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Center for Energy & Environmental Policy Research

THE 2014
GLOBAL
RESEARCH FORUM

Sustainable Production and Consumption Conference:
Global Transitions to Sustainable Production and Consumption Systems

可持续生产与消费全球研究论坛
可持续生产和消费系统的全球性转变

Industrial energy and environmental efficiency in China:
Analysis based on 36 major cities with undesirable outputs

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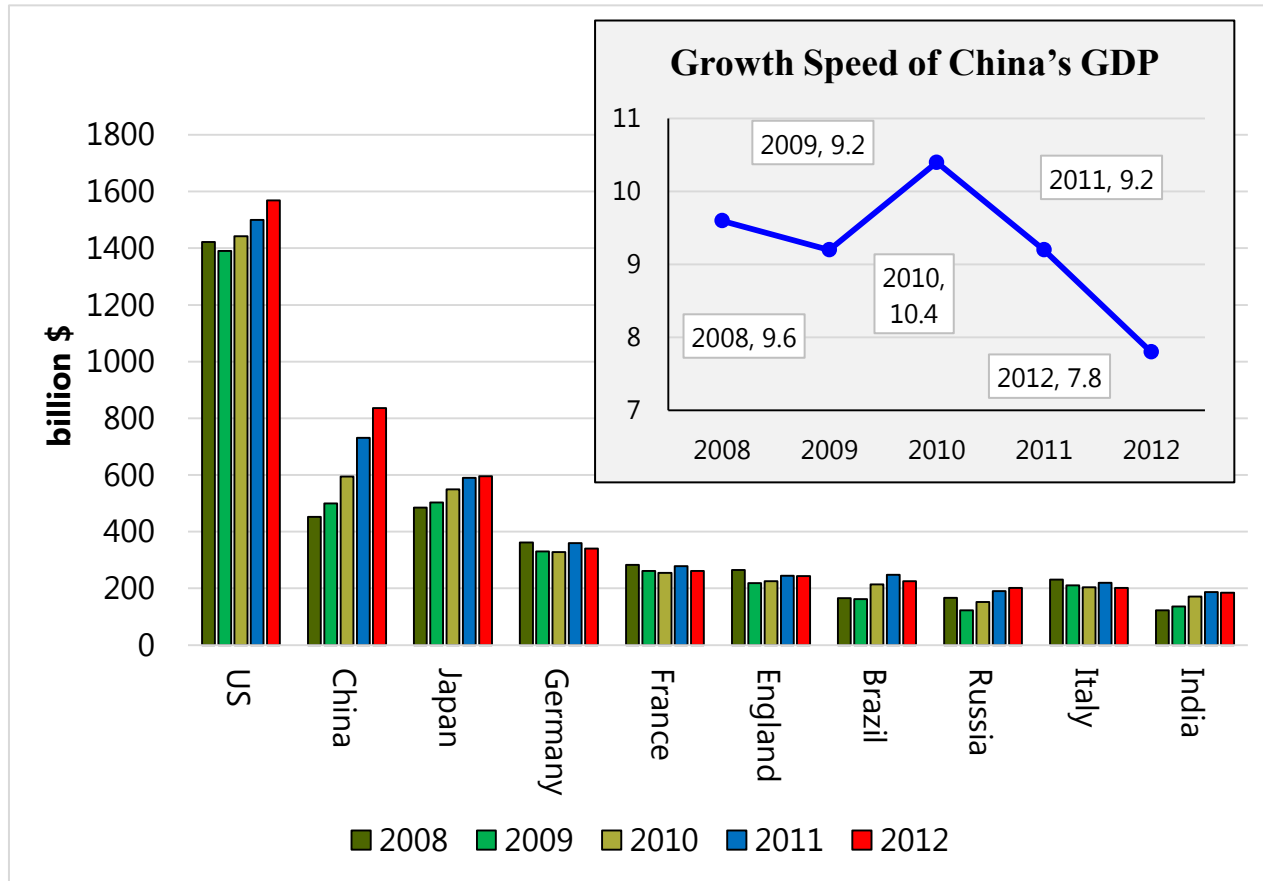
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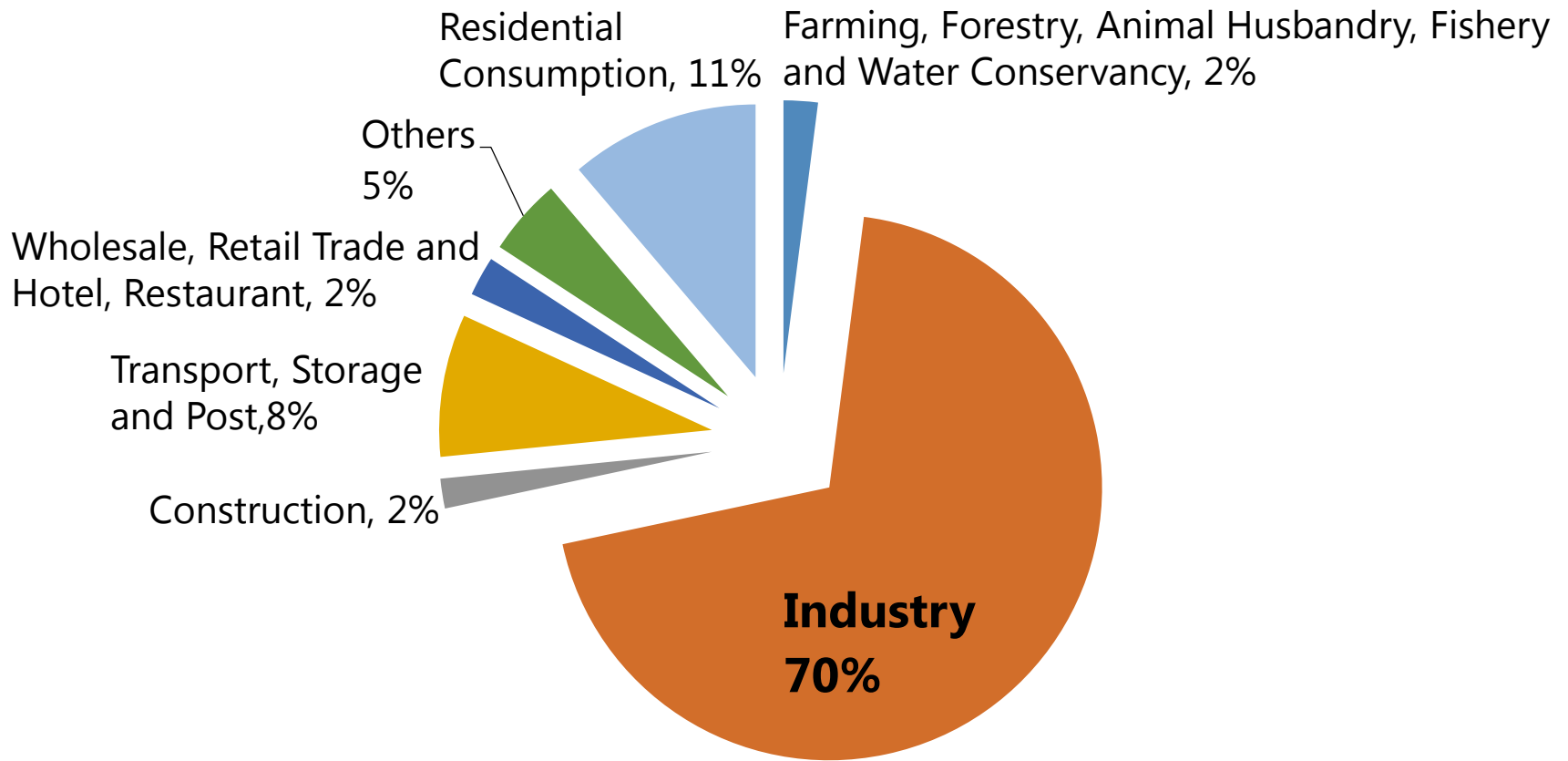
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GDP of Top 10 Countries 2008—2012



Source: World Bank; World economy outlook 2012

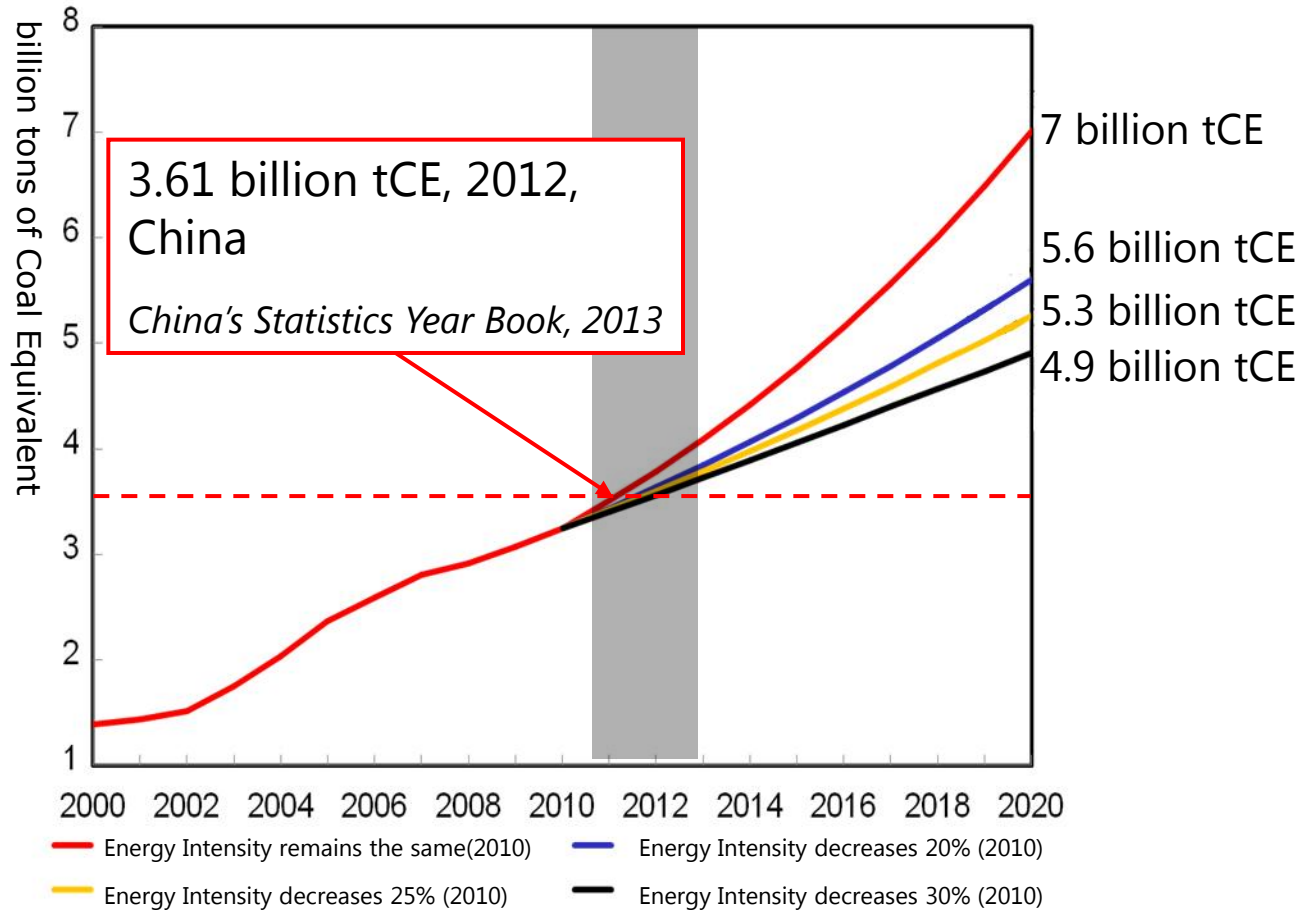
Energy consumption structure of China(2011)



Source: China Energy Statistical Yearbook 2012

Background: What will happen in China in 2020

Energy consumption forecast based on energy intensity : 2000-2020



Energy Intensity = Energy consumption per GDP

Y.-D. Dai, Y.-Z. Yue. (2013) In Chinese

Background: Why 2005-2010 and city level?



- **2005-2010:**

- Energy efficiency showed a terrible trend in 2000-2005
- China launched strict energy saving policies in every provinces and cities in 2005-2010.

- **City level:**

- Environment affects the development of city greatly
- Urbanization
- Homogeneity (let examples be the same type)

Model: SBM-DEA with bad outputs

- DEA method is widely applied in energy/ environmental efficiency researches

Guedes E C C, Milioni A Z, de Avellar J V G, et al. Adjusted spherical frontier model: allocating input via parametric DEA[J]. 2012, 63(3): 406-417.

Silva R C, Milioni A Z. The Adjusted Spherical Frontier Model with weight restrictions[J]. European Journal of Operational Research. 2012.

Milioni A Z, de Avellar J V G, Gomes E G, et al. An ellipsoidal frontier model: Allocating input via parametric DEA[J]. European Journal of Operational Research. 2011, 209(2): 113-121.

Wang K, Wei Y, Zhang X. A comparative analysis of China's regional energy and emission performance: Which is the better way to deal with undesirable outputs?[J]. Energy Policy. 2012, 46(0): 574-584.

Silva R C, Milioni A Z. The Adjusted Spherical Frontier Model with weight restrictions[J]. European Journal of Operational Research. 2012.

Model: SBM-DEA with bad outputs

$$\min \tau = t - \frac{1}{m} \left(\sum_{i=1}^m \frac{s_i^+}{x_{ik}} \right) \epsilon$$

$$\text{s.t. } 1 = t + \frac{1}{r+f} \left(\sum_{h=1}^r \frac{s_h^e}{y_{hk}} + \sum_{d=1}^f \frac{s_d^b}{b_{dk}} \right) \epsilon$$

$$\sum_{j=1}^n x_{ij} \Lambda_j + s_i^+ = x_{ik} t, \quad i = 1, 2, \dots, m \quad \epsilon$$

$$\sum_{j=1}^n y_{hj} \Lambda_j - s_h^e = y_{hk} t, \quad h = 1, 2, \dots, r$$

$$\sum_{j=1}^n b_{dj} \Lambda_j + s_d^b = b_{dk} t, \quad d = 1, 2, \dots, f \quad \epsilon$$

$$\Lambda_j \geq 0, \quad j = 1, 2, \dots, n \quad s_i^+ \geq 0, \quad i = 1, 2, \dots, m \quad \epsilon$$

$$s_h^e \geq 0, \quad h = 1, 2, \dots, r \quad s_d^b \geq 0, \quad d = 1, 2, \dots, f \quad \epsilon$$

- K. Tone, Dealing with undesirable outputs in DEA: a Slacks-Based Measure (SBM) approach, *Nippon Opereshonzu*, Risachi Gakkai Shunki Kenkyu Happyokai Abusutorakutoshu, 2004 (2004) 44-45.

Example Cities

Province capital (except Lhasa)

Sub-province level Cities: 15 cities

Dalian	Qingdao
Ningbo	Xiamen
Shenzhen	(Duplicates removed)

Low carbon pilot project: 8 cities

Tianjin	Hangzhou
Baoding	Nanchang
Chongqing	Guiyang
Xiamen	Shenzhen

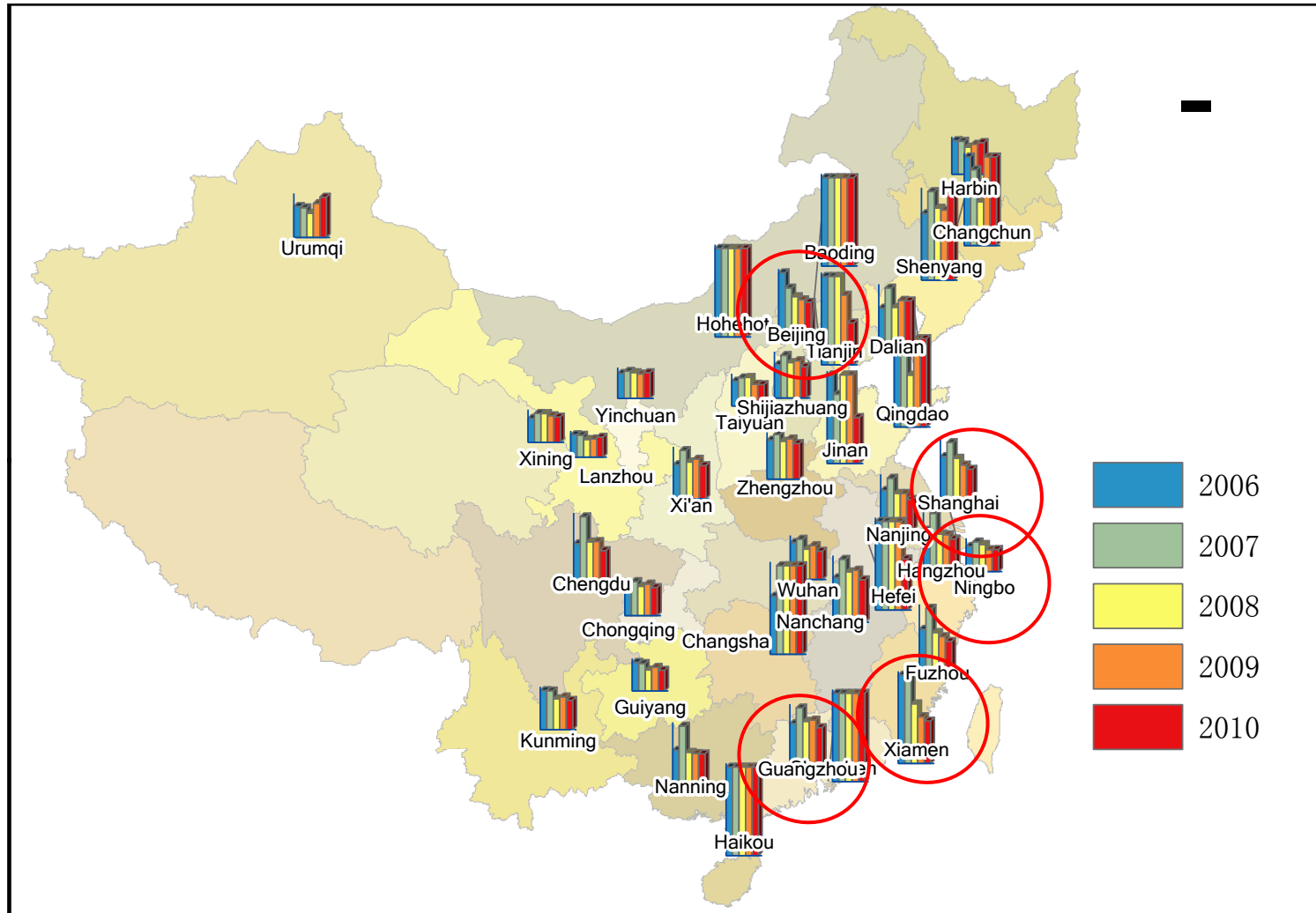
Finally, we take 36 cities into account.

Data/Indicators description

Good output	Value-added of Industrial Enterprises above Designated Size
Energy input	Total energy consumption of industrial enterprises above designated size
Labor input	Annual average number of employed person of industrial enterprises above designated size
Capital input	Net value of fixed assets of industrial enterprises above designated size
Bad output 1	Volume of Industrial Waste Gas Emission
Bad output 2	Total Volume of Industrial Waste Water Emission
Bad output 3	Total Volume of Industrial Solid Waste

Conclusion 1: Leadings? be cautious

Industrial efficiency comparisons of 36 cities (2006-2010)

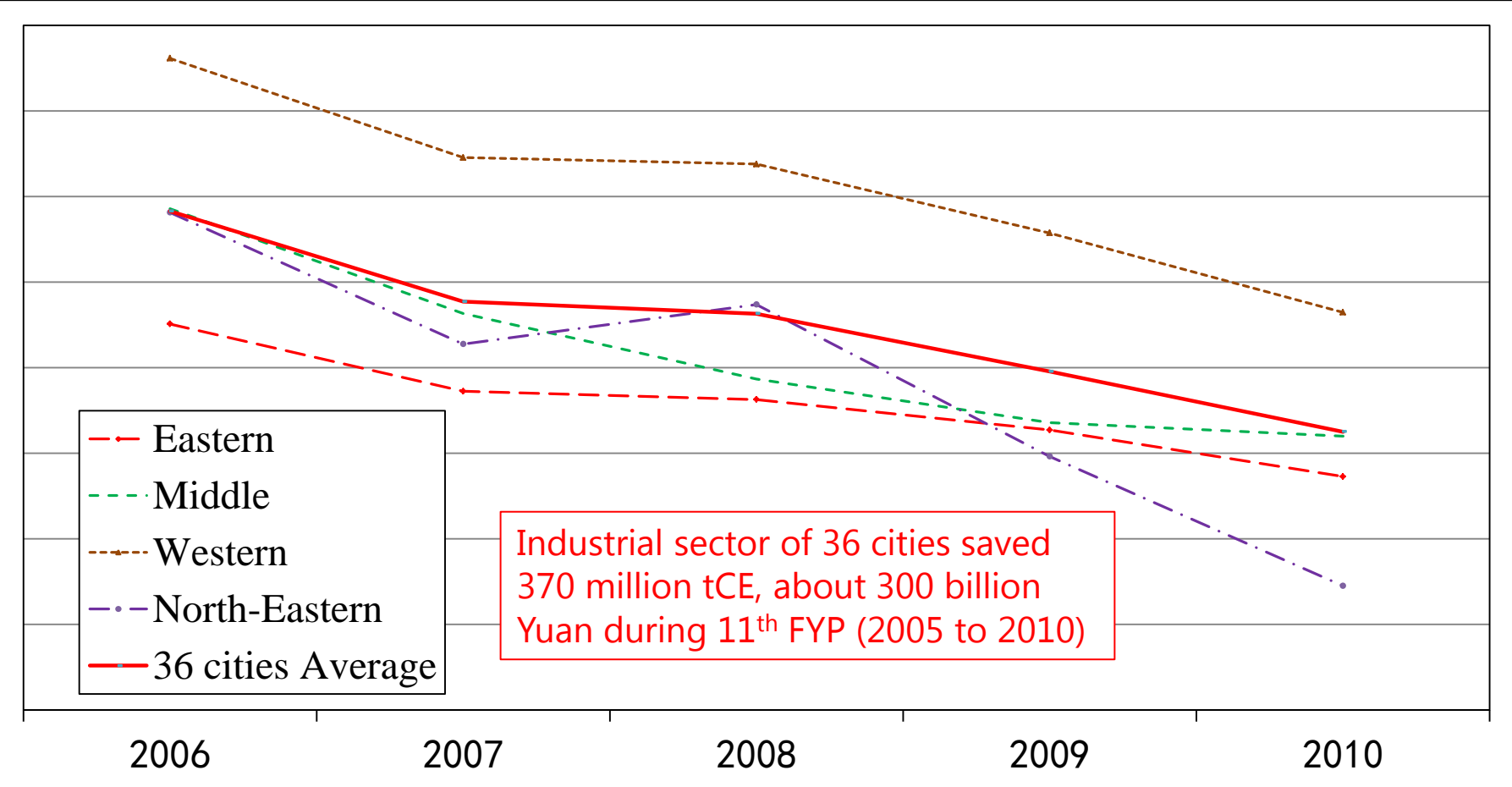


Conclusion 1: Leadings? be cautious

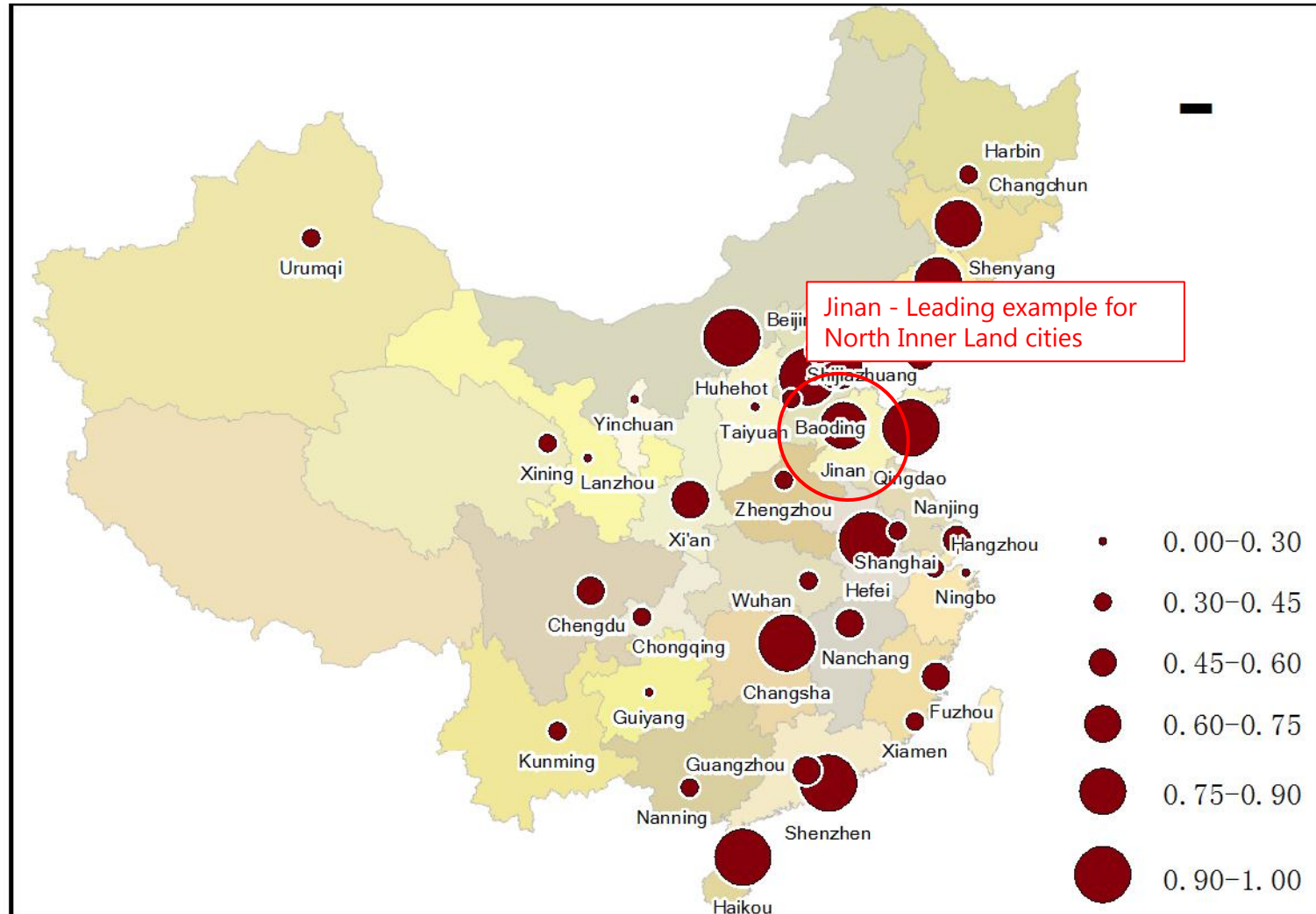
- Guangzhou : High Labor Input:
 - Employees per add-value: 0.46 VS 0.22(Huhehot)
- Beijing/Shanghai : High Capital Input:
 - Investment per add-value: 1.74/1.32 VS 0.61(Qingdao)
- The rest can be divided into 3 categories:
 - Low pollution, High energy consumption
 - High labor or capital investment
 - High pollution, High energy consumption

Conclusion 2: policies are effective

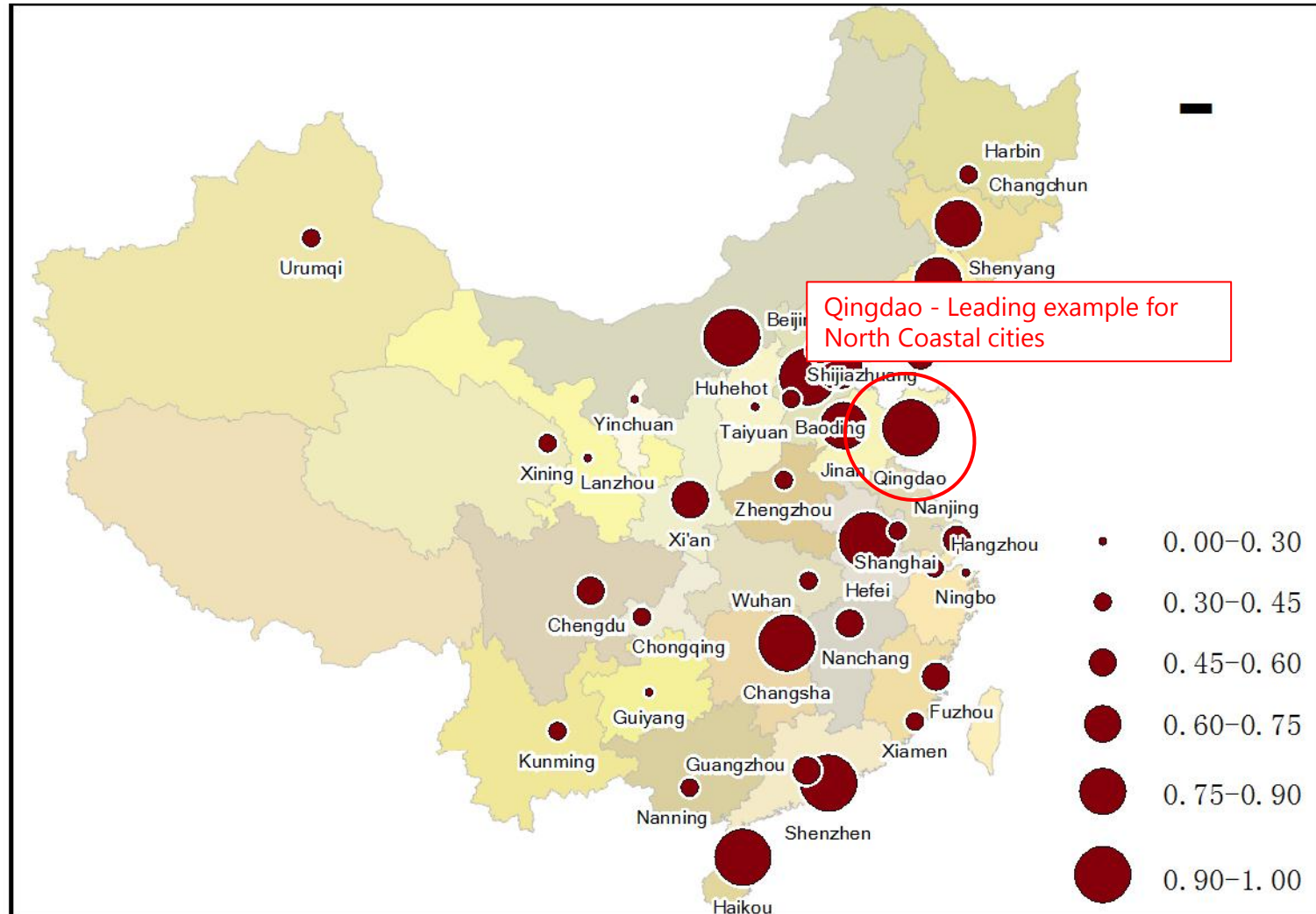
Efficiency rank of 4 areas and average during 2006 to 2010
(The lower the better)



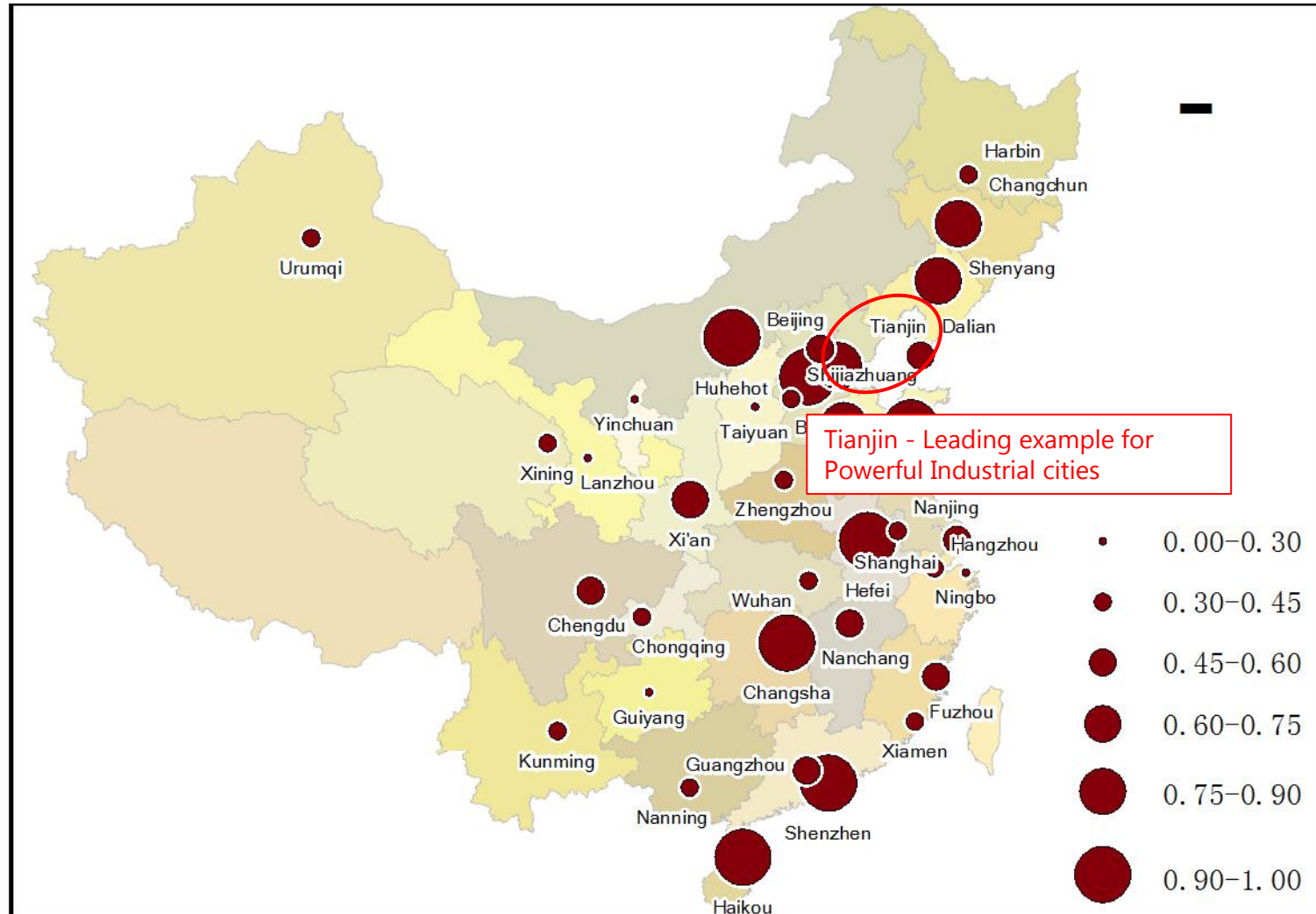
Conclusion 3: The real leadings



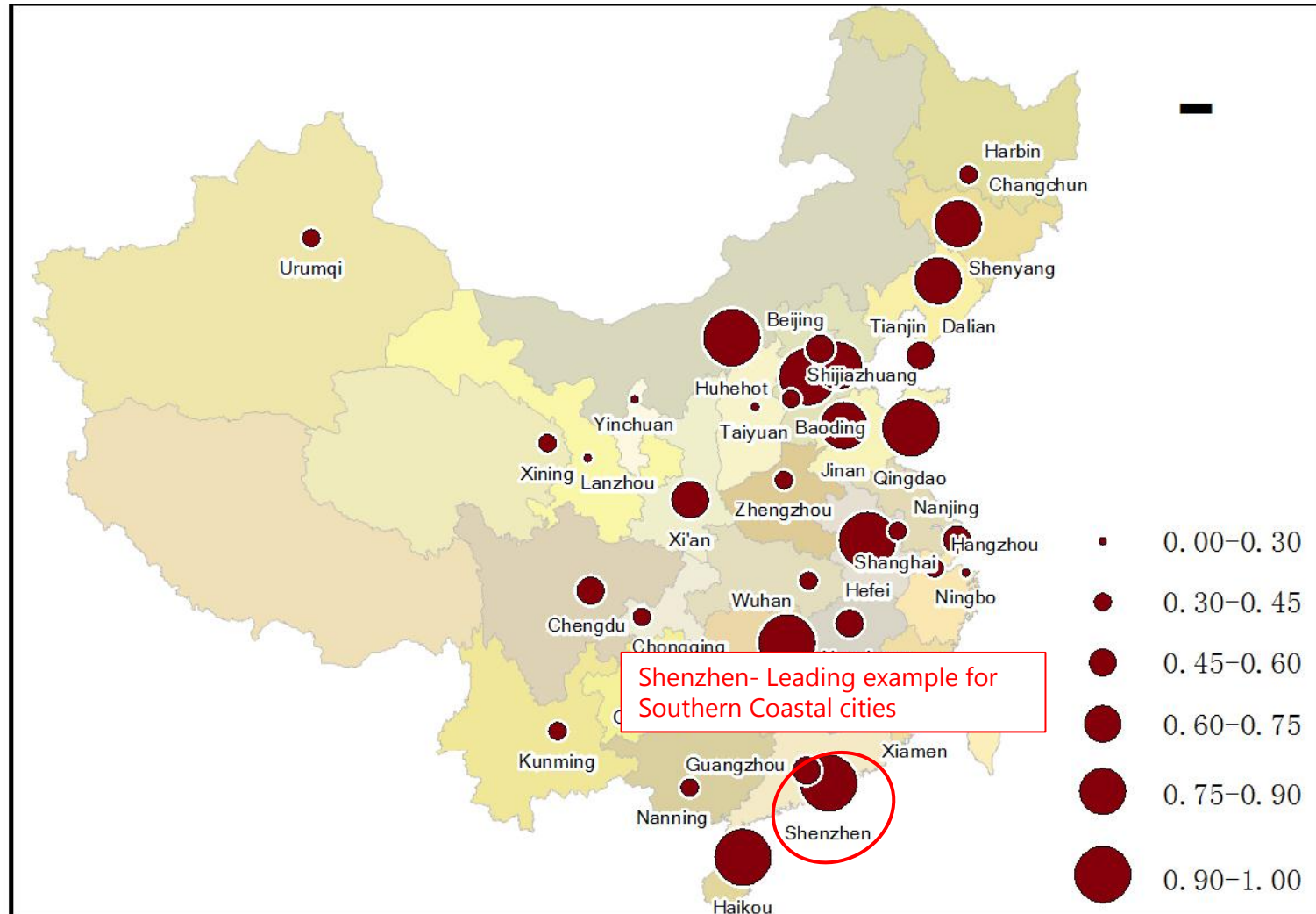
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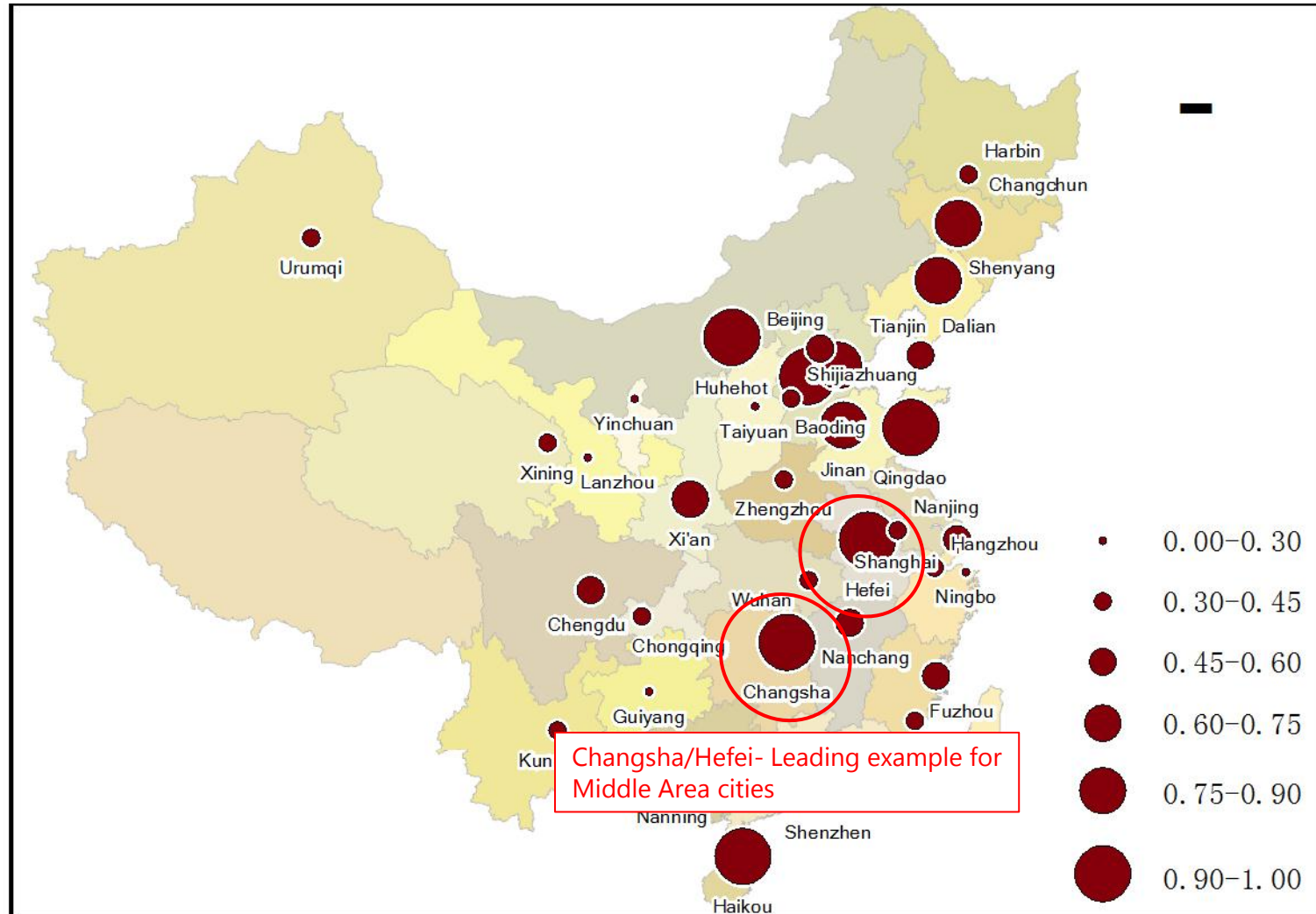
Conclusion 3: The real leadings



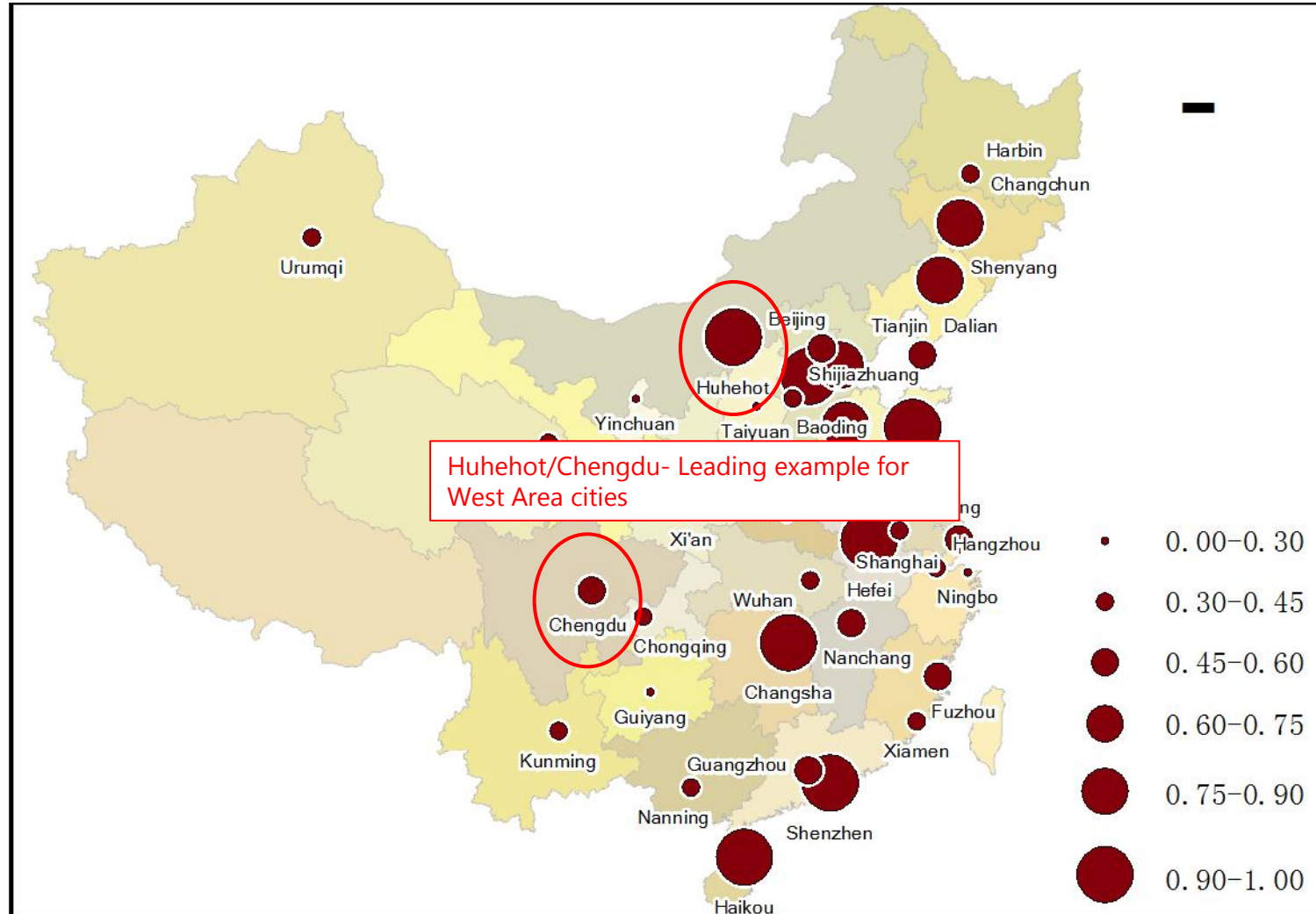
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Thanks!

Vielen Dank! Grazie! Merci! Gracias! 謝謝! ありがとう! 감사!