



The spatial-temporal evolution toward polycentricity in Chinese cities: dynamics and explanations

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Introduction

The role of polycentric urban city/region (Davoudi, 2003; Faludi, 2005; Parr, 2004)

- an analytical tool
- a planning paradigm to achieve more efficient, sustainable and cohesive spatial development
- an organizing framework for policy intervention (ESDP, 1999).
 - Spatial and regional policy of EU: Polycentricity as an integral policy tool to realize *economic competitiveness and social cohesion*

Polycentrism has been incorporated into China's spatial planning

- mitigate agglomeration inefficiencies;
- balance territorial development;
- coordinate economic development and sustainability goals at city and regional scales (Wang et al., 2019; Wang et al., 2020).

Research Objective

- The extent to which Chinese cities are transitioning towards a polycentric structure over time, along with the determinants shaping this transformation, are ambiguous (Li, 2020; Li & Derudder, 2022; Liu & Wang, 2016).
- Urban spatial patterns are diverse and complex considering a wide range of Chinese cities
- Polycentrism is not universal panacea for cities of all sizes--effectiveness depends on a “critical mass” and developmental stage of cities.
- This study aims to:
 - Evaluate the evolutionary pathway of urban structure in relation to cities of varying sizes
 - Interpret the polycentric patterns considering demographic, economic, and governmental policy dimensions
 - Propose a stylized framework to depict the evolution of urban structures tailored to Chinese context.

Debates on the evolution of urban spatial structure

Urban spatial structure in the Chinese context (initial stage)

- Chinese megacities have undergone decentralization and agglomeration inefficiencies (Hu et al., 2018).
- a dual interplay of market mechanisms and top-down governmental policies (Cheng & Shaw, 2018).
- Public policies affecting urban spatial patterns:
 - A) migration control
 - the relax of Hukou policy (1994)
 - dismantled internal mobility barriers
 - B) regional development policies
 - special development zones & industrial parks
 - C) Establishment of the land and housing market (late 1990s)
 - bid-price: service sectors replace manufacturing in urban center
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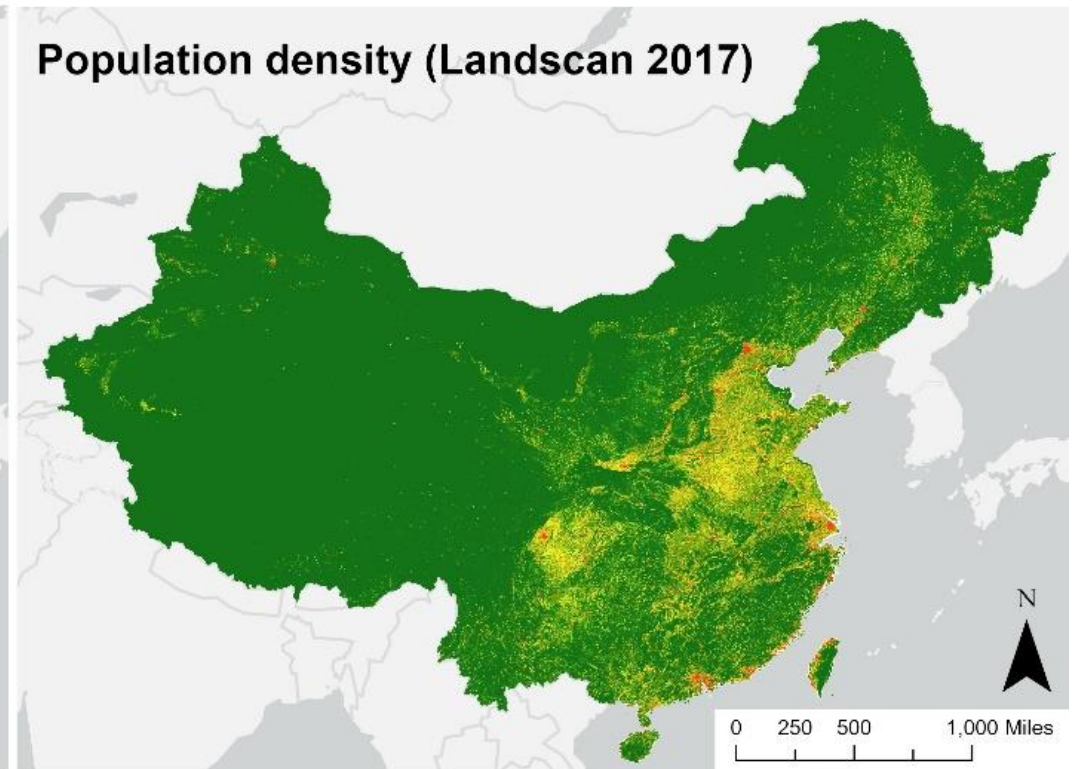
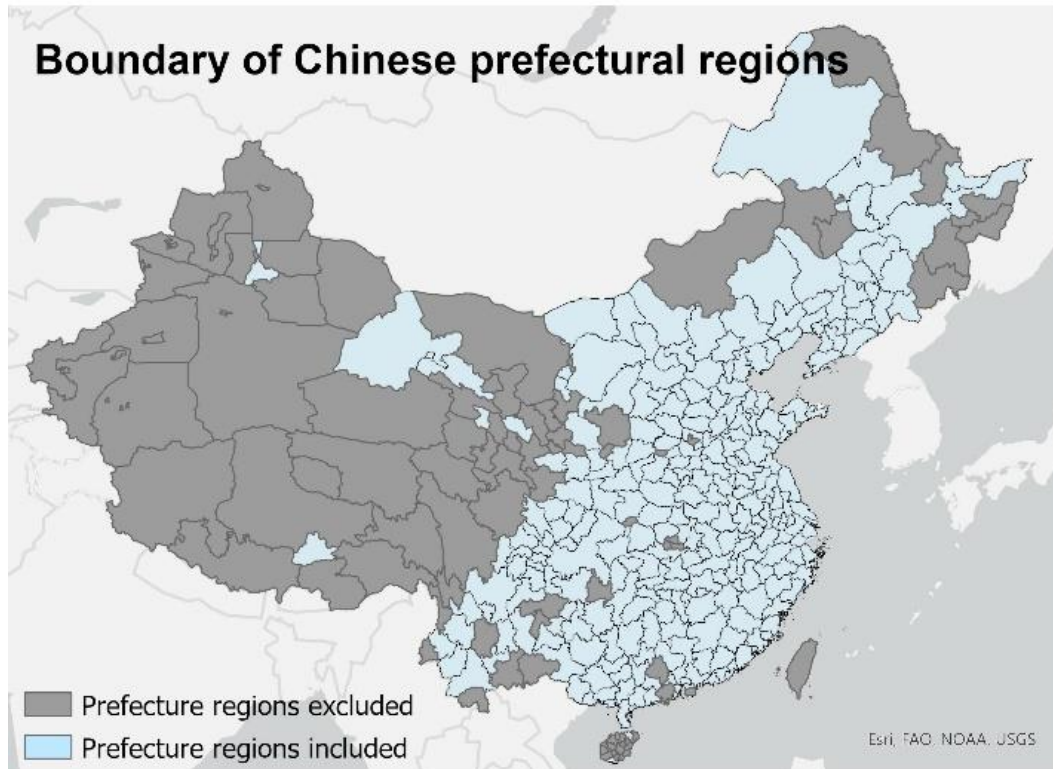
Debates on the evolution of urban spatial structure

Urban spatial structure in the Chinese context (continuing)

- multifaceted challenges of urbanization: traffic congestion, skyrocketing housing prices.
 - stringent market regulation + tailored policy
 - settle in smaller cities was lifted, settle in megacities became increasingly restricted
 - stringent restrictions on real estate transactions in large cities and main center
 - large cities toward a decentralized and polycentric pattern
 - smaller cities: more choices in locational decision making, driven by personal preferences and accessibility
-
- **More recent trend:** shifted focus from prioritizing economic growth to emphasizing on developing more efficient and sustainable urbanization patterns.
 - Polycentricity: mitigating agglomeration diseconomies, cultivating new economic hubs, and coordinating regional growth
 - City-level planning policies: subcenters, enclave, special zones
 - industrial parks, administrative centers, high-speed rail districts, and innovation centers

Data and Methods---delineating regions, identifying centers, and operationalizing polycentricity

- Regions: 269 Chinese prefectural cities, exclude cities lacking significant centers
- LandScan datasets: 1km-by-1km population cell in 2002 and 2017



Identifying (sub)centers -- A combined approach

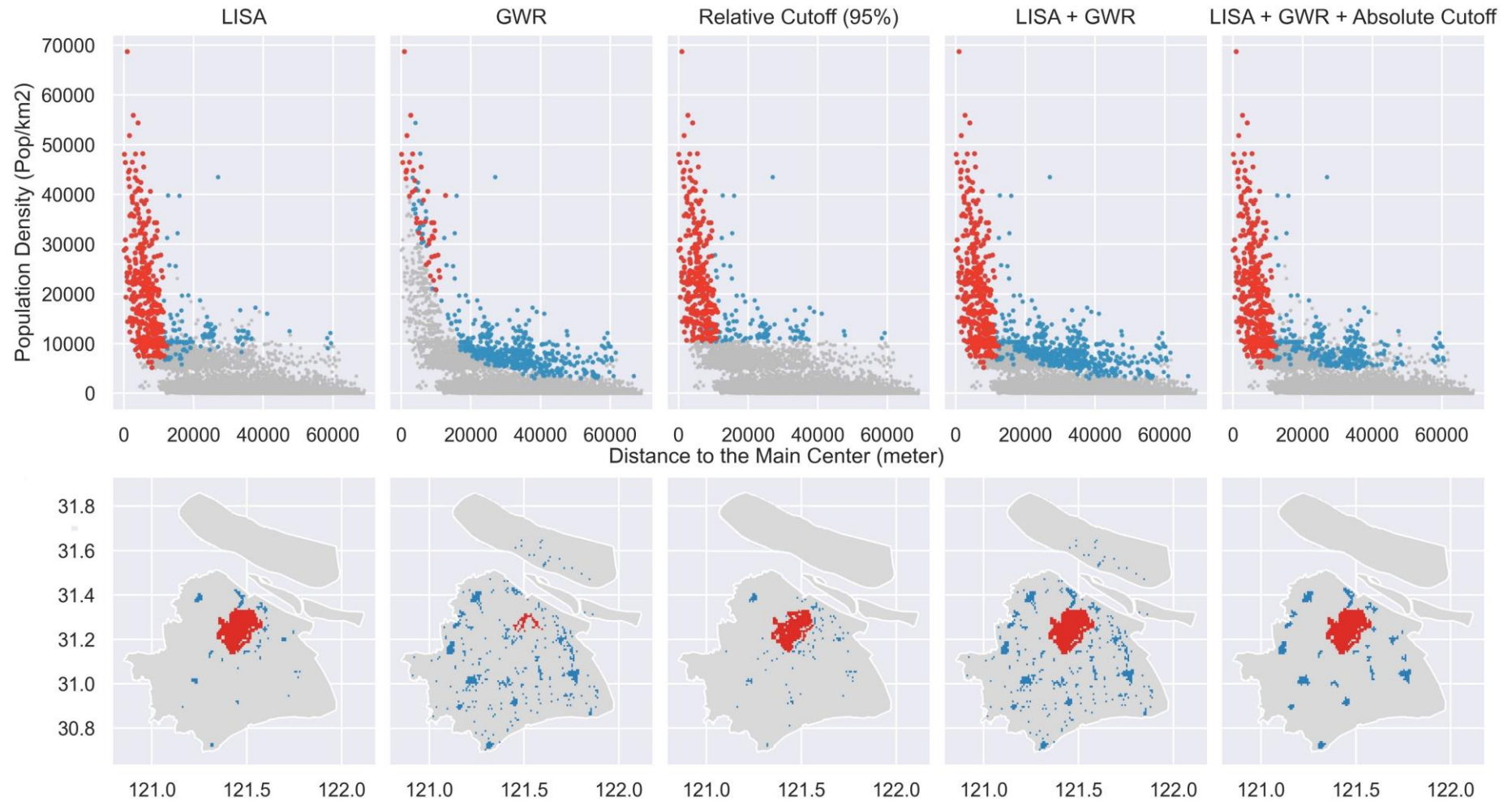
Shanghai as an example:

Step 1: LISA – selecting significant HH and HL cells

Step 2: GWR regression –selecting significant residuals

Step 3: Combining the selected cells in LISA and GWR

Step 4: Selecting (sub)centers that have at least two continuous cells and total population at least 50,000



Stepwise Polycentricity (SP)

Step 1:

$$P(n) = \left(1 - \frac{\sigma_f}{\sigma_{f,max}}\right)$$

σ_f : the population standard deviation of all identified centers;

$\sigma_{f,max}$: the maximum standard deviation of a binary monocentric city

Step 2:

$$SP(n) = \frac{P(n)}{P_{Zipf}(n)}$$


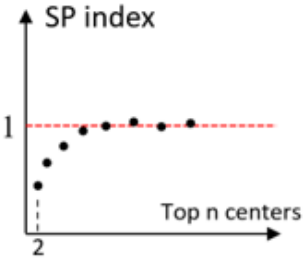

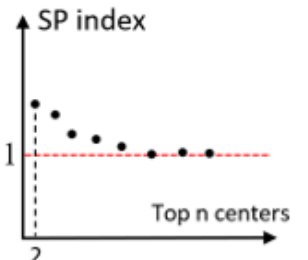

$P_{Zipf}(n)$: a city with (sub)centers strictly follows the Zipf law

Zipf's law: the population of a center is inversely proportional to its rank.

Continuous Polycentricity

$$P(n) = \left(1 - \frac{\sigma_f}{\sigma_{f,max}}\right)$$

Table 1: The definitions, trajectories, and stylized diagrams of the stepwise polycentricity (SP) typology modified from Zhang and Derudder (2019)

Group Names	Definitions	Trajectories of stepwise polycentricity	Diagrams of urban structure
Group 1: <u>Monocentricity</u>	<ul style="list-style-type: none"> • Single-centered region—only one center identified 	N/A	
Group 2: Multicentricity	<ul style="list-style-type: none"> • A region with two or more centers, but the size distribution of centers is less balanced than that of a benchmark region following Zipf's Law. • The SP indices for a minimum of the top two centers are less than 1. 		
Group 3: Polycentricity	<ul style="list-style-type: none"> • A region with at least two centers and the size distribution of centers either follows Zipf's Law or demonstrates a more balanced distribution compared to a benchmark city following Zipf's Law. • The SP indices for a minimum of the top two centers are equal to or greater than 1. 		

The evolutionary patterns of urban spatial structure for Chinese cities

- a general convergence towards multicentricity (G2) from two distinct directions (G1 and G3)
- the coexistence of trends in both increasing and decreasing polycentricity

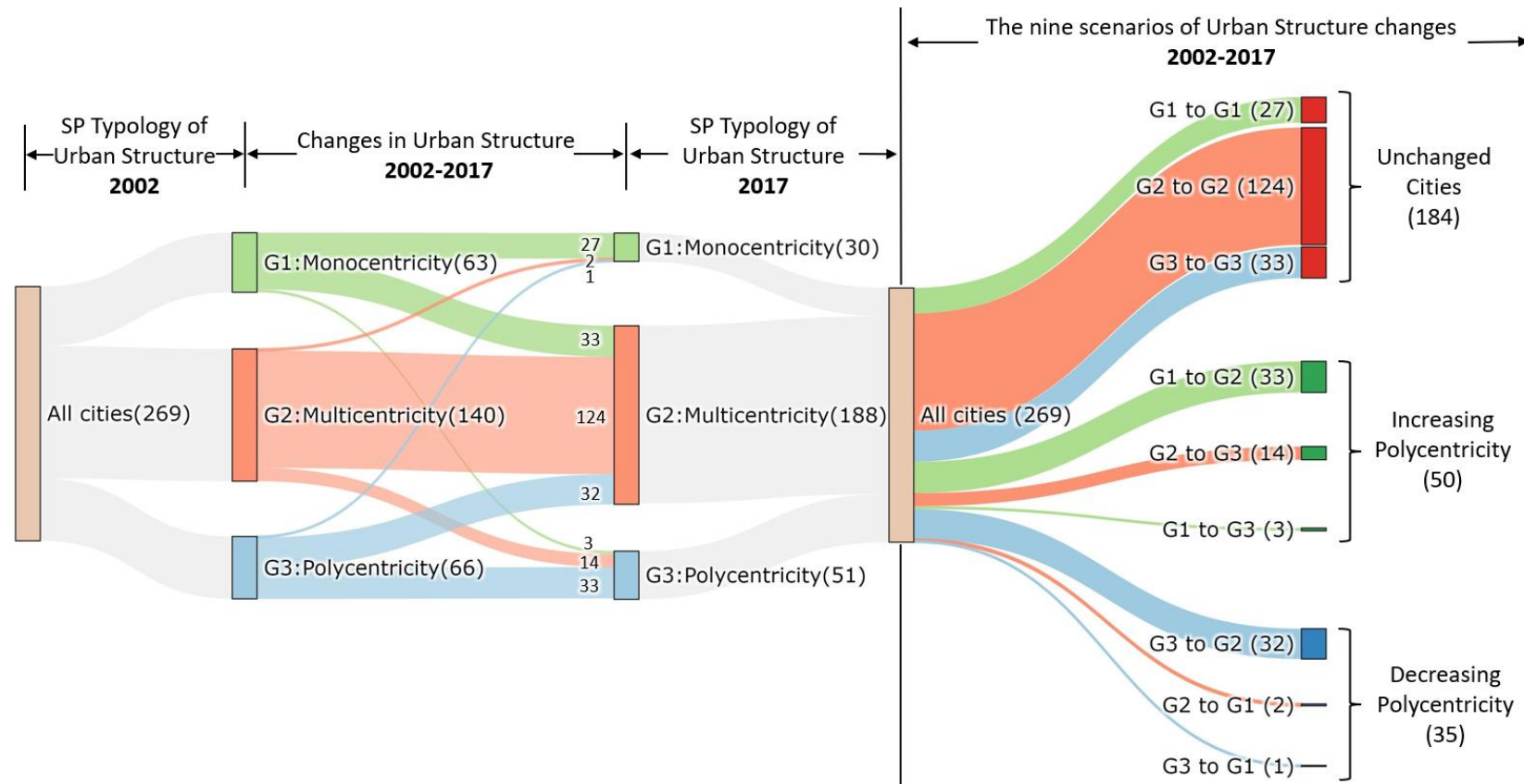
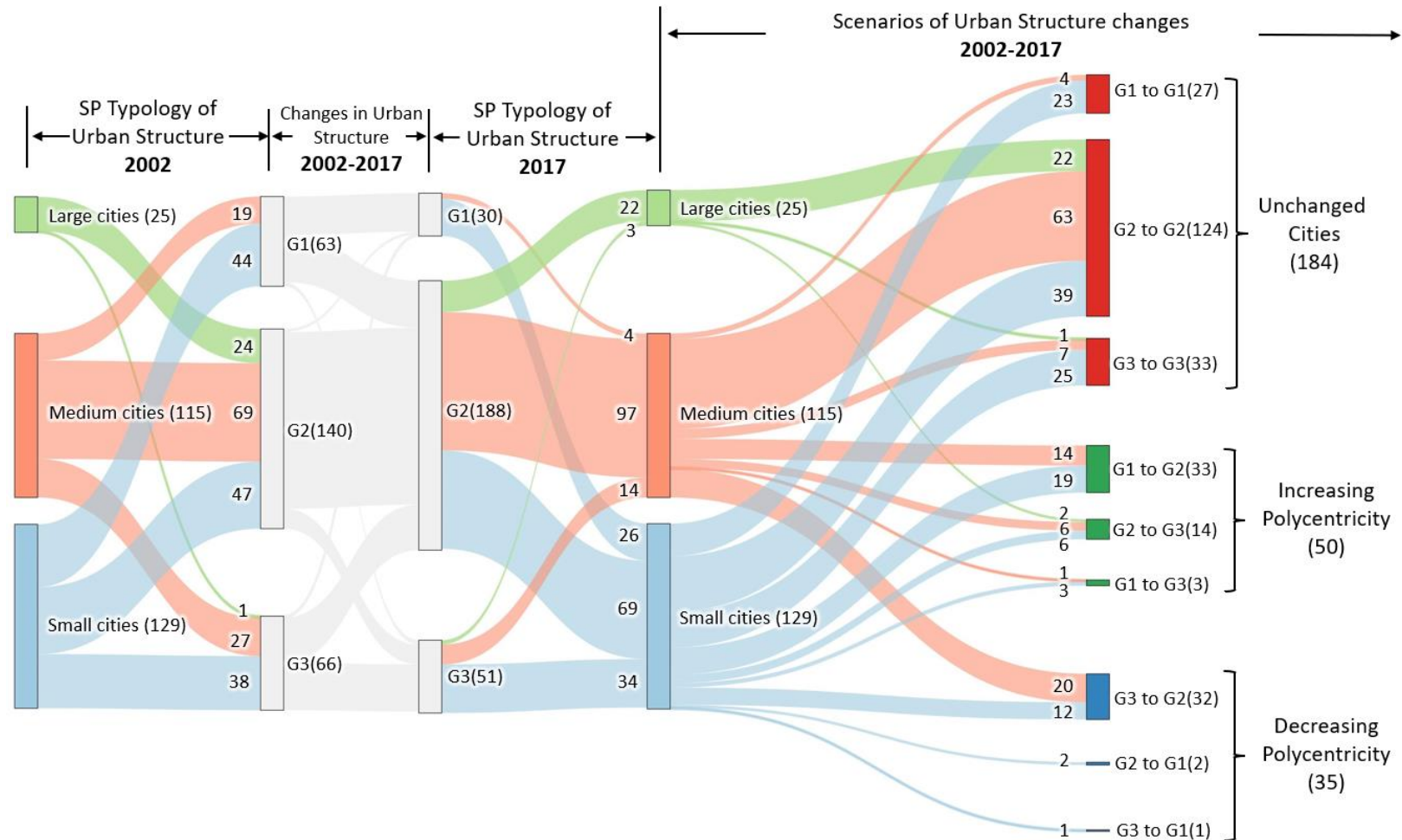


Figure 3: urban spatial structure of 269 Chinese prefectural cities in 2002 and 2017 categorized by the SP typology (G1, G2, G3), and their evolutionary patterns into three groups: unchanged cities, cities with increasing polycentricity, and cities with decreasing polycentricity.

The evolutionary patterns of urban spatial structure for Chinese cities

- a noticeable trend towards multicentricity (G2) for medium- and small-sized cities
- a blend of increasing and decreasing trends in polycentricity for medium- and small-sized cities



A further examination on the “unchanged” scenarios using **continuous polycentricity**

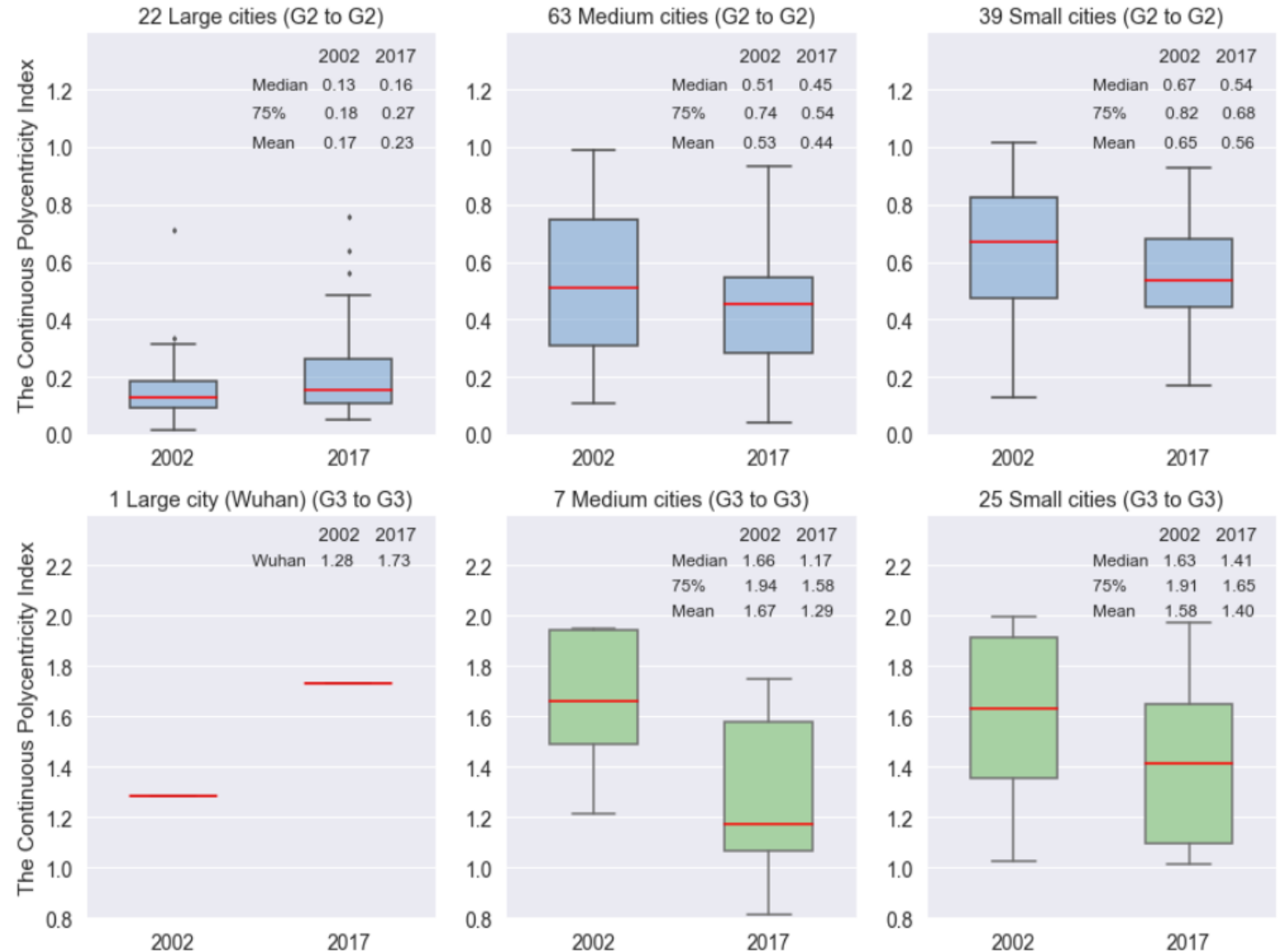
A total of 184 cities are categorized as “unchanged” (68% of all cities)

Large cities (G2 to G2; G3 to G3)

- moderate increase in polycentricity (25)

Medium- and small-sized cities:

- a prevailing trend of declining polycentricity
- 134 cities



The relationships between polycentric configuration and population and economic growth

GDP-related comparisons statistically insignificant.

Population?

- Large cities:
 - G2 to G3 > G2 to G2
- Small and medium cities:
 - G2 to G2 > other Groups

Table 2: population and GDP per capita levels in 2017 and growth rates between 2002 and 2017 for six groups of interest: G2 to G2, G1 to G1, G3 to G3, G1 to G2, G2 to G3, and G3 to G2.

Cities	Reference G2 to G2	G3 to G3	G3 to G2	G1 to G2	G2 to G3
Total population 2017					
Large city	12239	-	-	-	10764
Medium & Small city	4802	3341-**	4093-*	3637-**	3707-*
Growth rate of population 2002-2017					
Large city	1.37	-	-	-	1.74+*
Medium & Small city	1.06	1.05	1.16+*	1.15+*	1.10
GDP per capita 2017					
Large city	98.5	-	-	-	128.3
Medium & Small city	52.3	49.2	52.8	54.7	49.1
Growth rate of GDP per capita 2002-2017					
Large city	4.77	-	-	-	4.22
Medium & Small city	6.59	6.96	6.53	7.28	6.47

P-value is significant at * p<.05, ** p<.01. Reference group: G2 to G2.

(1) The unit of population is a thousand people, and the unit of GDP per capita is a thousand RMB. (2) The growth rate is defined as the value in 2017 divided by the value in 2002.

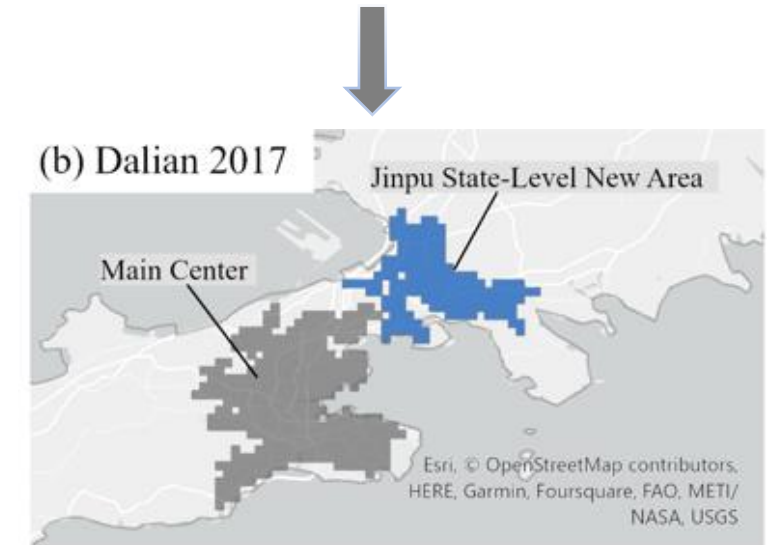
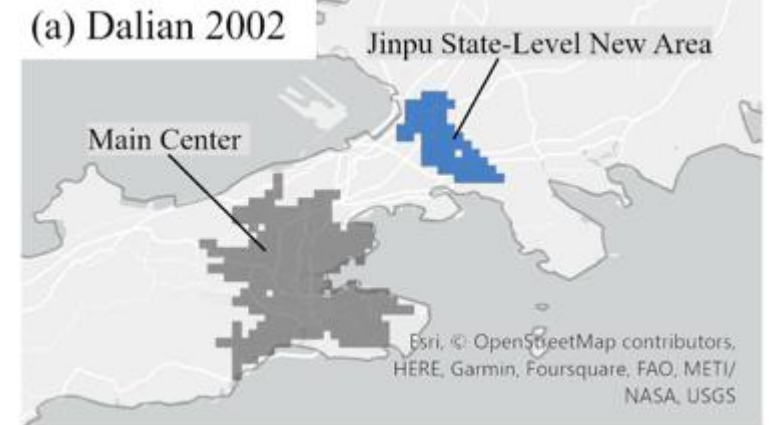
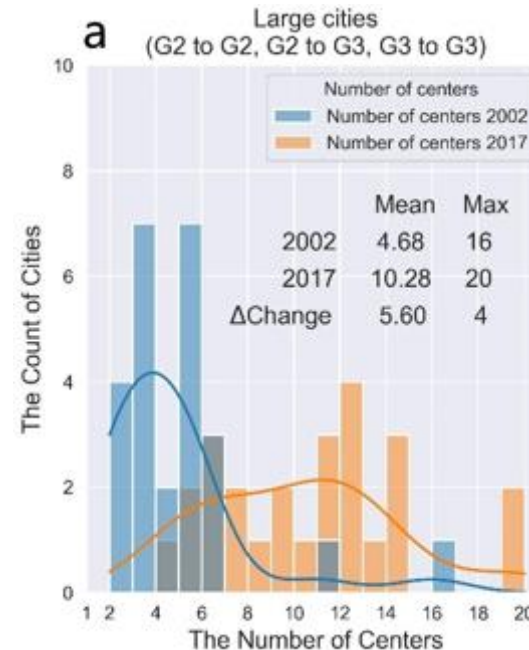
(3) Data source: the CEIC database and the statistical yearbooks of prefectural cities of China.

The interpretation of polycentric configuration

Large cities

- decentralization and polycentricity
- migrants toward city subcenters (65% vs. 230%):
 - stringent regulation and housing prices
 - Special zone development
 - 11 out of 19 State-level new economic districts
 - Sub-level Master plans (city and county scale)
 - Regional cooperation and governance (enclave development and industrial parks)

	Column 1
City	Large city; increasing polycentricity
Count of cities	25 cities
Scenarios	G2 to G2 (22) G3 to G3 (1) G2 to G3 (2)
2002	
Main center population	2,150,381
Subcenters population	452,012
2017	
Main center population	5,050,429
Subcenters population	3,554,799
Growth rate of total population (%)	
Main center population (%)	65.31%
Subcenters population (%)	230.88%

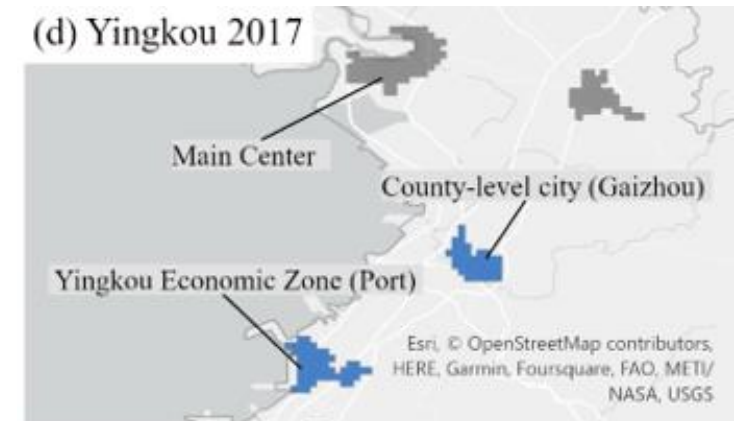
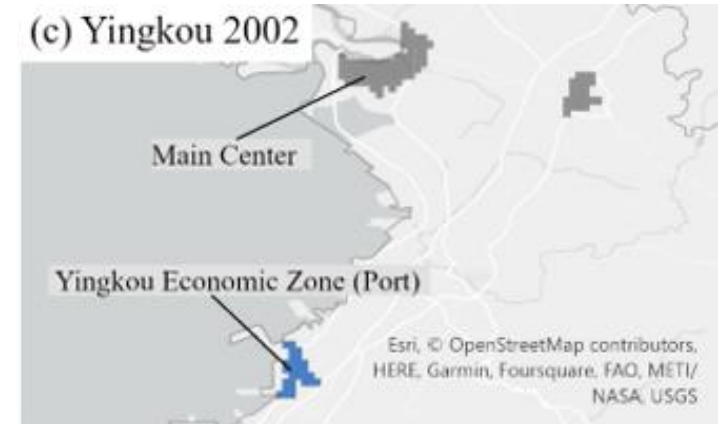
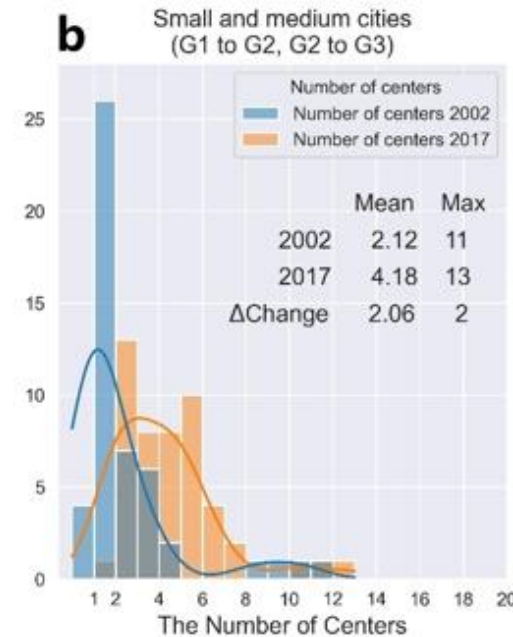


The interpretation of polycentric configuration

Small- and medium-sized cities? (mixed trends)

- towards increased polycentricity:
 - G1 to G2, G2 to G3 (45 cities)
 - Population decentralization: subcenters (288%) vs. main center (50%)
 - Growth of subcenters: 2.06
- Functional new zones and towns – local scale (enclave development)

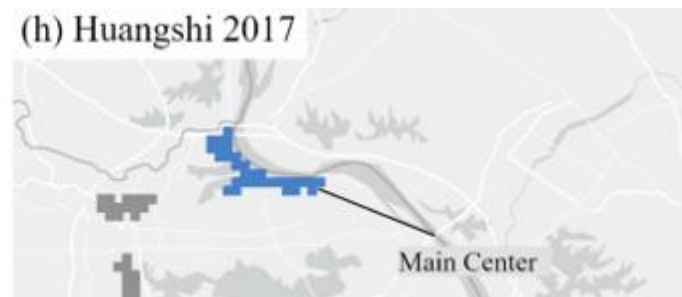
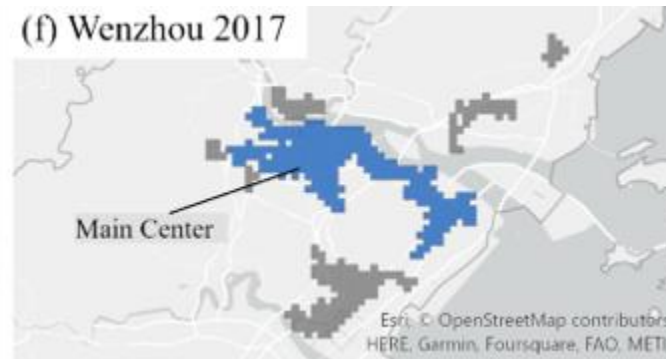
	Column 2
City	Small & medium cities; increasing polycentricity
Count of cities	45 cities
Scenarios	G1 to G2 (33) G2 to G3 (12)
2002	
Main center population	323,214
Subcenters population	80,459
2017	
Main center population	486,060
Subcenters population	312,923
Growth rate of total population (%)	
Main center population (%)	50.38%
Subcenters population (%)	288.92%



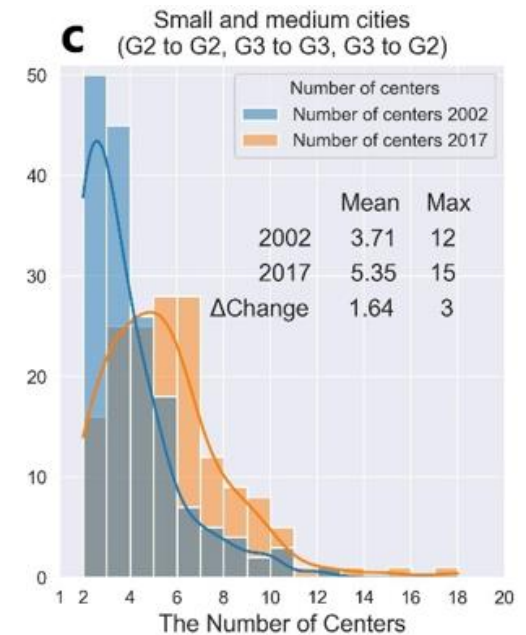
The interpretation of polycentric configuration

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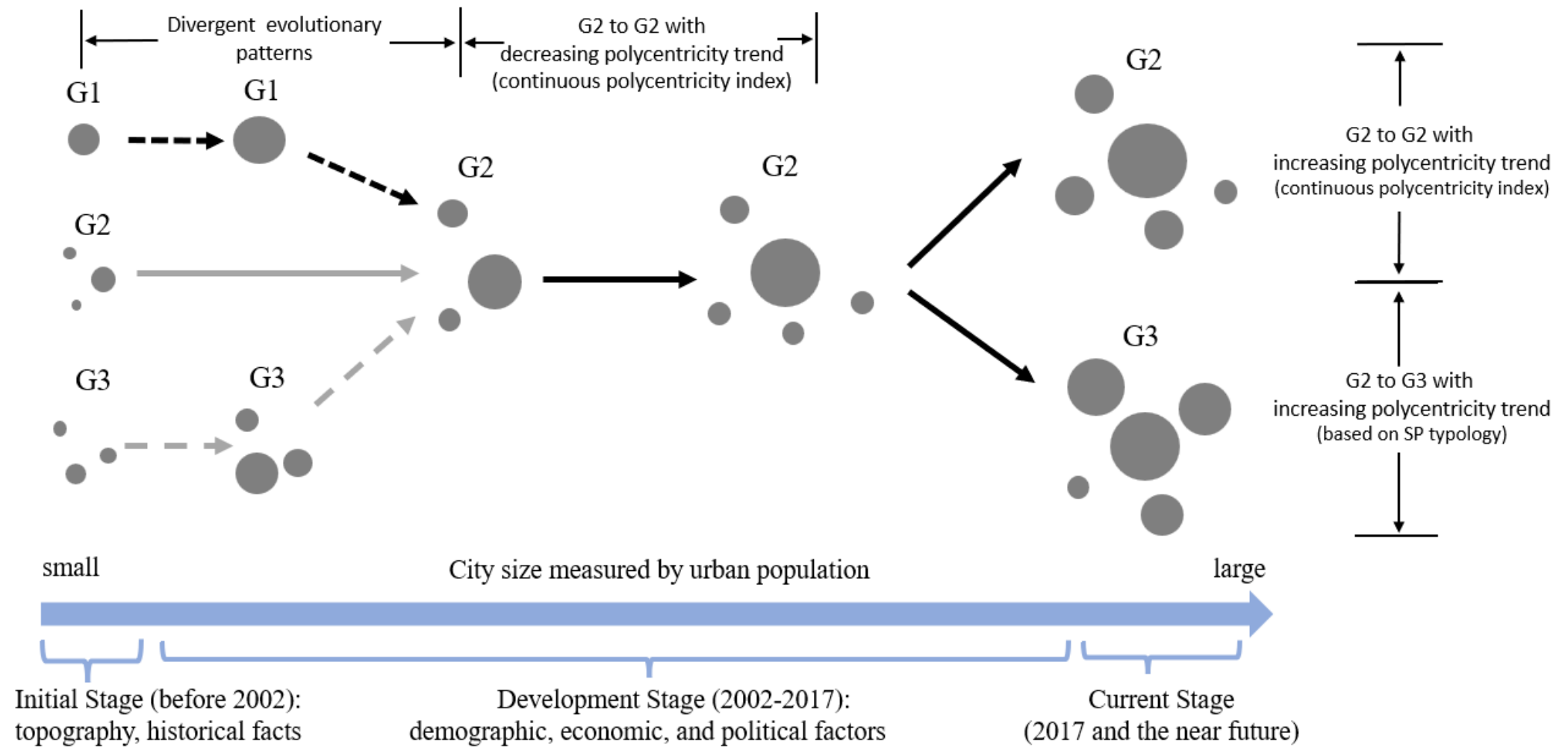
- towards decreased polycentricity
 - G3 to G2, G2 to G2, G3 to G3 (164 cities)
 - Population growth: subcenters (80%) vs. main center (72%)
 - Growth of subcenters: 1.64



	Column 3
City	Small & medium cities; decreasing polycentricity
Count of cities	166 cities
Scenarios	G2 to G2 (102) G3 to G3 (32) G2 to G3 (32)
2002	
Main center population	362,312
Subcenters population	252,311
2017	
Main center population	621,784
Subcenters population	455,072
Growth rate of total population (%)	
Main center population (%)	71.62%
Subcenters population (%)	80.36%



The evolutionary patterns of urban spatial structure for Chinese cities



Conclusion

- We observe a universal trend toward polycentricity only in the 25 largest cities
 - 22 cities have exhibited a moderate increase toward polycentricity
 - 2 cities, Shenzhen and Foshan, have shifted from a multicentric to a polycentric pattern.
- Governmental regulations that promote subcenter development and the stringent growth controls on the traditional urban core drive the polycentric and decentralized urban spatial pattern observed in large cities.
- Evolutionary patterns are more diverse and complex for small- and medium-sized cities
 - Increased polycentricity: 45 cities
 - G1 to G2: the emergence of subcenter(s): population driven
 - G2 to G3: the transformation of multicentric to polycentric ones: policy driven
 - Decreased polycentricity: 134 cities
 - G2 to G2 and G3 to G3
 - G3 to G2: influx of migrants toward main center

Questions and Comments

Thank you!

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Debates on the evolution of urban spatial structure

Market forces and the U.S. case

- two opposing forces that shape urban spatial structure:
 - agglomeration advantages (centripetal): input sharing, labor market pooling, and knowledge spillovers -> monocentric pattern
 - agglomeration diseconomies (centrifugal), alongside reduced transport costs and evolving housing preference -> decentralization pattern
- Two alternative models
 - Polycentricity: “decentralized concentration” —agglomeration economies and transport costs persist as the centripetal forces shaping cities.
 - Generalized dispersion (Lang, 2003): the absence of prominent urban centers and the benefits of agglomeration dilute throughout region
- the viability of polycentric spatial structure may vary depending on local context and there is no universal agreement on which specific urban patterns should be encouraged.

The interpretation of stepwise polycentricity (SP) trajectories

Shenzhen

- G2 (multicentric)-> G3 (polycentric)

Tianjin

- G2 to G2
- nuanced shift toward polycentricity

Wuhan

- G3 to G3

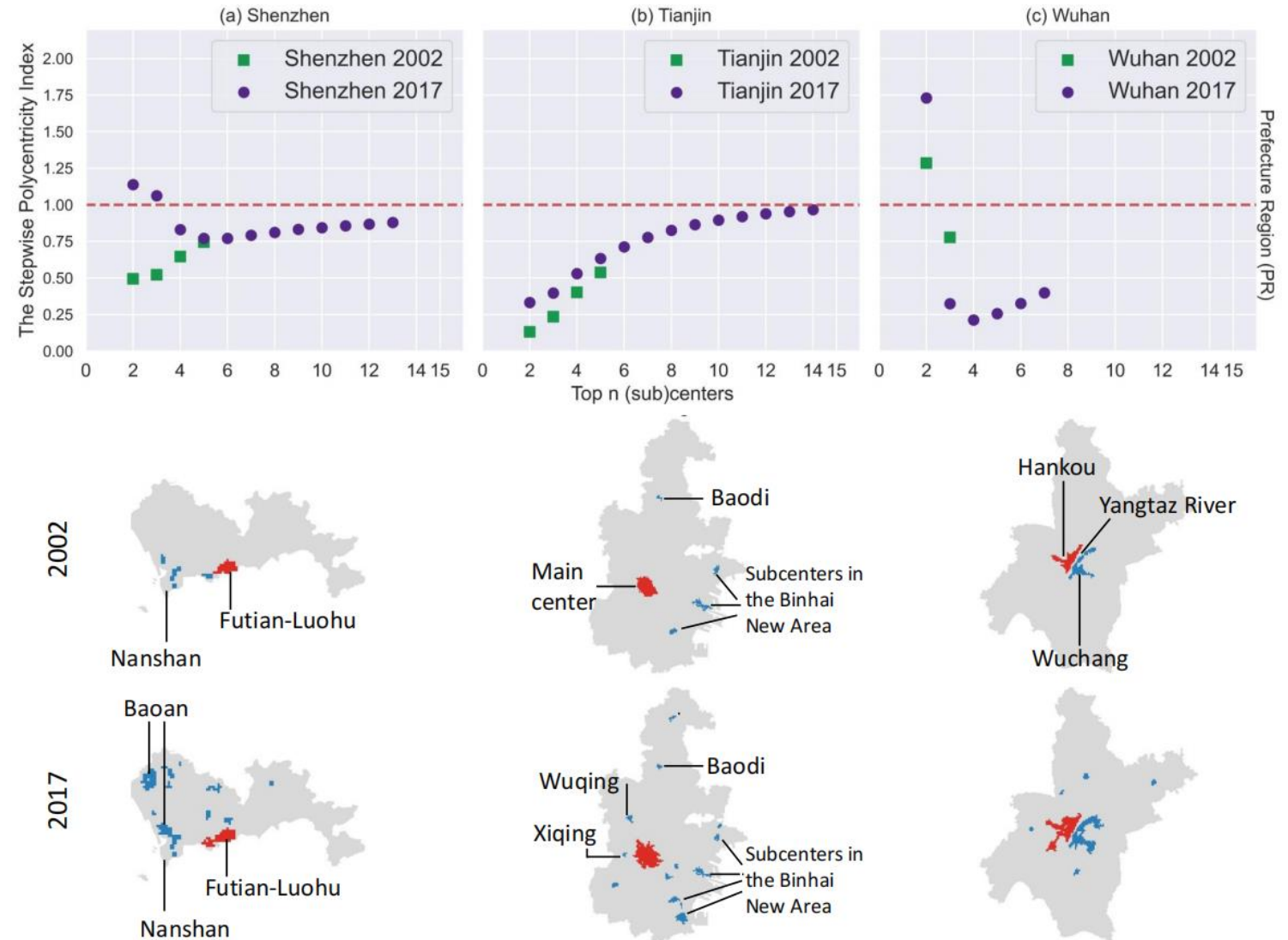


Figure 2: the stepwise polycentricity (SP) trajectories for Shenzhen, Tianjin, and Wuhan (the first row); the identified centers of the corresponding cities in 2002 and 2017 with the main center represented in red and subcenters represented in blue color (the second and third rows)