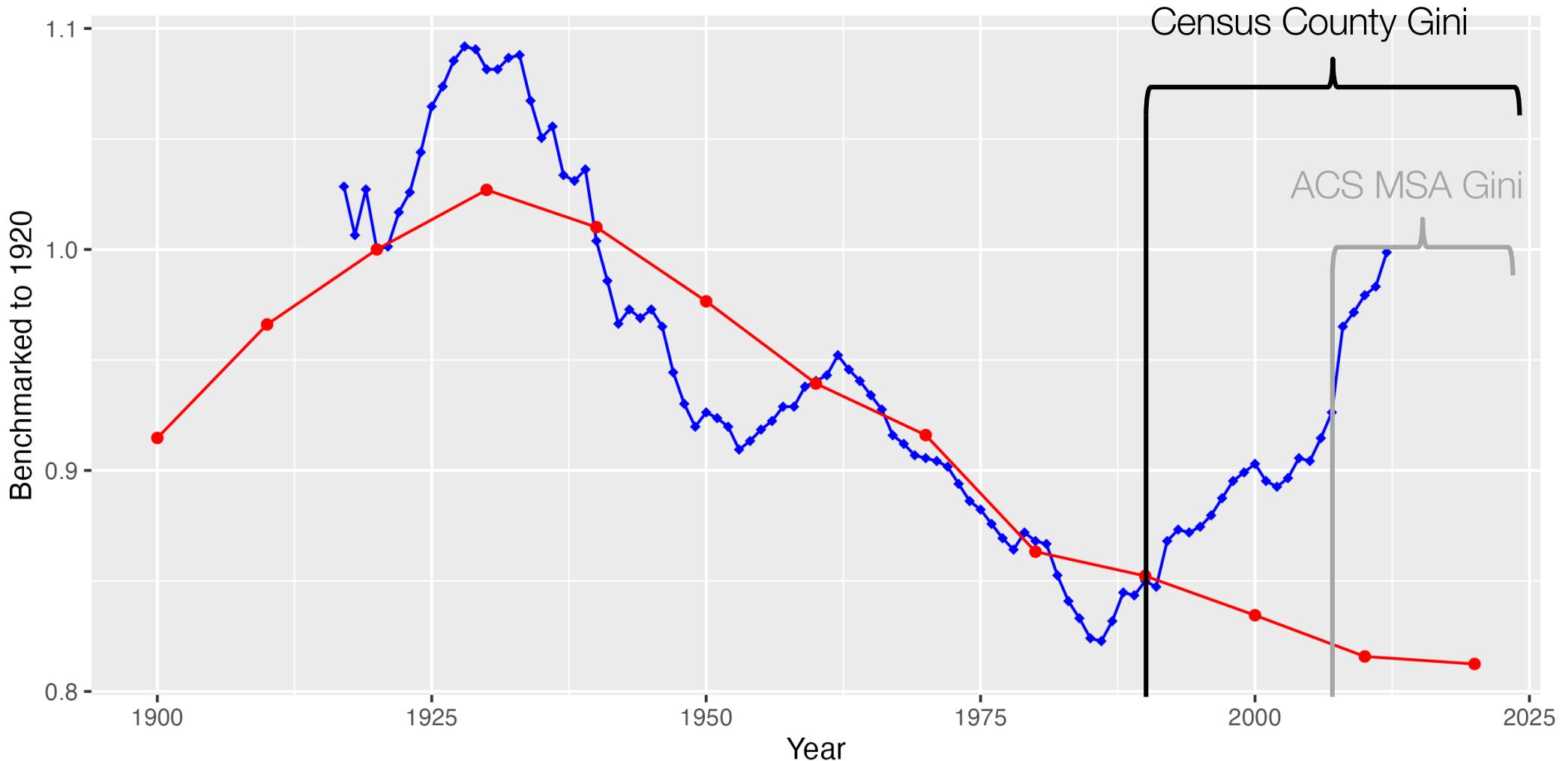


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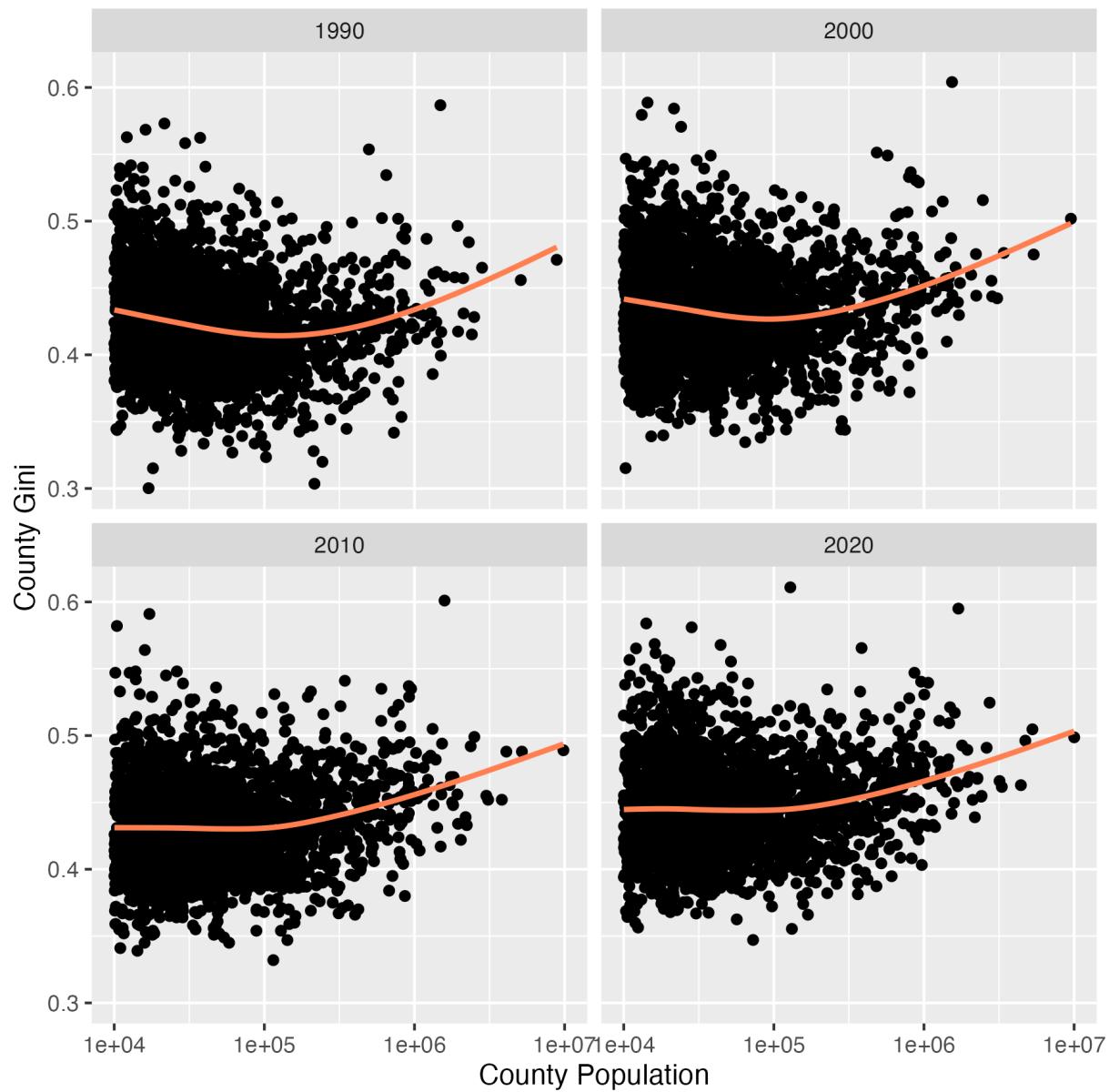


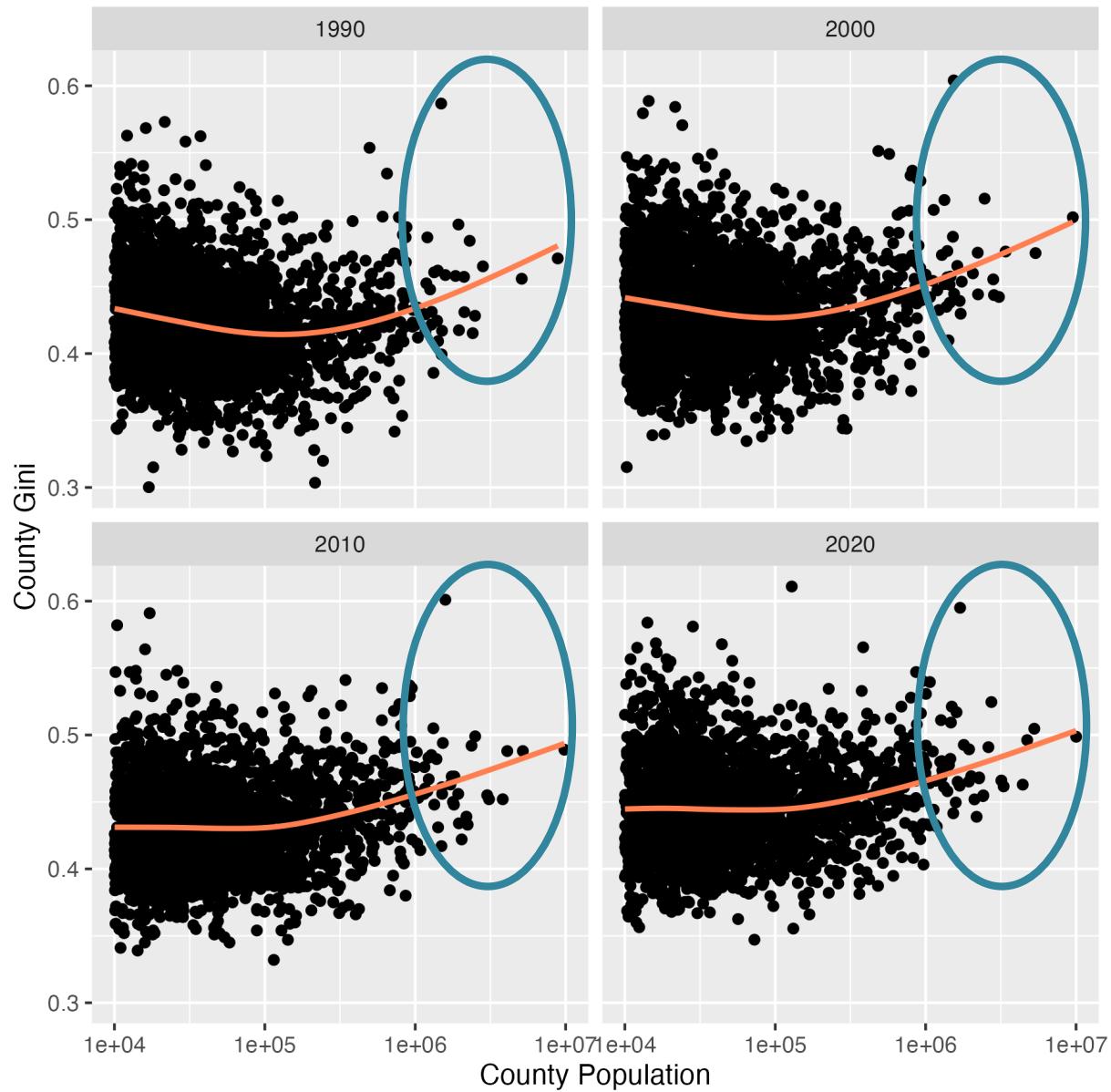


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on this timescale

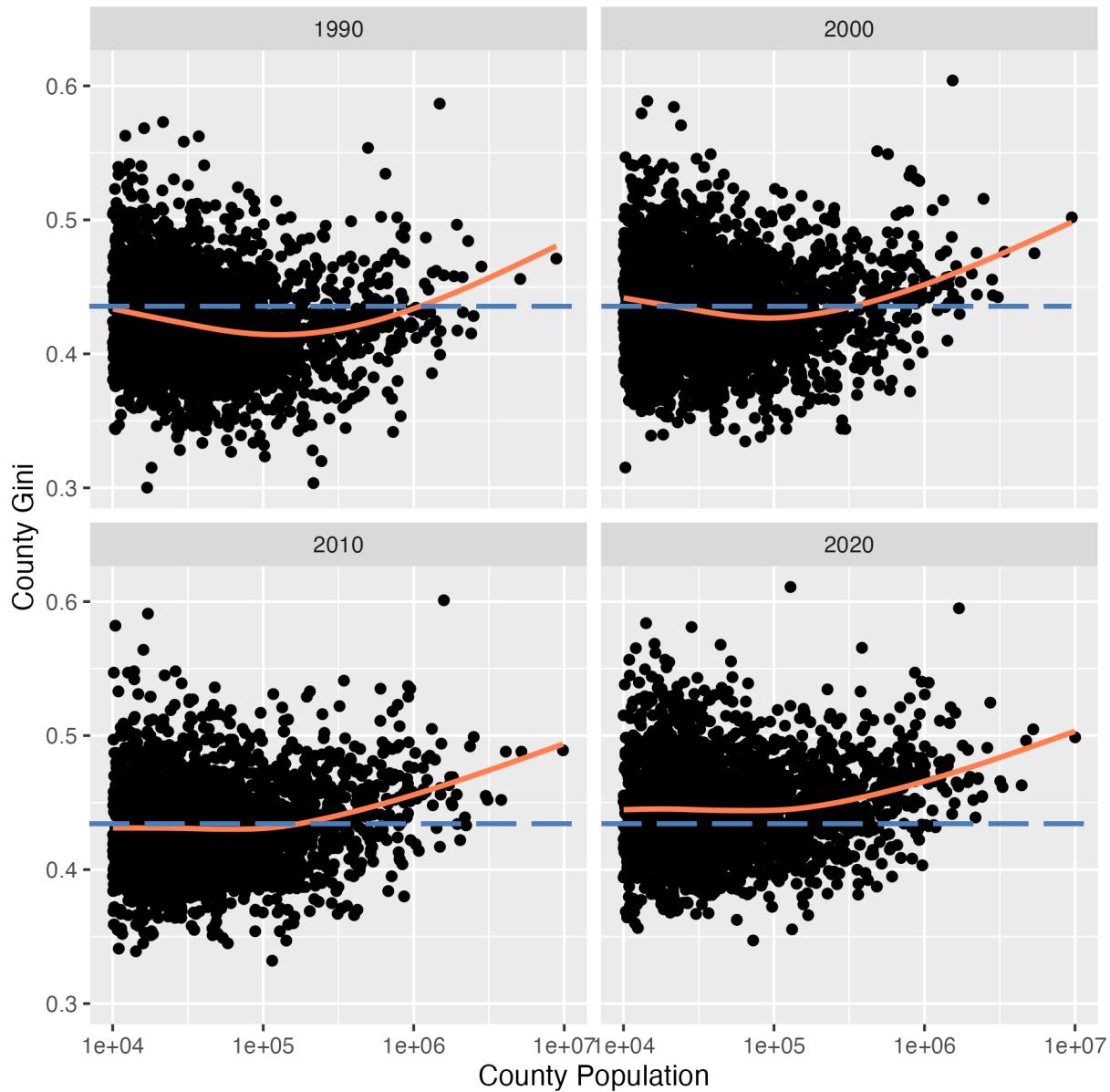


Between-city population inequality moved with macro-level income inequality until the 21st Century...

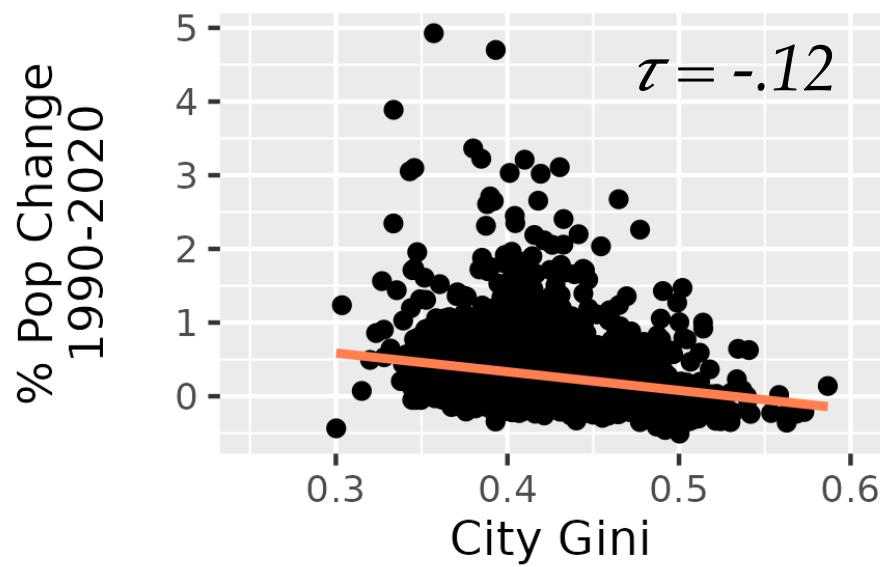
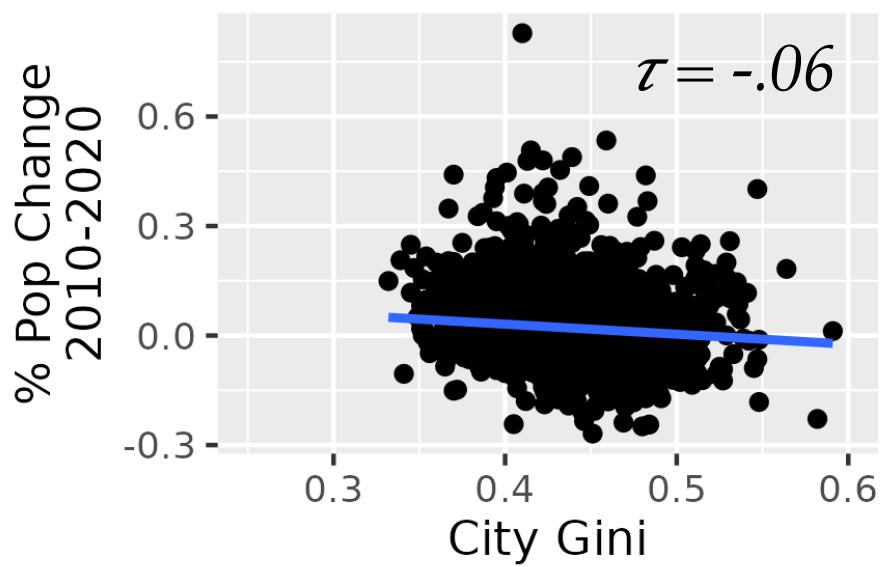
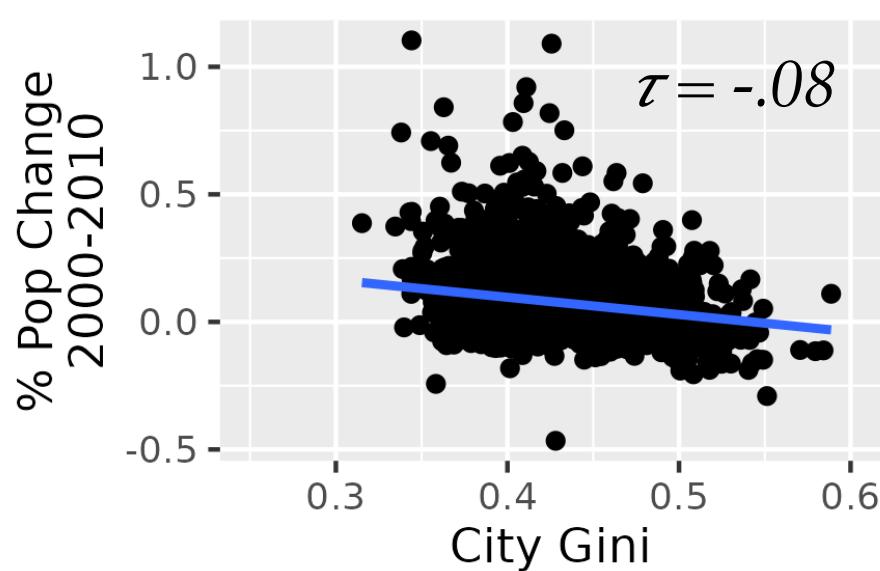
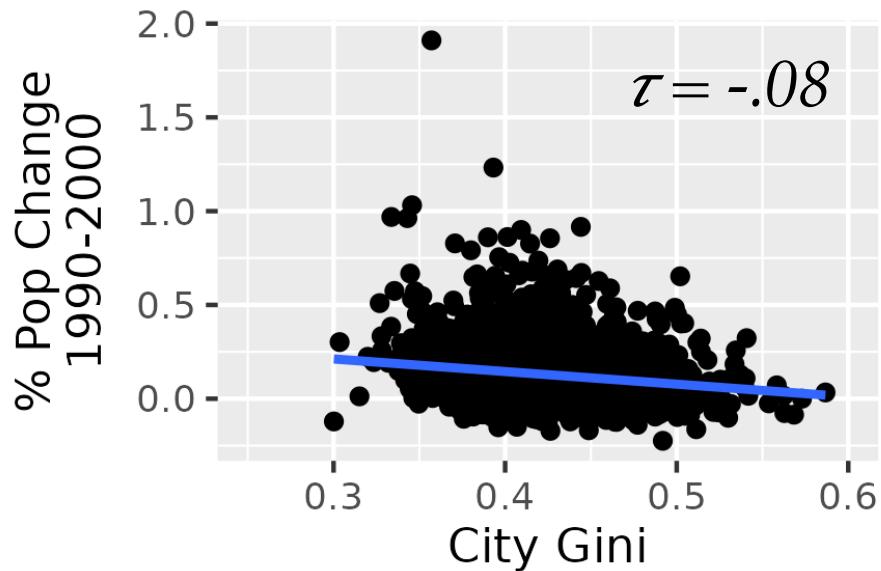




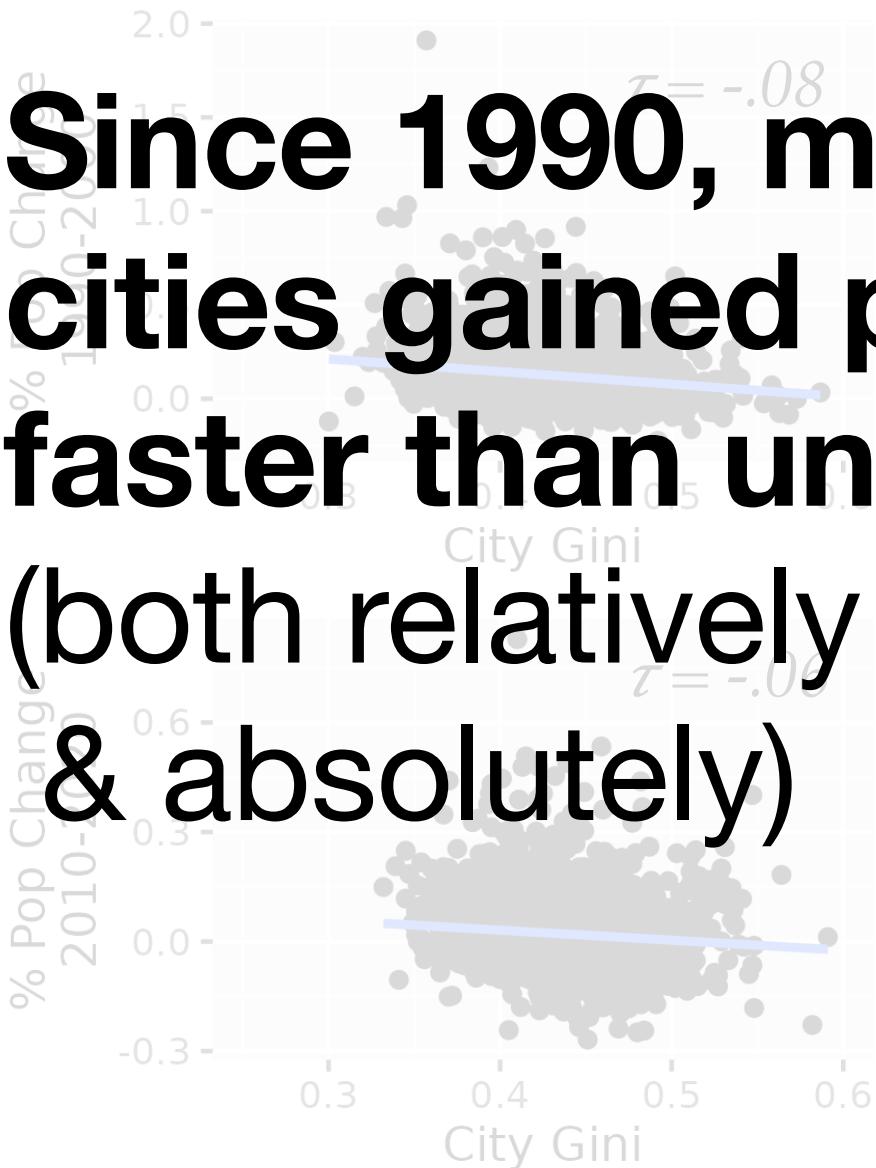
**Bigger cities
have tended to
have higher
income
inequality**



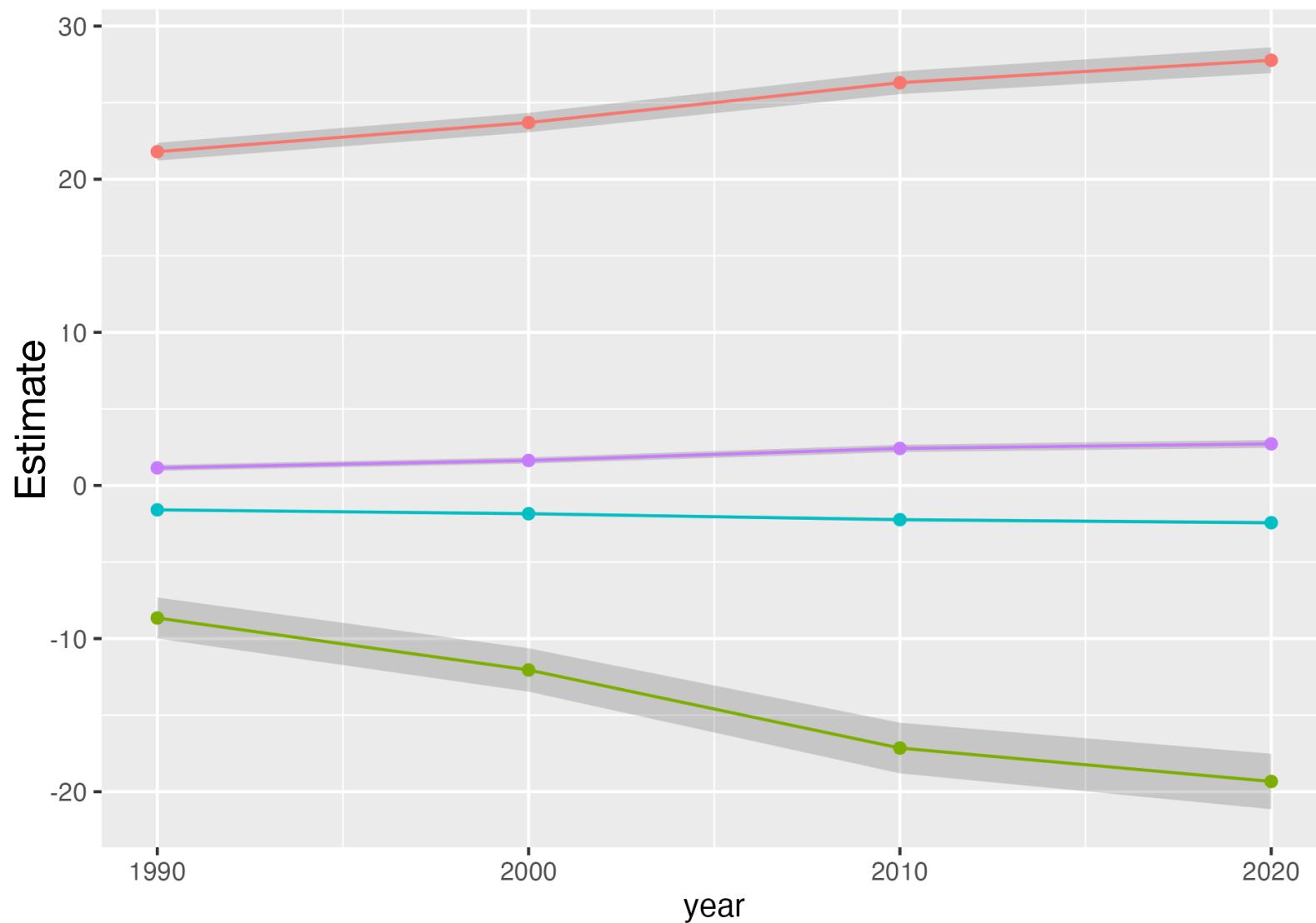
But, mid-sized cities have become more unequal recently



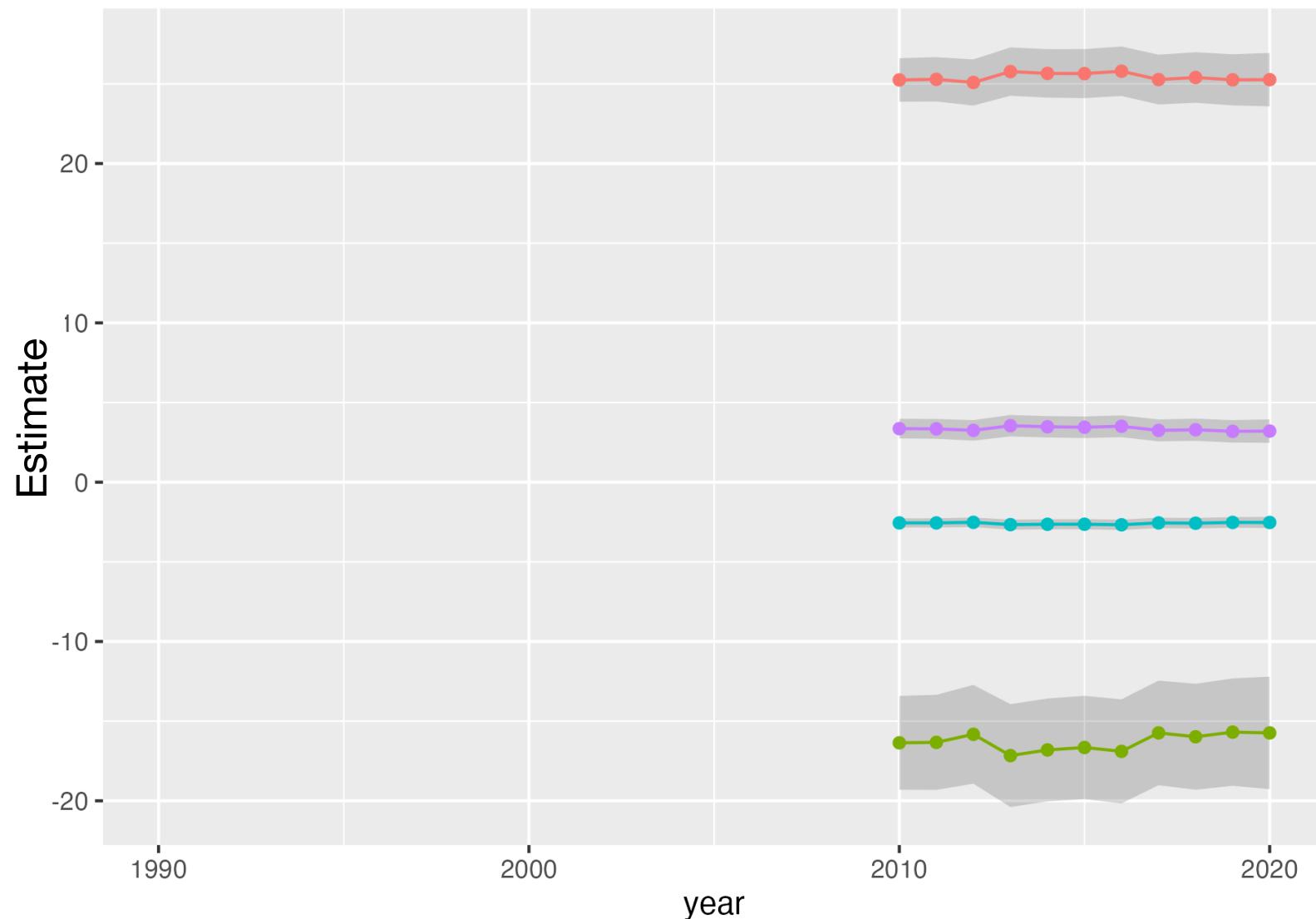
Since 1990, more equal cities gained population faster than unequal cities (both relatively & absolutely)



**Decadal
estimates
by county
since 1990**

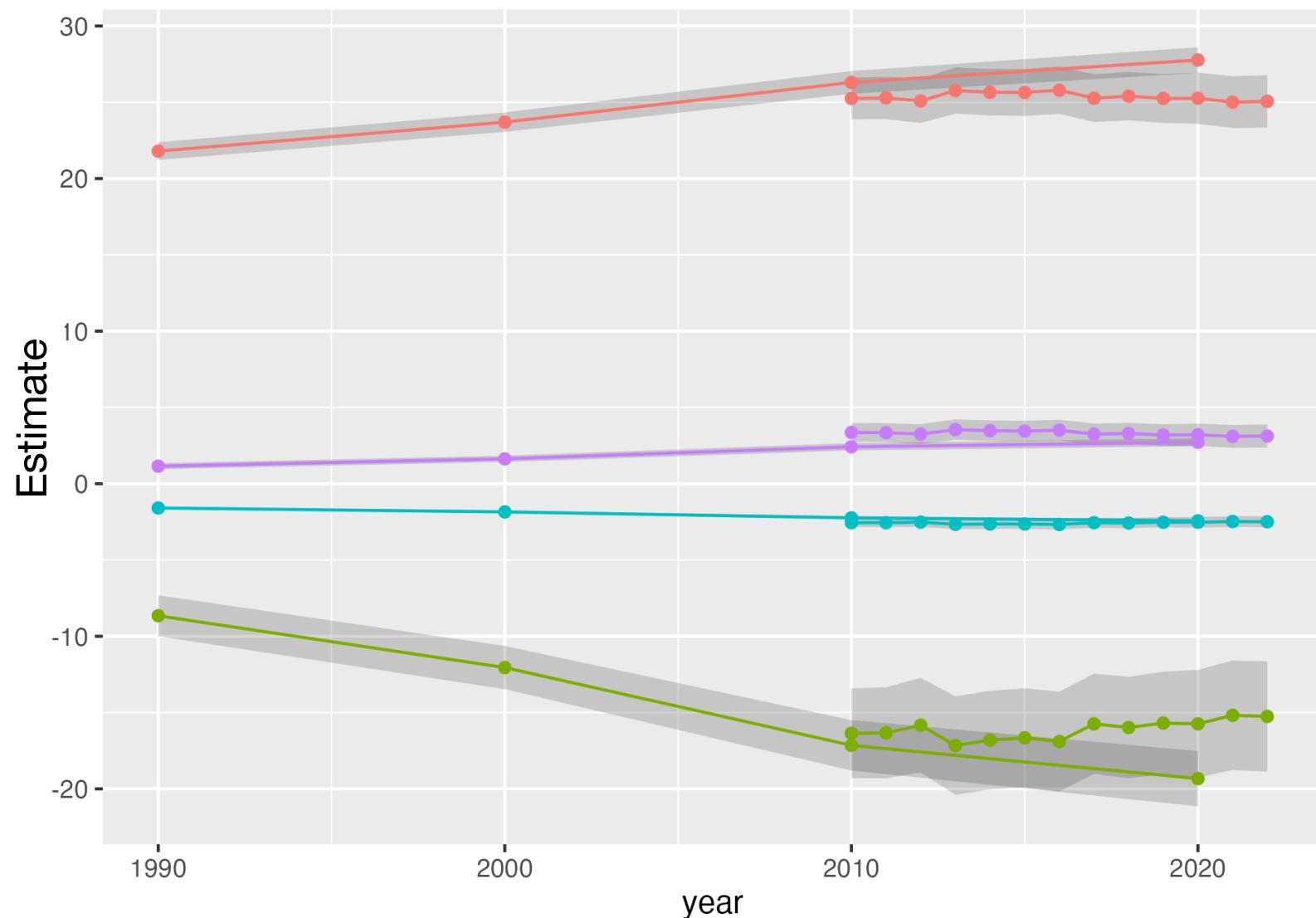


$$\log(\text{pop}) \sim 1 + \log(\text{rank}) + \text{gini} + \log(\text{rank}) * \text{gini}$$



**Yearly
estimates
by city
since 2010**

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

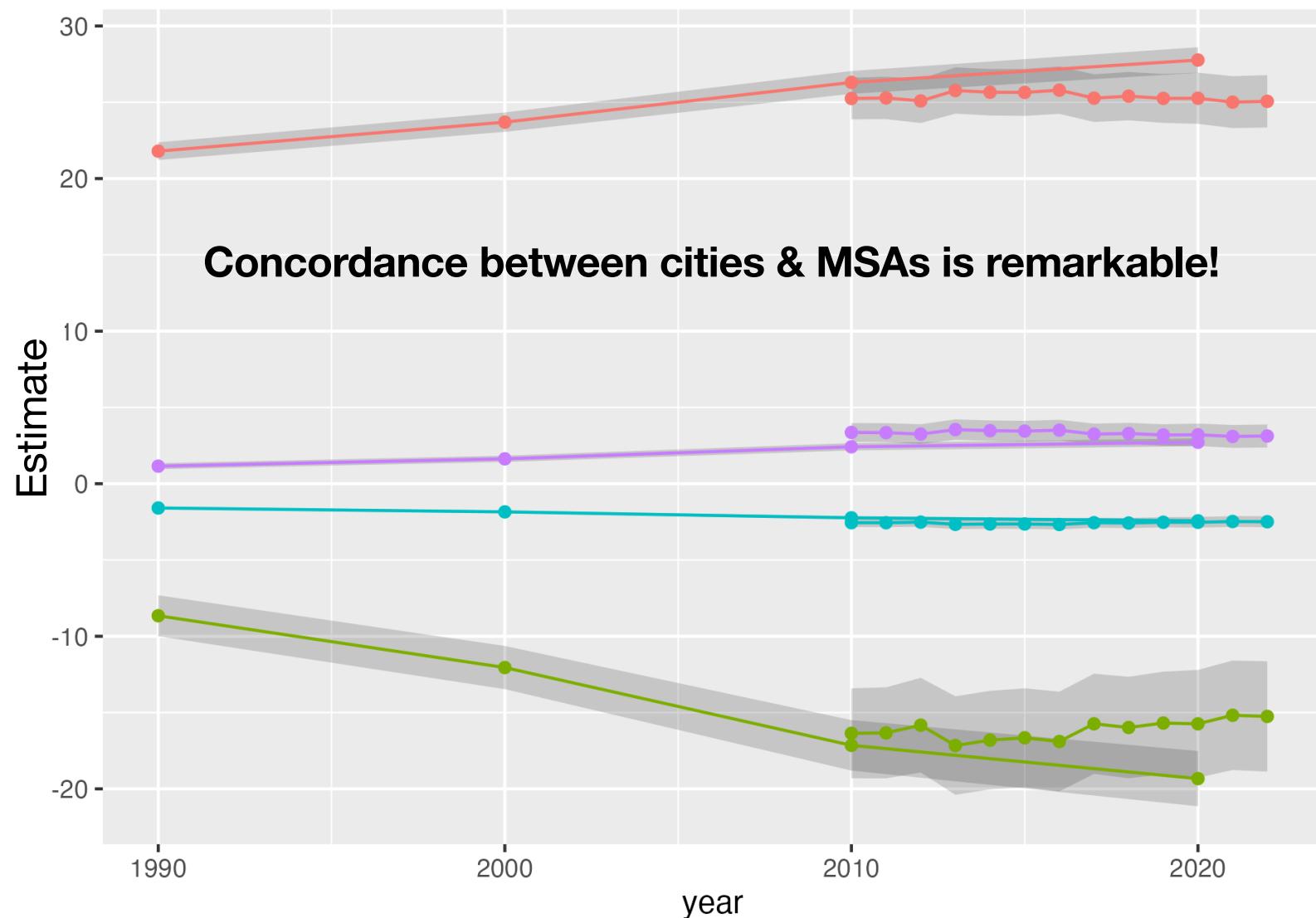


**Both
estimates**

Effect

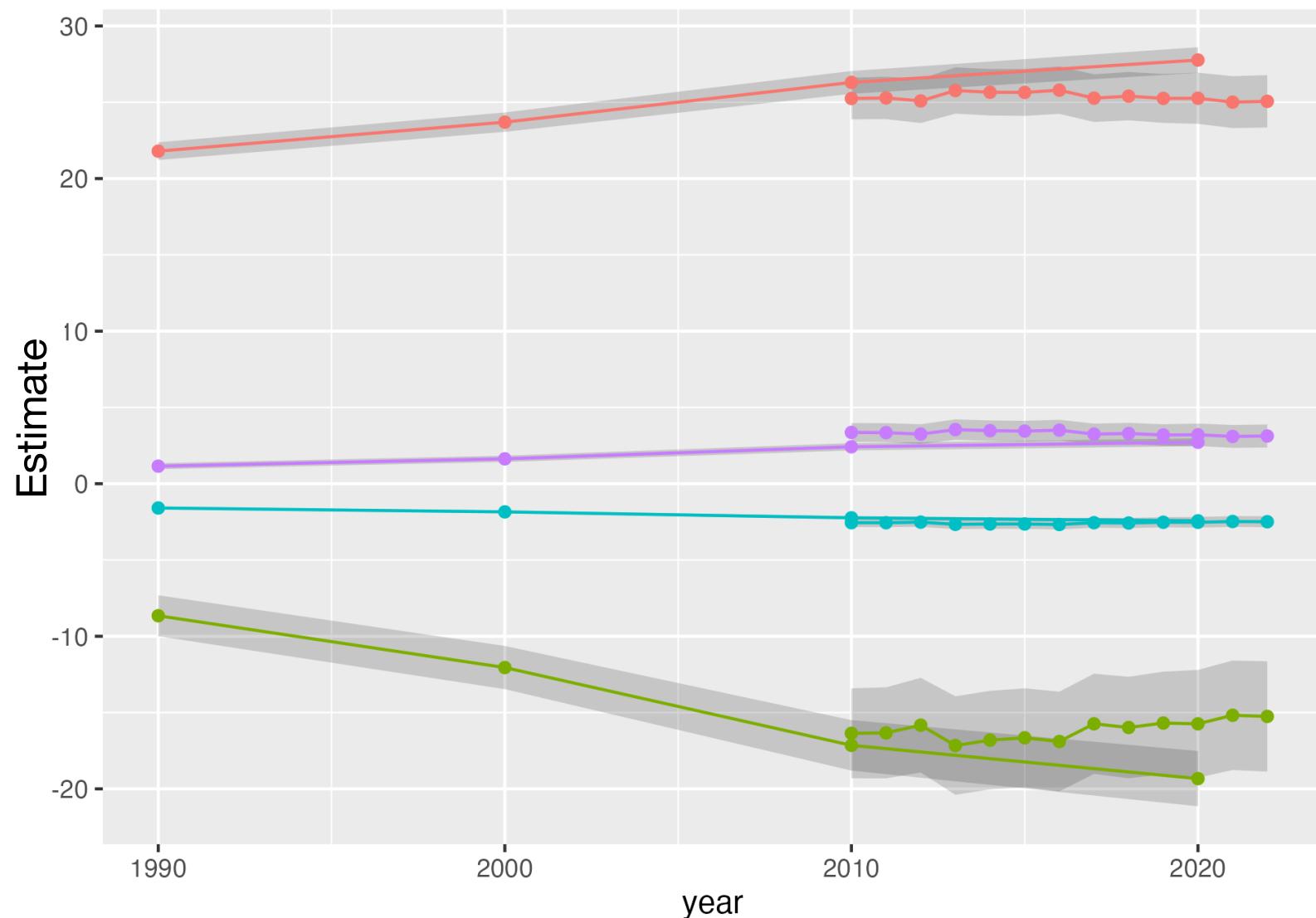
- Intercept
- Gini
- Scaling
- Moderation

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



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

**Both
estimates**



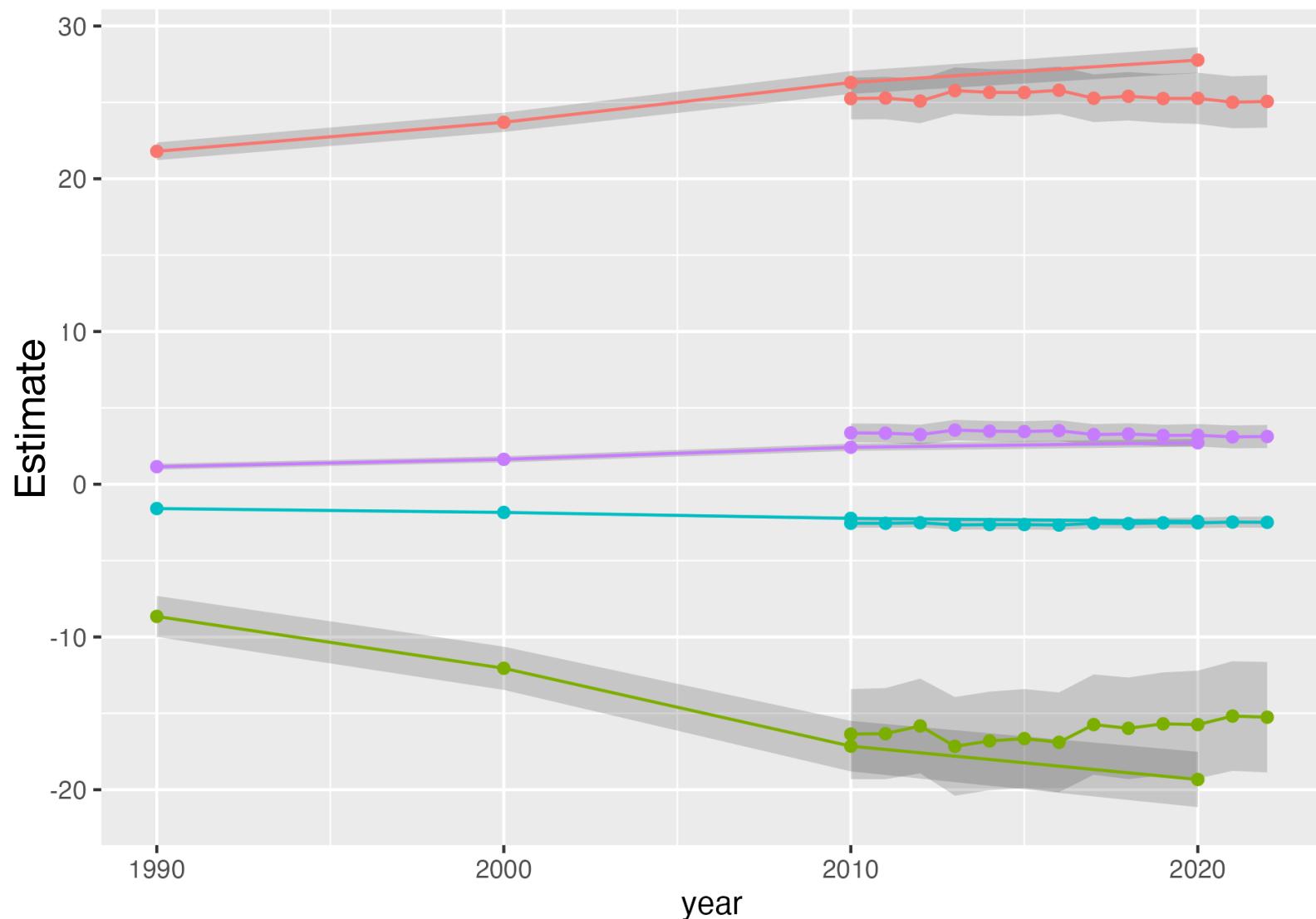
**Both
estimates**

Effect

- Intercept
- Gini
- Scaling
- Moderation

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

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



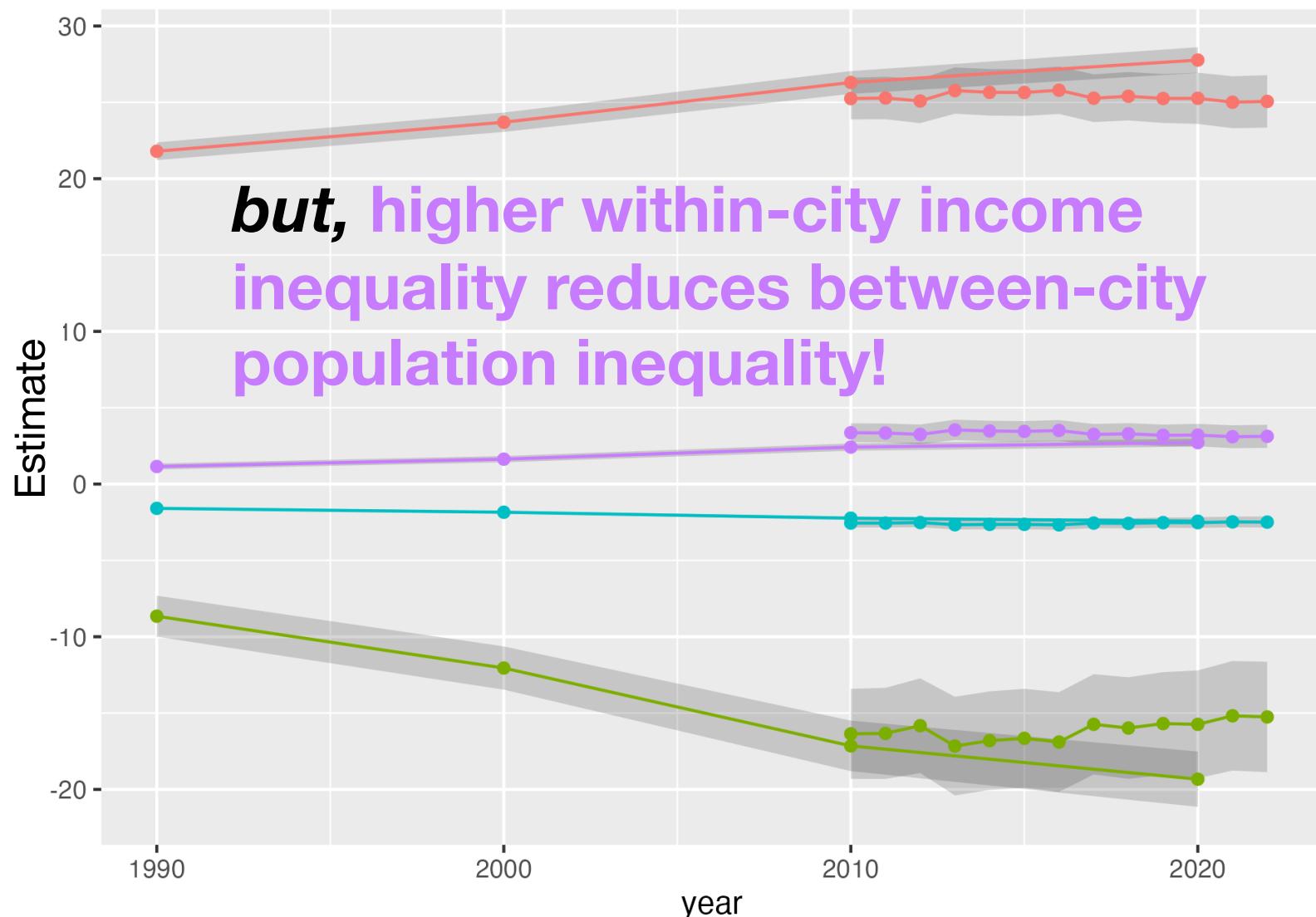
**Both
estimates**

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

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[nature](#) > [scientific data](#) > [data descriptors](#) > article

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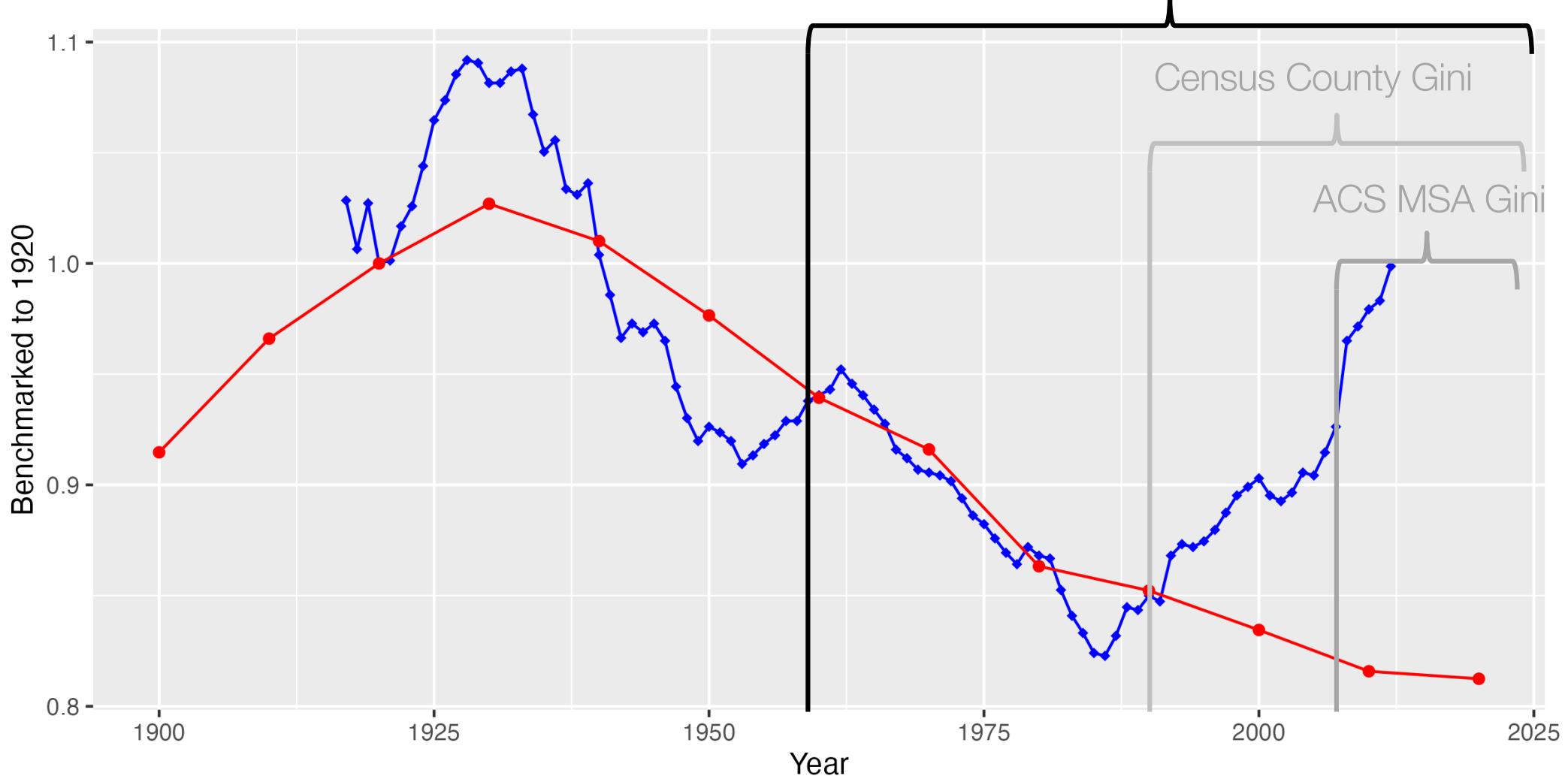
GEOWEALTH-US: Spatial wealth inequality data for the United States, 1960–2020

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

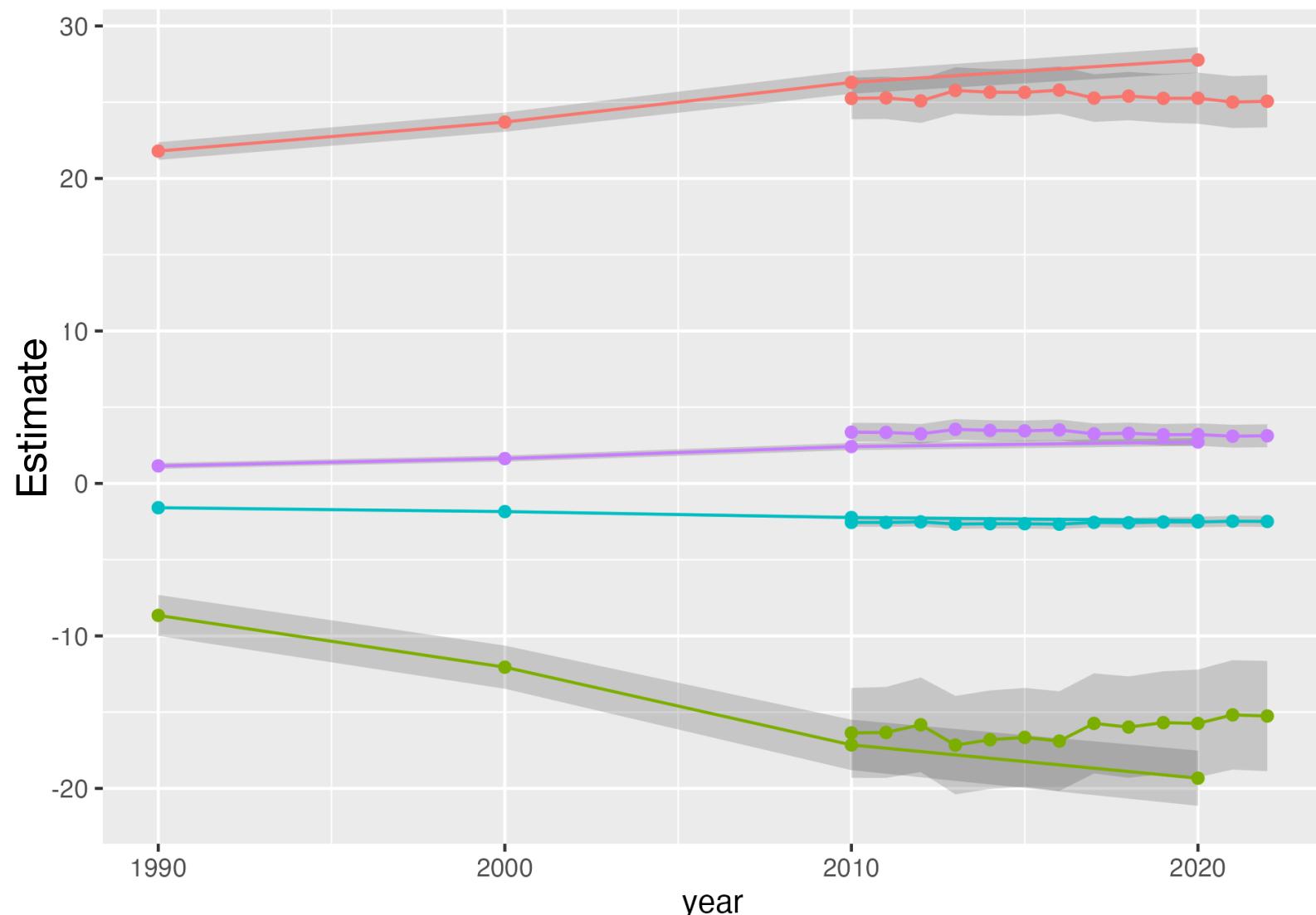
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GEOWEALTH County Gini



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



**Both
estimates**

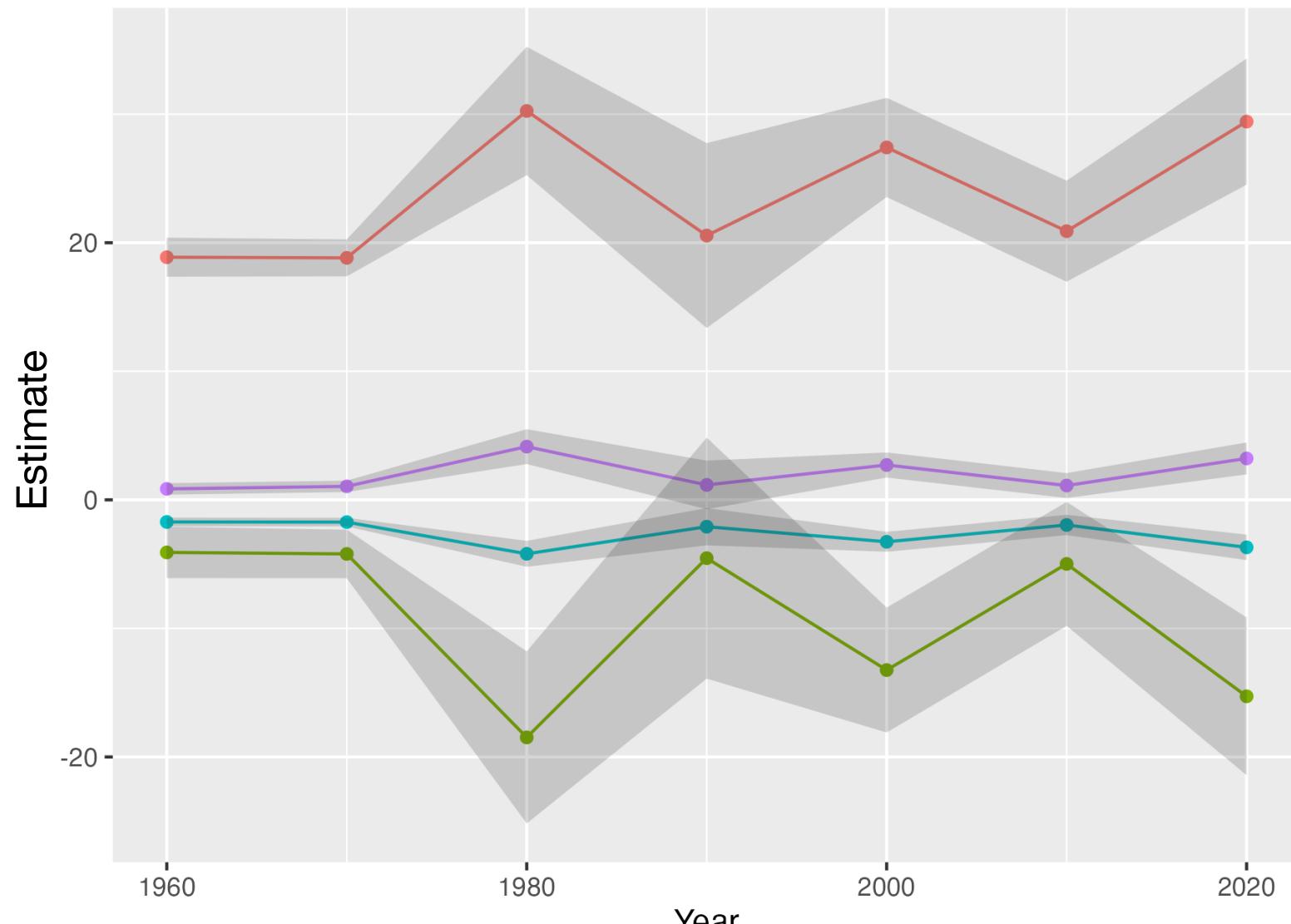
Effect

- Intercept
- Gini
- Scaling
- Moderation

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

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

Suss et al. estimates



Effect

- Intercept
- Gini
- Scaling
- Moderation

Holding city rank
constant, large
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**Suss et al.
estimates**



Effect

- Intercept
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Holding city rank
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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, the top “gets” more from more people
- (4) Disparity compounds over time due to generational transfer and migration
- (5) This top causes scaling to emerge between cities

Within-city inequality doesn't go hand-in-hand with pop growth

Economic inequality
no longer associates w/
economic opportunity!

generative value

regularity value

How often is this true?

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

contextual value

Where/when is this true?

... in “coherent” urban
systems ...

generative value

How is this true?

... because of within-city
inequality?

regularity value

How often is this true?

Lots of data about the present

contextual value

Where/when is this true?

Lots of data about the present, disaggregated by geography

generative value

How is this true?

Lots of data about, disaggregated by geography and time

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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