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

Ying Long, Associate Professor
School of Architecture, Tsinghua University, China

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In collaboration with Xiaobin Jin, Wei Sun, Yuyin Lu, Xuhong Yang
Rapid urban expansion in China during last decades
(around 30% residential developments)
## The existing rankings of ghost cities in China

<table>
<thead>
<tr>
<th>Evaluation Indicators</th>
<th>The Biaozhun Ranking</th>
<th>The Netease Ranking</th>
<th>The Fang Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concludes the top fifty &quot;ghost cities&quot; of the future and a &quot;Super star&quot; county</td>
<td>The urban construction speed exceeds the population growth in many cities of China, a large number of &quot;ghost cities&quot; have appeared</td>
<td>Top 12 “ghost cities” of China in 2015</td>
</tr>
<tr>
<td></td>
<td>Less than 5 thousand people per square kilometre in a city’s built-up areas</td>
<td>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</td>
<td>The pace of the decline in residential real estate</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Order</th>
<th>Top 30</th>
<th>Top 50</th>
<th>No</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sanya (Hainan)</td>
<td>*Erlianhaote (Inner Mongolia)</td>
<td>Kiamusze (Heilongjiang)</td>
<td>Erdos (Inner Mongolia)</td>
</tr>
<tr>
<td>2</td>
<td>*Tianmen (Hubei)</td>
<td>*Alar (Xinjiang)</td>
<td>*Anlu (Hubei)</td>
<td>Hohehot (Inner Mongolia)</td>
</tr>
<tr>
<td>3</td>
<td>△Chongqing (Chongqing)</td>
<td>*Beitun (Xinjiang)</td>
<td>*Penglai (Shandong)</td>
<td>Bayan Nur (Inner Mongolia)</td>
</tr>
<tr>
<td>4</td>
<td>Zhangjiajie (Hunan)</td>
<td>*Aletai (Xinjiang)</td>
<td>*Hailin (Heilongjiang)</td>
<td>Erlianhaote (Inner Mongolia)</td>
</tr>
<tr>
<td>5</td>
<td>Luoyang (Henan)</td>
<td>Zhangye (Gansu)</td>
<td>Jixi (Heilongjiang)</td>
<td>Zhengzhou (Henan)</td>
</tr>
</tbody>
</table>
Housing vacancy rate has been a national secret in each city.
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

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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.

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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.

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.
Methodology

Identifying ghost cities through the lens of the vitality of residential developments
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) = \( \ln (J \times P \times L) \)
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

\[ G = 1 / (V_{\text{new}}/V_{\text{old}} \times V_{\text{new}}) \]

The average vitality of residential developments in new urban areas \( (V_{\text{new}}) \) and residential developments in old urban areas \( (V_{\text{old}}) \) 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
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 km² in total, and the mean patch size is 3.6 km².

- 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

Available at the governmental website
### Residential projects as the core data for identifying ghost cities

<table>
<thead>
<tr>
<th>Year</th>
<th>Count sum</th>
<th>Type</th>
<th>Area sum in ha</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Market #</td>
<td>Social #</td>
<td>Market in ha</td>
</tr>
<tr>
<td>2002</td>
<td>2,576</td>
<td>2,182</td>
<td>394</td>
<td>4,042.1</td>
</tr>
<tr>
<td>2003</td>
<td>3,194</td>
<td>2,887</td>
<td>307</td>
<td>6,149.2</td>
</tr>
<tr>
<td>2004</td>
<td>10,840</td>
<td>3,965</td>
<td>6,875</td>
<td>13,839.8</td>
</tr>
<tr>
<td>2005</td>
<td>7,321</td>
<td>2,933</td>
<td>4,388</td>
<td>10,435.4</td>
</tr>
<tr>
<td>2006</td>
<td>7,880</td>
<td>3,897</td>
<td>3,983</td>
<td>10,270.5</td>
</tr>
<tr>
<td>2007</td>
<td>48,910</td>
<td>32,924</td>
<td>15,986</td>
<td>65,496.5</td>
</tr>
<tr>
<td>2008</td>
<td>43,545</td>
<td>29,682</td>
<td>13,863</td>
<td>60,112.3</td>
</tr>
<tr>
<td>2009</td>
<td>73,678</td>
<td>54,849</td>
<td>18,829</td>
<td>85,472.7</td>
</tr>
<tr>
<td>2010</td>
<td>87,017</td>
<td>78,234</td>
<td>8,783</td>
<td>127,848.2</td>
</tr>
<tr>
<td>2011</td>
<td>86,999</td>
<td>77,888</td>
<td>9,111</td>
<td>133,875.5</td>
</tr>
<tr>
<td>2012</td>
<td>72,618</td>
<td>62,861</td>
<td>9,757</td>
<td>116,444.5</td>
</tr>
<tr>
<td>2013</td>
<td>90,945</td>
<td>87,141</td>
<td>3,804</td>
<td>143,030.6</td>
</tr>
<tr>
<td>Sum</td>
<td>535,523</td>
<td>439,443</td>
<td>96,080</td>
<td>777,017.2</td>
</tr>
</tbody>
</table>

- In total, there are 535,523 residential projects within a total area of 7770.2 km² 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
10.6 million POIs for the whole China
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

Junction density
- .00 - .50
- .51 - .79
- .80 - 1.08
- 1.09 - 1.46
- 1.47 - 2.59
Urban function dimension

POI density
- .00 - .63
- .64 - 1.51
- 1.52 - 2.88
- 2.89 - 5.23
- 5.24 - 18.35
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)
- 5 CLC = county-level cities
- 6 Other towns means that the projects are beyond the administrative boundaries of cities in China
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.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Vitality</th>
<th>Junctions</th>
<th>POIs</th>
<th>LBSs</th>
</tr>
</thead>
<tbody>
<tr>
<td>URBAN</td>
<td>0.126</td>
<td>0.352</td>
<td>0.307</td>
<td>0.286</td>
</tr>
<tr>
<td>YEAR</td>
<td>0.008</td>
<td>0.003</td>
<td>0.040</td>
<td>0.015</td>
</tr>
<tr>
<td>CENTER</td>
<td>-0.025</td>
<td>-0.103</td>
<td>-0.056</td>
<td>-0.089</td>
</tr>
<tr>
<td>LEVEL</td>
<td>-0.132</td>
<td>-0.353</td>
<td>-0.057</td>
<td>-0.336</td>
</tr>
<tr>
<td>AREA</td>
<td>-0.041</td>
<td>-0.051</td>
<td>-0.082</td>
<td>-0.064</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.045</td>
<td>0.353</td>
<td>0.123</td>
<td>0.274</td>
</tr>
</tbody>
</table>

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 R² and the normalized coefficients do not change much.
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


Thanks

ylong@tsinghua.edu.cn

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