Evaluating cities' vitality and identifying ghost cities in China with emerging geographical data

Ying Long, Associate Professor

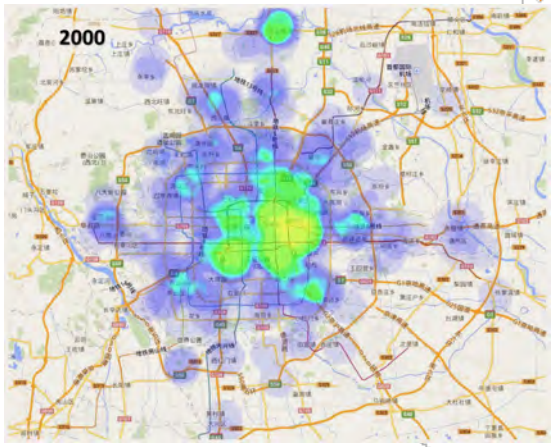
School of Architecture, Tsinghua University, China

November 14, 2016

In collaboration with Xiaobin Jin, Wei Sun, Yuyin Lu, Xuhong Yang

Rapid urban expansion in China during last decades

(around 30% residential developments)



Beijing

Tianjin

Shanghai

Chongqing

Guangzhou

Urban area (km2)	Rate (%)
1 - 50	0 - 1.1
51 - 100	1.2 - 3.0
101 - 200	3.1 - 5.0
201 - 400	5.1 - 8.0
> 400	> 9.0

0 500 1,000 Km


0745NEWS.CN
怀化新闻网

Search “Ghost Cities/鬼城” at Baidu

The existing rankings of ghost cities in China

	Ranking according to Baidu search	The Biaozhun Ranking	The Netease Ranking	The Fang Ranking
Ranking Title		Concludes the top fifty "ghost cities" of the future and a "Super star" county	The urban construction speed exceeds the population growth in many cities of China, a large number of "ghost cities" have appeared	Top 12 “ghost cities” of China in 2015
Evaluation Indicators	By keyword searching, the retrieval condition is ‘province name’ + ‘city name’ + ‘鬼城’	Less than 5 thousand people per square kilometre in a city’s built-up areas	Population growth less than or equal to zero, the change rate of population density less than or equal to zero, and the growth rate of urban area greater than or equal to zero	The pace of the decline in residential real estate
Data Sources		http://biaozhun007.com/articles/city/422.html	http://news.163.com/15/1209/01/BABTGM1O00014MTN.html	http://news.anshan.fang.com/2015-12-08/18506456_1.html
Order	Top 30	Top 50	No	No
1	Sanya (Hainan)	*Erlianhaote (Inner Mongolia)	Kiamusze (Heilongjiang)	Erdos (Inner Mongolia)
2	*Tianmen (Hubei)	*Alar (Xinjiang)	*Anlu (Hubei)	Hohehot (Inner Mongolia)
3	△Chongqing (Chongqing)	*Beitun (Xinjiang)	*Penglai (Shandong)	Bayan Nur (Inner Mongolia)
4	Zhangjiajie (Hunan)	*Aletai (Xinjiang)	*Hailin (Heilongjiang)	Erlianhaote (Inner Mongolia)
5	Luoyang (Henan)	Zhangye (Gansu)	Jixi (Heilongjiang)	Zhengzhou (Henan)


Housing vacancy rate has been a national secret in each city.
办公室入口
OFFICE ENTRANCE
D-2

Contents lists available at ScienceDirect

Cities

journal homepage: www.elsevier.com/locate/cities

Understanding urban China with open data

Xingjian Liu [a], Yan Song [b], Kang Wu [c], Jianghao Wang [d], Dong Li [e], Ying Long [f,*]

[a] The University of Hong Kong, China
[b] University of North Carolina – Chapel Hill, USA
[c] Capital University of Economics and Business, China
[d] Chinese Academy of Sciences, China
[e] China Academy of Urban Planning and Design, China
[f] Beijing Institute of City Planning, China

ARTICLE INFO

Article history:
Available online xxxx

Keywords:
China
Open data
Urban analytics

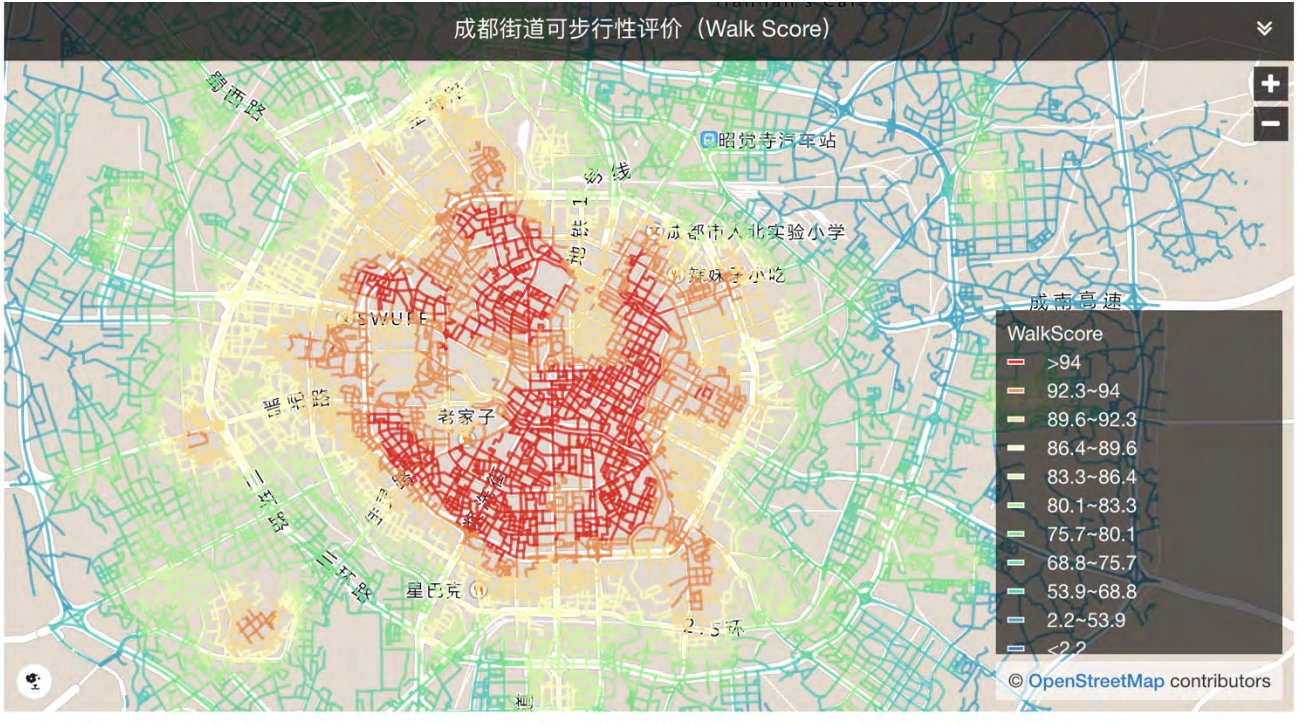
ABSTRACT

A solid understanding of urbanizing China – the world's largest and most rapidly transforming urban society – calls for improved urban data provision and analysis. This paper therefore looks at major technological, social–cultural, and institutional challenges of understanding urban China with open data, and showcases our attempt at understanding Chinese cities with open urban data. Through our showcases, we hope to demonstrate the usefulness of open urban data in (1) mapping urbanization in China with a finer spatiotemporal scales; (2) reflecting social and environmental dimensions of urbanization; and (3) visualizing urban China at multiple scales.

北京城市实验室
Beijing City Lab

http://www.beijingcitylab.com

HOME | PROJECTS | MEMBERS | WORKING PAPERS | SLIDES | DATA RELEASED | RANKING | BLOGS | LINKS&PARTNERS | ABOUT



Following the framework of our proposed Street Urbanism, we have evaluated the Walk Score for all grids and streets of Chengdu. We are not working on modifying the algorithm for adapting the Chinese context. Meanwhile, we are expecting to duplicate the study for all Chinese cities.

The Beijing City Lab (BCL) is a research network, dedicated to studying, but not limited to, China's capital Beijing. The Lab focuses on employing interdisciplinary methods to quantify urban dynamics, generating new insights for urban planning and governance, and ultimately producing the science of cities required for sustainable urban development. The lab's current mix of planners, architects, geographers, economists, and policy analysts lends unique research strength.

Methodology

Identifying ghost cities through the lens of the vitality of residential developments

Three components of urban vitality

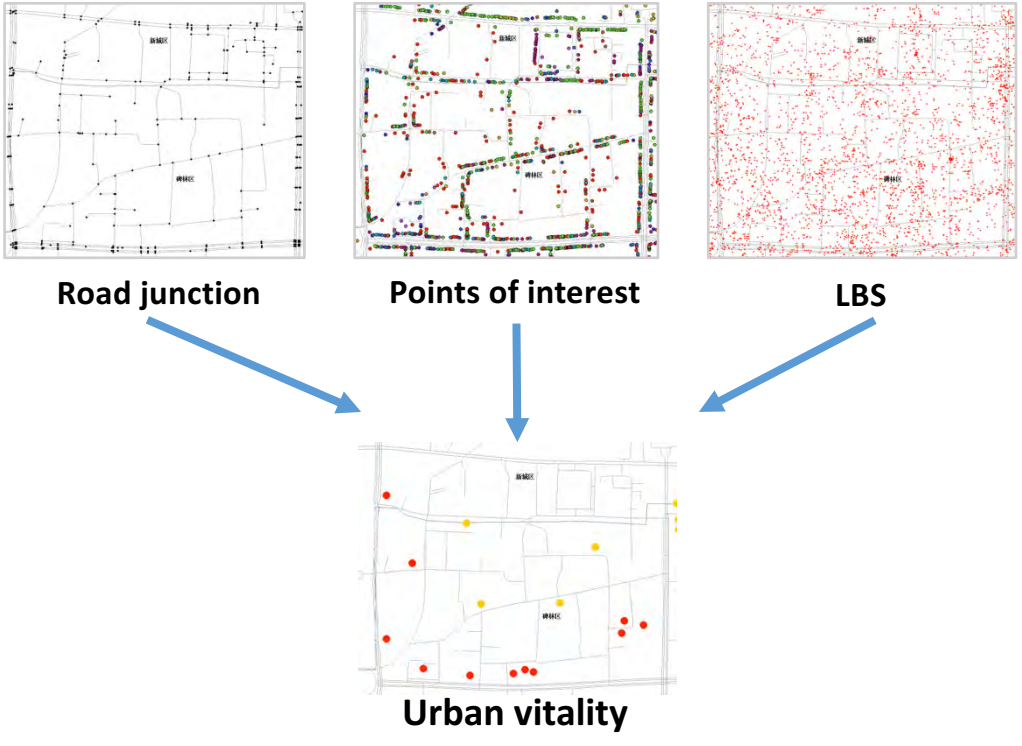
Urban form

Urban function

Urban activity

- Kevin Lynch believes that the primary criterion in the quality assessment of urban space form is the vitality, which is defined as a settlement (the dimension *urban morphology*) that supports the vital functions (the dimension *urban function*) and the biological requirements and capabilities of human beings (the dimension *urban society*), and how to protect the continuation of the species (Lynch, 1984).

Calculating urban vitality for each place



- Urban form = Road junction density (J)
- Urban function = Points of interest (POIs) density (P)
- Urban activity = LBS density (L)
- Urban vitality (V) = ln (J * P * L)

Ghost cities are always associated with new developments


No urban fabric/form on urbanized/developed areas

No urban function on existing urban form

No urban activities in functioned urban areas

Identifying ghost cities via aggregating the vitality of residential projects

$$G = 1 / (V_{new}/V_{old} * V_{new})$$

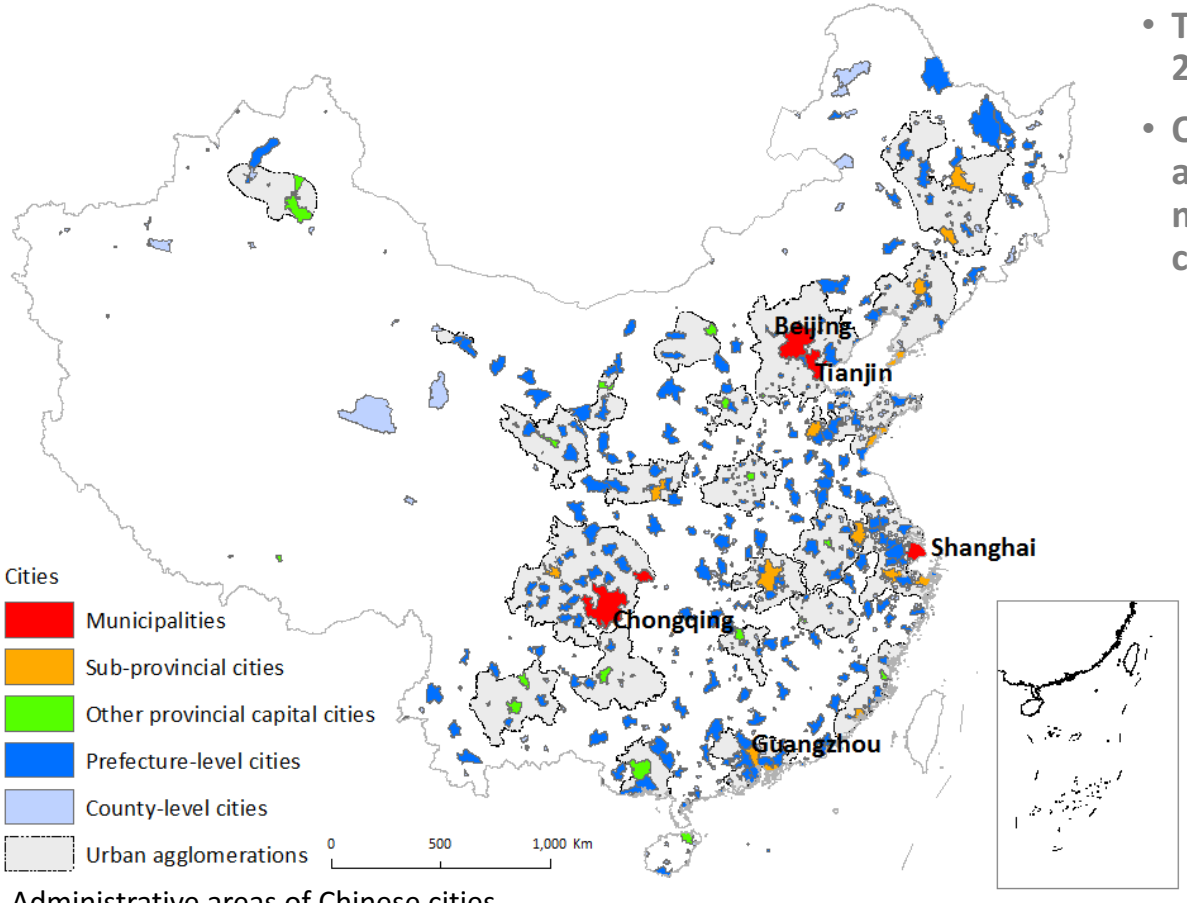
The average vitality of residential developments in new urban areas (V_{new}) and residential developments in old urban areas (V_{old}) can be calculated for each city by overlaying residential transactions with the administrative boundaries of cities.

- **G: The degree on a city being a ghost city**

- **The degree to which a city belongs to a ghost city is related to vitality in new urban areas and the difference in vitality between old and new urban areas. The larger the difference and the lower the vitality in the new residential projects, the more likely the city to be a ghost city.**

Data used for this study

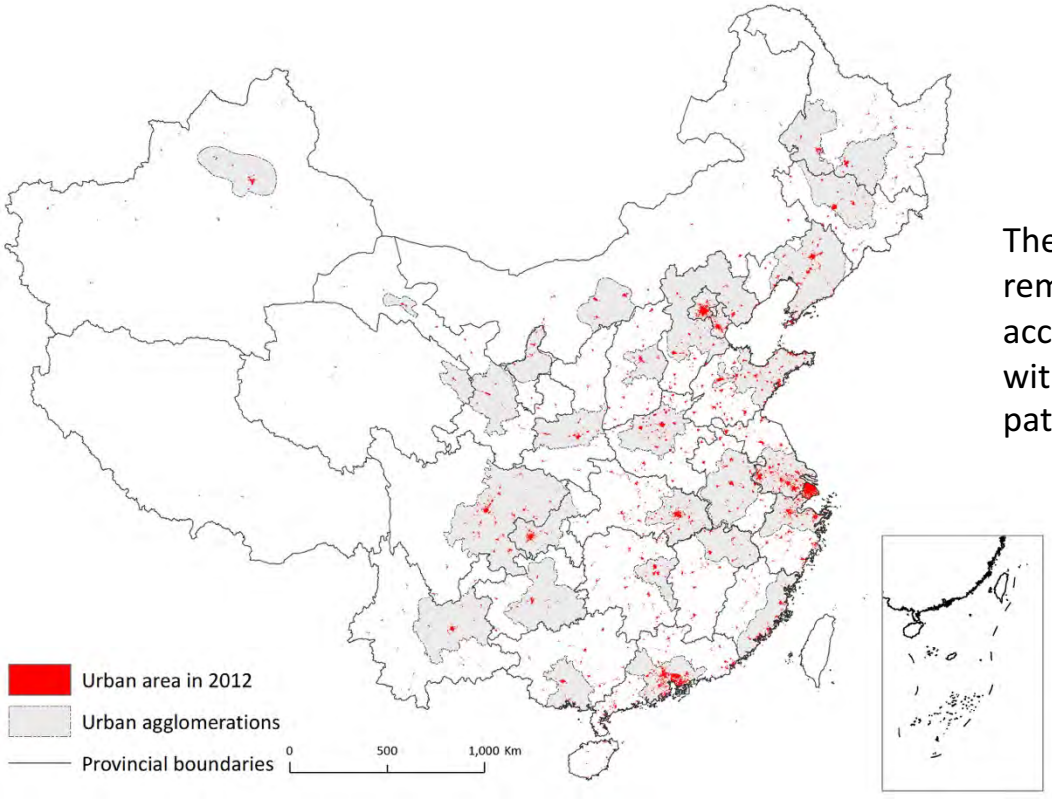
The Chinese city system



Administrative areas of Chinese cities

- There are 653 Chinese cities in 2014.
- On the basis of the Chinese administrative system, there are mainly five levels of cities classified in this way, including:
  - municipalities (MD) directly led by the nation (with 4 cities, tier 1)
  - sub-provincial cities (SPC) (with 15 cities, tier 2)
  - other provincial cities (OPCC) (with 17 cities, tier 3)
  - prefecture-level cities (PLC) (with 250 cities, tier 4)
  - county-level cities (CLC) (with 367 cities, tier 5)

Urban areas in 2000 for differentiating new and old developments



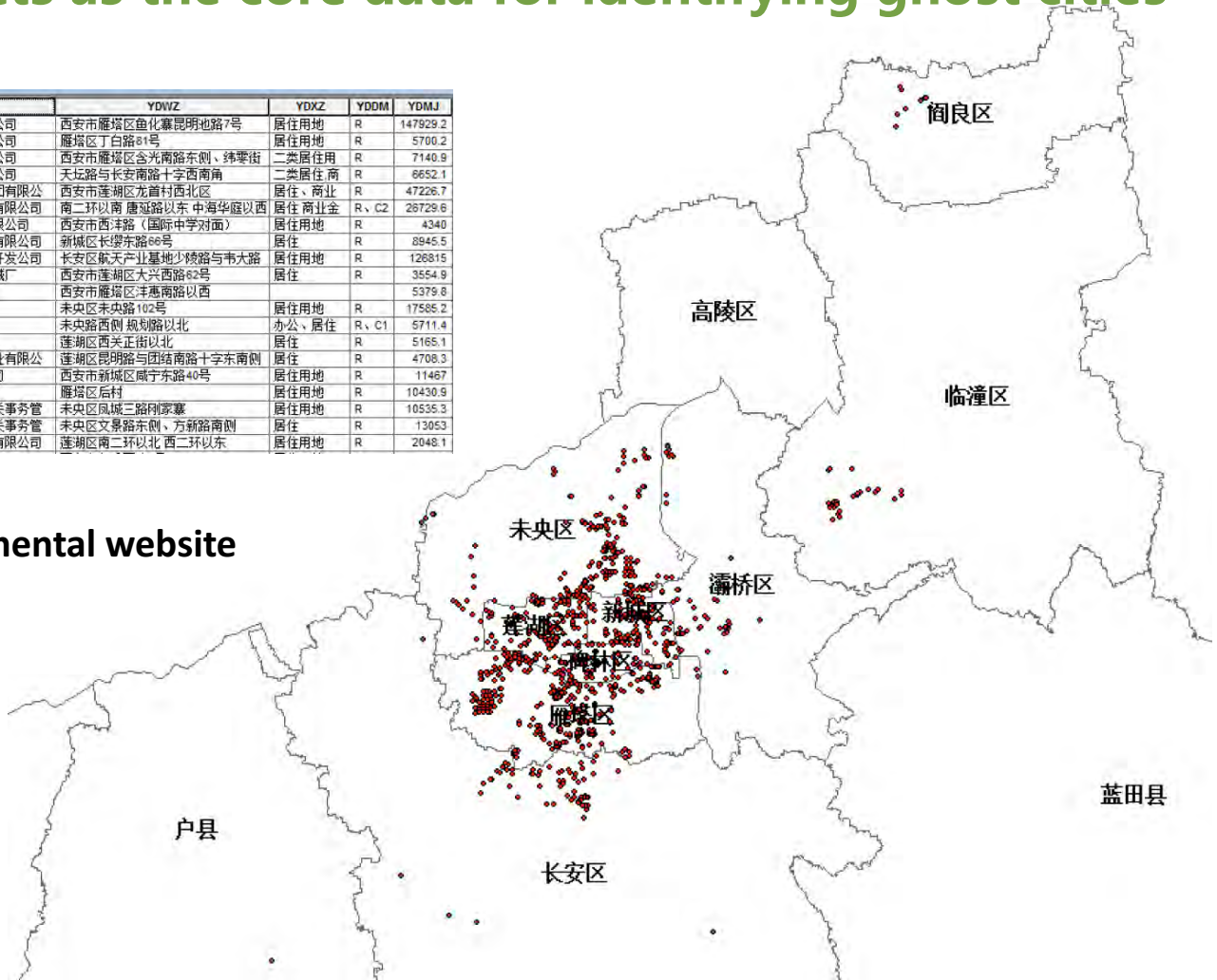
The urban areas are interpreted from remote sensing images, and the overall accuracy is 94.3%. There are 9,128 patches within 33,148 km^2 in total, and the mean patch size is 3.6 km^2.

- **We assume that the formation of ghost cities is generally due to the newly developed areas, thus making it necessary to define the relevant boundaries.**

Residential projects as the core data for identifying ghost cities

YWNF	XMBH	XMMC	YDDW	YDWZ	YDXZ	YDDM	YDMJ
2008	西规地字第（2008）	希城花园	陕西金泓投资有限公司	西安市雁塔区鱼化寨昆明地路7号	居住用地	R	147929.2
2008	西规地字第（2008）	"凯跃大厦"项目	陕西金泉置业有限公司	雁塔区丁白路81号	居住用地	R	5700.2
2010	西规地字第（2010）	金色嘉园	陕西金房实业有限公司	西安市雁塔区含光南路东侧、纬零街	二类居住用	R	7140.9
	西规地字第（2009）	象牙公寓	陕西裕洋置业有限公司	天坛路与长安南路十字西南角	二类居住,商	R	6652.1
2008	西规地字第（2008）	荣民花园	陕西荣民房地产集团有限公	西安市莲湖区龙首村西北区	居住、商业	R	47226.7
2008	西规地字第（2008）	莱安逸境	陕西置地投资发展有限公司	南二环以南 唐延路以东 中海华庭以西	居住 商业金	R、C2	26729.6
2008	西规地字第（2008）	竹园 阳光嘉苑	陕西竹园村置业有限公司	西安市西洋路（国际中学对面）	居住用地	R	4340
	西规地字第（2009）	祥林 铭邸	陕西祥林实业集团有限公司	新城区长缨东路66号	居住	R	8945.5
2008	西规地字第（2008）	金桥-紫慧长安	陕西省鸿业房地产开发公司	长安区航天产业基地少陵路与韦大路	居住用地	R	126815
	西规地字第（2009）	职工经济适用房	陕西省玻璃纤维机械厂	西安市莲湖区大兴西路62号	居住	R	3554.9
2010	西规地字第（2010）	经济适用房建设项目	陕西省汽车检测站	西安市雁塔区洋惠南路以西			5379.8
2010	西规地字第（2010）	职工住房项目	陕西省气象学校	未央区未央路102号	居住用地	R	17585.2
2008	西规地字第（2008）	省民政厅救灾救助和社	陕西省民政厅	未央路西侧 规划路以北	办公、居住	R、C1	5711.4
	西规地字第（2009）	省林业厅职工住宅楼	陕西省林业厅	莲湖区西关正街以北	居住	R	5165.1
	西规地字第（2009）	时代风尚SMART	陕西省时代博金置业有限公	莲湖区昆明路与团结南路十字东南侧	居住	R	4708.3
2008	西规地字第（2008）	咸宁东路职工住宅楼	陕西省建筑构件公司	西安市新城区咸宁东路40号	居住用地	R	11467
2010	西规地字第（2010）	省委东院配套基础设施	陕西省委办公厅	雁塔区后村	居住用地	R	10430.9
2008	西规地字第（2008）	北郊一号小区扩建工程	陕西省人民政府机关事务管	未央区凤城三路刘家寨	居住用地	R	10535.3
	西规地字第（2009）	省公安厅文景路住宅楼	陕西省人民政府机关事务管	未央区文景路东侧、方新路南侧	居住	R	13053
2008	西规地字第（2008）	高新左岸	陕西盛宇置业投资有限公司	莲湖区南二环以北 西二环以东	居住用地	R	2048.1

Available at the governmental website



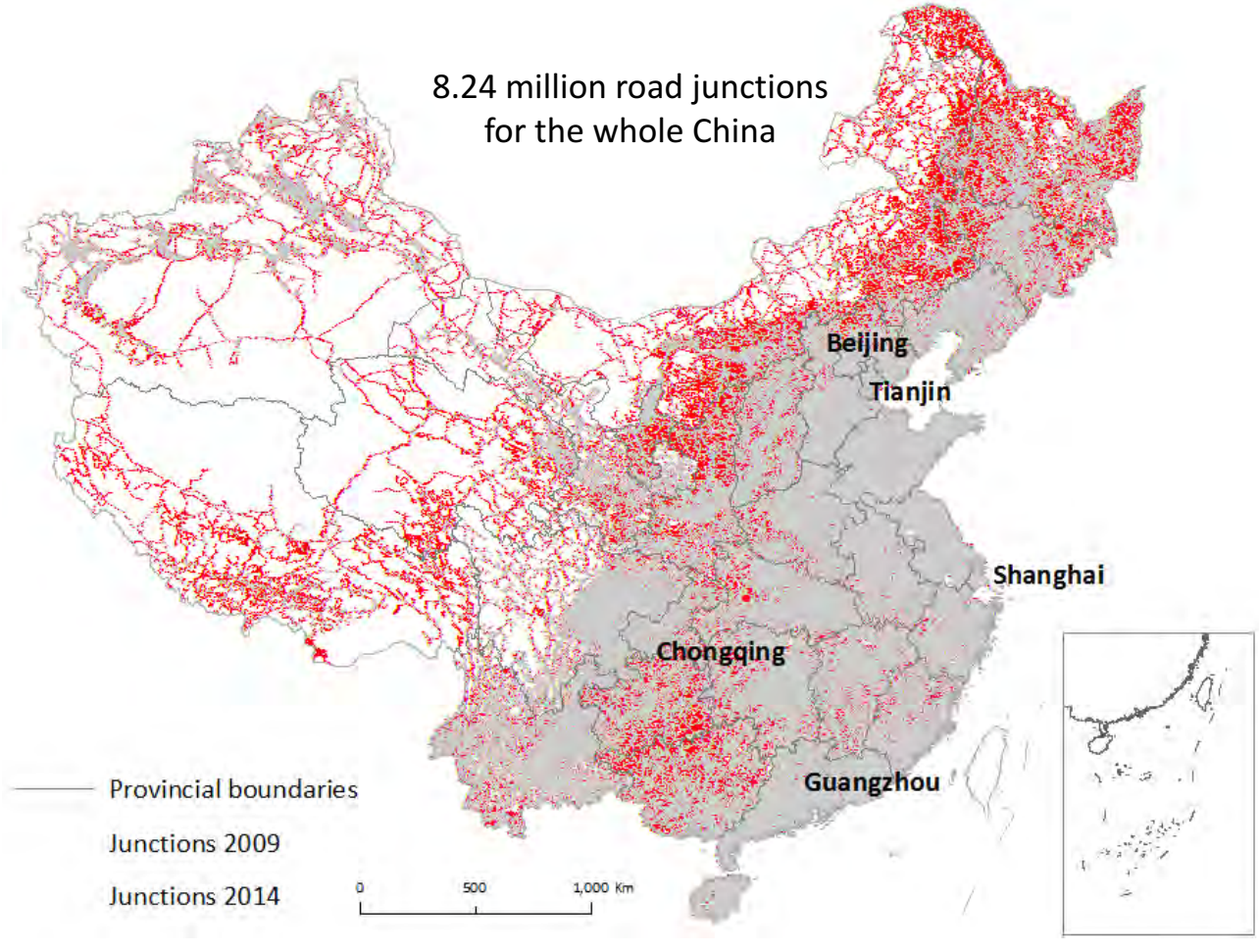
Residential projects as the core data for identifying ghost cities

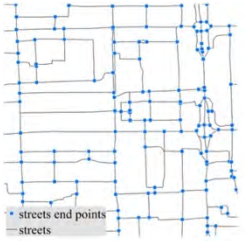
Year	Count sum	Type		Area sum in ha	Type	
		Market #	Social #		Market in ha	Social in ha
2002	2,576	2,182	394	4,042.1	3,726.4	315.7
2003	3,194	2,887	307	6,149.2	5,715.5	433.7
2004	10,840	3,965	6,875	13,839.8	11,641.6	2,198.2
2005	7,321	2,933	4,388	10,435.4	8,755.3	1,680.1
2006	7,880	3,897	3,983	10,270.5	9,232.9	1,037.7
2007	48,910	32,924	15,986	65,496.5	54,676.9	10,819.6
2008	43,545	29,682	13,863	60,112.3	48,901.4	11,210.9
2009	73,678	54,849	18,829	85,472.7	71,338.1	14,134.6
2010	87,017	78,234	8,783	127,848.2	109,779.3	18,068.9
2011	86,999	77,888	9,111	133,875.5	108,372.4	25,503.1
2012	72,618	62,861	9,757	116,444.5	87,714.5	28,730.0
2013	90,945	87,141	3,804	143,030.6	136,326.1	6,704.5
Sum	535,523	439,443	96,080	777,017.2	656,180.2	120,837.0

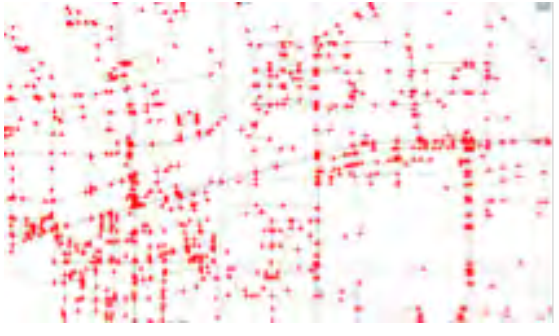
- In total, there are 535,523 residential projects within a total area of 7770.2 km^2 from 2002-2013
- Each project is stored as a point in GIS

Road junctions in 2014

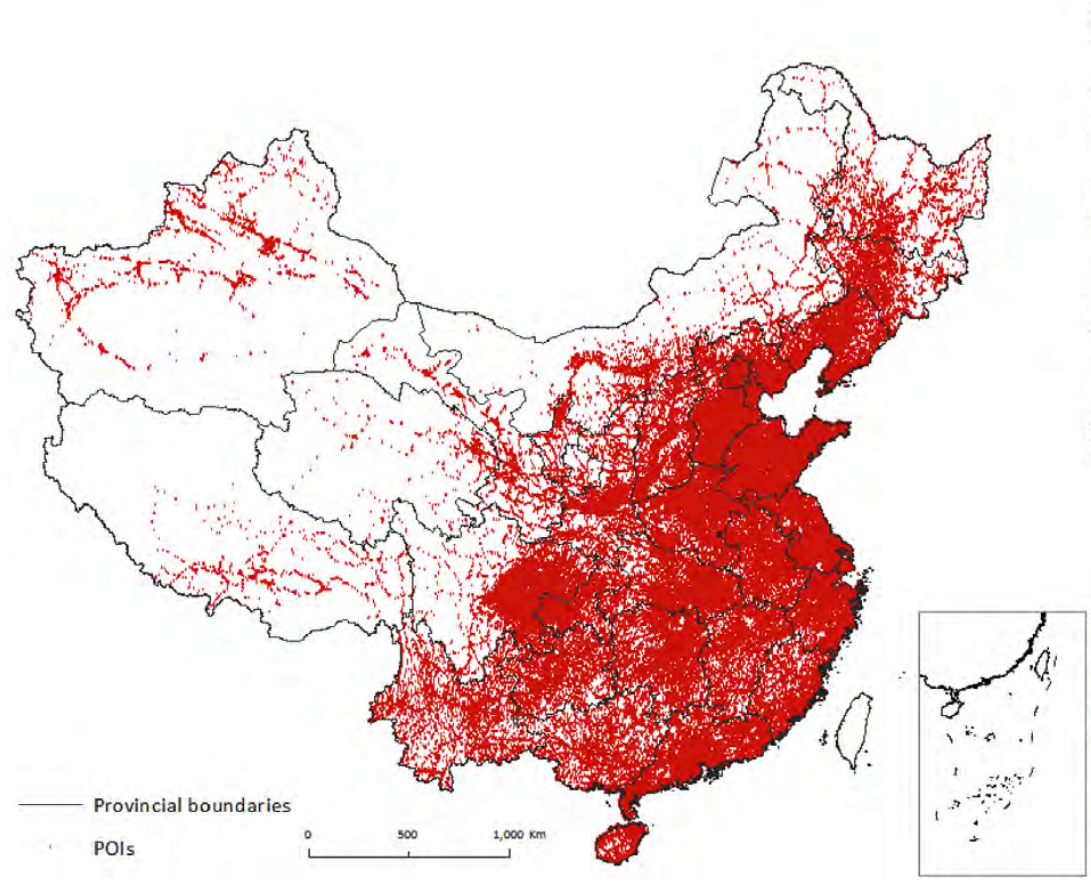
8.24 million road junctions
for the whole China

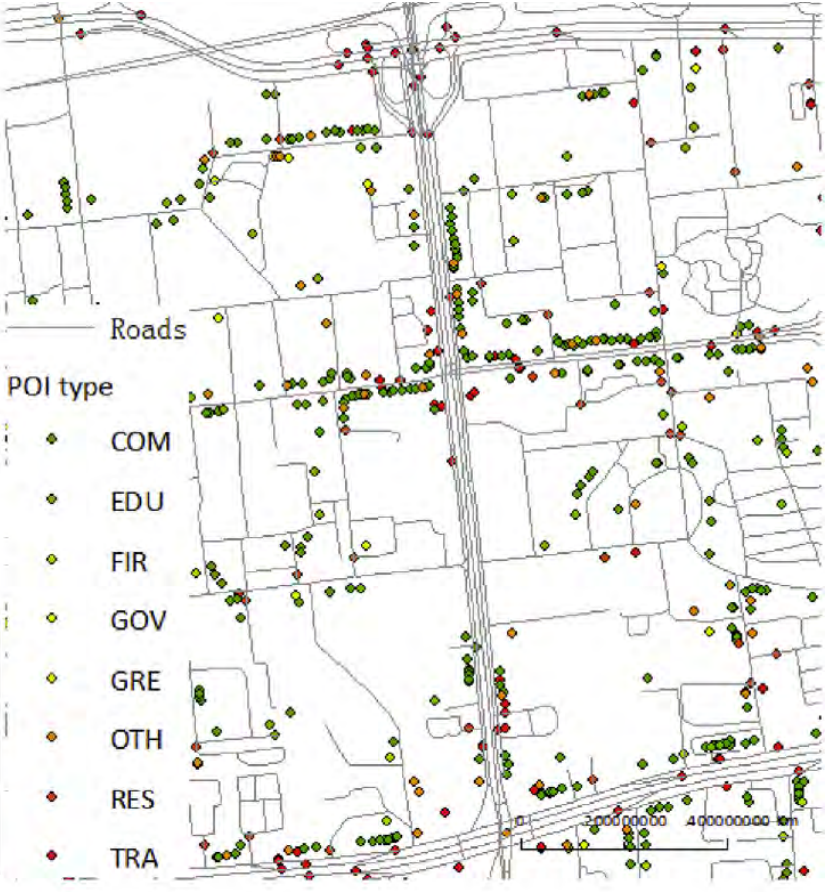




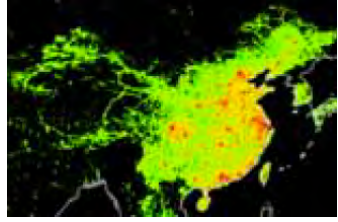


Points of interest in 2014

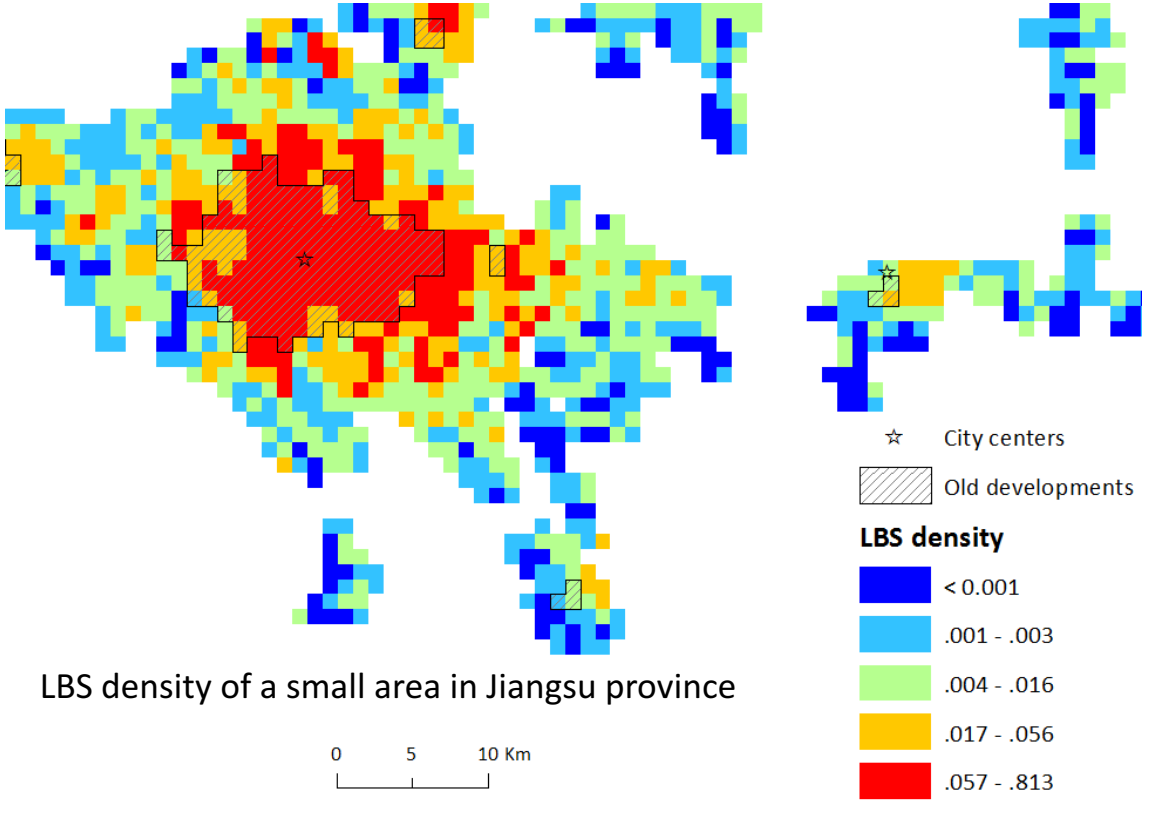




10.6 million POIs for the whole China



LBS data in 2015

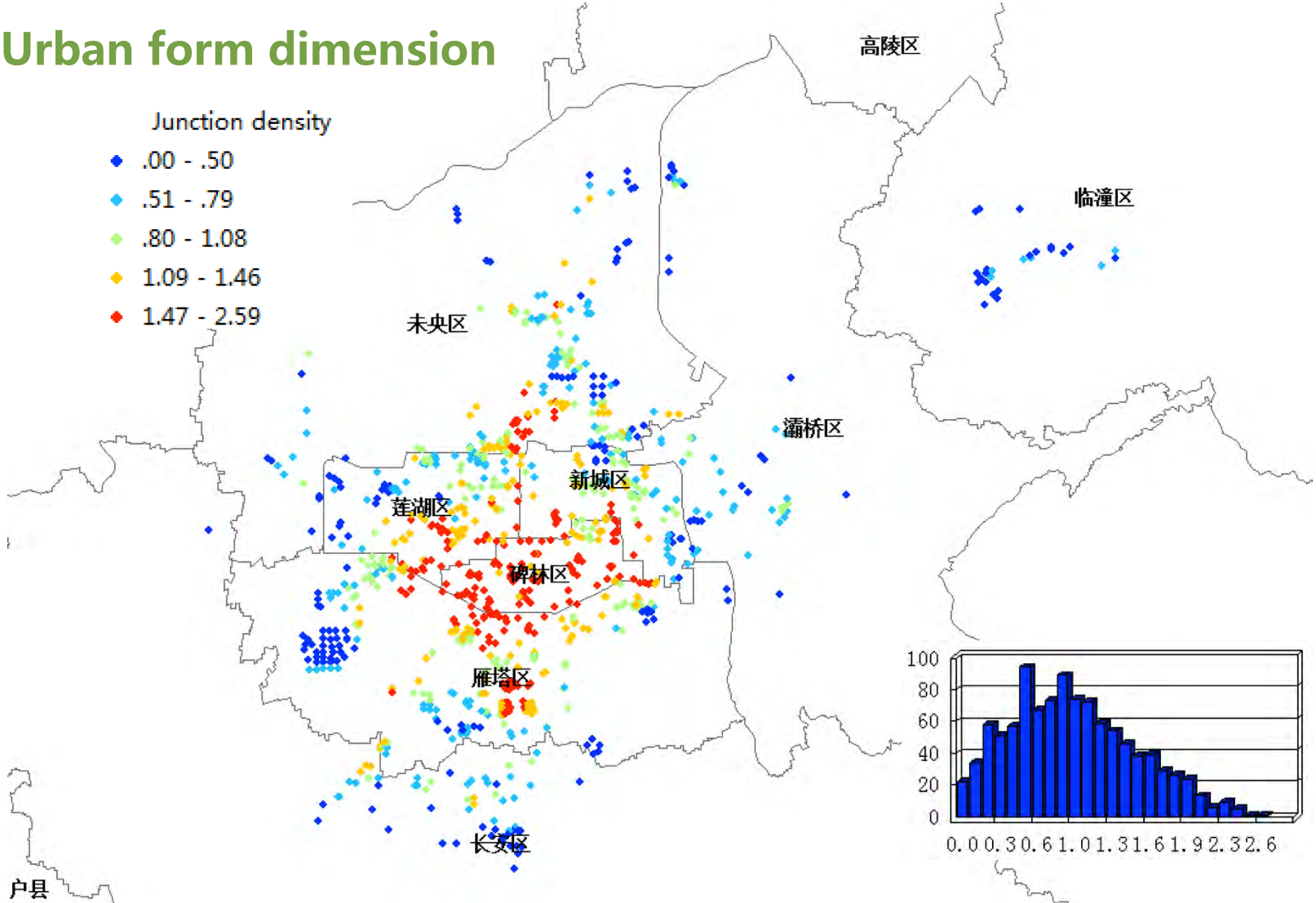


LBS density of a small area in Jiangsu province

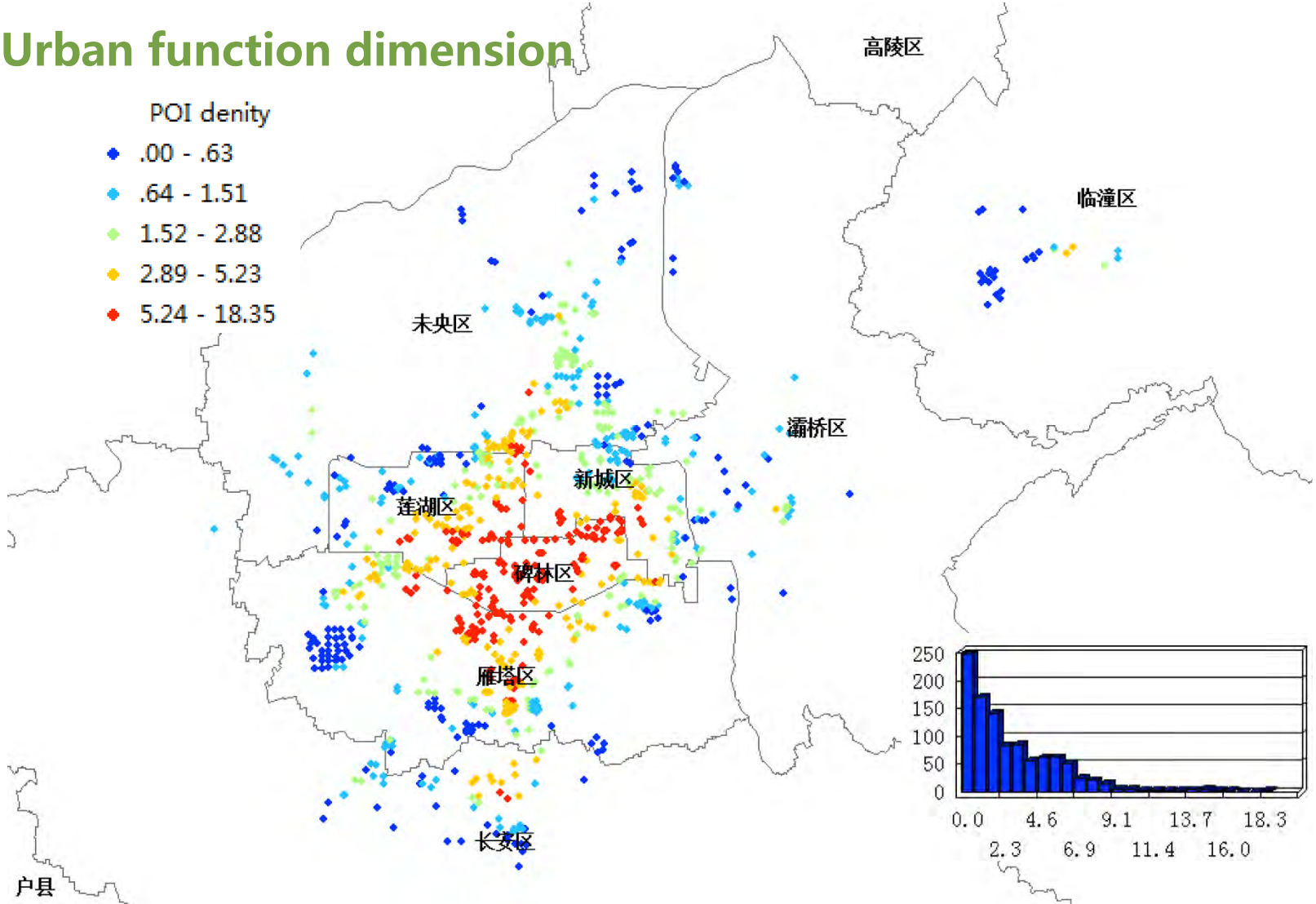
- We have gathered 1km*1km LBS data from Baidu, one of the largest internet companies in China, and the data cover a whole week in July of 2015
- Considering the data cover of about 800 million users in China, the data can well reflect human activities in China

Results

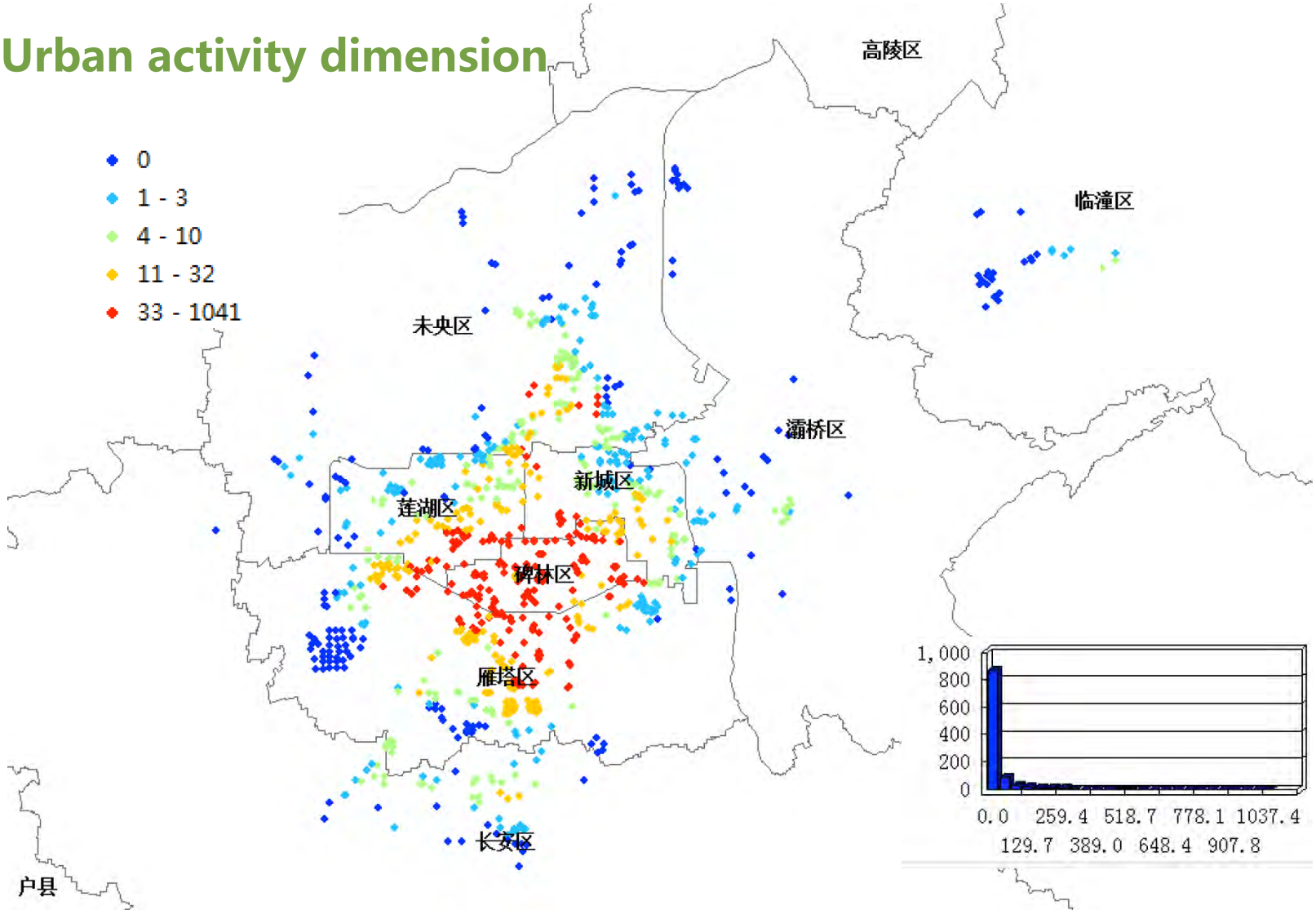
Urban form dimension



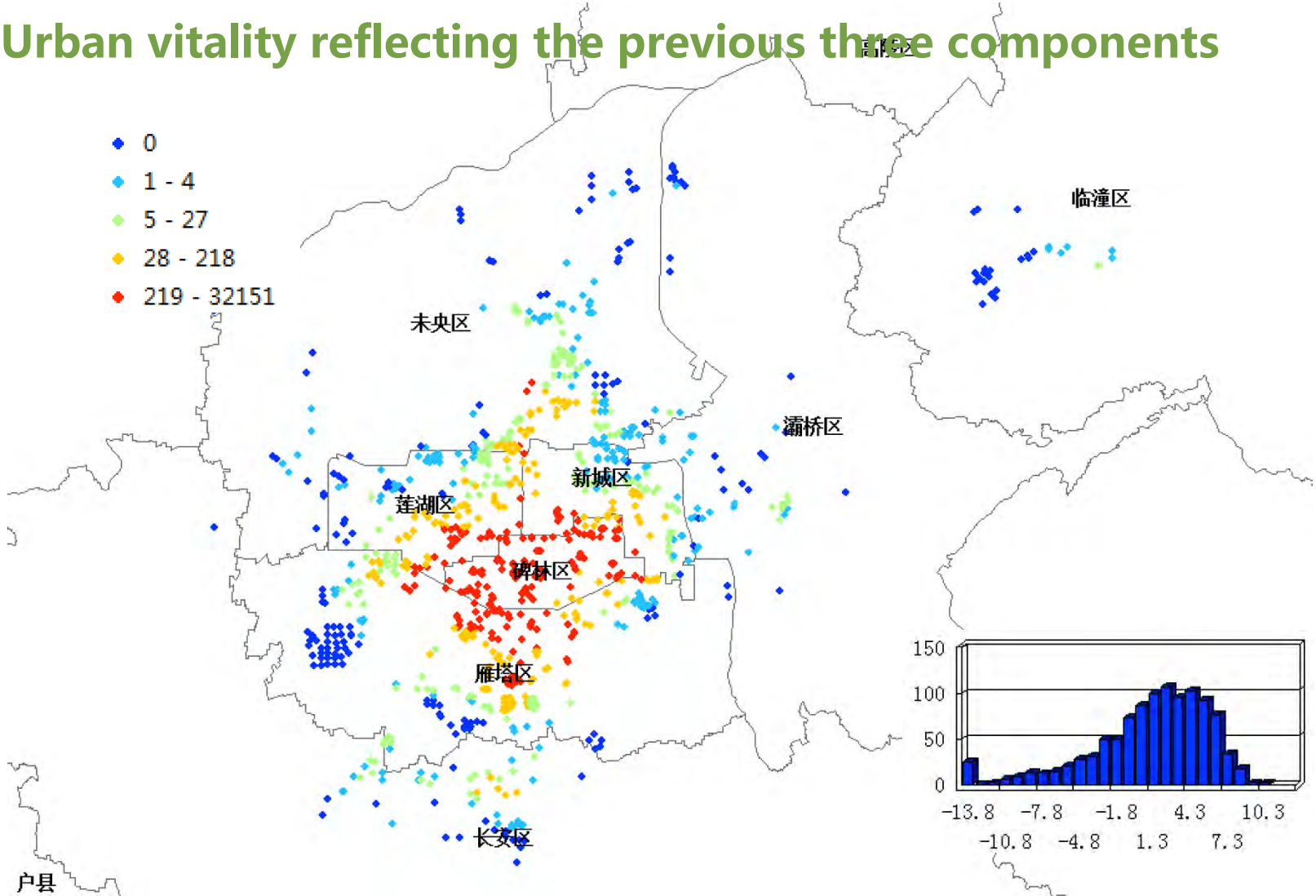
Urban function dimension



Urban activity dimension

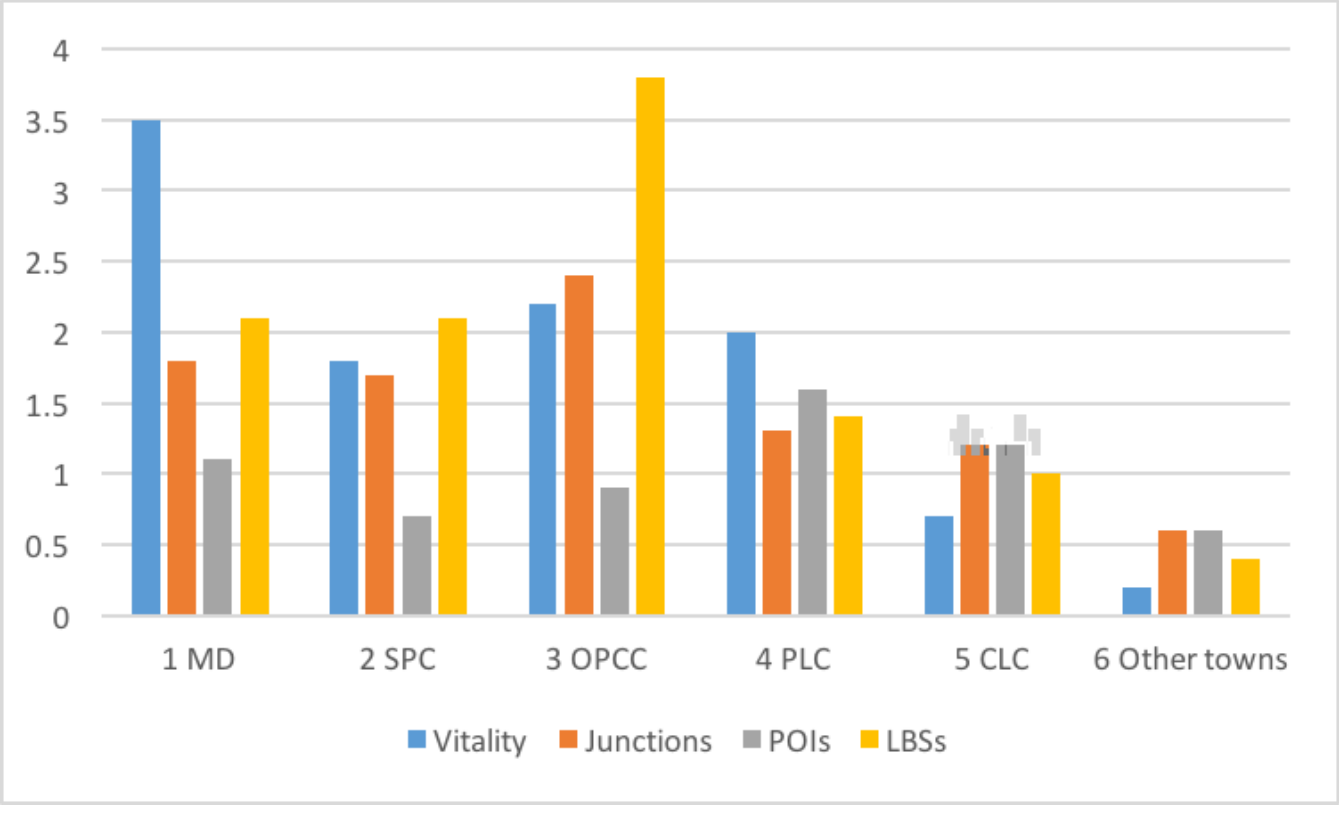


Urban vitality reflecting the previous three components



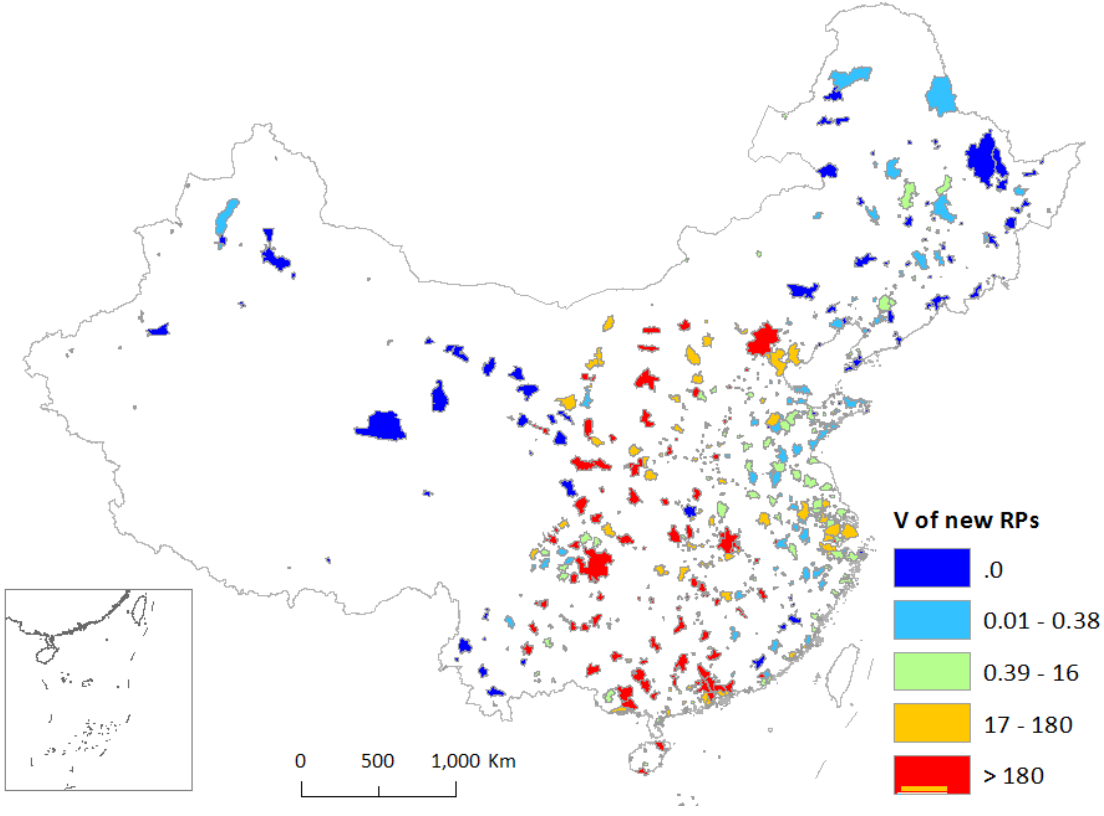
We find the average vitality of residential projects in new urban areas is only 8.8% of that in old urban areas, denoting the potential existence of ghost cities in newly developed areas in Chinese cities.

The urban vitality and its components by each level of cities



- 1 MD = cities directly led by the nation (with 4 cities, tier 1), 2 SPC = sub-provincial cities (with 15 cities, tier 2), 3 OPCC = other provincial cities (with 17 cities, tier 3), 4 PLC = prefecture-level cities (with 250 cities, tier 4), and 5 CLC = county-level cities, and 6 Other towns means that the projects are beyond the administrative boundaries of cities in China

The average vitality of residential projects (RPs) in new urban areas for all Chinese cities



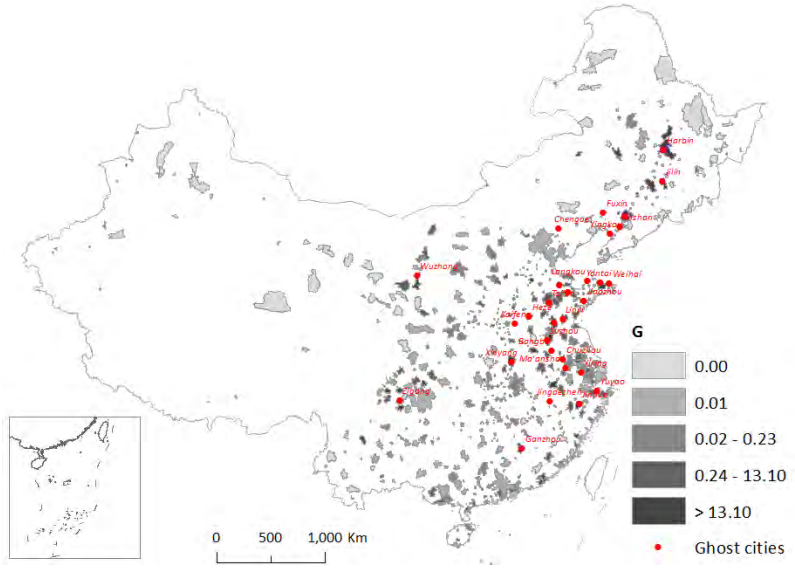
- The results indicate that the cities in the middle region of China have the greatest vitality values and those in north eastern China and western China are with lower values.

The regression model for residential project vitality suggests that residential projects in old urban areas, being close to the city center in an administratively higher tier city, with a smaller development size and more recent development, positively contribute to a higher level of vitality.

Variable	Vitality	Junctions	POIs	LBSs
URBAN	0.126	0.352	0.307	0.286
YEAR	0.008	0.003	0.040	0.015
CENTER	-0.025	-0.103	-0.056	-0.089
LEVEL	-0.132	-0.353	-0.057	-0.336
AREA	-0.041	-0.051	-0.082	-0.064
Adjusted R^2	0.045	0.353	0.123	0.274

Note: All variables are significant at the 0.05 level. All coefficients have been normalized in the linear regression process. When we use the logarithm value of vitality as the dependent variable, the adjusted R^2 and the normalized coefficients do not change much.

The ghost index (*G*) for all Chinese cities



Thirty ghost cities are identified according to the *G* indicator evaluation results, and most of these cities are distributing in north eastern China, particularly in Shandong and Anhui provinces.

We have also benchmarked our identified ghost cities against existing rankings, the Baidu search engine, and night-time light images.

Although we admit that ghost cities may exist in the particular urbanizing phase in China, and some cities that are ghost cities now may be well developed in future, this study provides a thorough evaluation on the ghost city condition in China.

Our profiling results illustrate a big picture for Chinese past residential developments and then the ghost cities.

This may shed light on policy implications for Chinese urban development.

Highlights of this study

- **Borrow the theory of urban vitality to identify and evaluate ghost cities**
  - Three components: form, function and activity
  - LBS should not be the only data for the ghost city study
- **Evaluate each city in a bottom-up manner by using ubiquitous and increasingly available big/open data from official websites, commercial internet companies and social networks**
  - Both “ghost” level and “ghost” size in our study
- **Develop theoretical models to explain the contributing factors on vitality at the residential project level**
  - Providing the possibility for proposing necessary policies to fight against ghost cities in modern China
- **The proposed ghost indicator *G* considers not only the vitality in new urban areas, but also the gap between new and old urban areas**
  - Making it possible to overcome the gap of urban form, function and information communication technology (ICT) penetration across various cities

Potential biases of this study

- The access to the real boundary of each residential community may lead to more objective evaluation and identification results.
- The informal residential developments also contribute to the formation of ghost cities. This should be addressed in our next study as well.

References

- Batty, M. (2016). Empty buildings, shrinking cities and ghost towns. *Environment and Planning B: Planning and Design, 43*, 3-6.
- Chen, Q. (2014). Will the number of ghost cities continue increasing? . http://www.zhihu.com/question/26193868/answer/33116107
- Chi, G., Liu, Y., & Wu, H. (2015). Ghost Cities Analysis Based on Positioning Data in China. arXiv preprint arXiv:1510.08505.
- Doll, C. N. H., Muller, J.-P., & Morley, J. G. (2006). Mapping regional economic activity from night-time light satellite imagery. *Ecological Economics, 57*, 75-92.
- Elvidge, C. D., Baugh, K. E., Dietz, J. B., Bland, T., Sutton, P. C., & Kroehl, H. W. (1999). Radiance Calibration of DMSP-OLS Low-Light Imaging Data of Human Settlements. *Remote Sensing of Environment, 68*, 77-88.
- Jacobs, J. (1961). The Death and Life of Great American Cities. New York: Random house.
- Lynch, K. (1984). Good City Form. Cambridge: The MIT Press.
- Kuang, W., Liu, J., Dong, J., Chi, W., & Zhang, C. (2016). The rapid and massive urban and industrial land expansions in China between 1990 and 2010: A CLUD-based analysis of their trajectories, patterns, and drivers. *Landscape and Urban Planning, 145*, 21-33.
- Liu, X., & Long, Y. (2016). Automated identification and characterization of parcels with OpenStreetMap and points of interest. *Environment and Planning B: Planning and Design*, *43*, 341-360.
- Liu, Z., He, C., Zhang, Q., Huang, Q., & Yang, Y. (2012). Extracting the dynamics of urban expansion in China using DMSP-OLS nighttime light data from 1992 to 2008. *Landscape and Urban Planning, 106*, 62-72.
- Long, Y. (2016). Redefining Chinese city system with open data. *Beijing City Lab*.
- Long, Y., Gu, Y., & Han, H. (2013). Spatiotemporal heterogeneity of urban planning implementation effectiveness: Evidence from five urban master plans of Beijing. *Landscape and Urban Planning, 108*, 103-111.
- Long, Y., Han, H., Tu, Y., & Shu, X. (2015). Evaluating the effectiveness of urban growth boundaries using human mobility and activity records. *Cities, 46*, 76-84.
- Long, Y., & Wu, K. (2016). Shrinking cities in a rapidly urbanizing China. *Environment and Planning A*, 48, 220-222.
- Ma, T., Zhou, Y., Zhou, C., Haynie, S., Pei, T., & Xu, T. (2015). Night-time light derived estimation of spatio-temporal characteristics of urbanization dynamics using DMSP/OLS satellite data. *Remote Sensing of Environment, 158*, 453-464.
- Montgomery, M. R. (2008). The Urban Transformation of the Developing World. *Science, 319*, 761-764.
- Nie, X.-y., & Liu, X.-j. (2013). Types of “Ghost Towns” in the Process of Urbanization and Countermeasures. *Journal of Nantong University (Social Sciences), 29*, 111-117. (in Chinese)
- O'Callaghan, C., Boyle, M., & Kitchin, R. (2014). Post-politics, crisis, and Ireland's ‘ghost estates’. *Political Geography, 42*, 121-133.
- Shepard, W. (2015). *Ghost Cities of China: The Story of Cities without People in the World's Most Populated Country*. Zed Books.
- Su, X. (2014). Rank of ghost cities in 2014. http://house.ifeng.com/detail/2014_10_12/50060123_0.shtml
- Tian, G., Liu, J., Xie, Y., Yang, Z., Zhuang, D., & Niu, Z. (2005). Analysis of spatio-temporal dynamic pattern and driving forces of urban land in China in 1990s using TM images and GIS. *Cities, 22*, 400-410.
- Wang, L., LI, C., Ying, Q., Cheng, X., Wang, X., Li, X., Hu, L., Liang, L., Yu, L., Huang, H., & Gong, P. (2012). China’s urban expansion from 1990 to 2010 determined with satellite remote sensing. *Chin Sci Bull, 57*, 2802-2812
- Xiao, P., Wang, X., Feng, X., Zhang, X., & Yang, Y. (2014). Detecting China’s Urban Expansion Over the Past Three Decades Using Nighttime Light Data. *IEEE Journal of Selected Topics in Applied Earth Observation and Remote Sensing, 7*, 4095-4106.
- Zijderveld, A. C. (1998). *A Theory of Urbanity: The Economic and Civic Culture of Cities* (Transaction Publishers, New Brunswick, NJ)

Thanks

ylong@tsinghua.edu.cn

This work is supported by grants from the National Natural Science Foundation of China (No. 41340016 and 51408039). The authors would like to thank Mr/Ms Xuefeng Huang and Jinyuan Xie for their assistance on data processing. Our thanks are also given to Ms Tracey Taylor for editing the language of this paper.