Functional Urban Area Delineations of Cities
Using Massive Didi Car-hailing Records in China

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(This research has been in collaboration with Dr Shuang Ma in the same school)

The concept of FUA: Functional Urban Area

- The concept of functional urban areas (FUAs or metropolitan areas or functional regions), where cities, towns, and rural areas are socioeconomically tied to the urban core, is an important tool for understanding economic and political regions of urban areas to address the aforementioned challenges and problems.

- Understanding the geographic distribution of FUAs will clarify human interactions with the environment and present a new relationship between urbanization and the biosphere.

Pervious Studies

Publication	Study area	Data	Method	Spatial Unit
Shen & Batty, 2019	London	Disaggregate commuting data	Multilevel modularity optimization algorithm that detects community structures within weighted flow graphs.	Middle-layer Super Output Area
Bosker, Park, & Roberts, 2018	Indonesia	Commuting flows, remotely sensed nighttime lights, and population	Systematic comparisons of these approaches using different data.	Subnational administrative units
Houssou, Guillaume, & Prigent, 2018	Porto	Taxi flows and POI data sets	A graph-based approach with community detections that combine the use of POIs.	A cartographic division using road networks.
Zhang et al., 2016	Shenyang and Beijing	Remotely sensed images	A Convolutional Neural Network (CNN) based method used to classify aerial images.	Disjoint regions using major roads
Arcaute et al., 2015	21 cities in England and Wales	Commuting and population density	Considers density-based cities and then adds areas to cities according to a commuting threshold.	Wards
Yuan et al., 2015	Beijing	Data sets for POIs, taxi trajectories, buses, and subways	A topic model-based approach to fuse POIs and mobility patterns.	Disjoint regions using major roads
Zhu et al., 2015	Seattle	Crowd-Augmented Travel Survey Data	A supervised learning via multi-output regression for travel survey data.	Census cells
Demšar et al., 2014	Greater London	Taxi flows	Edge-based community detection algorithm that uses the calculation of the similarity between each pair of vertices.	Traffic Analysis Zones (TAZ)
Dijkstra & Poelman, 2014	European Union	Population grid	Approach associated with dense clusters of populations.	LAU2s
Gajović, 2013	Kraljevo in Serbia	Distances, census and some calculated indexes	Two methods of unsupervised learning: k-means clustering and self-organizing maps in machine learning.	Administrative or statistical territorial units
Farmer & Fotheringham, 2011	Ireland	Travel-to-work data	Network-based method for network of travel-to-work flows with geographic weighting.	Electoral district (EDs)
Ratti et al., 2010	Great Britain	Telephone calls	A fine-grained approach based on analyzing networks of individual human transactions.	9.5 km by 9.5 km pixels
Karlsson & Olsson, 2006	Fyrstad in Sweden	Commuting flows	The local labor market, the commuting zone, and the accessibility approach	Municipality

To capture the social and economic effects using commuting patterns

1) Capture FUAs by inferred commuting

- Inferred community approaches
- local economic outcomes
- telephone calls
- Twitter networks
- the accessibility of public transport
- other indicators have been used to indicate inferred commuting patterns

2) Capture FUAs by observed commuting

- Accurately capture interactions
- travel-to-work flow network
- taxi flows

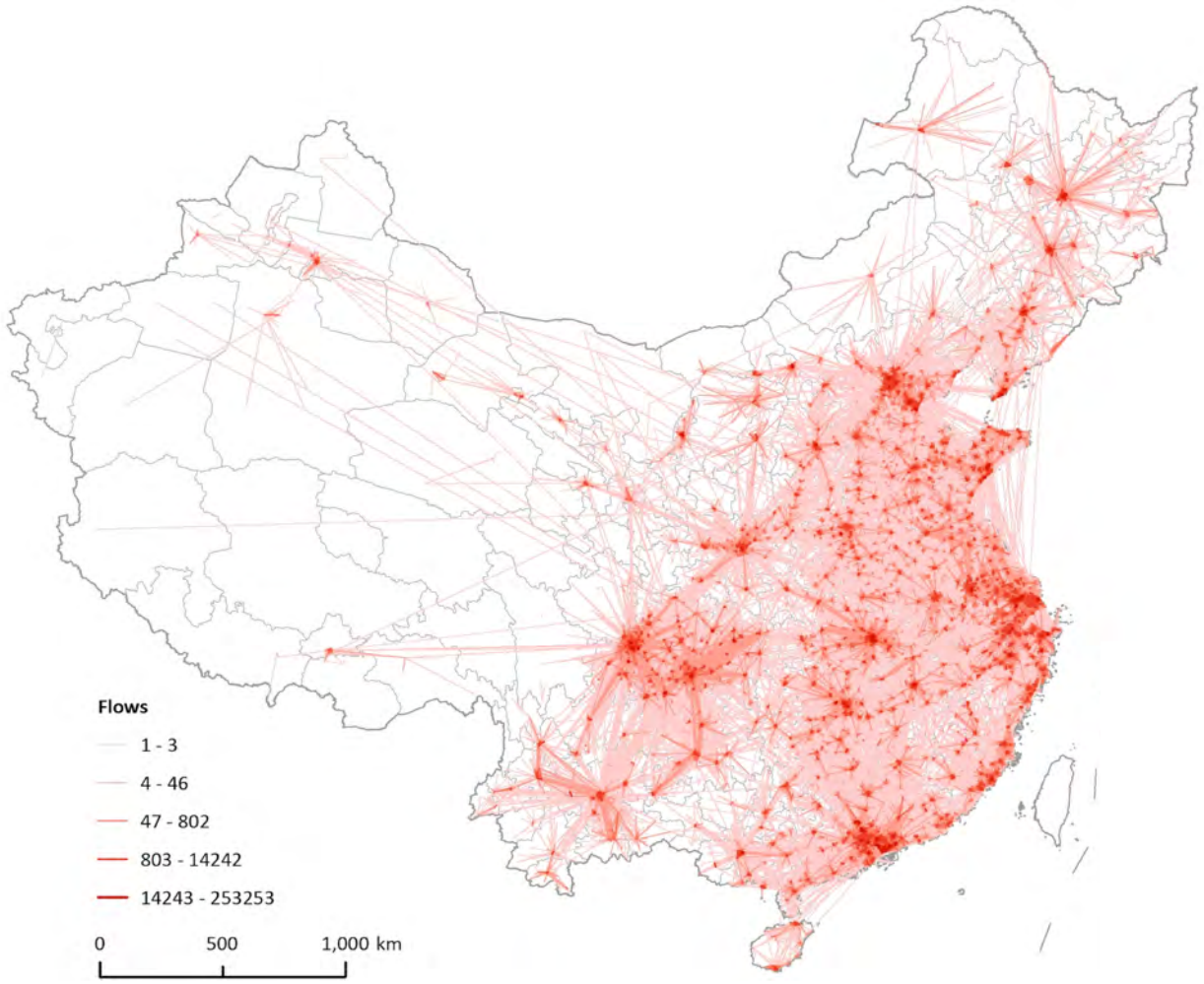
Key Data Description

DiDi

More Than a Journey
The World's Leading Transportation Platform

Didi Chuxing ("DiDi") is the world's leading mobile transportation platform. The company offers a full range of app-based transportation options for 550 million users, including Taxi, Express, Premier, Luxe, Bus, Designated Driving, Enterprise Solutions, Bike Sharing, E-bike Sharing, Car Rental and Sharing and food delivery. More Than a Journey

Key Data Description



The traffic Flows throughout China

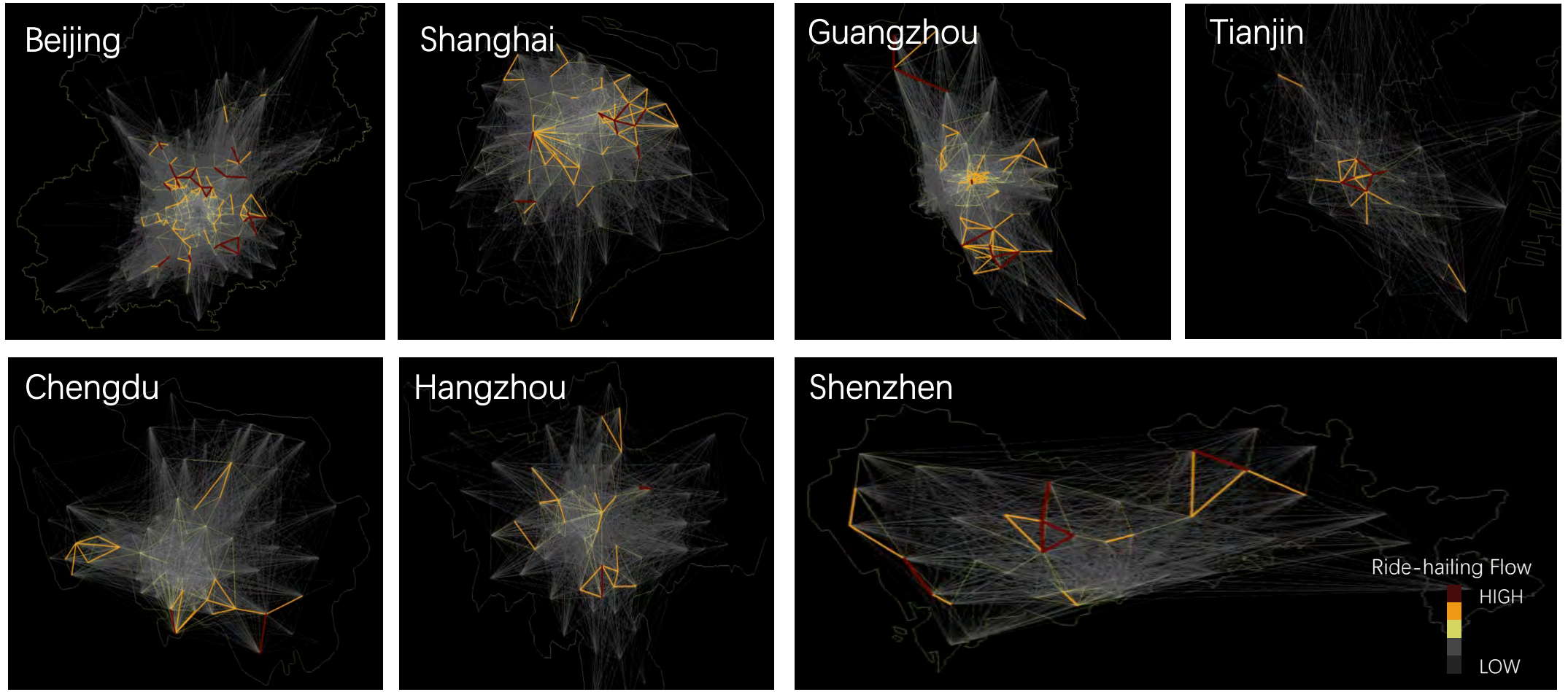
The fast growth of mobile internet, cloud computing, and location-based services make the ride-hailing companies, Didi Chuxing, Grab, Lyft, and others, scale users around the world. They collect and share vast amounts of information, and can provide a new lens to delineate FUAs using a community detection algorithm.

- The Didi ride-hailing service occupies **85.7%** of the total ride-hailing trips, with other services
- Didi Chuxing now has approximately **4.5 billion** registered users and **25 million daily rides**, with a huge capacity for growth
- Didi company provides four main types of travel services: **taxi, express, private car, and hitch**. The ride-hailing data used for this study included all four of these modes.

Data used in the study

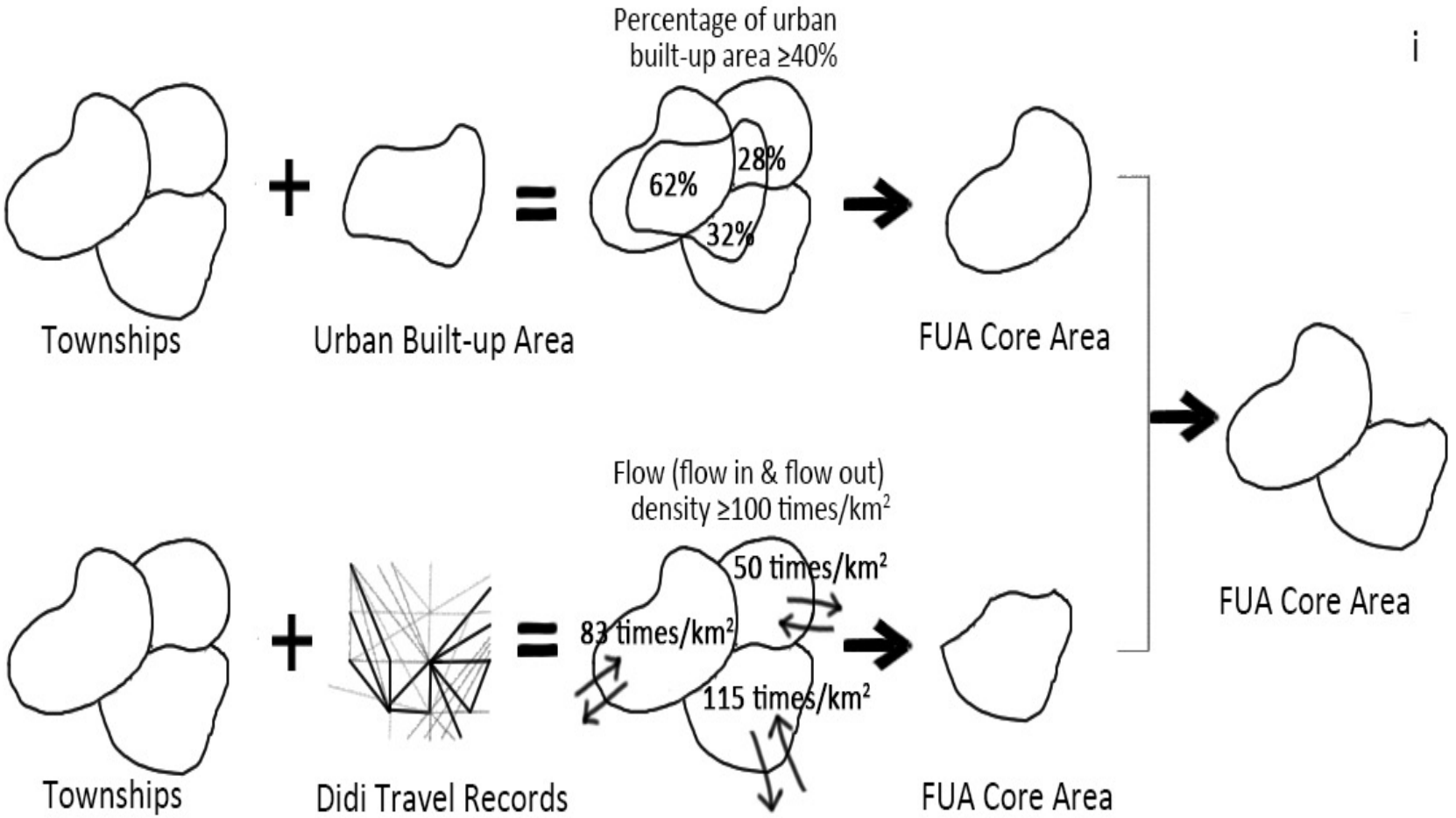
Townships in China	Didi Ride-hailing Records	2015 urban built-up areas	Urban Agglomerations
The orientation and destination of every travel flow in all 39,007 townships in China.	43,846,160 records that covered 39,007 townships in 654 Chinese mainland. These data are between commuting time 7:30 to 9:00.	VIIRS/Day Night Band (DNB) (the updated version of DMSP/OLS). The urban area is for the entire Chinese mainland 72,208 km^2 in 2015, including 28,416 patches	23 officially recognized urban agglomerations in 2010 Urban Agglomeration

Profiles of the Didi records for typical cities



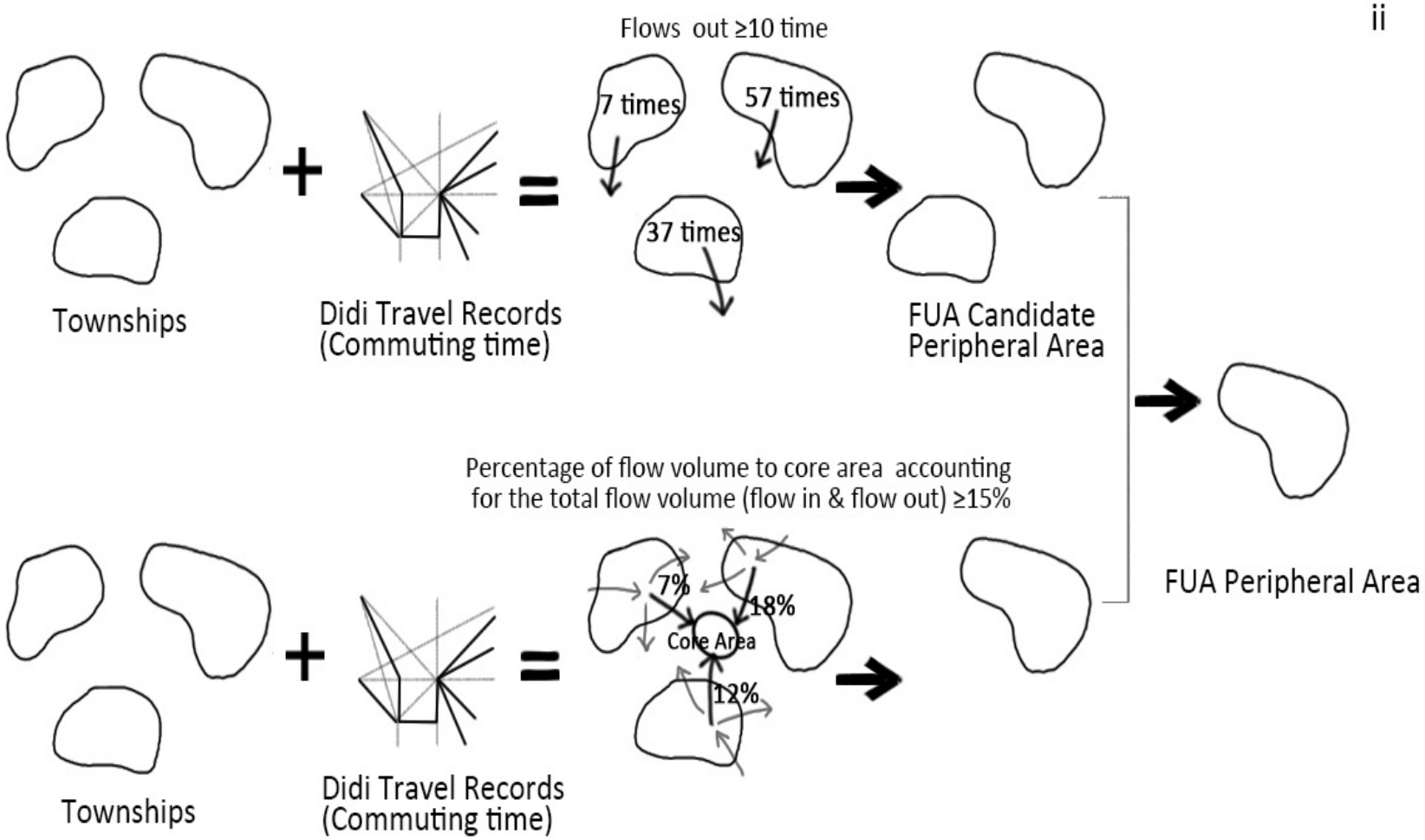
Core area

The potential cores of the FUAs were required to be “big enough” and “dense enough”, thus the core areas had to be townships that (a) had at least **40% urban built-up areas** within their boundaries, or (b) had at least a 100/km2 of flow density

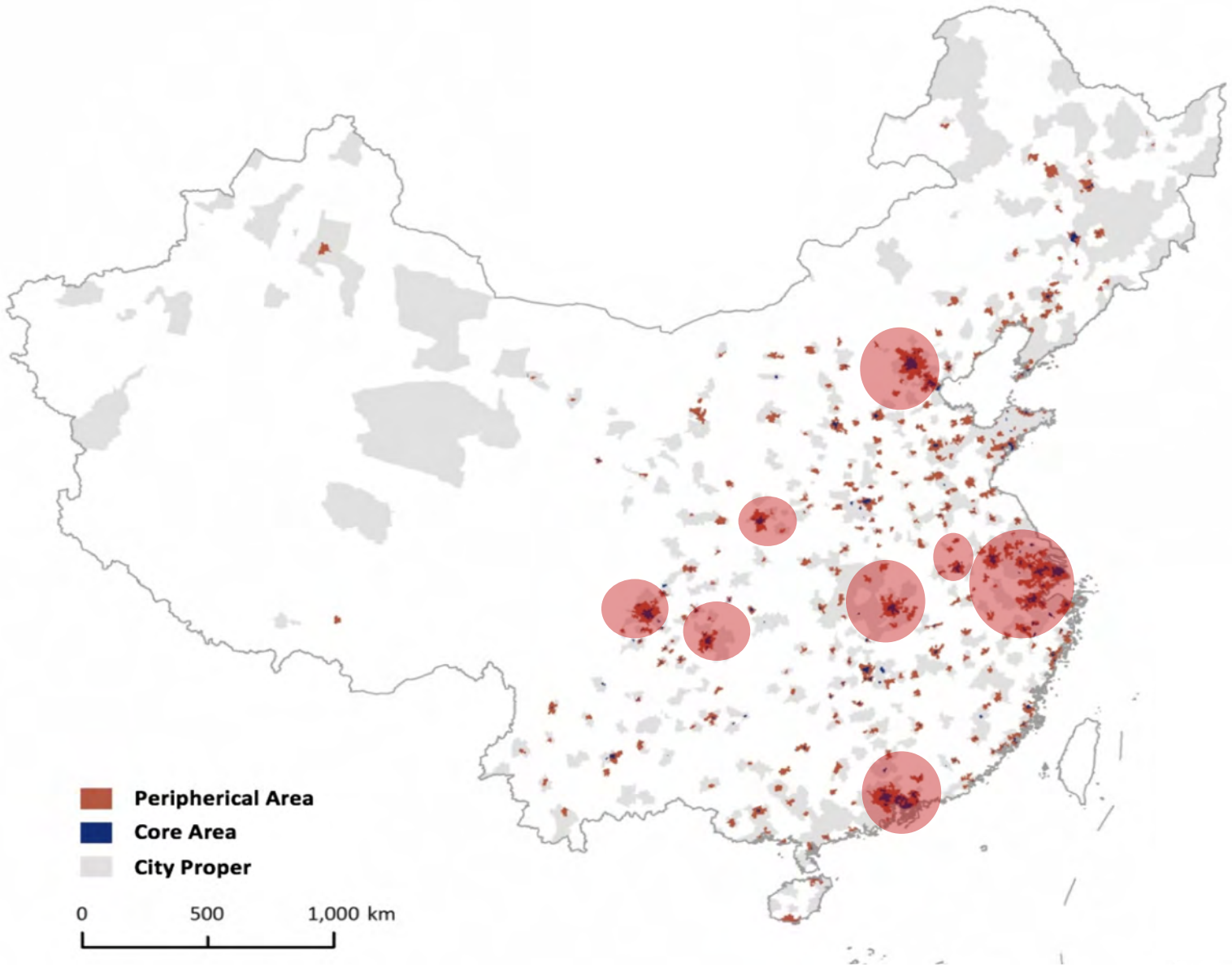


Peripheral area

We explicitly defined these areas as townships that (a) had commutes that were as long as a threshold of 10 commuting flow volume (only flow out) and (b) had at least **15% of the residents living** in the townships that traveled to core areas to work.



The delineated FUAs in China

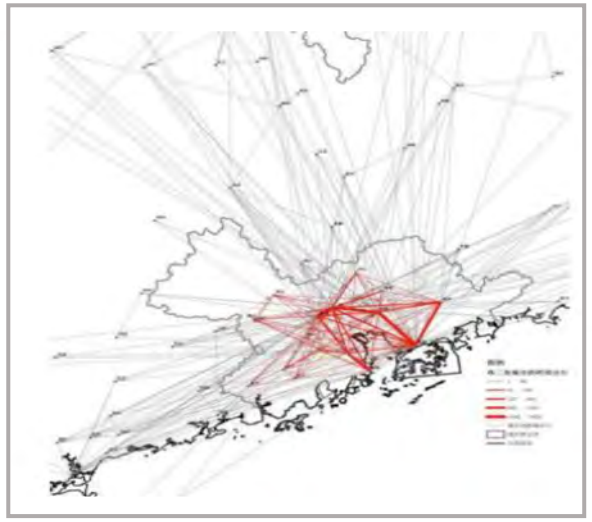


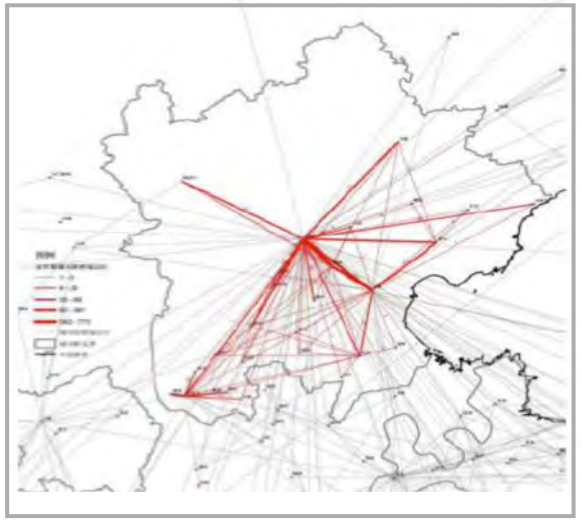
Top 10 largest FUAs in China

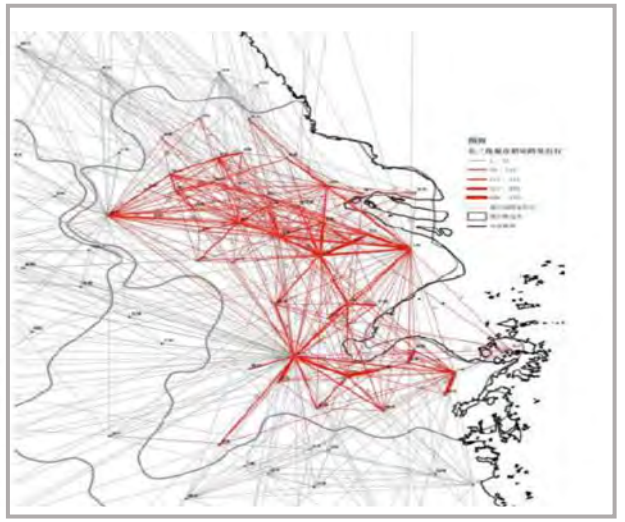
308 FUAs that cover 4,456 townships out of 39,007 townships in China

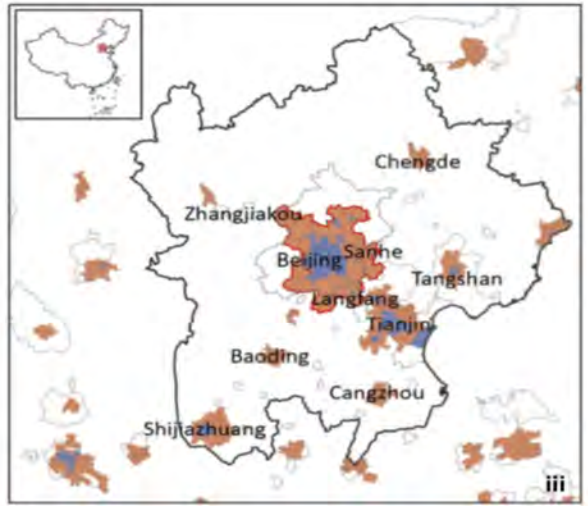
FUAs	Area in km^2	Townships Amount
Guangzhou_Shenzhen	13,716.6	206
Beijing & Langfang	10,882.7	264
Shanghai & Suzhou	9,626.8	265
Chengdu & Deyang	7,323.8	214
Hangzhou & Shaoxing	6,377.9	146
Wuhan	5,045.1	39
Chongqing	4,920.7	62
Nanjing	4,481.7	88
Tianjin	4,331.9	133
Xi'an & Xianyang	4,005.9	91

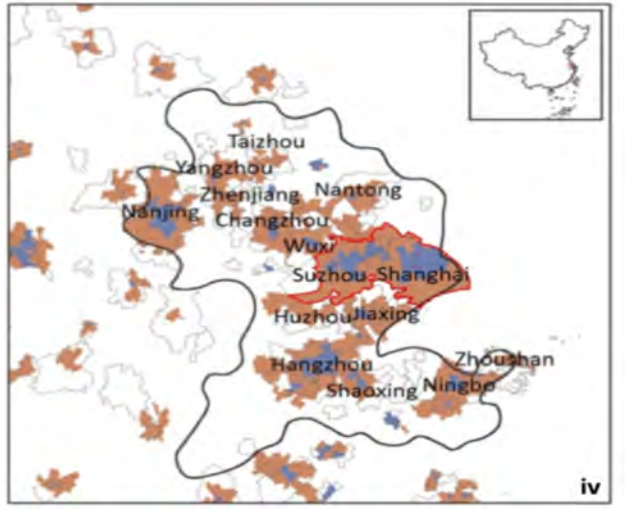
FUAs for urban agglomerations: Pearl River Delta, Beijing-Tianjin-Hebei, Yangtze River Delta





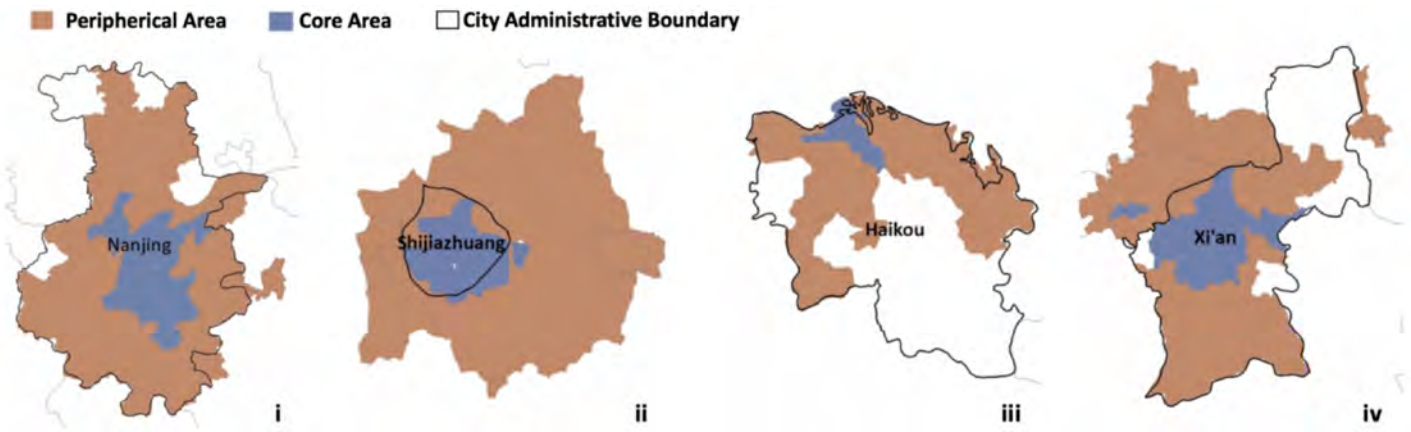






Peripherical Area Core Area Administrative City Urban Agglomeration FUA of City

Comparison with existing administrative boundaries



We evaluated the administrative boundaries of 36 Chinese cities, including municipality level cities, provincial capital cities, and sub-provincial cities. We classified these cities into four categories according to the spatial relationships between the administrative boundaries and the delineated FUAs

Notice：Because the commuting relationships between Guangzhou and Shenzhen / Shanghai and Jiangsu are quite close，we evaluate them at the same time.

Type 1
FUAs that agree quite well with the city administrative boundaries

unit : km2

City	Core Area	Periphery Area
Dalian	527	1385
Nanjing	825	4223

Type 2
City administrative boundaries that should expand

unit : km2

City	Core Area	Periphery Area
Guangzhou_ Shenzhen	4,715	9,002
Chengdu	1,485	5,839
Zhengzhou	476	2,008
Hefei	608	1,695
Changsha	458	1,834
Nanchang	147	1,692
Shijiazhuang	214	1,618

Type 4
City administrative boundaries that should shrink in some directions and expand in other directions

unit : km2

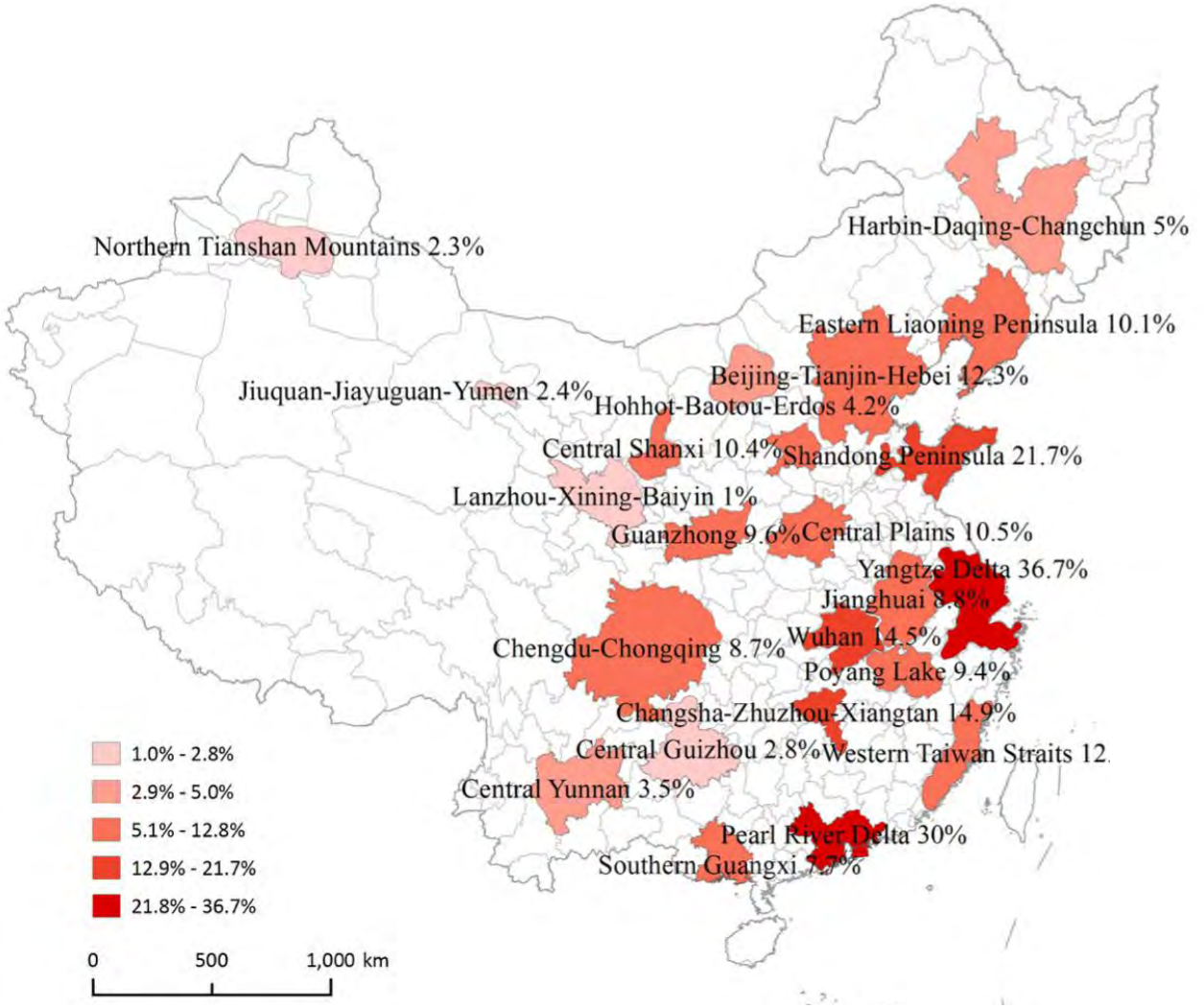
City	Core Area	Periphery Area
Shanghai	2,674	6,953
Hangzhou	1,222	5,156
Xi′ an	777	3,229
Qingdao	838	2,905
Ningbo	370	2,767
Taiyuan	368	2,017
Jinan	215	2,210
Yinchuan	47	2,232
Changchun	756	1,086
Kunming	320	1,424
Fuzhou	233	1,466
Guiyang	84	1,318

Type 3
City administrative boundaries that should shrink

unit : km2

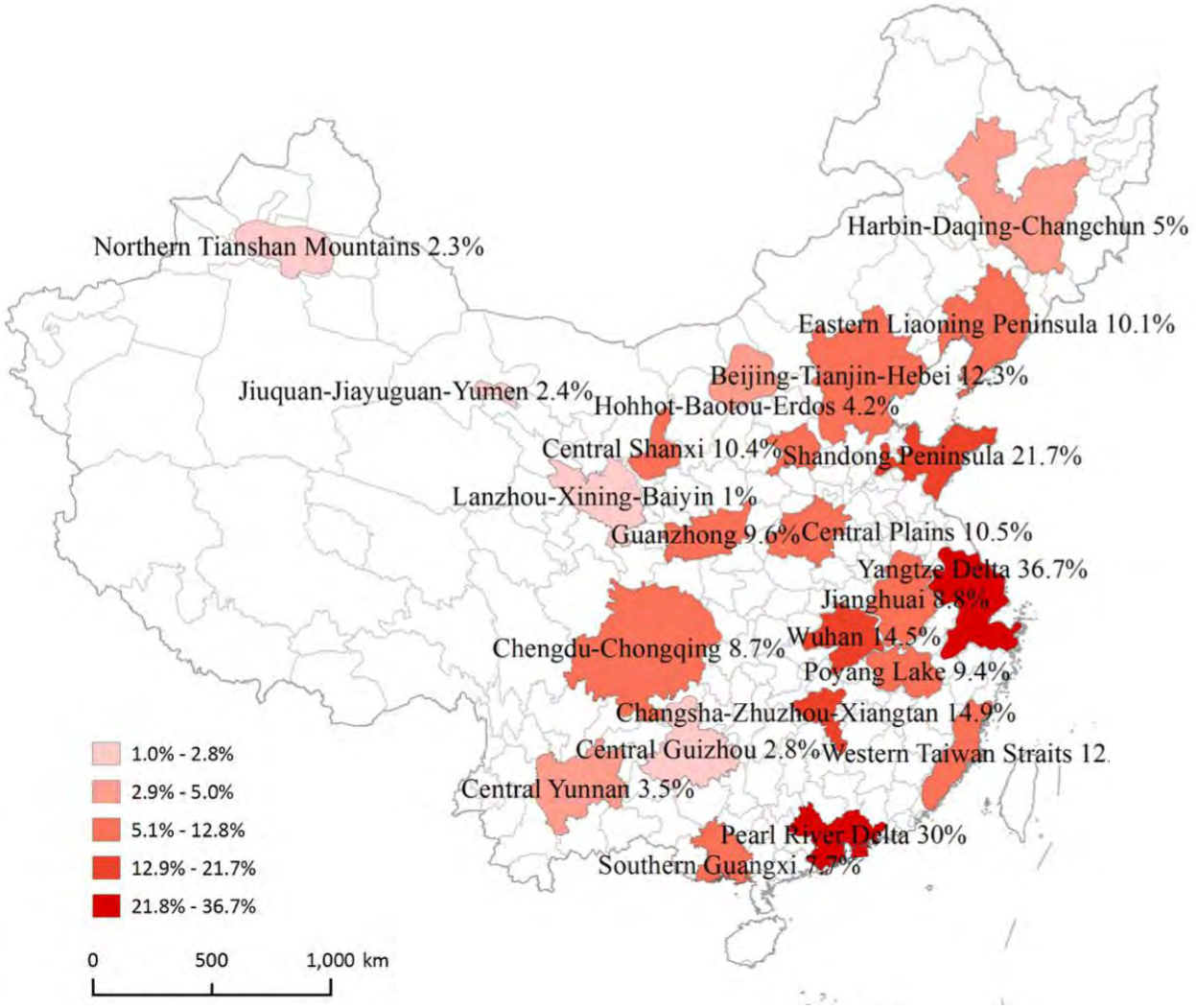
City	Core Area	Periphery Area
Wuhan	1,048	3997
Tianjin	1,206	3126
Harbin	195	2,062
Shenyang	221	1,725
Nanning	132	1,703
Urumchi	0	1,491
Haikou	96	1,051

Evaluating the development of urban agglomerations using FUAs delineated



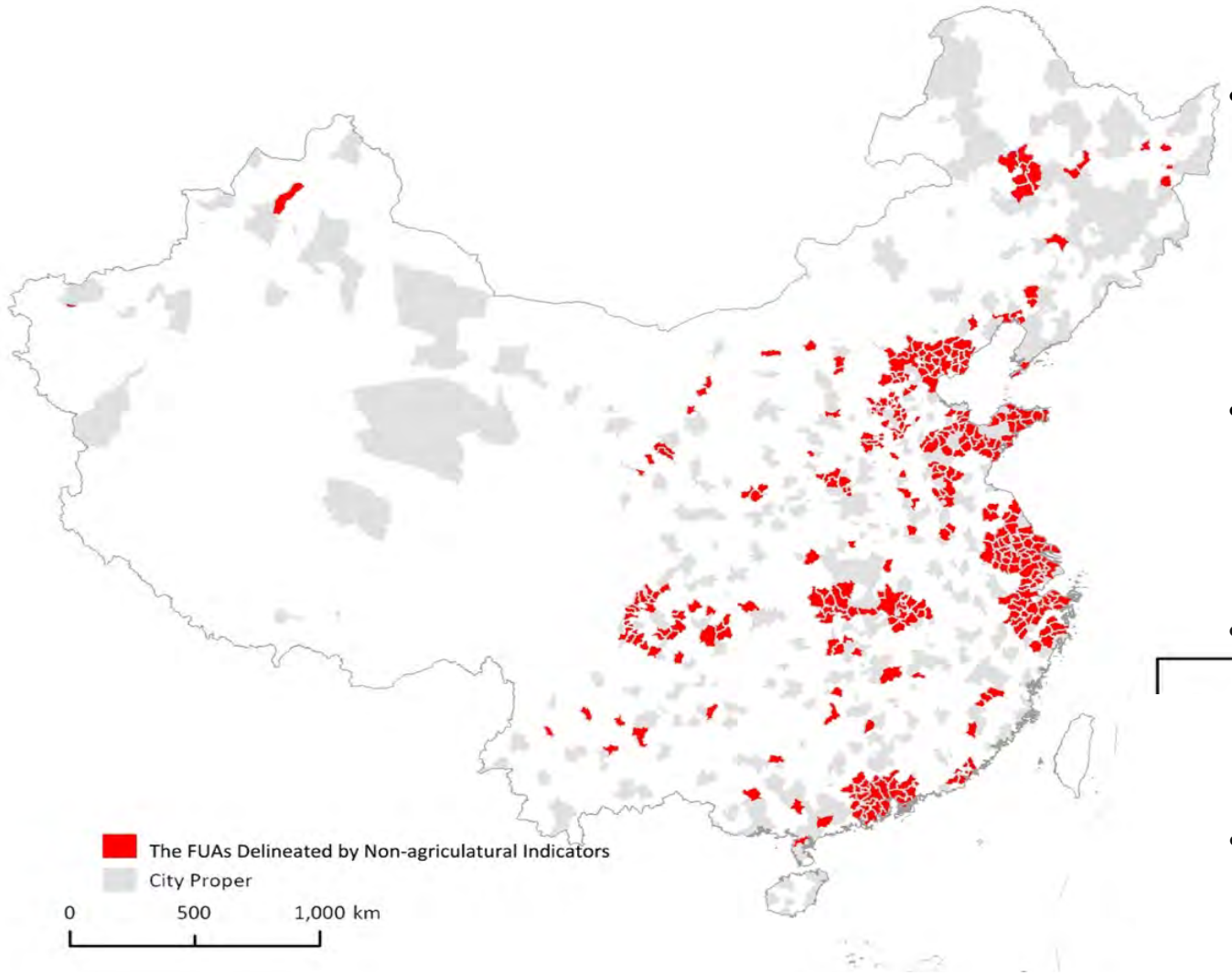
- FUAs are integrated in geographic space, and they are useful to measure the development quality of urban agglomerations using the FUA ratio, which indicates the extent and pattern of social and economic interactions in an urban agglomeration.
- **Northern Tianshan Mountains， Jiuquan-Jiayuguan-Yumen, Lanzhou-Xining-Baiyin , Hohhot-Baotou-Erdos, Central Guizhou<5%**
- To enhance the agglomeration effect of central cities.
- **Chengdu-Chongqing, Central Shanxi, Guanzhong**
- To ensure the balance western & eastern China

Evaluating the development of urban agglomerations using FUAs delineated



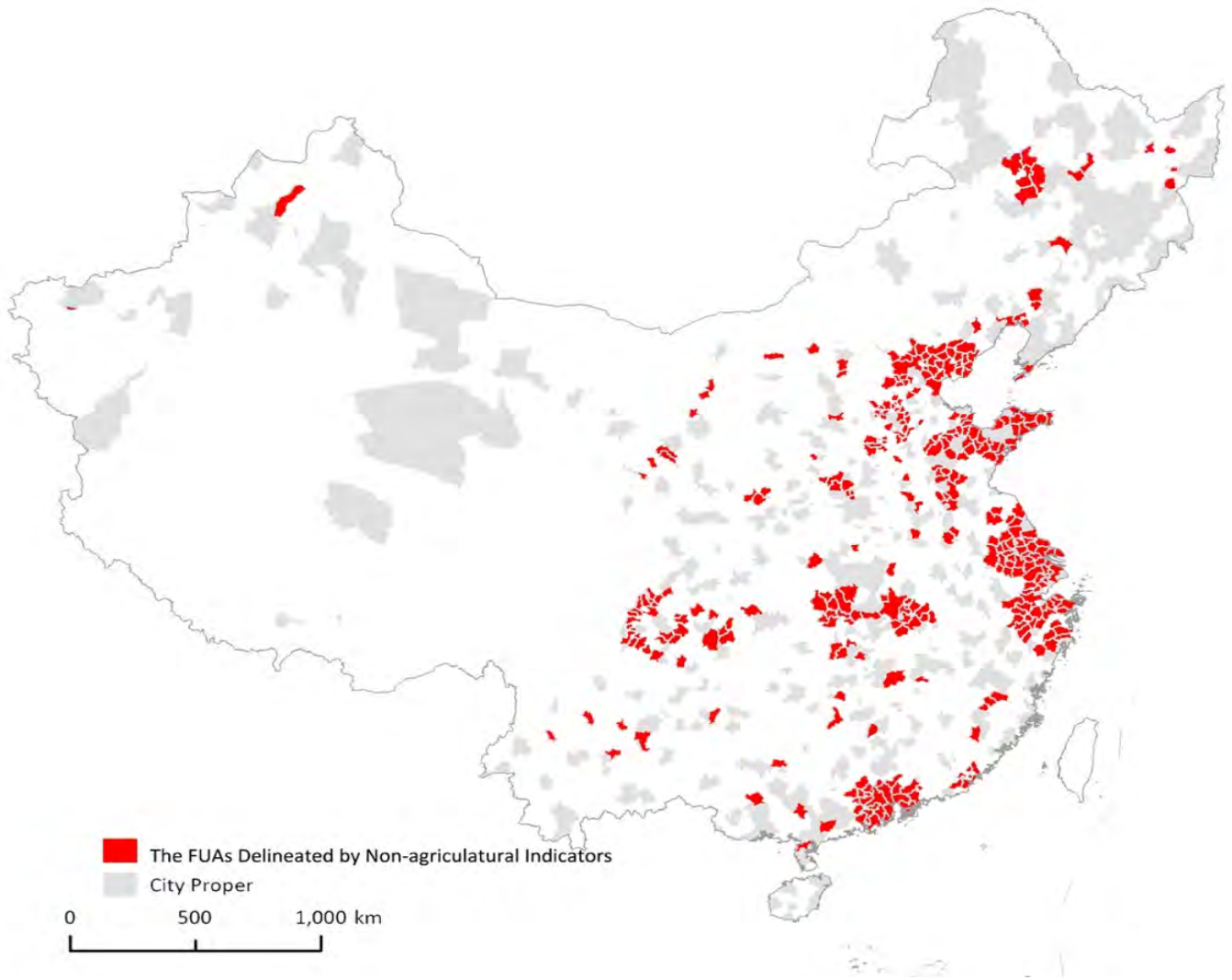
- The advantages of the Yangtze Delta, Pearl River Delta, and Shandong Peninsula are obvious in terms of these ratios.
- The FUA ratios for the eastern coastal agglomerations are relatively high as well, such as in the Western Taiwan Straits Urban Agglomerations.
- The ratios for a few central regions and most of the western regions of the FUA areas are significantly lower.Such as: in the Northern Tianshan Mountains, Lanzhou-Xining-Baiyin, Central Guizhou, and Harbin-Daqing-Changchun, the FUA ratios are less than 8%.
- Some urban agglomerations in central China, such as the Beijing-Tianjin-Hebei, Central Plains, Wuhan, and Central Shanxi urban agglomerations, have stable and medium FUA ratios.

Comparison with previous studies



- Attempted to delineate FUAs, and they chose cities proper and counties as spatial units.
- They collected data from the Chinese Urban Statistics Yearbook (2001) and the Economic and Social Statistics Yearbook (2001) that included the nonagricultural population ratio, the nonagricultural GDP ratio the per capita GDP, and the population density.
- The former two data sets represented the economic connections between urban and rural areas, whereas the later data sets reflected the urbanization level of a unit. (Wang & Ye ,2004)
- This study relied heavily on statistical yearbooks whilst the quality of the data among cities is inconsistent
- A large number of towns or downtown areas in counties are ignored
- The county and cities proper are too large as spatial units （3,364 km^2 ） .

Comparison with previous studies



- According to the OECD, industrialization and mobility improvements have enabled the movement of goods and labor between cities to expand across far wider spatial areas in China.

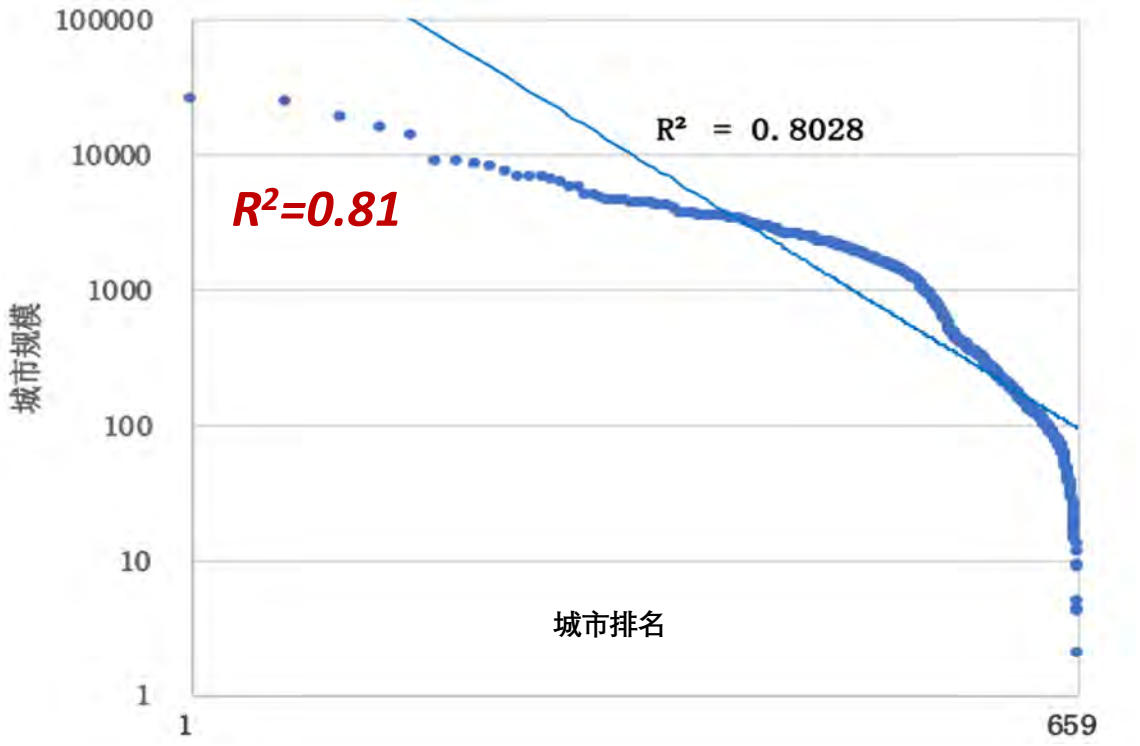
1) The OECD study was based on **population density at the county or city level**, whereas our study used the massive ride-hailing records based on traffic flows at the township level, which resulted in a finer spatial resolution.

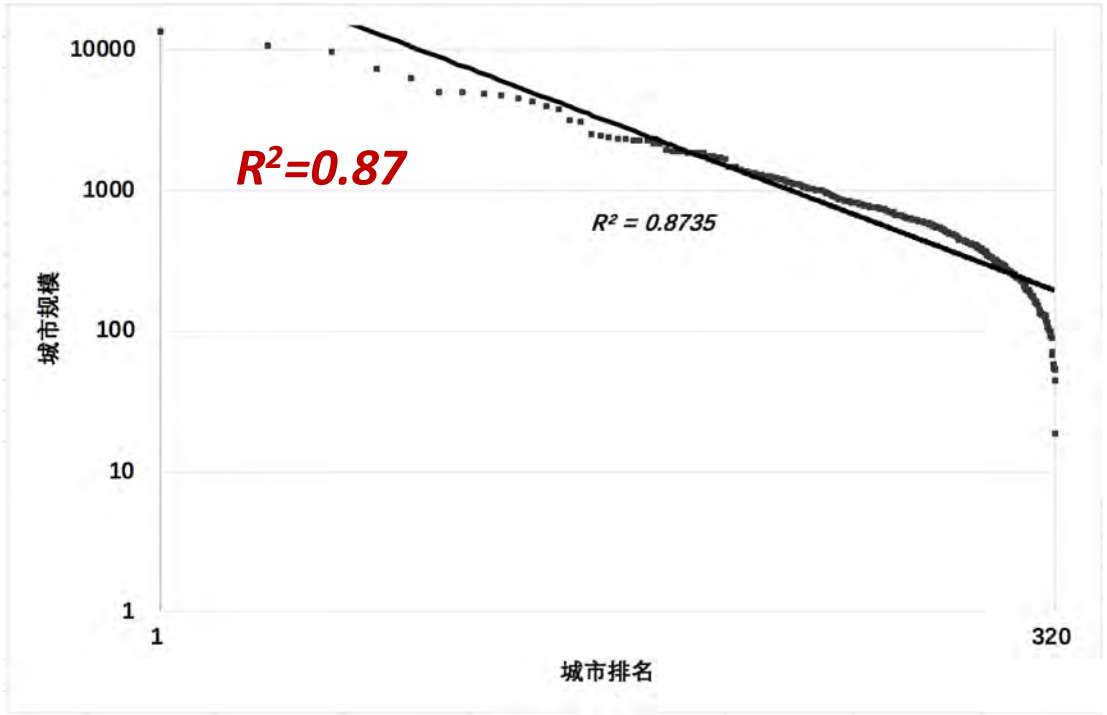
2) We used actual commuting flows instead of proxies, including the capacities of existing and planned national highway and railway networks, which are indirect measurements.

3) This study relied on increasingly available open-access large data sets that consist of higher spatial resolutions and result in **more accurate FUA delineations.**

The universal law governing city systems

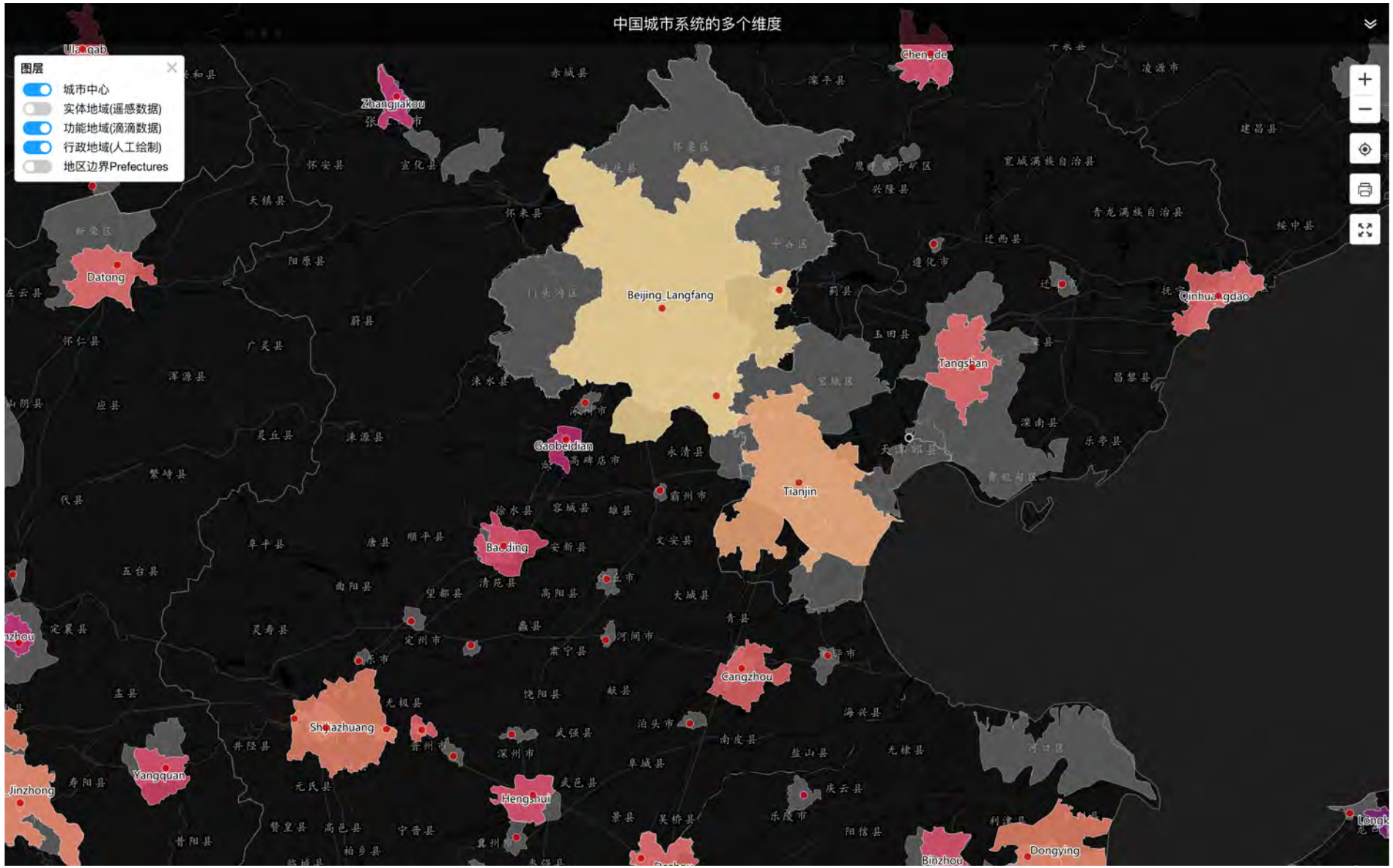
Zipf's law Definition of Chinese urban system from the perspective of functional urban area is more satisfying to Zipf's law, which proves the significance and reliability of our research method.





Administrative City: Ranking-Scale

Online visualization of the delineated FUAs in China (freely online and open to everyone)

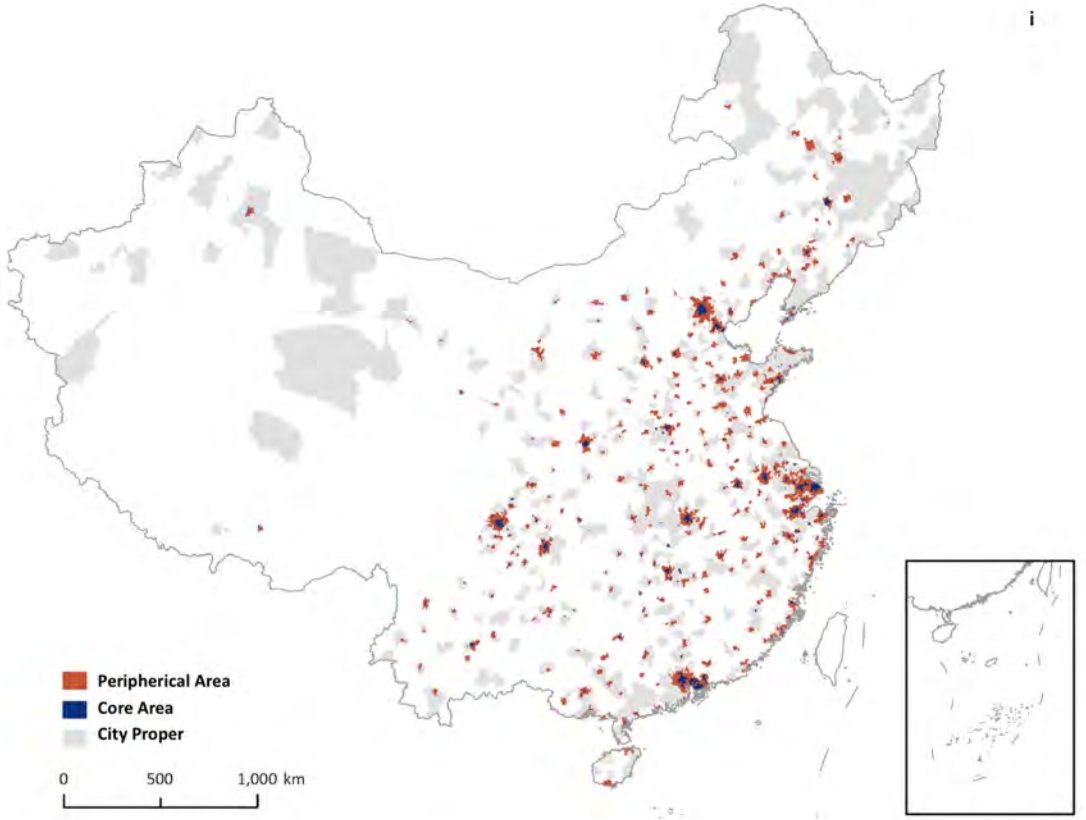


GeoHey·极海

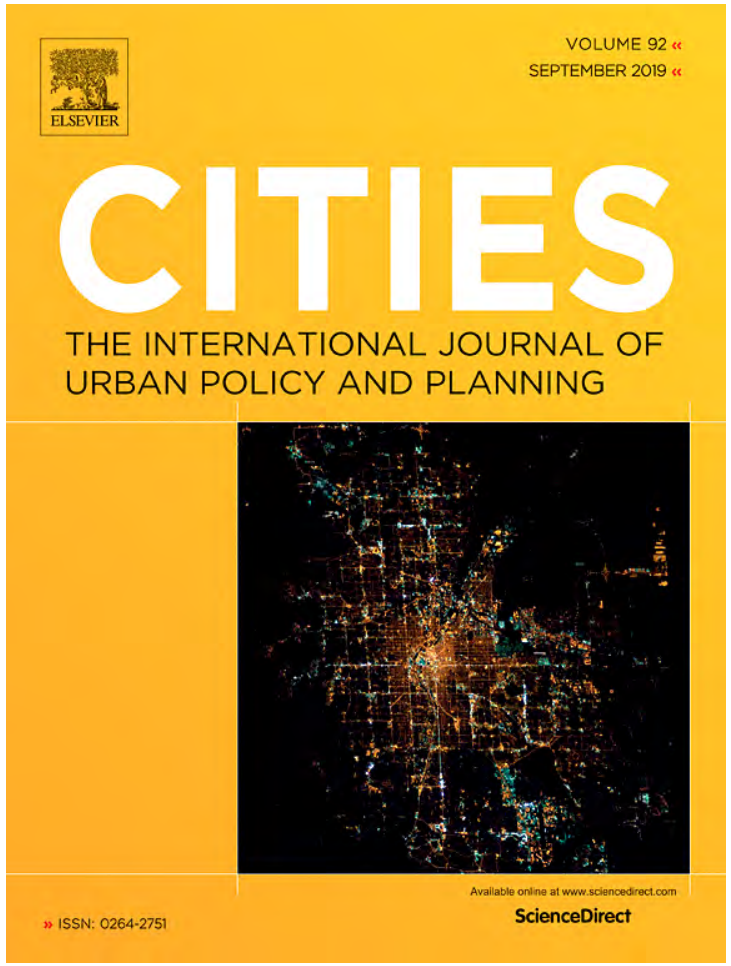
https://geohey.com/apps/dataviz/9bcb8484f2c94f558ae0511983161883/share?ak=MDhmNjM0NjdiMjM4NDBkYmFmNzYwMjA2OGQ3ZjNlNWE

To sum up with the research highlights

- Analyze the urban functional areas for all Chinese mainland
- Propose suggestions to adjust the administrative boundaries in in cities in Chinese mainland by comparing with defined urban functional areas
- Evaluating urban agglomeration development by evaluating the FUA rate in every urban agglomeration
- Compare FUA delineations using Didi car-hailing records with FUA delineations using previous approaches



The study is to appear in the international journal Cities



Functional Urban Area Delineations of Cities on the Chinese Mainland Using Massive Didi Ride-hailing Records

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Abstract: The problem associated with a city's administrative boundary being "under-" or "over-bounded" has become a global phenomenon. A city's administrative boundary city does not effectively represent the actual size and impact of its labor force and economic activity. While many existing case studies have investigated the functional urban areas of single cities, the problem of how to delineate urban areas in geographic space relating to large bodies of cities or at the scale of an entire country has not been investigated. This study proposed a method for FUA identification that relies on ride-hailing big data. In this study, over 43 million anonymized 2016 car-hailing records were collected from Didi Chuxing, the largest car-hailing online platform in the world (to the best of our knowledge). A core-periphery approach is then proposed that uses nationwide and fine-grained trips to understand functional urban areas in Mainland China. This study examined 4,456 out of all 39,007 townships in an attempt to provide a new method for the definition of urban functional areas in Chinese Mainland. In addition, four types of cities are identified using a comparison of functional urban areas with their administrative limits, and a further evaluation is conducted using 23 Chinese urban agglomerations. With the rapidly increasing use of internet-based ride-hailing services, such as Didi, Grab, Lyft, and Uber, globally, this study provides a practical benchmark for the delineation of functional urban areas at larger scales .

Key words: functional urban area, car-hailing records, national level, delineating standards, city system

Thanks for your attention !

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