The Future of Japanese Cities
Japan in 2120
Based on a Statistical Prediction Model

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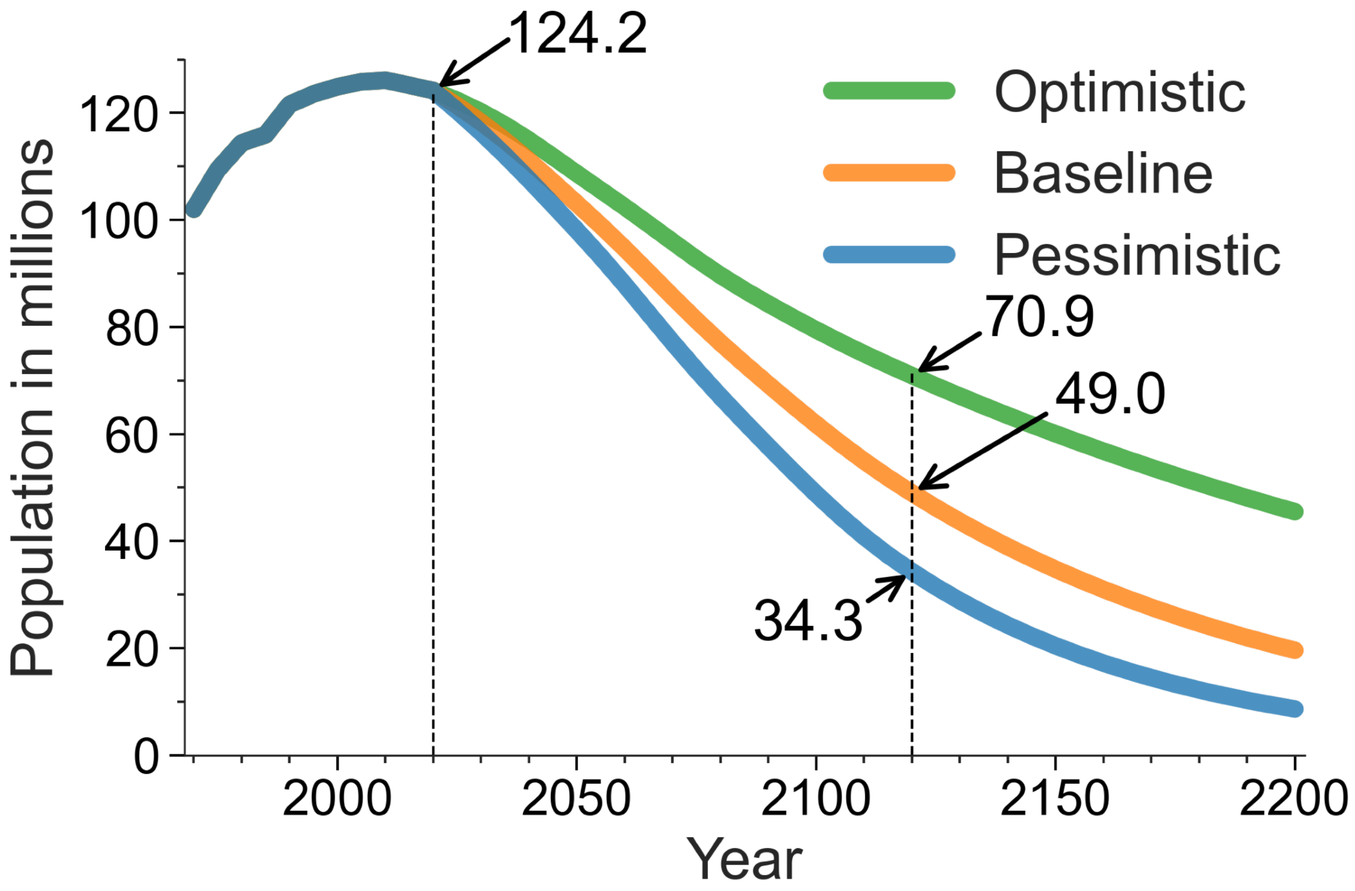
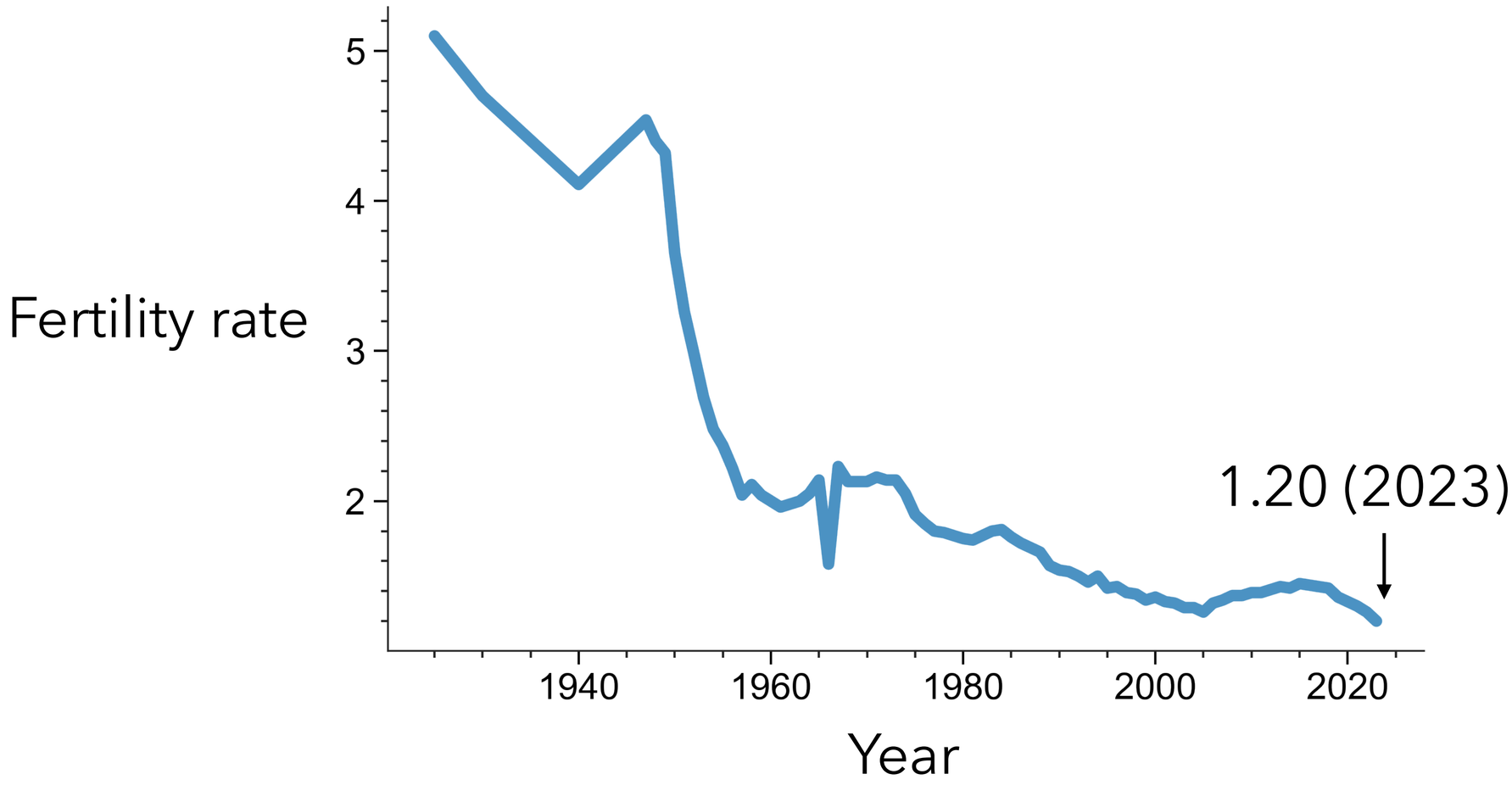
Future population forecast for Japan



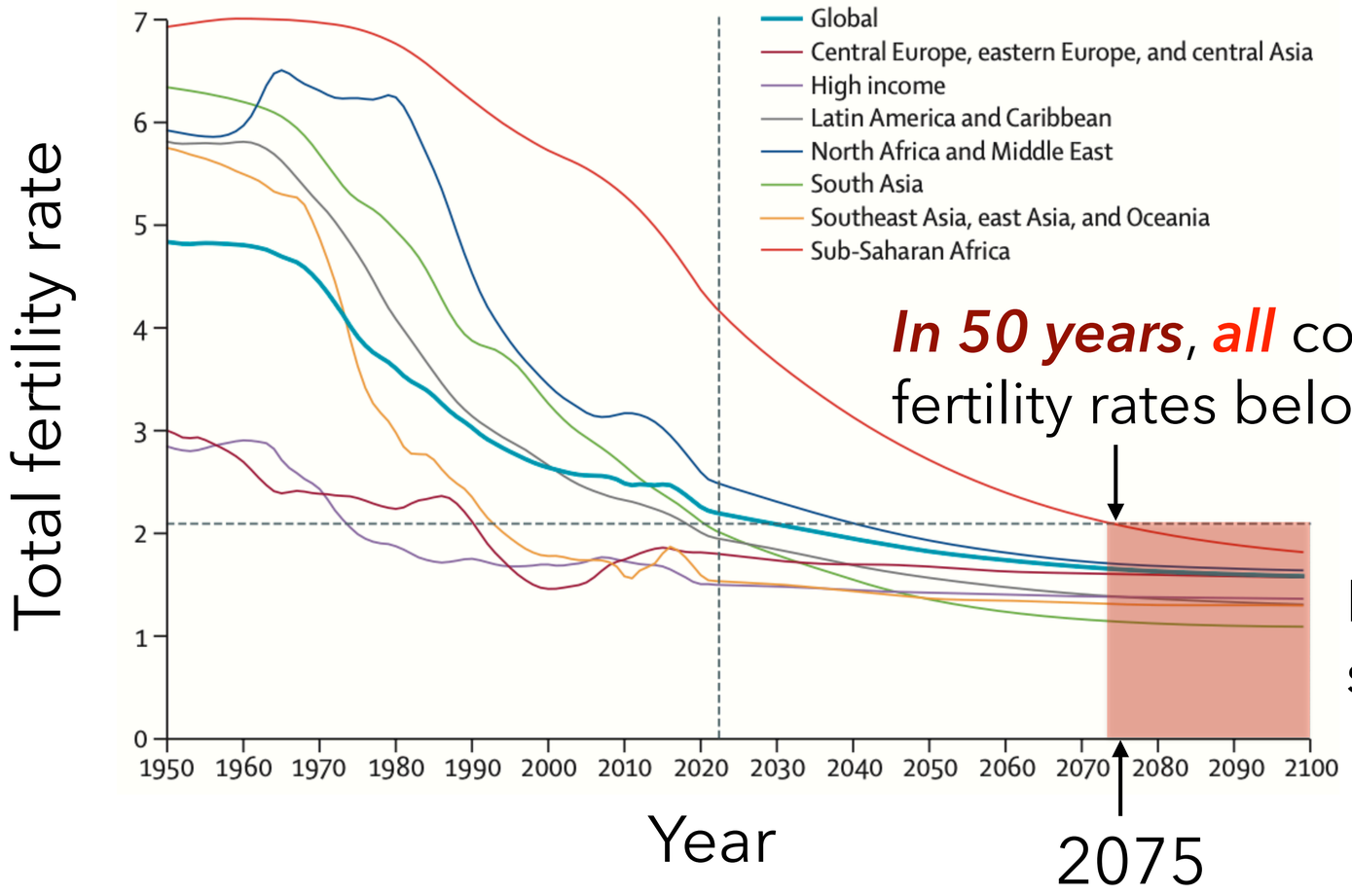
(Limited to areas connected by road to Honshu, Hokkaido, Shikoku, and Kyushu)

Declining fertility rate in Japan



Mitigation of population decline by immigration will soon end.

Institute for Health Metrics and Evaluation (IHME) of the US (Lancet2024)



In 50 years, ***all*** countries will have fertility rates below 2.0.

Immigration policy will not be the solution to population decline.

Motivation

1. While little analysis of the quantitative effects of population decline exists, we attempt to do so from the perspective of urban and regional economics.
2. Beyond the problems of individual cities and regions, there are deeper issues behind population decline, including declining birth rates, that will take time to resolve. We are trying to create an opportunity to seriously address these issues.

Keys to regional population projections

1. Think of a region in terms of cities as *an agglomeration of people*.
2. Note the following two changes
   - Population decline
   - *Reduction in distance friction (transport and communication costs)*
3. Predict based on theories that are highly *capable of reproducing facts* (theory of economic agglomeration)

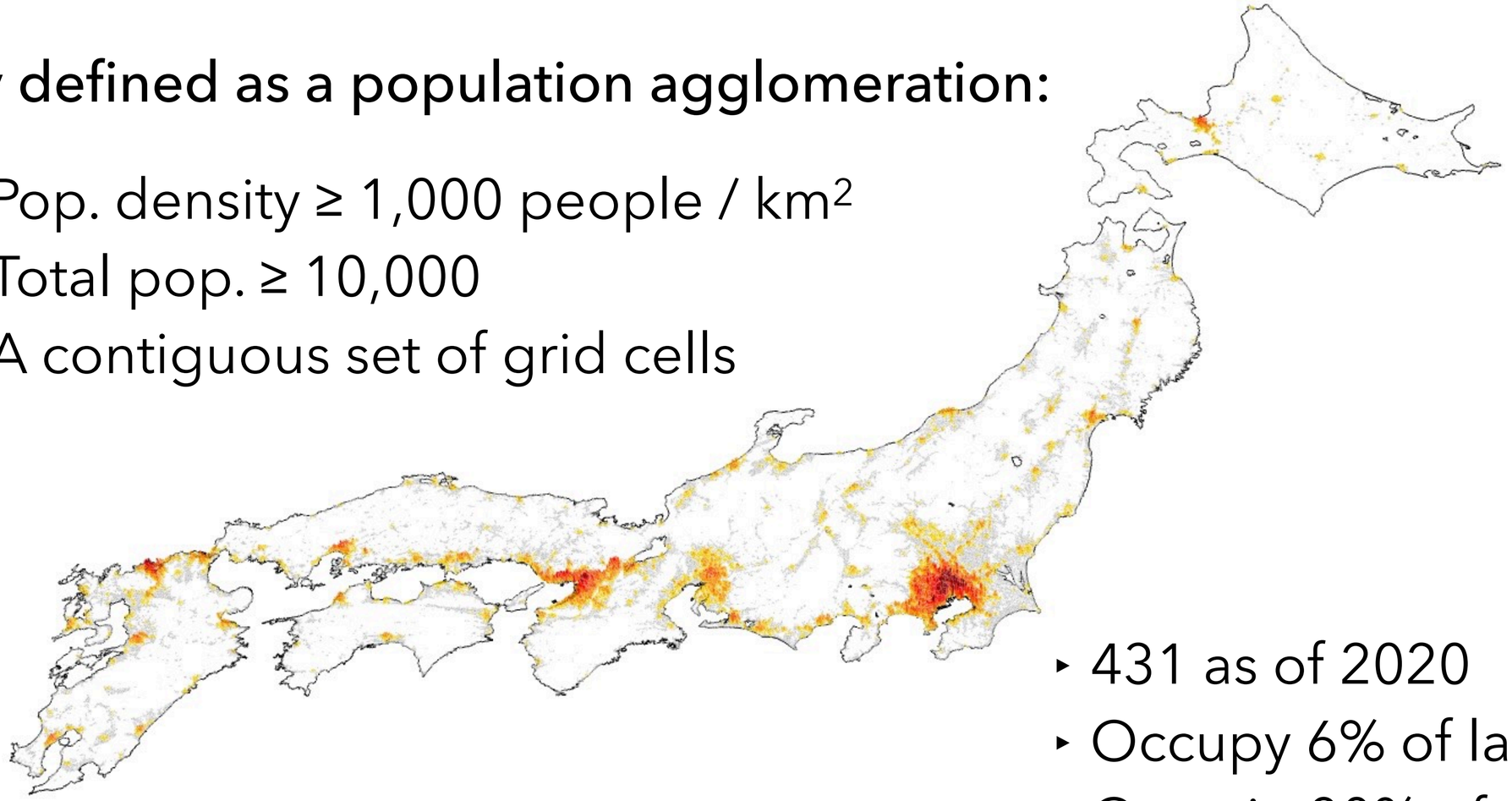
Why do we see the region through the "city"?

What is a “city”?

Basic data = 1km grid-cell data of population

A city defined as a population agglomeration:

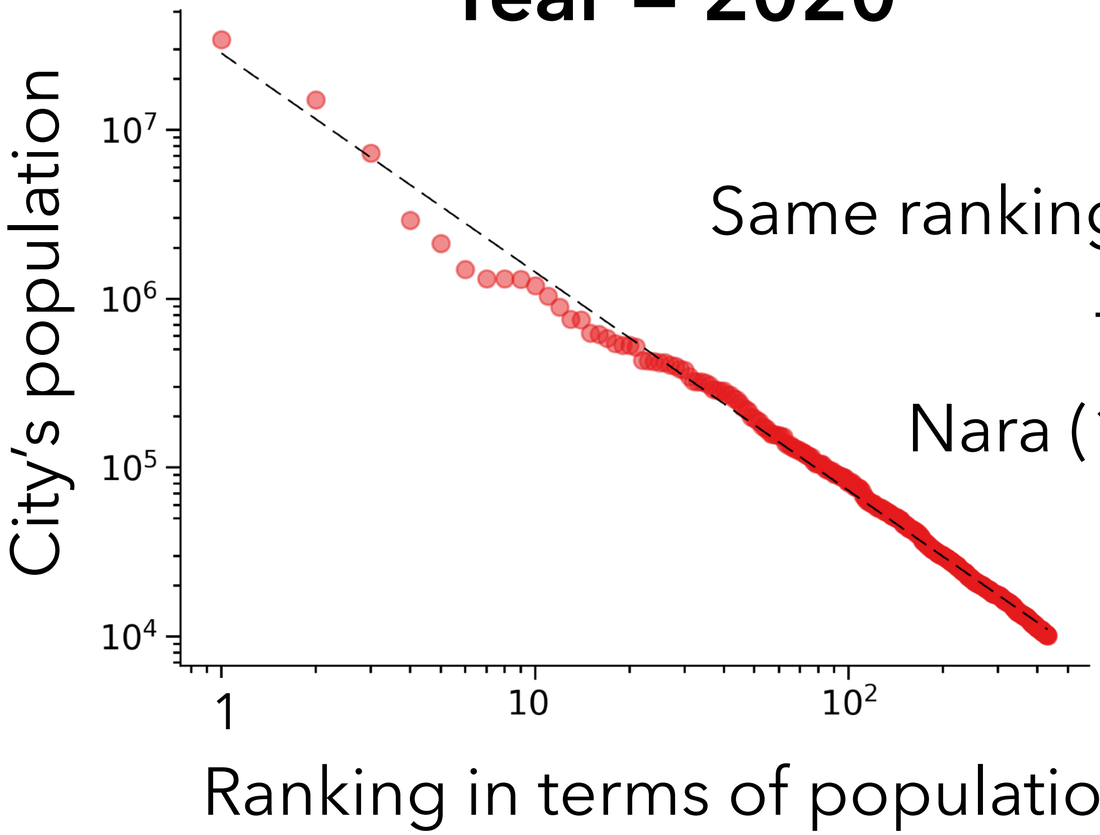
i. Pop. density ≥ 1,000 people / km^2
ii. Total pop. ≥ 10,000
iii. A contiguous set of grid cells



- 431 as of 2020
- Occupy 6% of land
- Contain 80% of population

Why city? – A persistent power law for city size distribution

Year = 2020



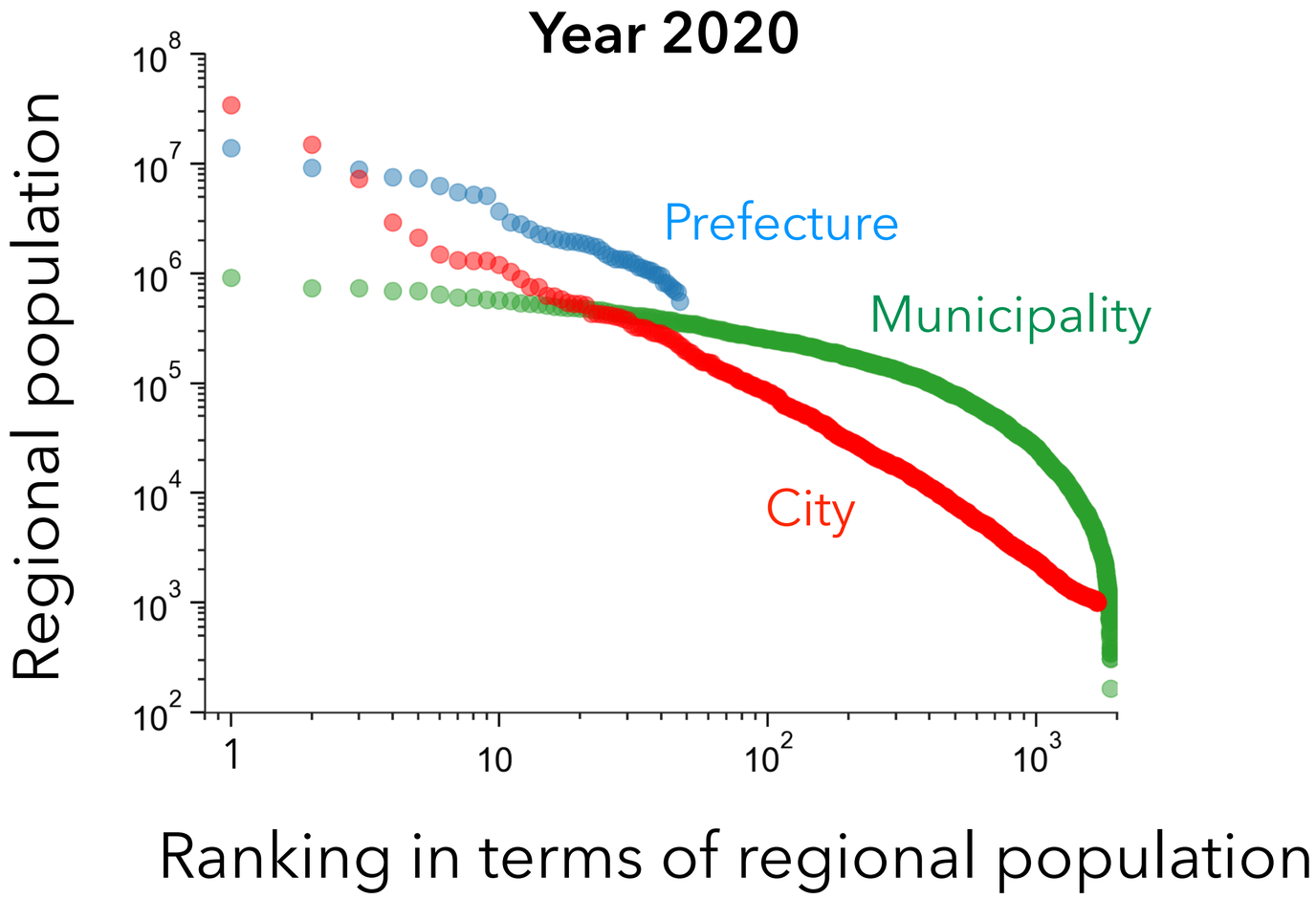
Power law

Same ranking ratio ➔ Same population ratio

Tokyo (1st) / Osaka (2nd) = 2.3

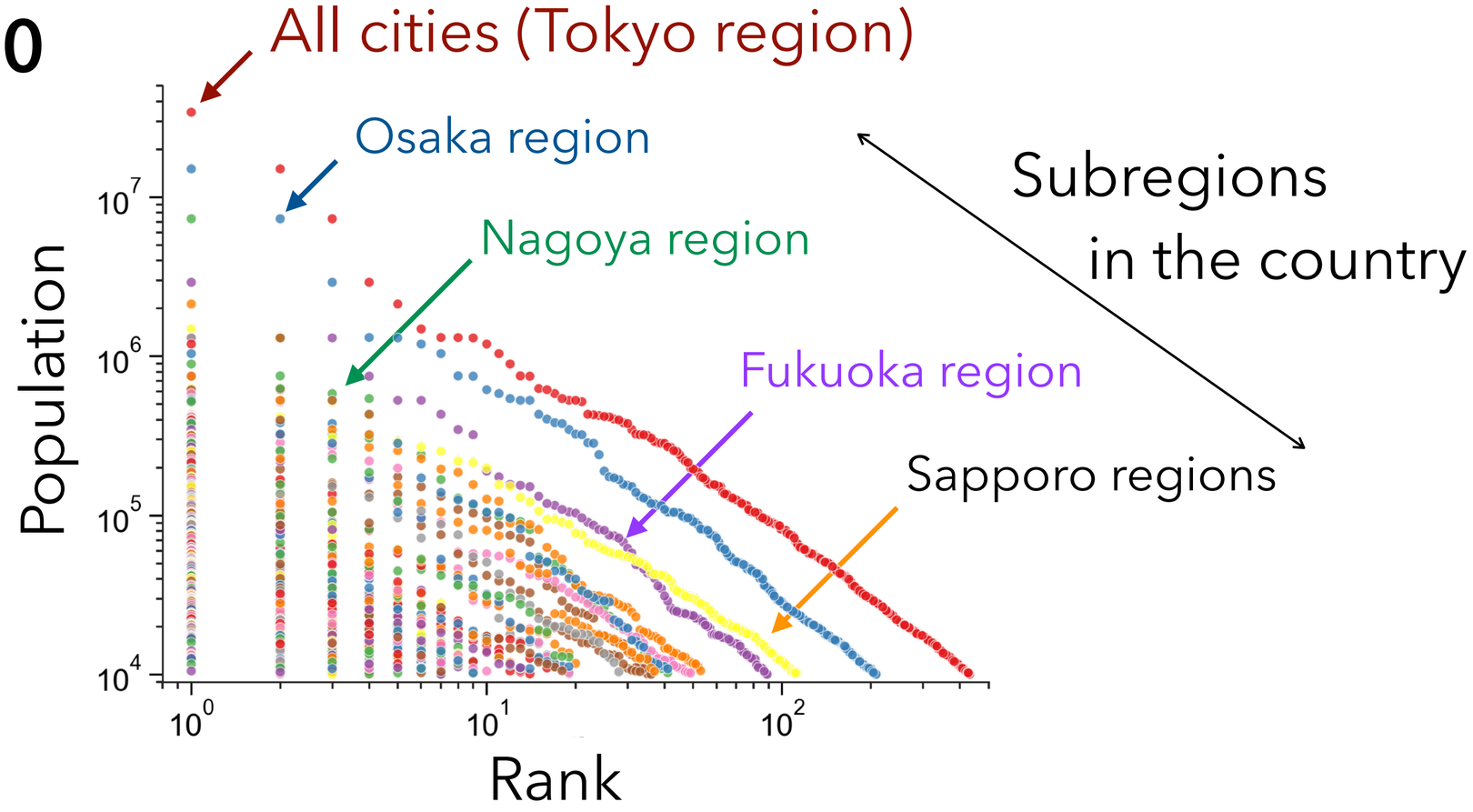
Nara (10th) / Matsuyama (20th) = 2.3

Power law does not hold under jurisdictions



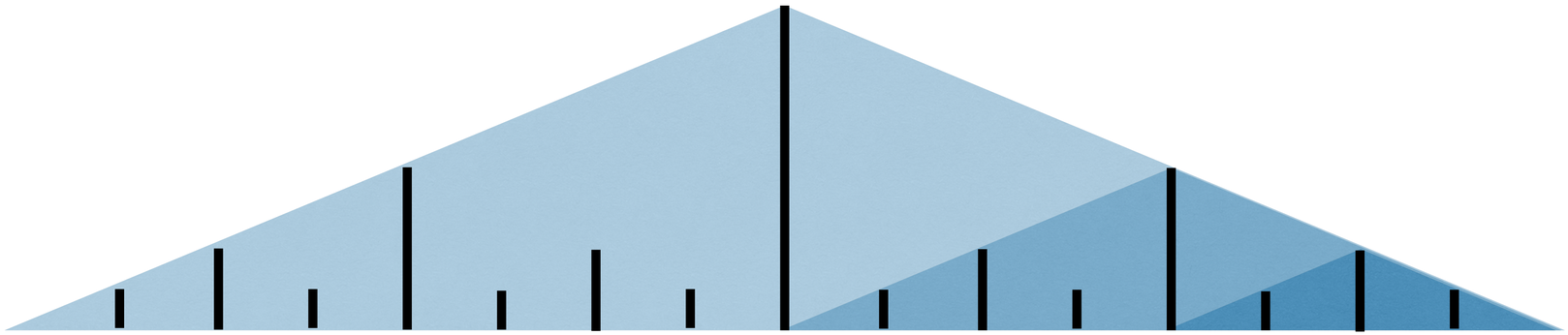
Fractal structure with the power law across regional levels

Year = 2020



Spatial fractal structure of the city system

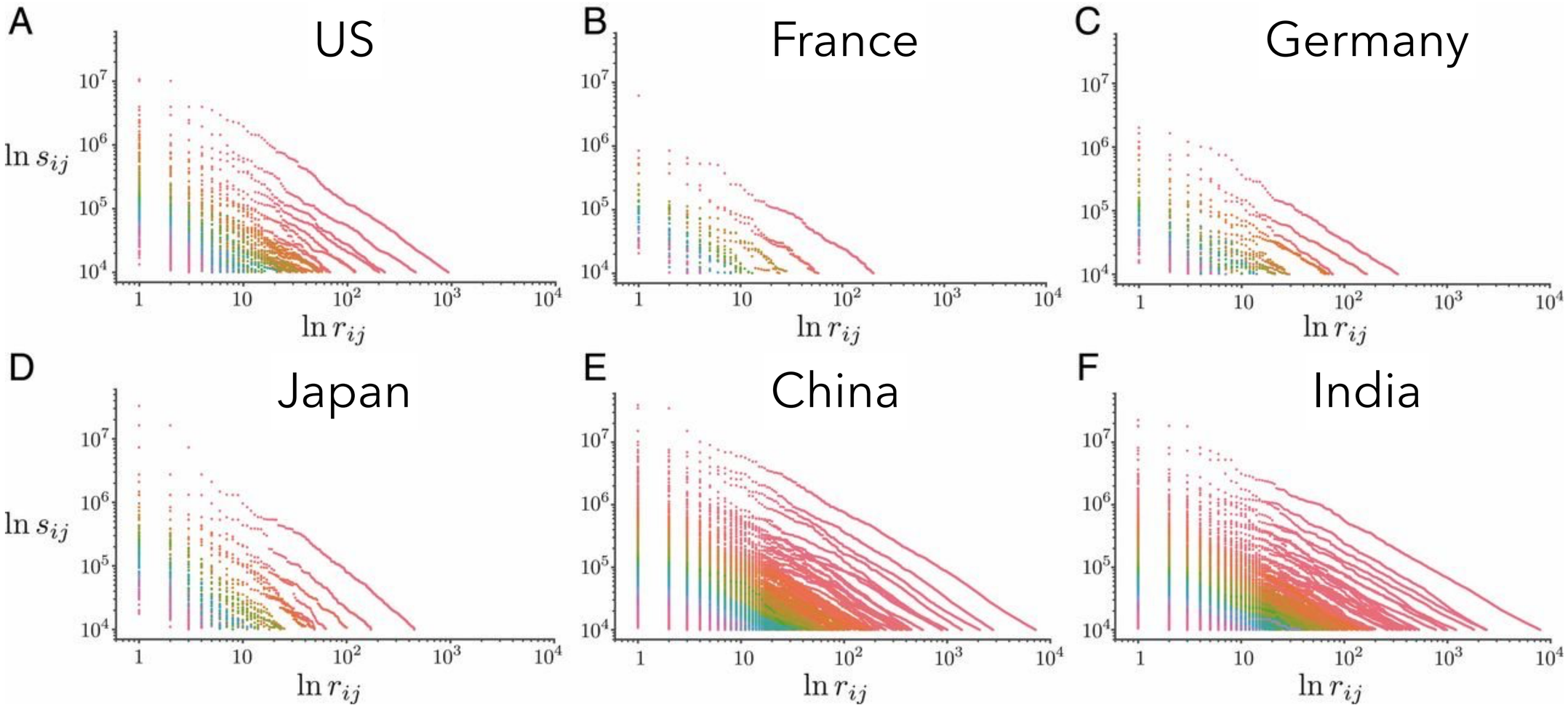
A region = A large city & the surrounding smaller cities



Similar and recursive structure

A universal regularity

Year = 2015



(Mori, Smith & Hsu, 2020)

Advantages of looking through the lens of cities

The regularity makes it easy to judge

- Reproducibility by theory of fact
- Consistency of predictions and theories

Reasons to consider reduction in distance friction

Decrease in distance frictions
Past and future

Changes in the past 50 years

- Development of bullet train and highway network
  (More than half of the population can meet face-to-face on a day trip.)
- Spread of the Internet and smartphones
  (Instantaneous data sharing and text dialogue, Video conferencing)

Changes in the future

- Automated driving and logistics
- Virtual reality ➔ Need for physical movement ↘

What do declining populations and distance frictions mean for regions?

Population of 30+ million: About the size of today's Tokyo metropolitan area

- Will most of the population be concentrated in Tokyo?
- Will each region shrink at the same rate?

A world where automated driving and virtual reality are the norm

- Will there be no distinction between urban and rural ?
- Will the city become more powerful ?

Economic agglomeration theory that can reproduce order

Two "geographical advantages" that determine a city's population and location

2nd nature of geography: Economies of agglomeration

➔ Form of distribution (similarity structure with power law)

1st nature of geography: Natural & historical conditions

➔ Map location of distribution

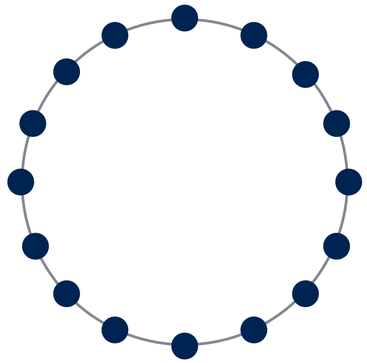
Ex. The largest city is located on the Kanto Plain, where there is a vast area of flat land.

Reproduction of order through the theory of economic agglomeration

Virtual economy

– Simplified economy, leaving only the essence

Virtual national land



- Symmetrical land without 1st nature advantage of geography.
- Many industries with varying degree of agglomeration economies.

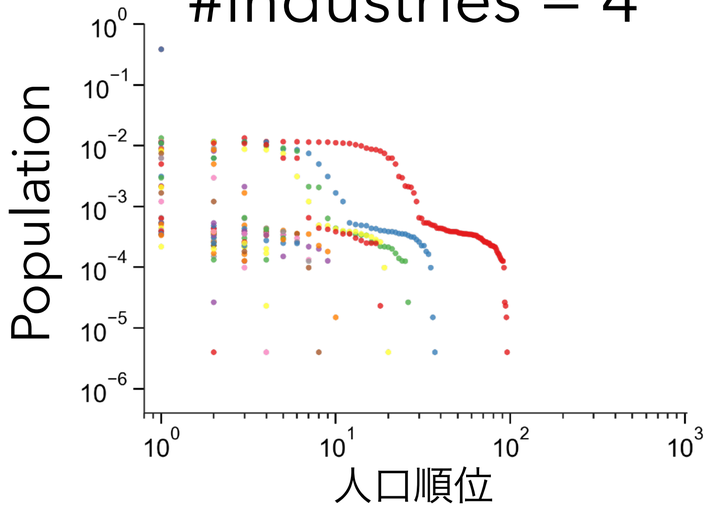
Equilibrium

- Many households and firms make decisions to maximize their respective gains.
- Prices are determined so that supply and demand are balanced in all markets.

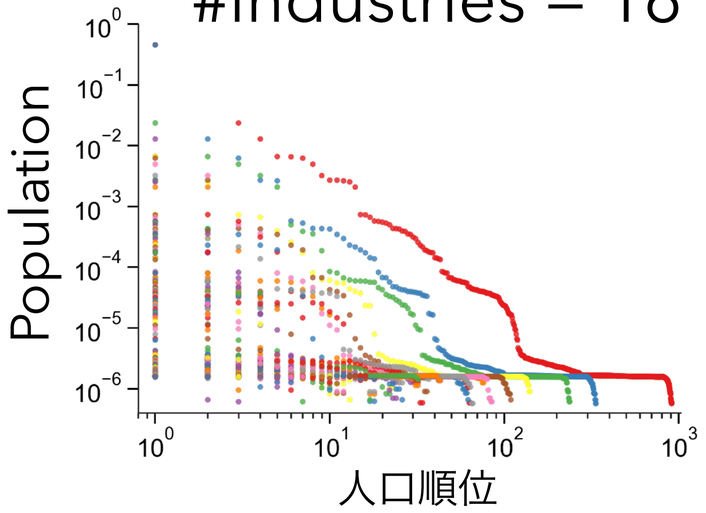
Mori et al. (2023)

Realized order in a virtual economy

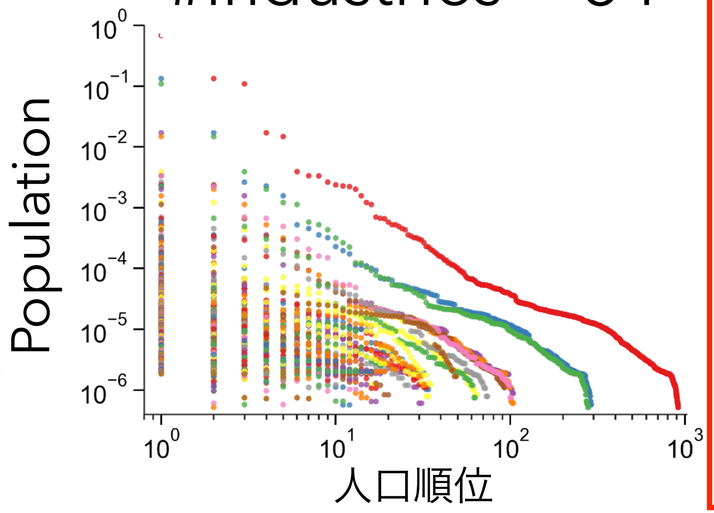
#industries = 4



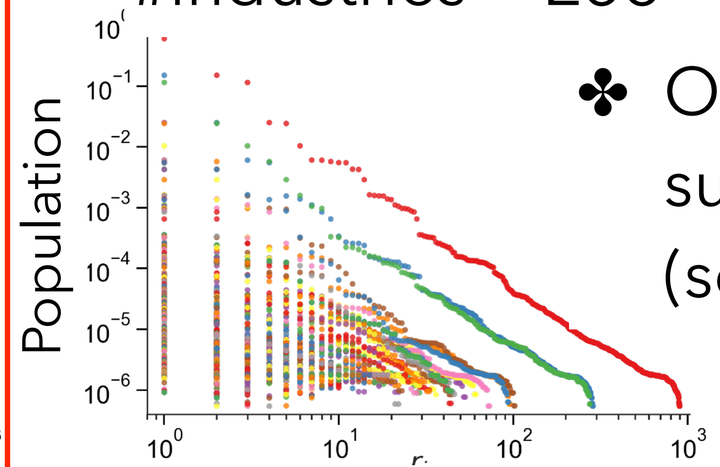
#industries = 16



#industries = 64



#industries = 256



- Order emerges under sufficiently diverse industries (scale economies)

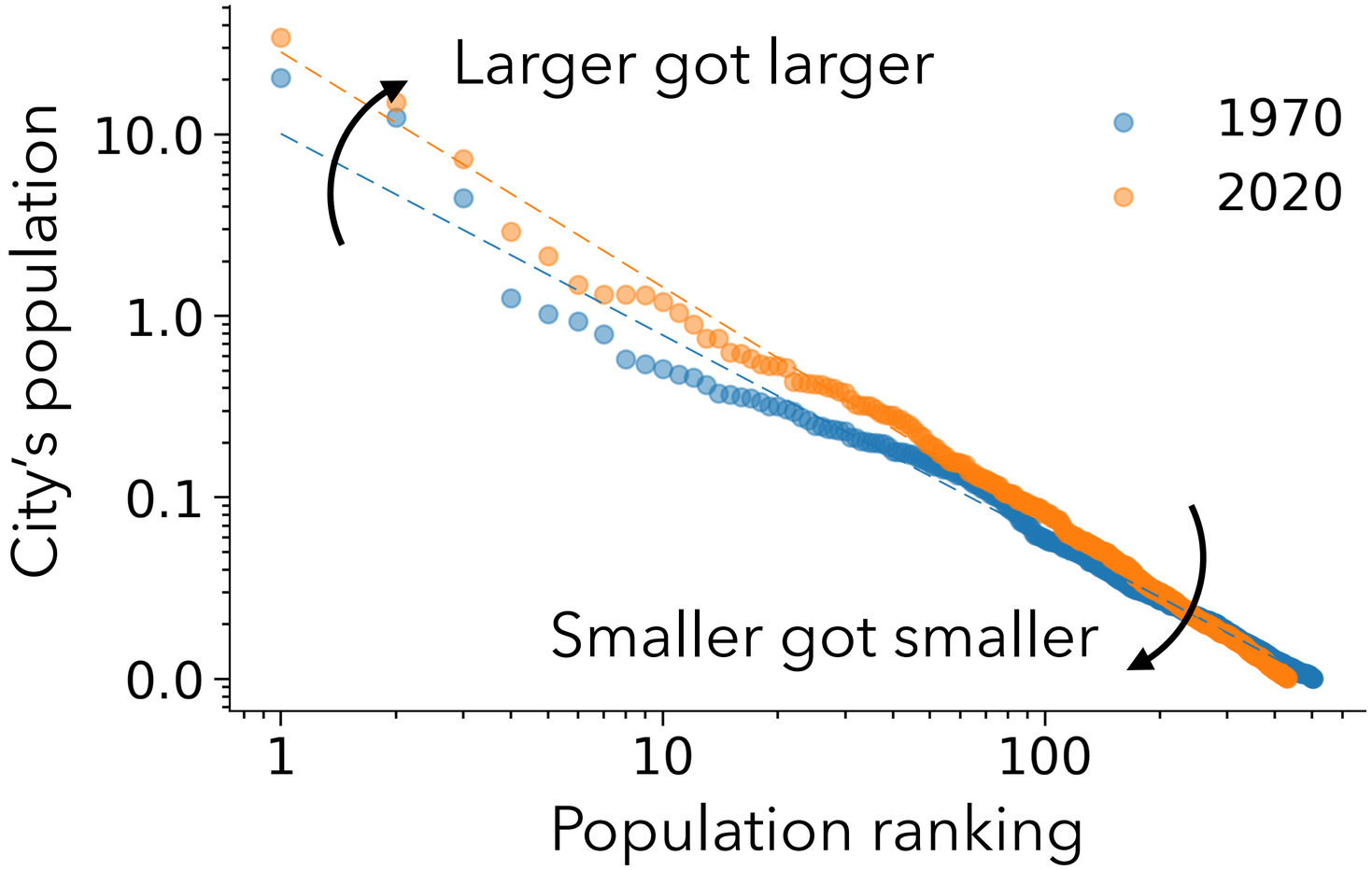
Mori et al. (2023)

Reduction in distance friction and changes in urban agglomeration

Facts and theory

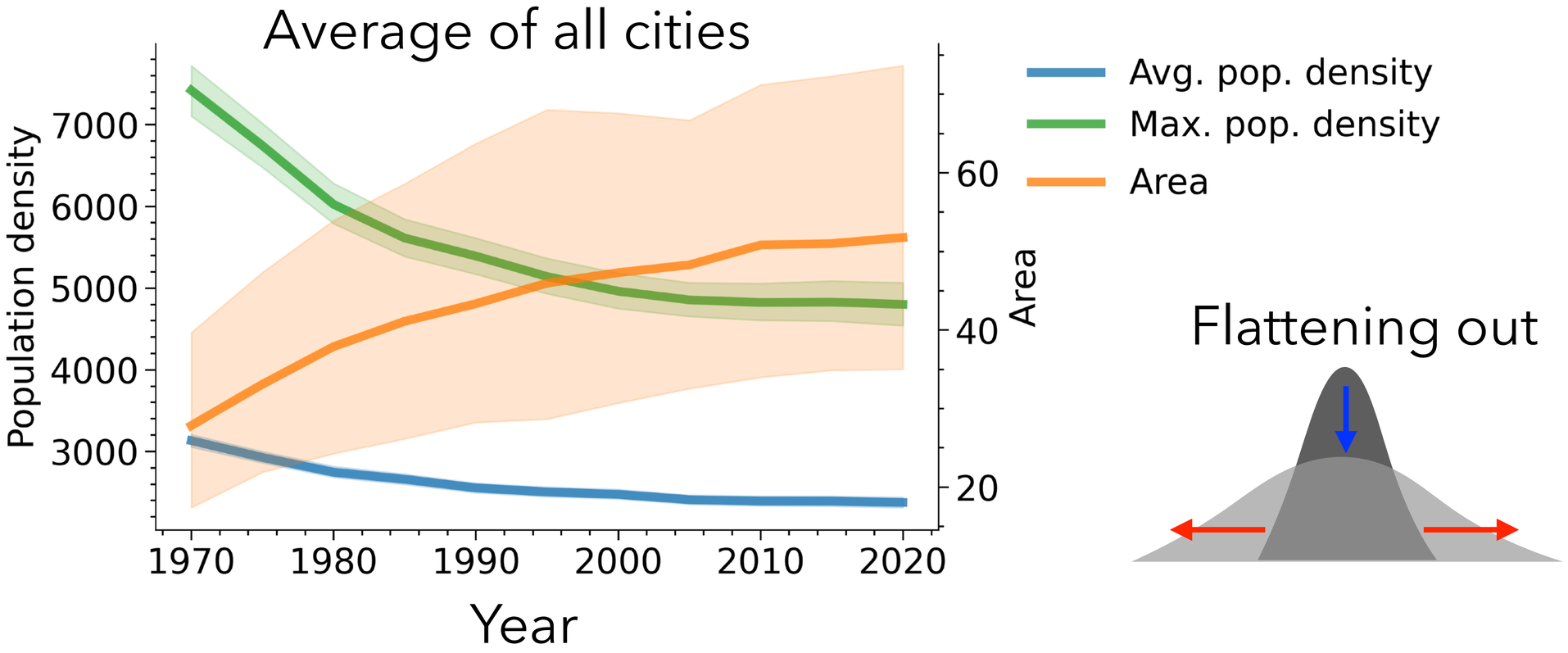
Changes in the past 50 years – *Country level*

"Concentration" at the country level



Changes in the past 50 years – *City level*

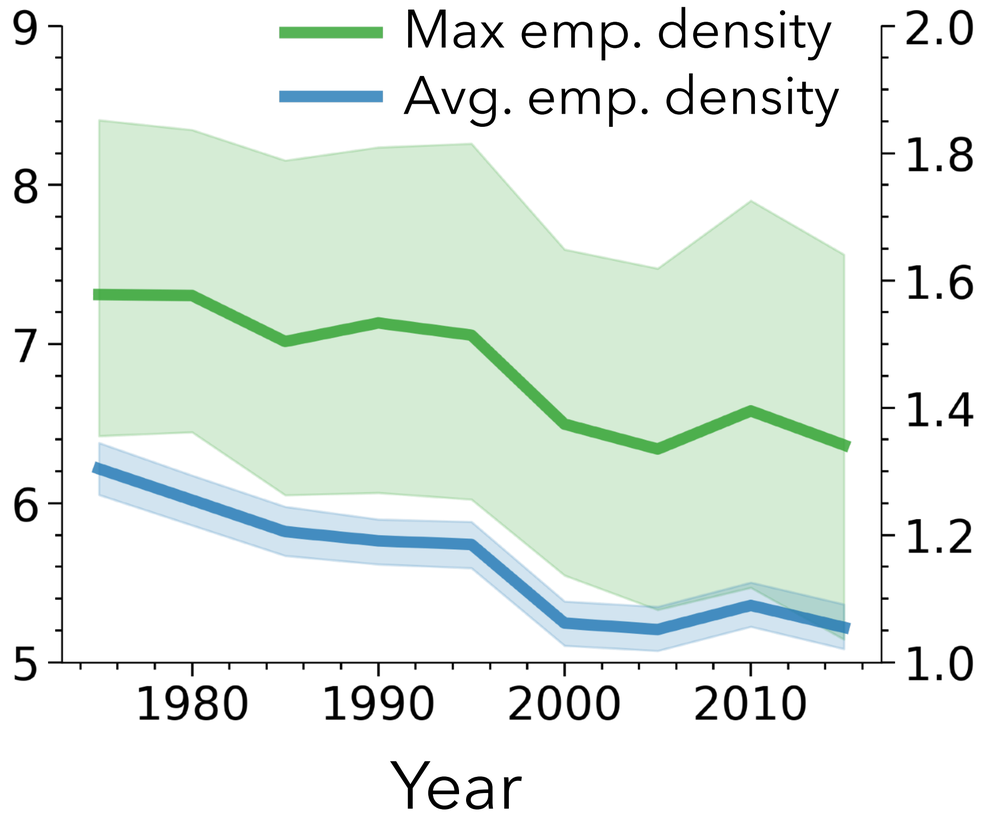
"Flattening" (or dispersion) at the city level



Changes in the past 50 years – *City level*

Flattening of the employment distribution

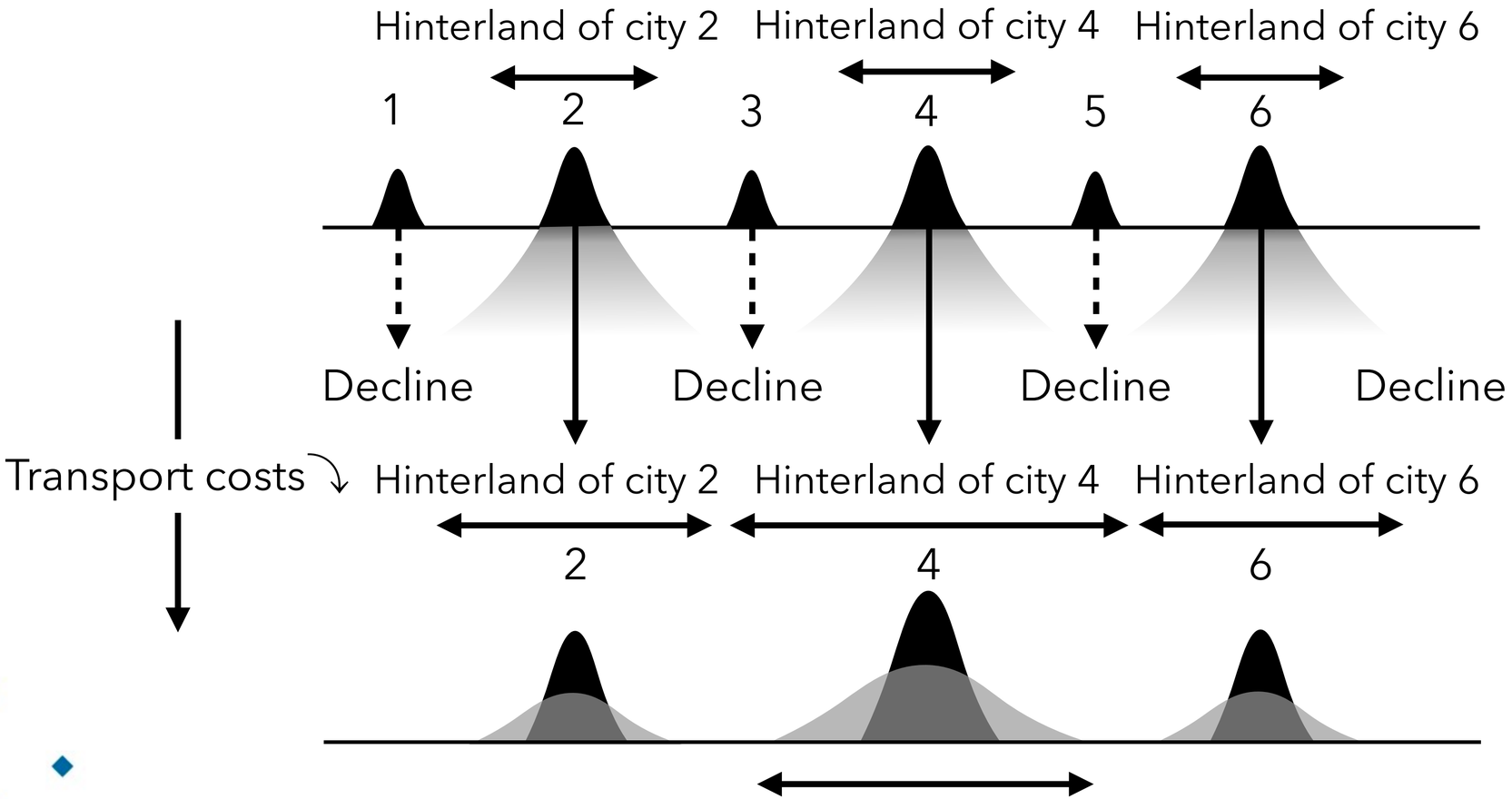
Max. emp. density
(1000 persons/km²)



Avg. emp. density
(1000 persons/km²)

Theory behind the changes

Akamatsu, Mori, Osawa & Takayama (2023)



Concentration at the country level

Conflicts of cities' hinterland due to more globalized competition

↓

Selection of cities

Dispersion at the city level

Same agglomeration benefits under lower density

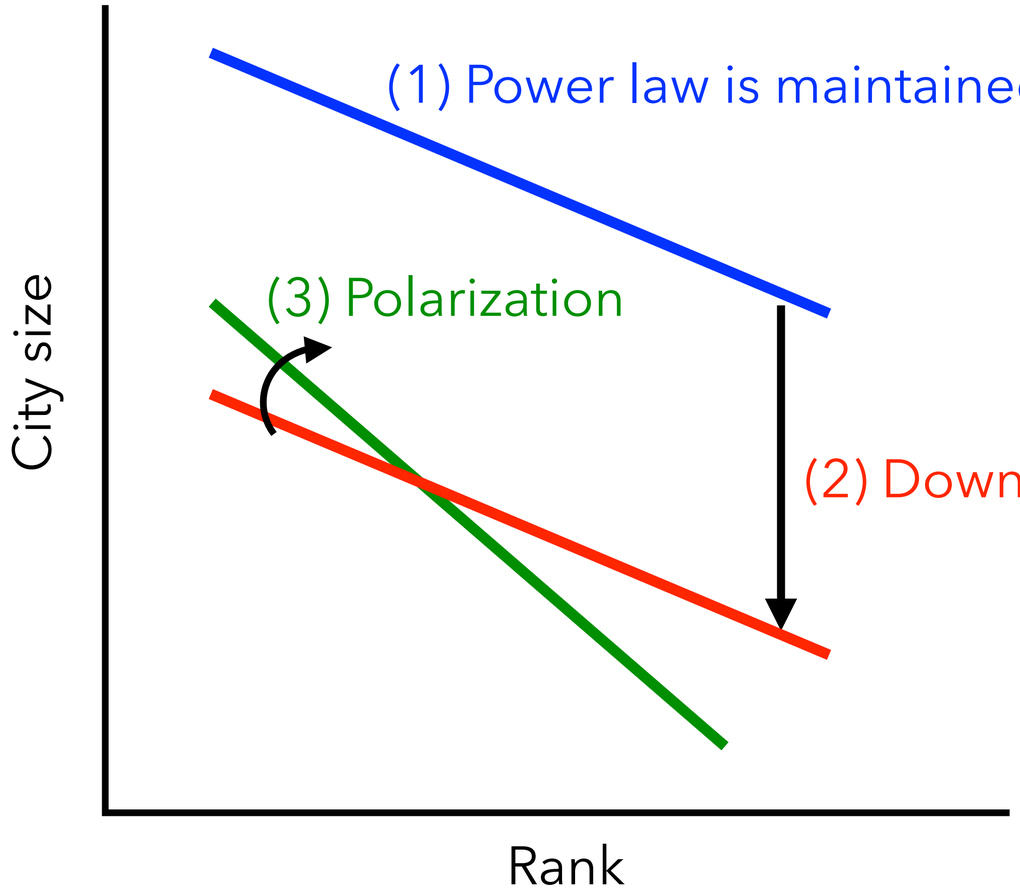
Sustainability of cities under declining population and diminishing distance frictions: The case of Japan

In progress

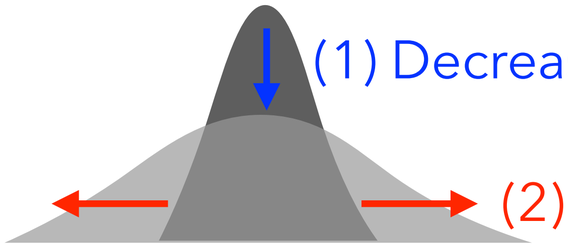
Tomoya Mori, *Kyoto University*
Daisuke Murakami, *Institute of Statistical Mathematics*

Theoretical predictions consistent with the past changes

The country level



The city level



Flattening of each city

A “reduced form” statistical forecasting model

Country level

- Official projection of total population
- Extrapolated trend of urbanization
- Extrapolated trend of the skewness of city-size distribution

City level – 4 city-specific times series models

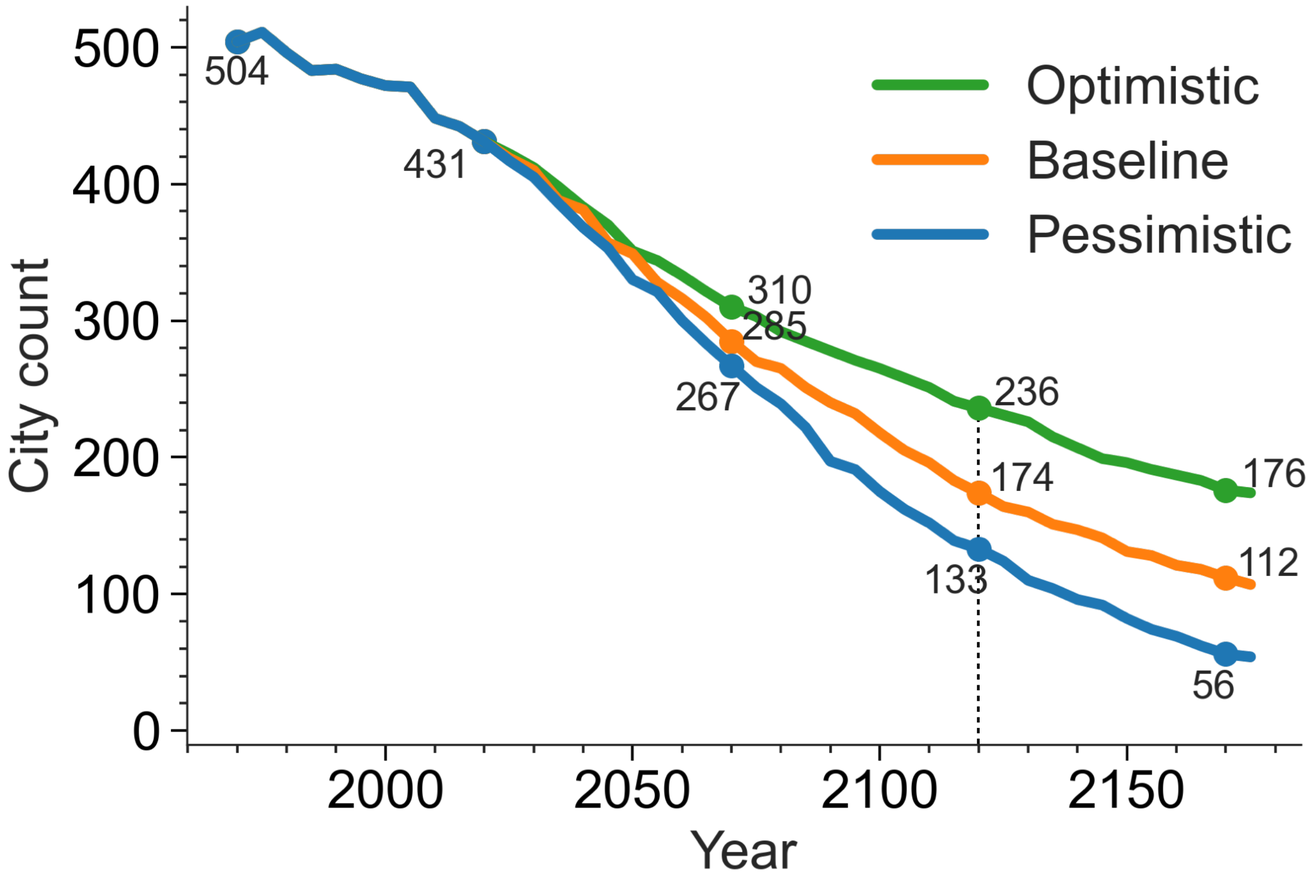
Grid level – 4 grid-specific times series models & their spatial version

✤ Endogenous births, deaths, mergers and splits of cities

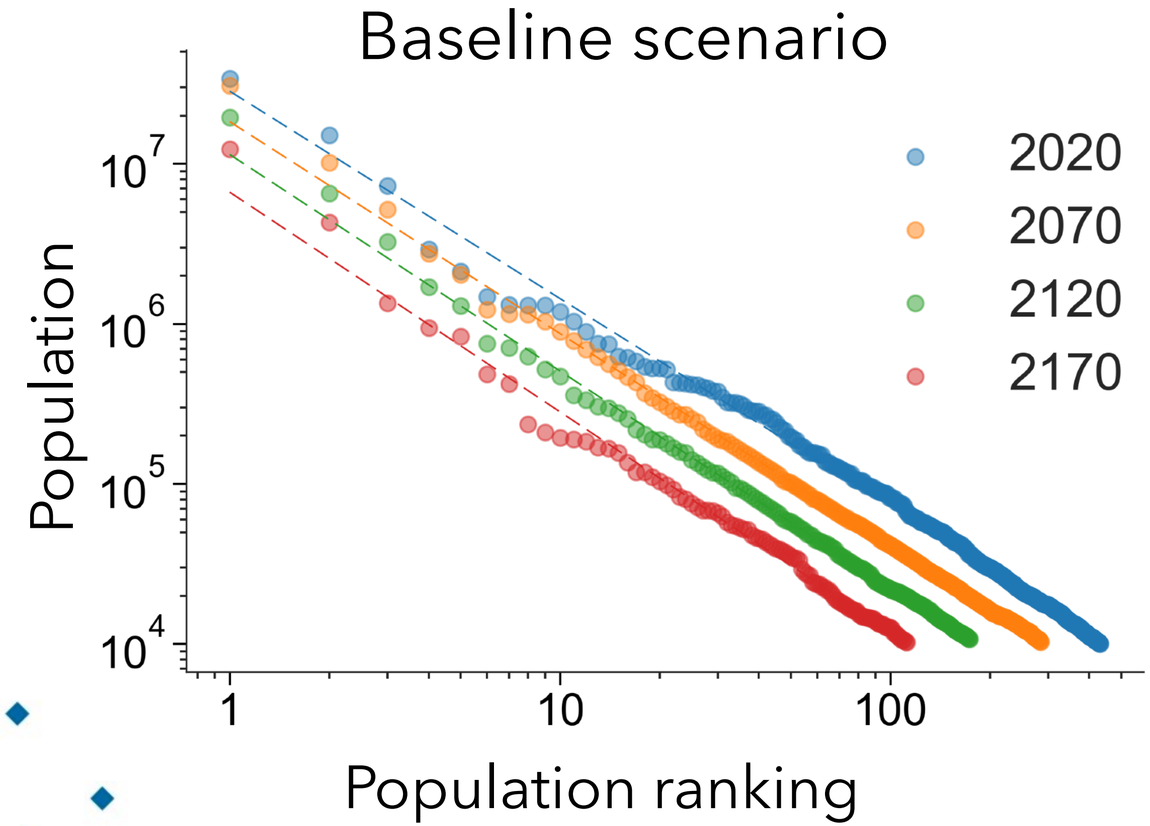
Learning data: 1970–2020

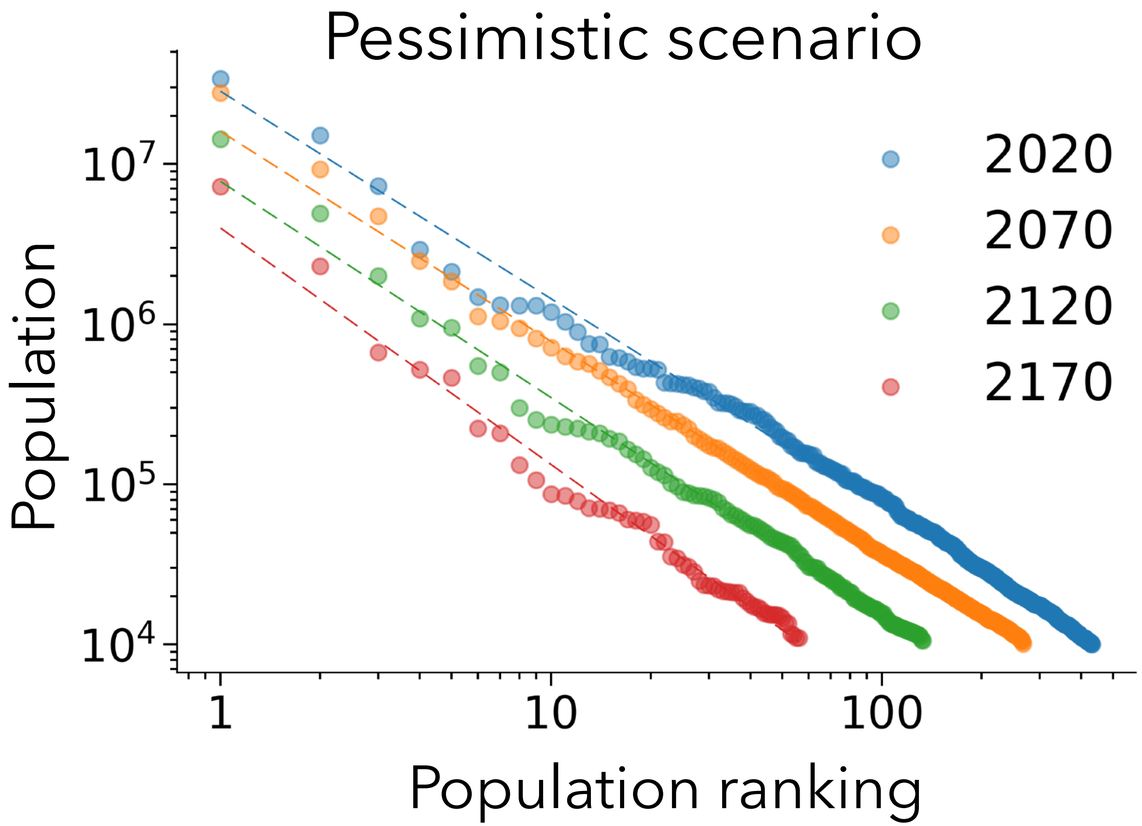
Forecasting city growth and decline

Predicted city counts



Predicted city-size distributions



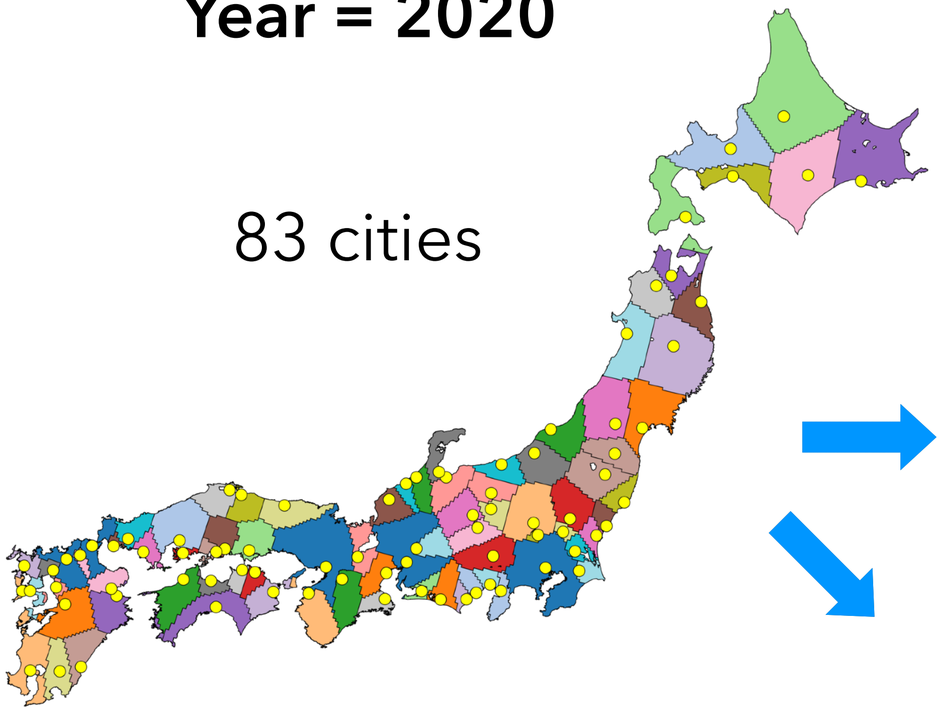


Polarization at the country level

100k cities

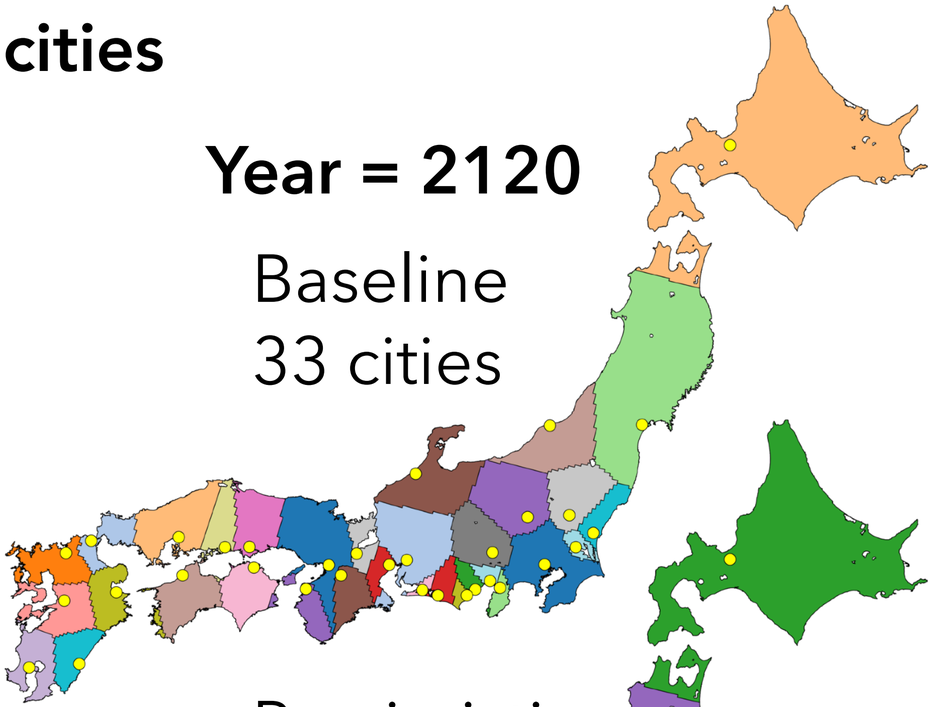
Year = 2020

83 cities



Year = 2120

Baseline
33 cities



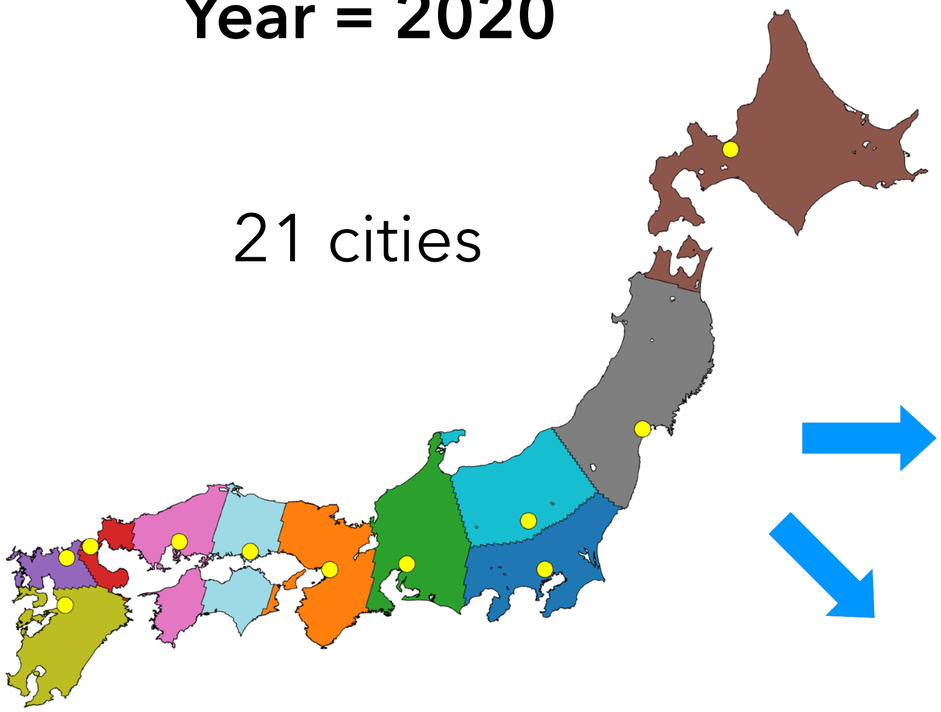
Pessimistic
23 cities

Polarization at the country level

500k cities

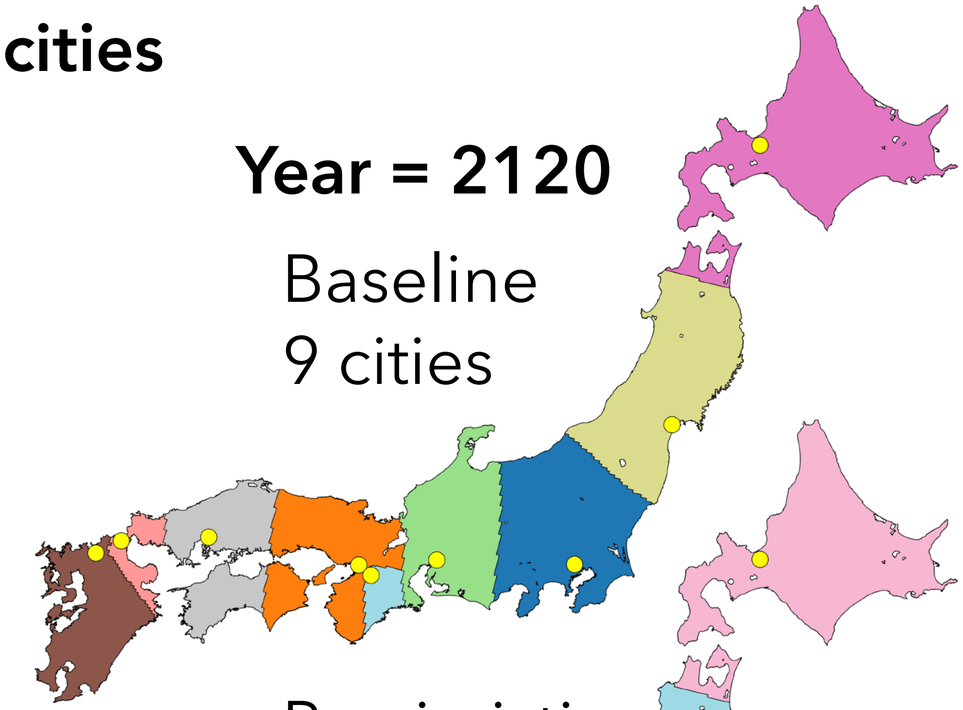
Year = 2020

21 cities



Year = 2120

Baseline
9 cities



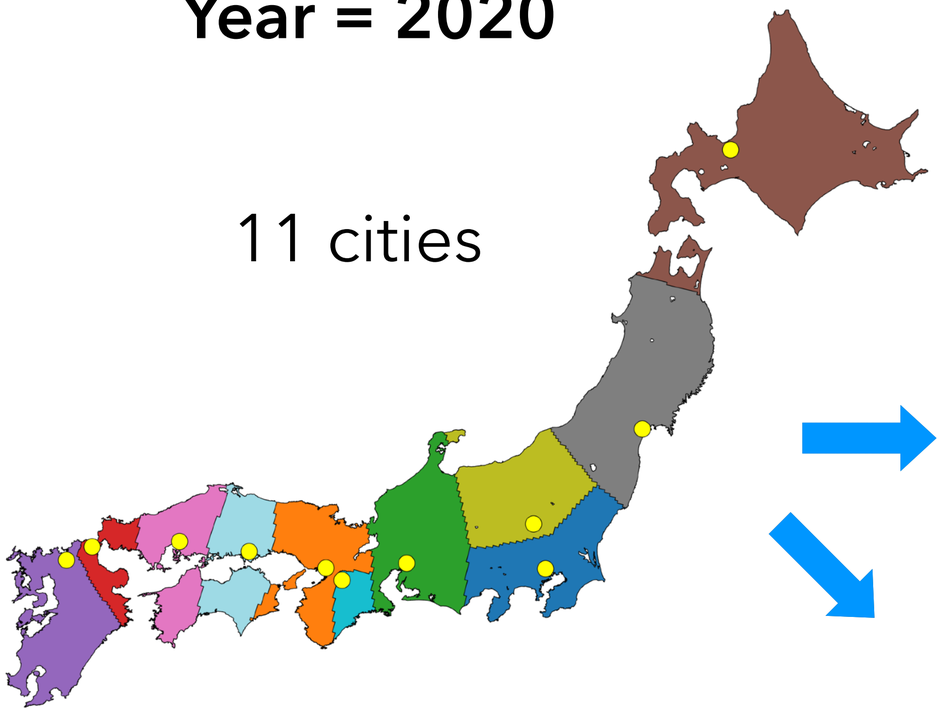
Pessimistic
7 cities

Polarization at the country level

1 million cities

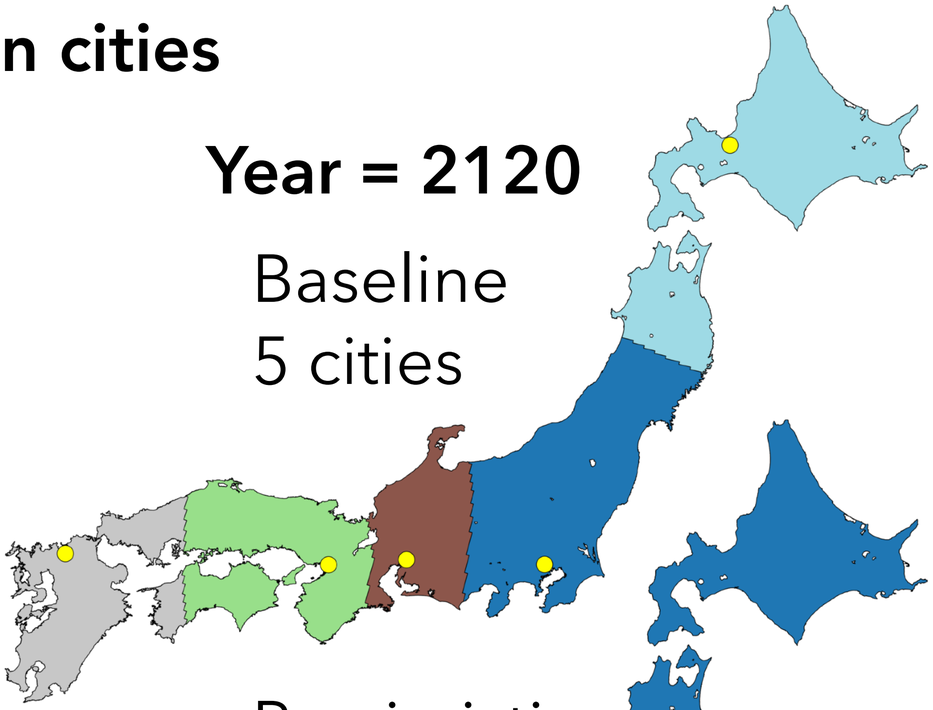
Year = 2020

11 cities



Year = 2120

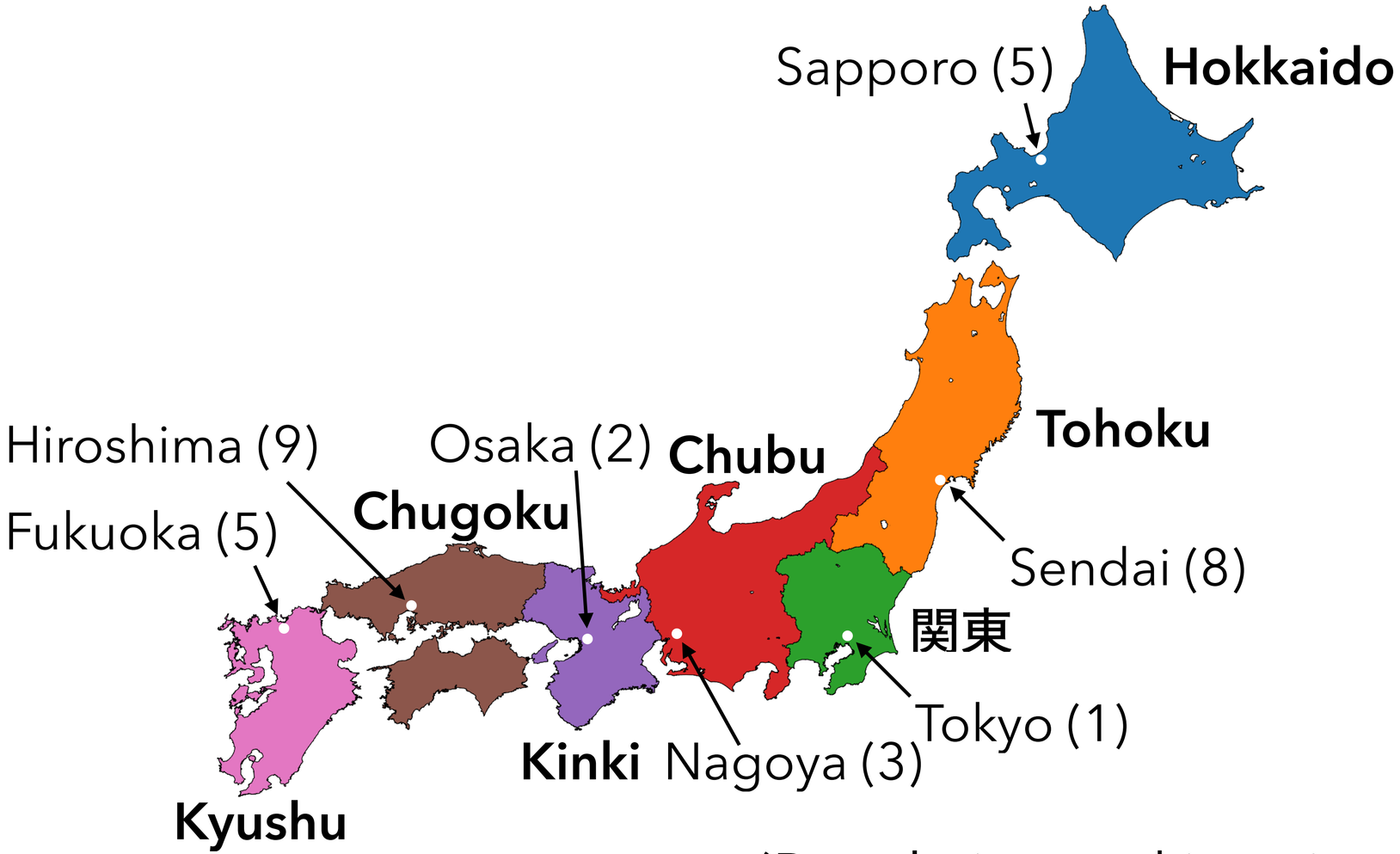
Baseline
5 cities



Pessimistic
4 cities

Polarization at the country level

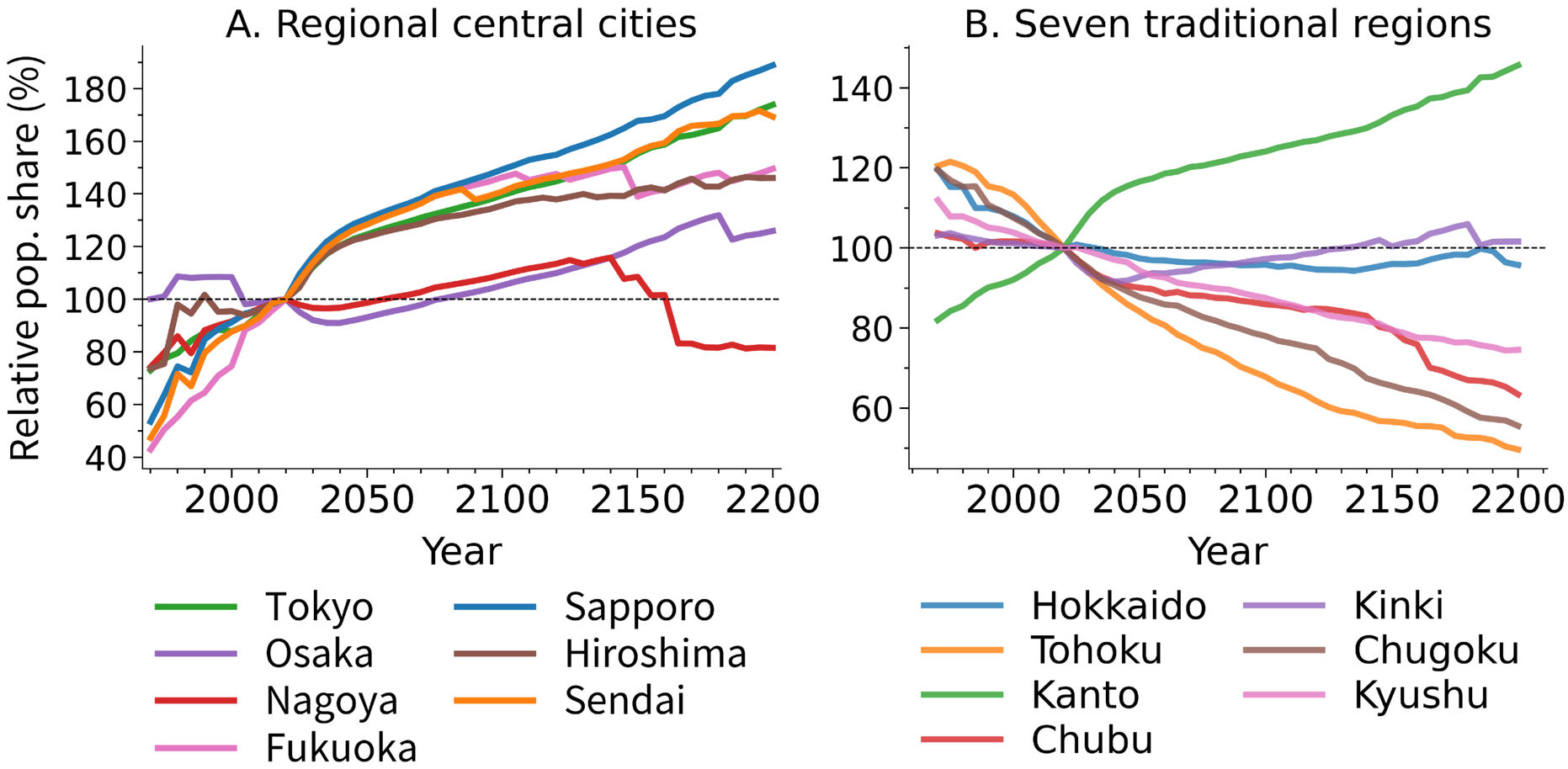
Traditional 7 regional divisions



(Population rankings in parentheses)

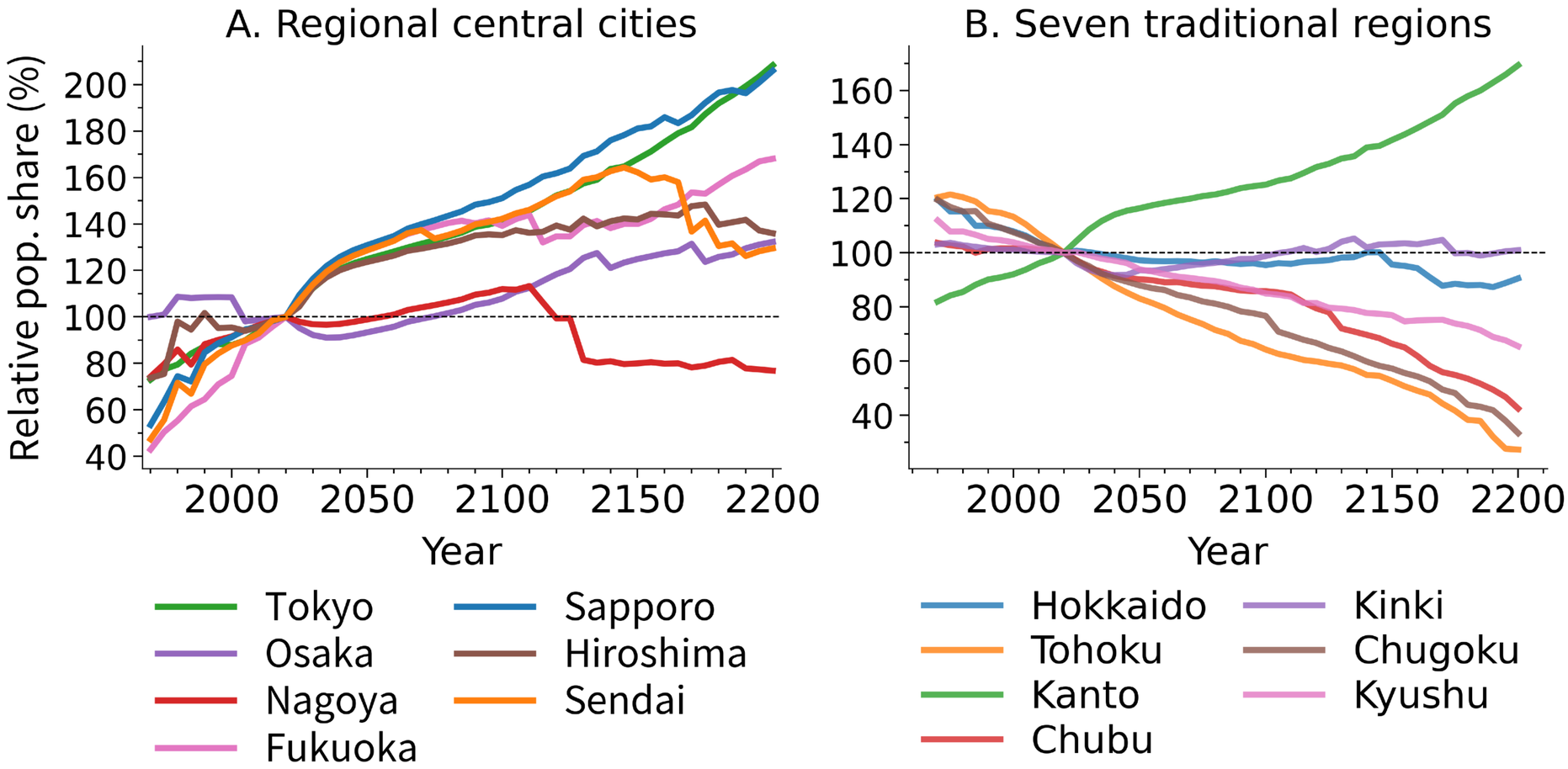
Polarization at the country level

Population concentration in 7 regional divisions (baseline)



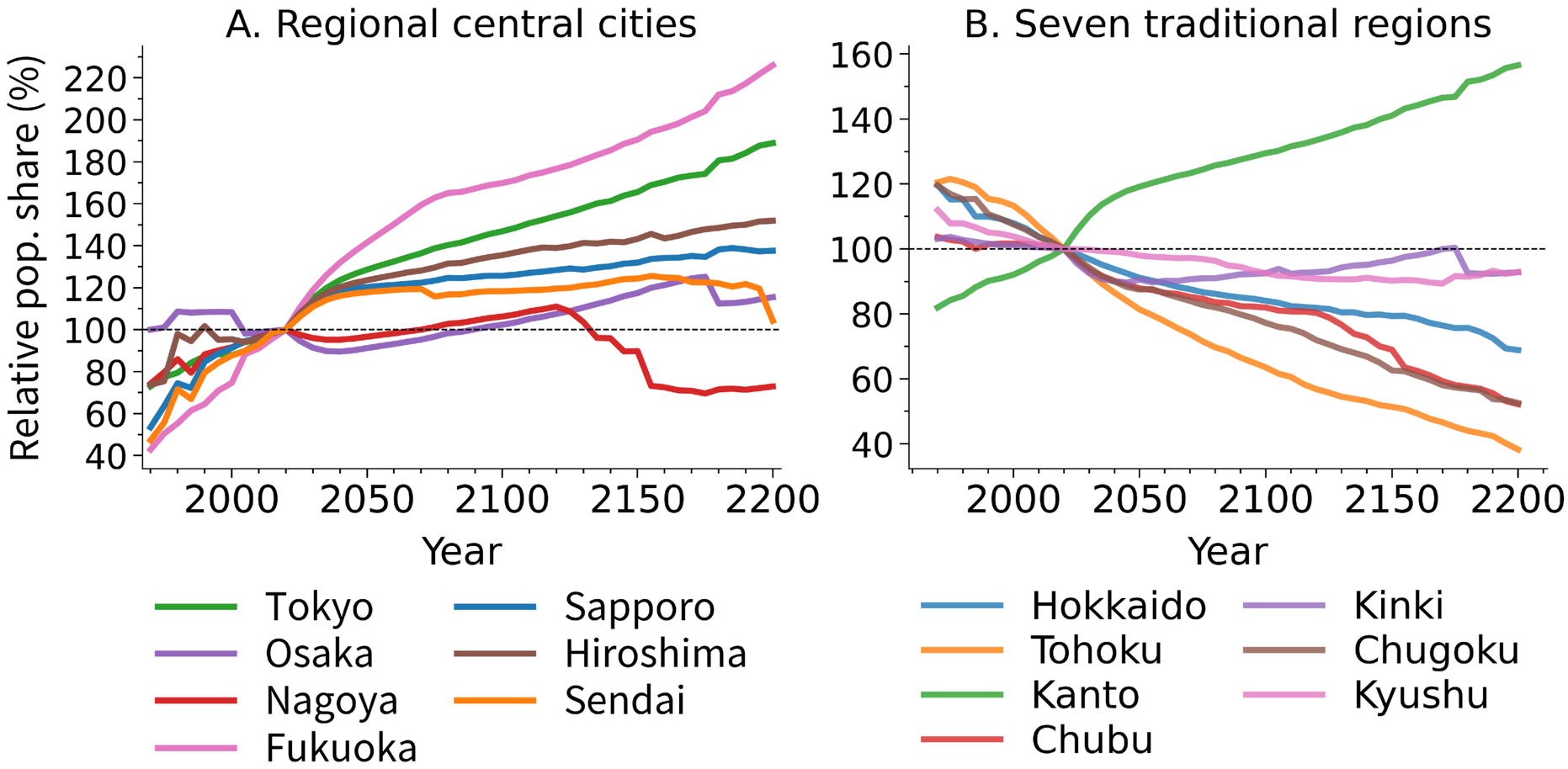
Polarization at the country level

Population concentration in 7 regional divisions (pessimistic)



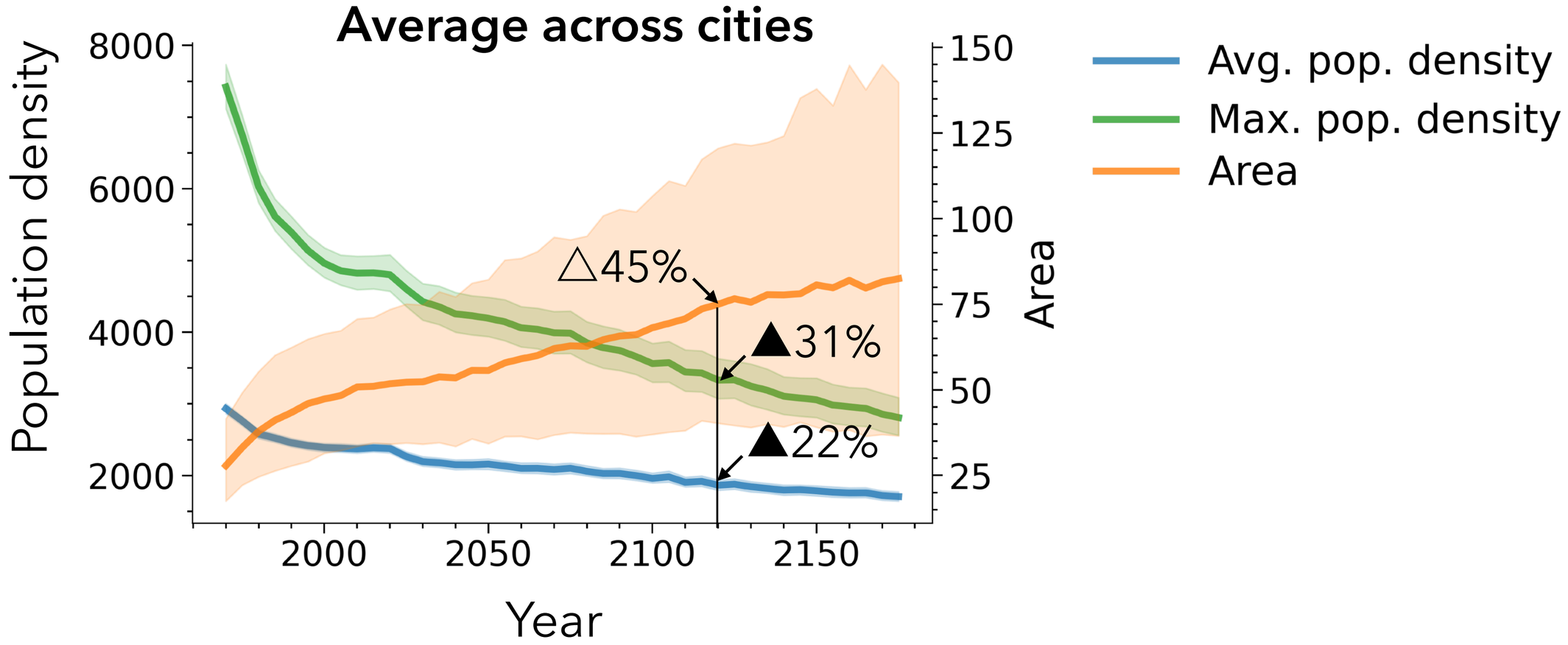
Polarization at the country level

Population concentration in 7 regional divisions (2020 weight)



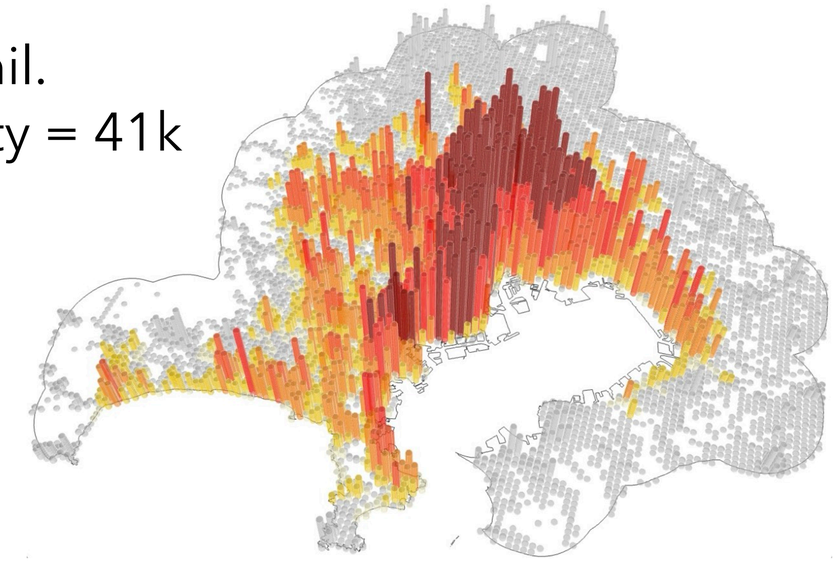
Predicted flattening of individual cities

Baseline scenario

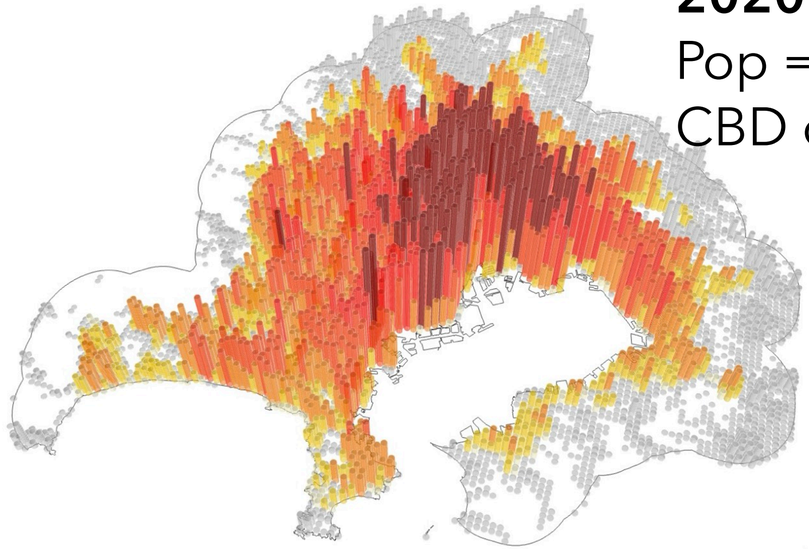


Flattening of large cities – Tokyo (largest)

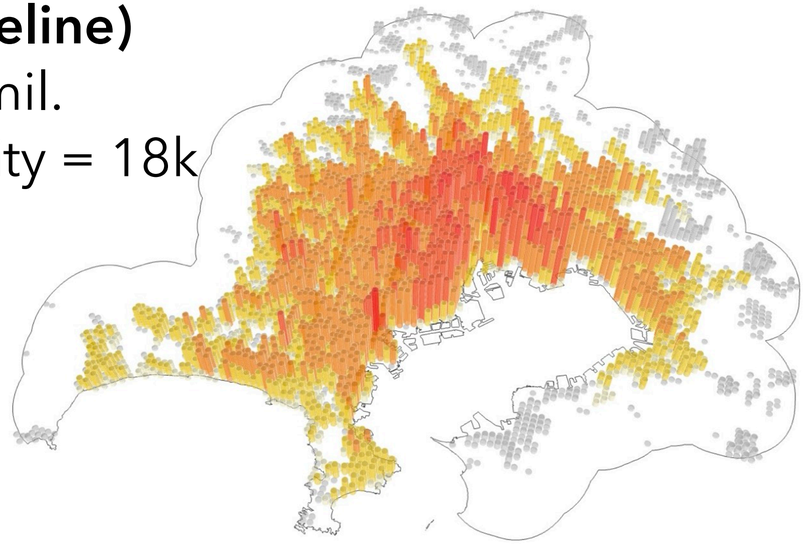
1970
Pop = 21 mil.
CBD density = 41k



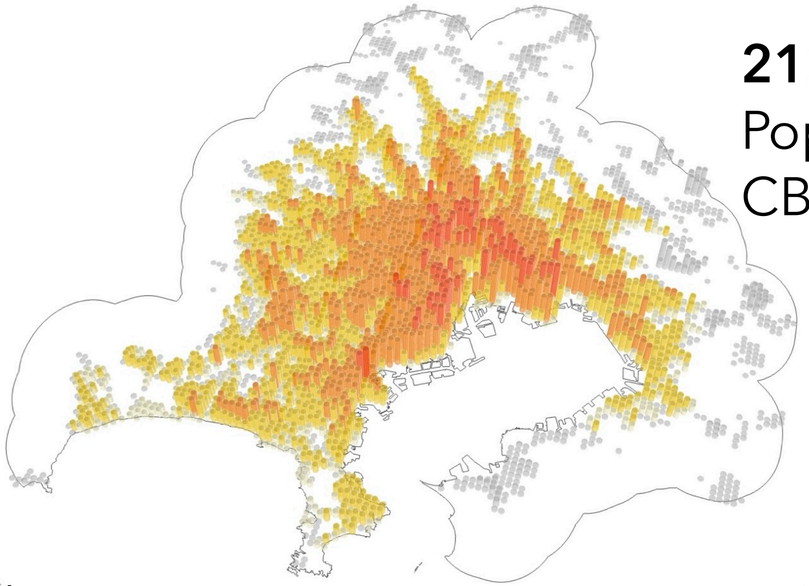
2020
Pop = 34 mil.
CBD density = 33k



2120 (Baseline)
Pop = 20 mil.
CBD density = 18k

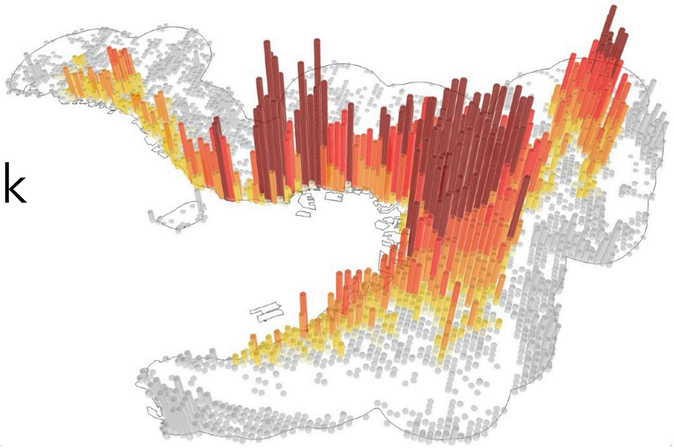


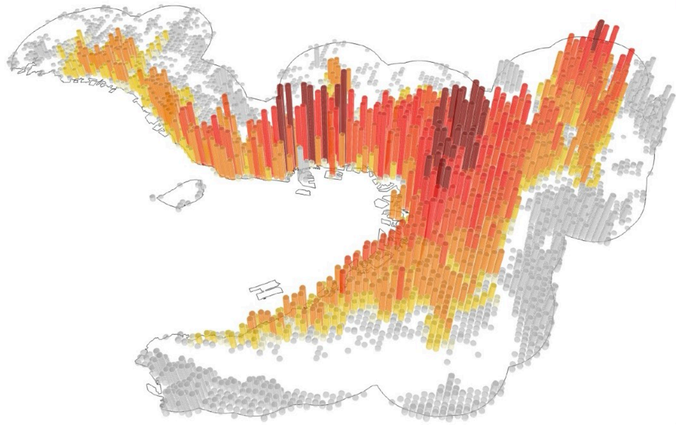
2120 (Pessimistic)
Pop = 14 mil.
CBD density = 14k



Flattening of large cities – Osaka (2nd largest)

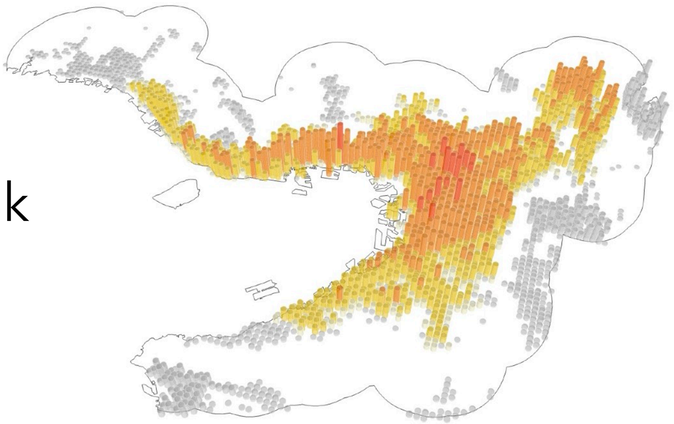
1970
Pop = 12 mil.
CBD density = 41k

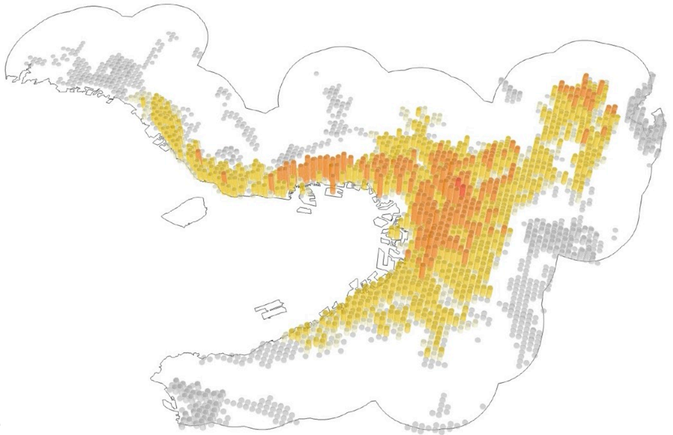




2020
Pop = 15 mil.
CBD density = 29k

2120 (Baseline)
Pop = 6.5 mil.
CBD density = 13k

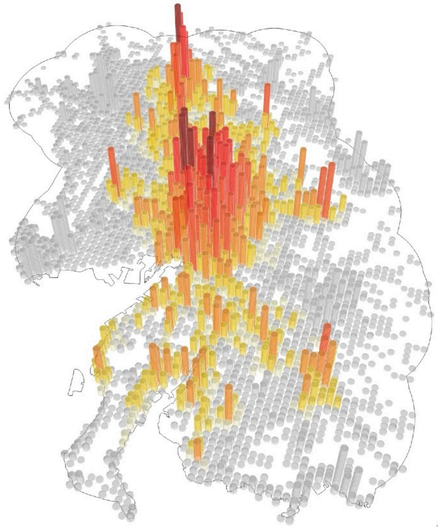


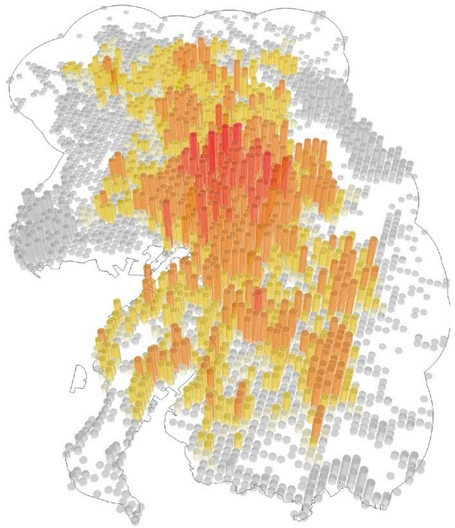


2120 (Pessimistic)
Pop = 4.9 mil.
CBD density = 10k

Flattening of large cities – Nagoya (3rd largest)

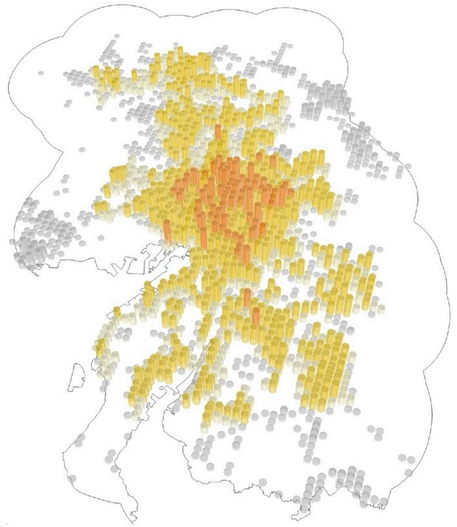
1970
Pop = 4.5 mil.
CBD density = 24k

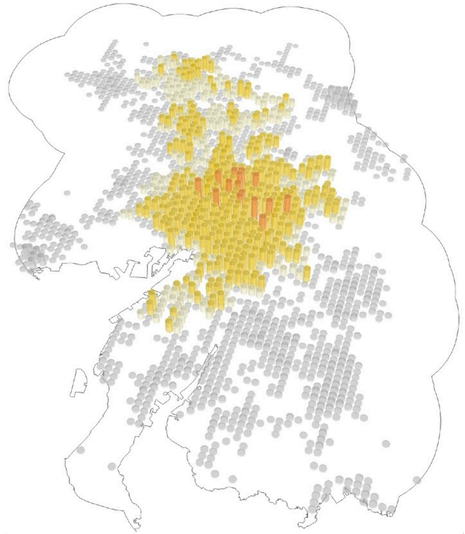




2020
Pop = 7.3 mil.
CBD density = 18k

2120 (Baseline)
Pop = 3.3 mil.
CBD density = 8.2k

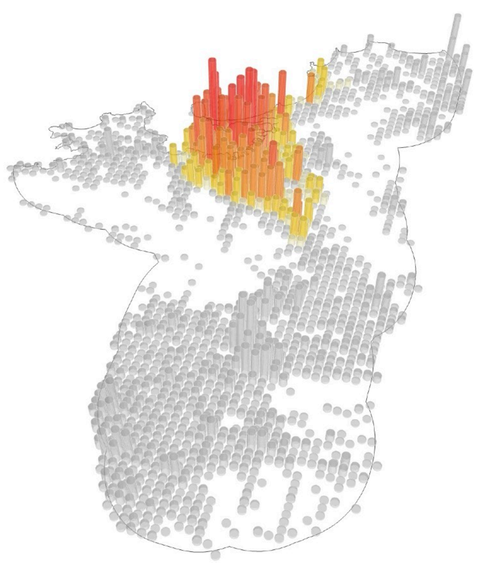


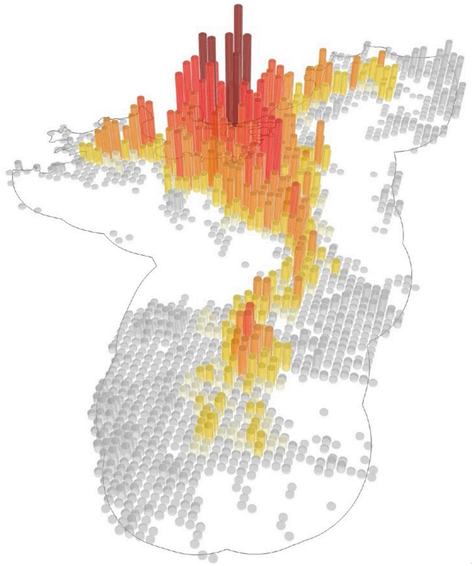


2120 (Pessimistic)
Pop = 2.0 mil.
CBD density = 6.8k

Flattening of large cities – Fukuoka (4th largest)

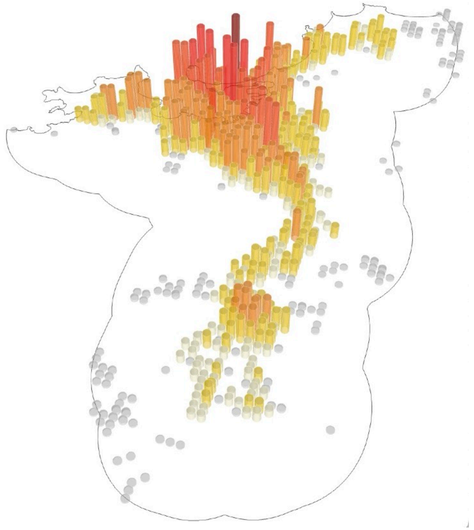
1970
Pop = 1.0 mil.
CBD density = 19k

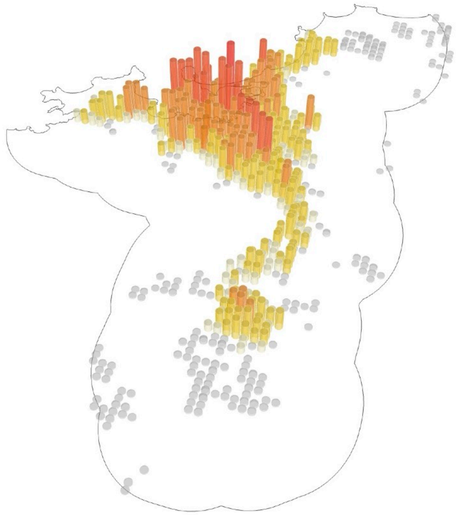




2020
Pop = 2.9 mil.
CBD density = 28k

2120 (Baseline)
Pop = 1.7 mil.
CBD density = 17k

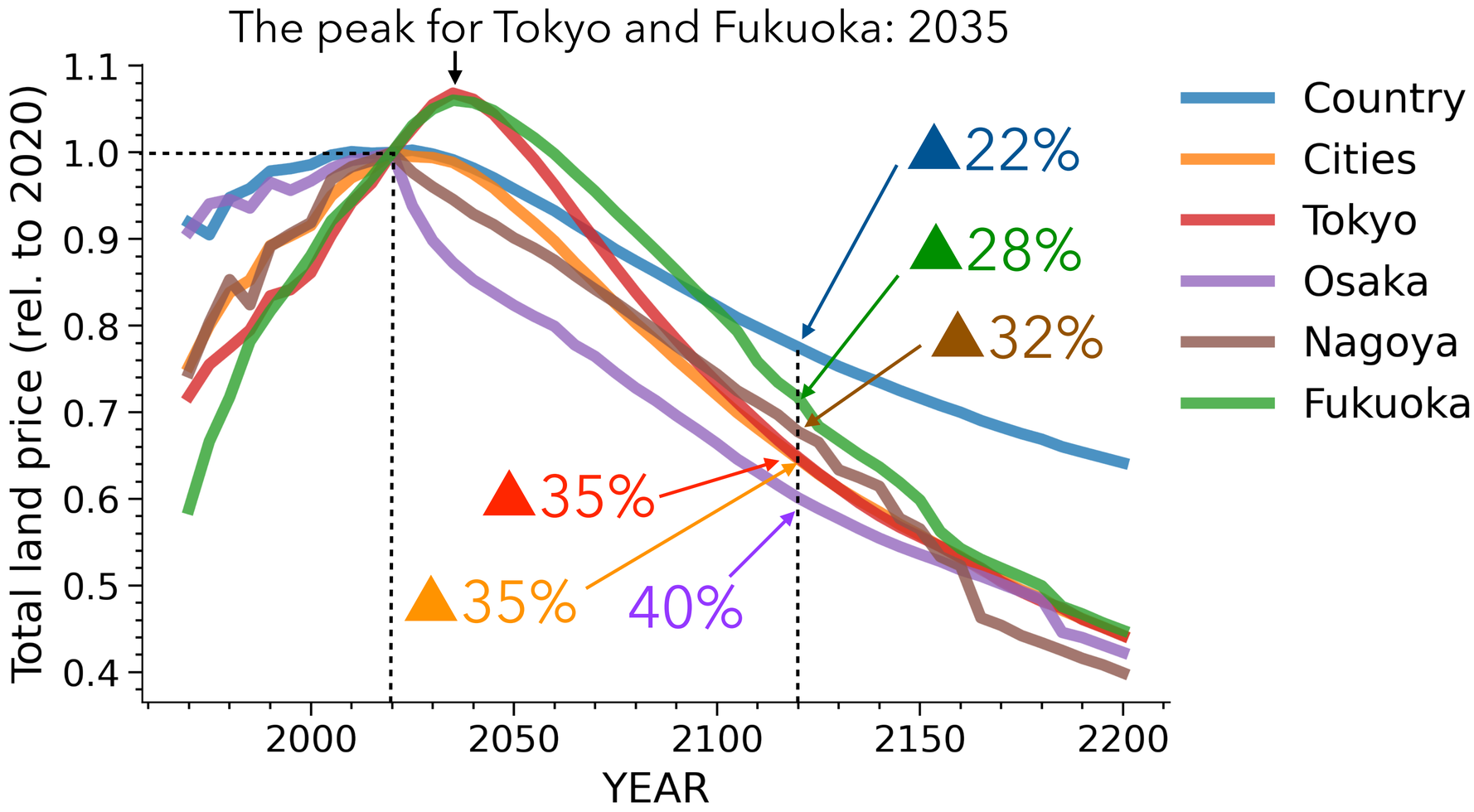




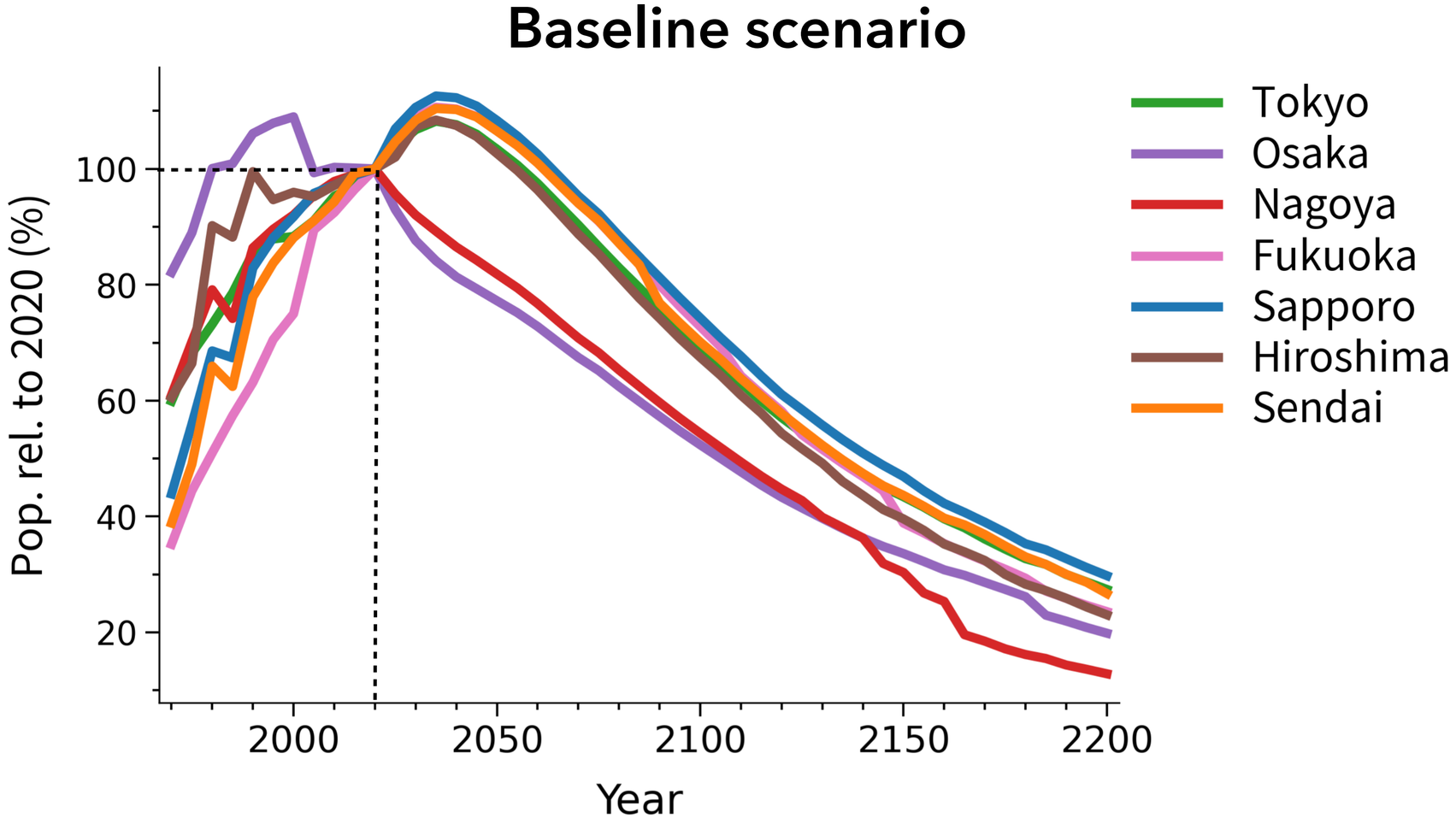
2120 (Pessimistic)
Pop = 1.1 mil.
CBD density = 13k

Land price

Baseline

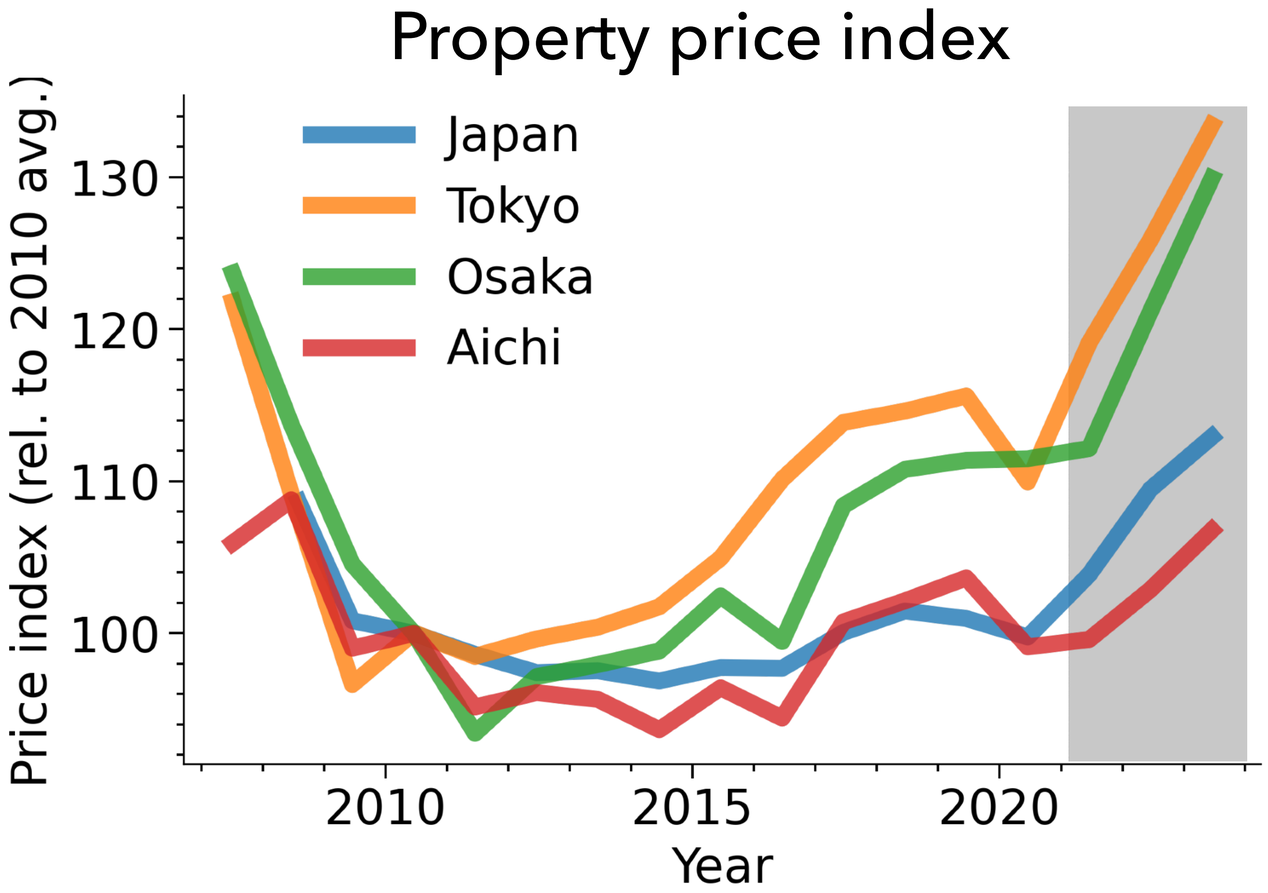


Population of the largest cities in the 7 regional divisions



Property prices in large cities

Real estate bubble in large cities



The bubble will burst soon.

(Data：MLIT, 2024)

Implications

Regional policies under declining population

Rural areas

"Compact city" – Concentrate urban functions and residential areas around the city center.

(Currently 703 municipalities are working on it.)

- #100k cities will decrease from 83 in 2020 to 20-30 in 2120
  ➔ Bold "selection and focus" is needed.
- Against the motivation of households & firms to disperse within a city
- For regions to shrink, promote "smart aggregation" by transforming to a scalable infrastructure

Regional policies under declining population

Rural areas

“Chiho Sousei” or Regional Development Policy

- Population maintenance/increase is the goal (most municipalities/ prefectures are working on it).
- But, in 100 years, the total population will decrease by 60-70%, with 60% of the remaining population concentrated in the three largest cities.

➔ Most regions won’t be able to maintain cities.

➔ Consolidation of hub cities (e.g., remaining 20-30 100k cities): Densification of logistics and human flow

Regional policies under declining population

Rural areas

- Rural areas off the major transport lines

  ➔ Exploit primary industry by utilizing rich agricultural and forestry resources.

  - Ishikari：Cooperative robotic agriculture
  - Miyazaki：Cyclical agriculture

- Rural cities along the Tokaido and Sanyo Highway: Difficult to revitalize

  ➔ Some may survive by reversing the hollowing out of the 80s.

  But, many are destined to disappear.

  Smart aggregation is necessary.

Regional policies under declining population

Major cities

Smart downsizing is urgent.

- Large cities, including Tokyo, are rapidly becoming lower density.
- Housing policies that encourage low-rise and human interaction
  ➔ Rebuilding local communities.
- Seek urban development with high affinity for automated driving and logistics automation
- Shift to disaster resilient zoning

A future that cannot be learned from the past
Limitations of prediction

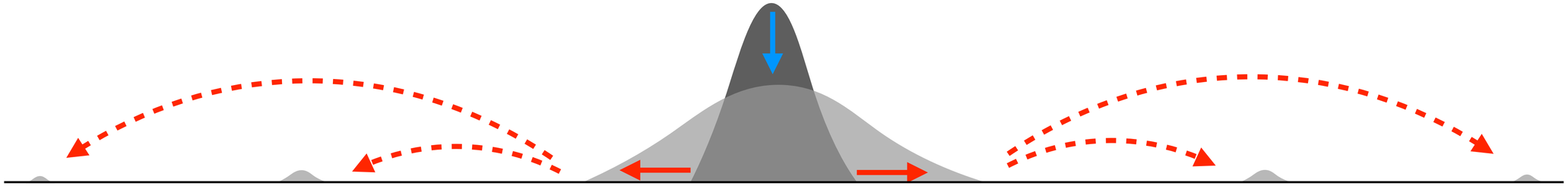
Localization of physical transport access

- Mass transportation by Shinkansen and air transportation need sufficient demand scale.
- Physical transport access will be polarized to a few major cities.
- In rural areas, virtual mobility will be the norm.

A future that cannot be learned from the past
Limitations of prediction

Blurring of urban boundaries

- Flattening of large cities may cross inter-city boundaries.
  (Two-location residence may be more popular.)



Measures for declining birthrate

- In Japan, it is the household's own responsibility to have and raise children.
- Provide support for child rearing comparable to that in Europe.

  ➔ Fertility rate will be boosted to 1.6 by this.

- Promote support for childbirth and child rearing not based on marriage
  - Disappearance of hierarchy in the family
  - Increased difficulty in maintaining marriages/family consensus
  - Avoidance of physical contact in younger generations

  ➔ What does the new form of the family look like?

Population distribution on the map

Past data

1975年　2000年　2020年

Projection under the baseline scenario

2050年　2070年　2120年　2170年　2200年

Projection under the pessimistic scenario

2050年　2070年　2120年　2170年　2200年