Green growth efficiency of Chinese cities and its spatio-temporal pattern

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Abstract

Based on panel data of 285 Chinese cities at and above the prefecture level from 2005 to 2016, remote sensing data and socio-economic data were used to create a green growth efficiency analysis database. Additionally, the TOPSIS model, super-efficient SBM model, and exploratory spatial analysis method supported by the entropy technology were applied to test and analyze the input-output index, comprehensive evaluation index, spatial-temporal pattern of green growth efficiency, spatial correlation effect, and the shift of the barycenter of green growth of Chinese cities. According to the results, (1) There are obvious spatial differences between Chinese cities in terms of the resources investment, socio-economic benefits, and environmental impact index of green growth of Chinese cities; the efficiency of urban resource conversion is low; and there remains much room for improvement. (2) In 2005, 2010, and 2016, the comprehensive evaluation index of green growth of Chinese cities increased first and then decreased, and the regional gap was small but was gradually expanding. The green growth efficiency decreased first and then increased with significant spatial differences. (3) In 2005, 2010, and 2016, the Moran's I of China's green growth efficiency was 0.1888, 0.0745, and 0.0584, respectively. There was a positive correlation but a weakening trend spatially, featuring "small agglomeration and large dispersion." (4) From 2005 to 2016, the center of gravity of China's green growth efficiency moved toward the southwest: the moving track was "Suiping County-Biyang County-Suizhou City." The research results could improve China's green growth efficiency and provide scientific support and a practical reference for narrowing the imbalance of green growth between regions.

Introduction

- China's industrial growth has been maintained at a steadily high rate, but the extensive growth mode remains dominant in the Chinese economy.
- Green growth plays an important role in many international organizations and is on the agendas of many countries. Some scientists and government officials believe that green growth is the key to eliminating global financial and economic crisis.
- Green growth is regarded as an alternative strategy for reducing pollutant emissions and preventing natural resource deterioration and depletion.

Methodology

- TOPSIS model;
- Slacks-Based measure (SBM)

$$Min\rho = \frac{\frac{1}{n}\sum_{i=1}^{n}\frac{\bar{x}}{x_{ik}}}{\frac{1}{r_1+r_2}\left(\sum_{s=1}^{r_1}\frac{\overline{y^d}}{y_{sk}^d}+\sum_{q=1}^{r_2}\frac{\overline{y^u}}{y_{qk}^u}\right)} \quad (1)$$

$$\begin{cases} \bar{x} \geq \sum_{j=1,\neq k}^{m} x_{ij}\lambda_j; \overline{y^d} \leq \sum_{j=1,\neq k}^{m} y_{sj}^d\lambda_j; \overline{y^u} \geq \sum_{j=1,\neq k}^{m} y_{qj}^u\lambda_j \\ \bar{x} \geq x_k; y^d \leq y_k^d; y^u \geq y_k^u \\ \lambda_j \geq 0, i=1,2,\dots,n; j=1,2,\dots,m, j\neq 0 \\ s=1,2,\dots,r_1; q=1,2,\dots,r_2 \end{cases} \quad (2)$$

- Spatial autocorrelation analysis

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n}w_{ij}(x_i-\bar{x})(x_j-\bar{x})}{\sum_{i=1}^{n}\sum_{j=1}^{n}w_{ij}\sum_{i=1}^{n}(x_i-\bar{x})^2} \quad (3) \qquad I_i = \frac{n(x_i-\bar{x})\sum_{j=1}^{n}w_{ij}(x_j-\bar{x})}{\sum_{i=1}^{n}(x_i-\bar{x})^2} \quad (4)$$

Results

1 Comprehensive evaluation of green growth based on TOPSIS model

- There are obvious spatial differences in the resources investment, socioeconomic benefits, or environmental impact indexes of China's urban green growth.
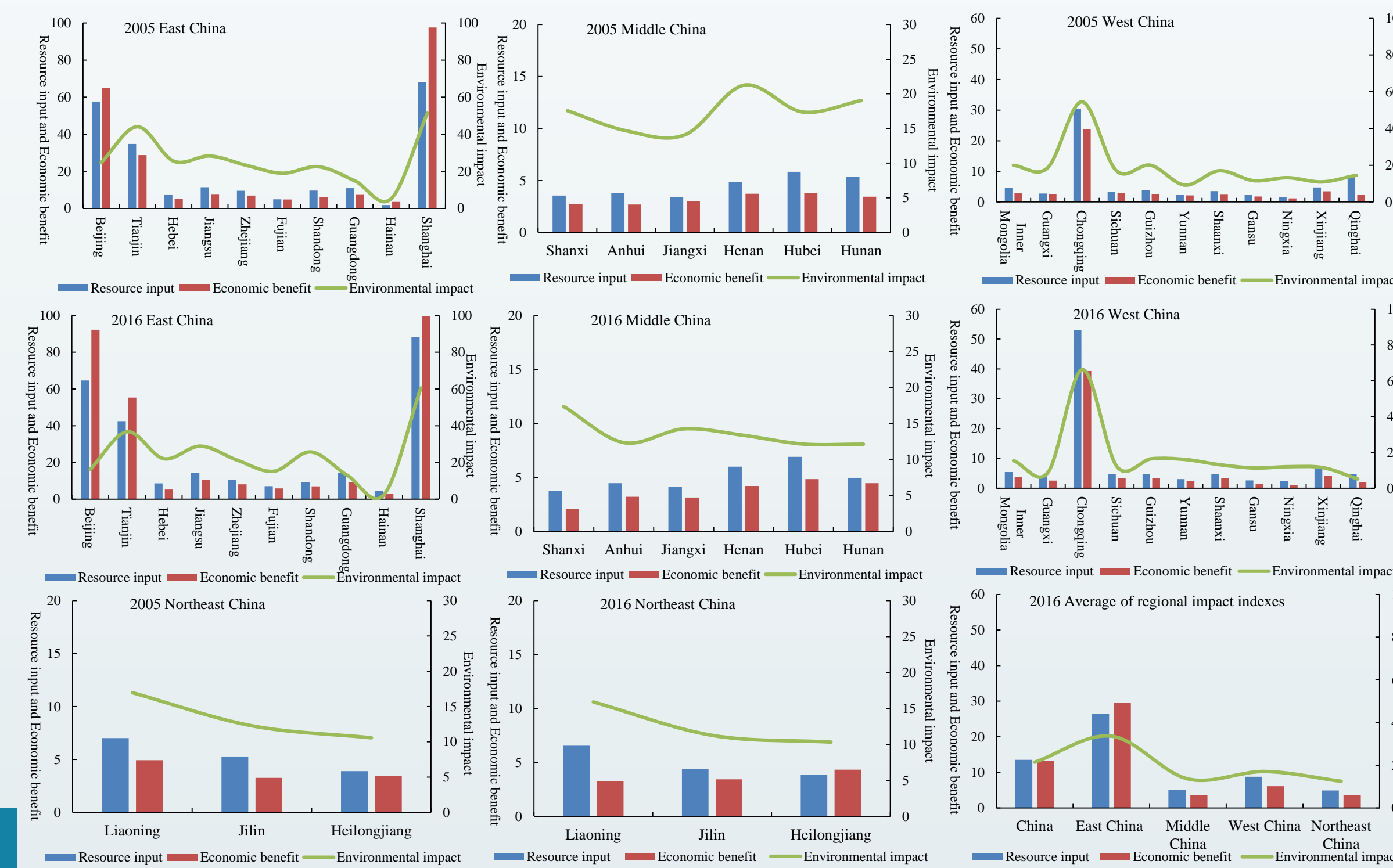- Mainly affected by the geographical location, economic base, and industrial structure of cities.

Fig. 1. Input-output index of green growth in regions in China from 2005 to 2016

2 Spatio-temporal characteristic of green growth efficiency

- China's urban green growth efficiency is not high as a whole, and there remains great potential and space for development.
- Showing a trend of decreasing first and then increasing, with a significant spatial difference.
- The low-efficiency areas with a zonal distribution, which is more consistent with regions with high incidence of poverty in China.
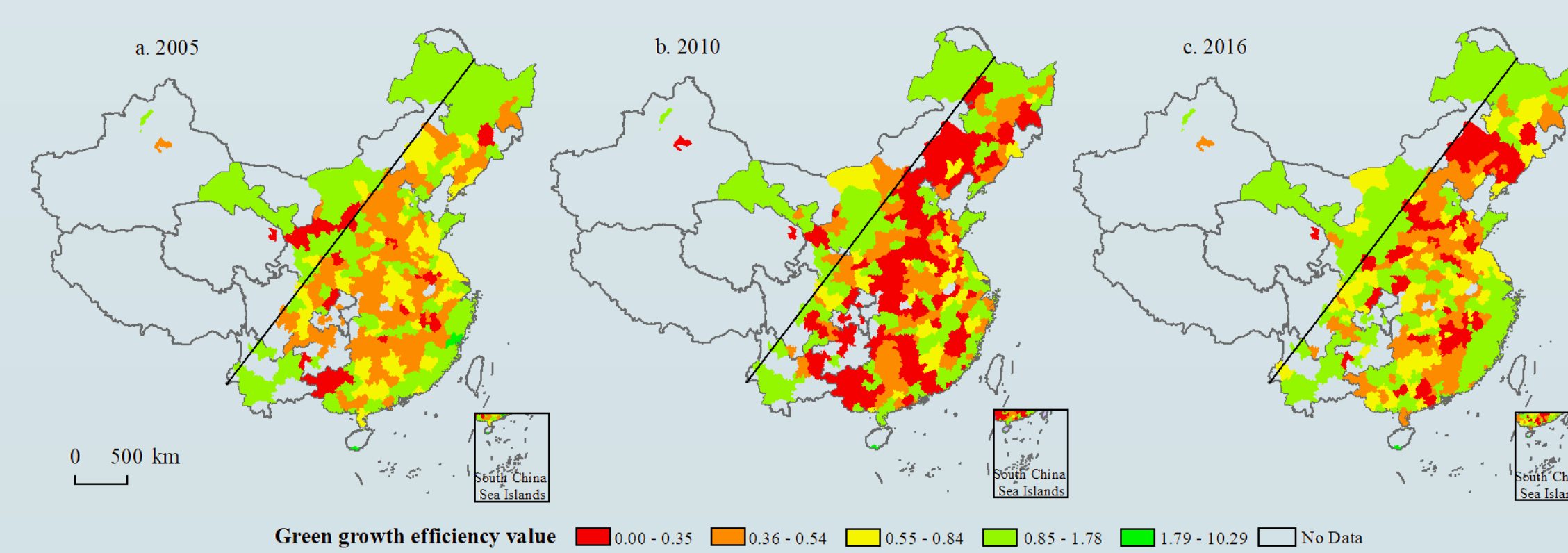- Environmental protection maintains apace with economic development.

Fig. 2. Spatio-temporal disparities of green growth efficiency of Chinese cities from 2005 to 2016

3 Spatial correlation effect of urban green growth efficiency

Moran's I

- The green growth efficiency of Chinese cities has significant spatial agglomeration effect.
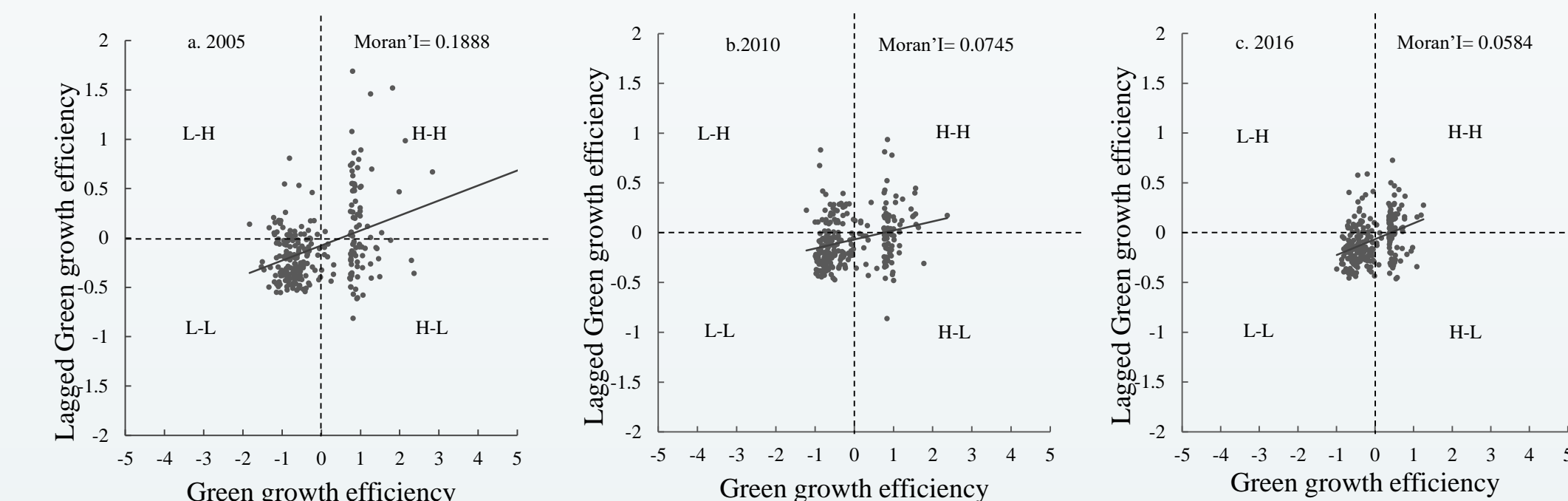

Fig. 3. Moran's I scatter figure of the green growth efficiency of Chinese cities

LISA

- The local correlation effect of China's green growth efficiency is relatively obvious.
- The H-H agglomeration areas were mainly distributed in China's southeast coastal areas.
- The L-L agglomeration areas are relatively concentrated, are mainly distributed in central China, tend to spread to the north and south.
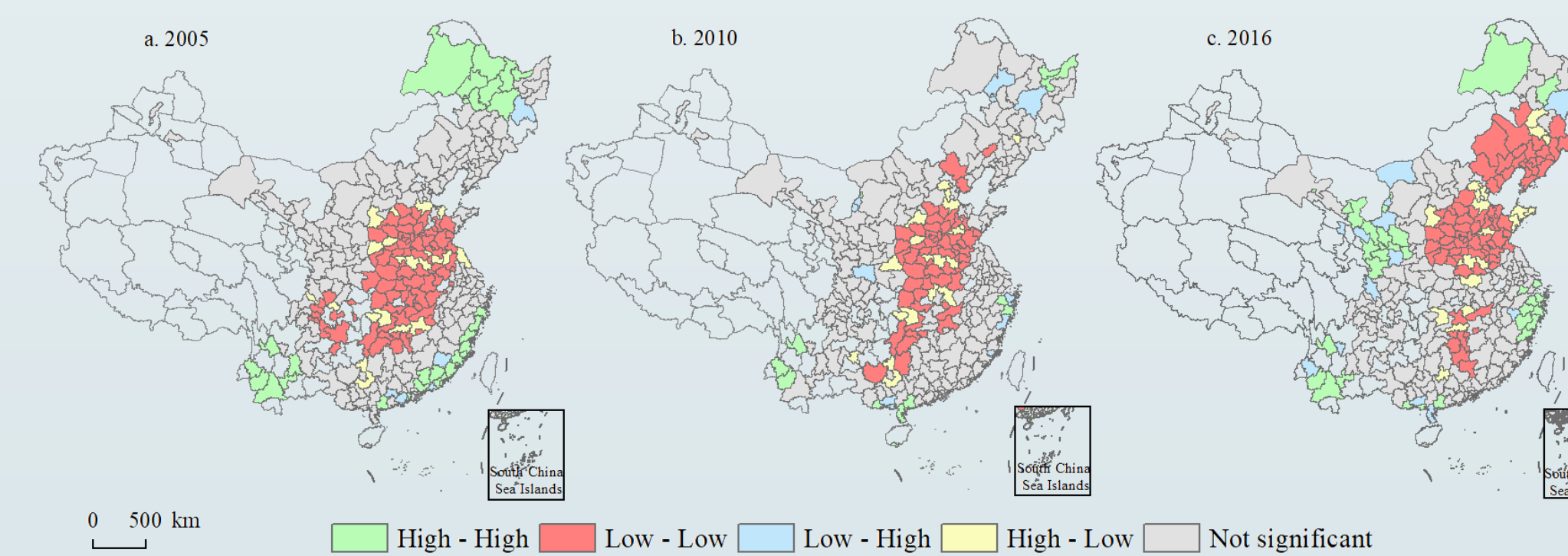

Fig. 4. LISA agglomeration figure of the efficiency of green growth in China from 2005 to 2016

4 The center of gravity of green growth efficiency

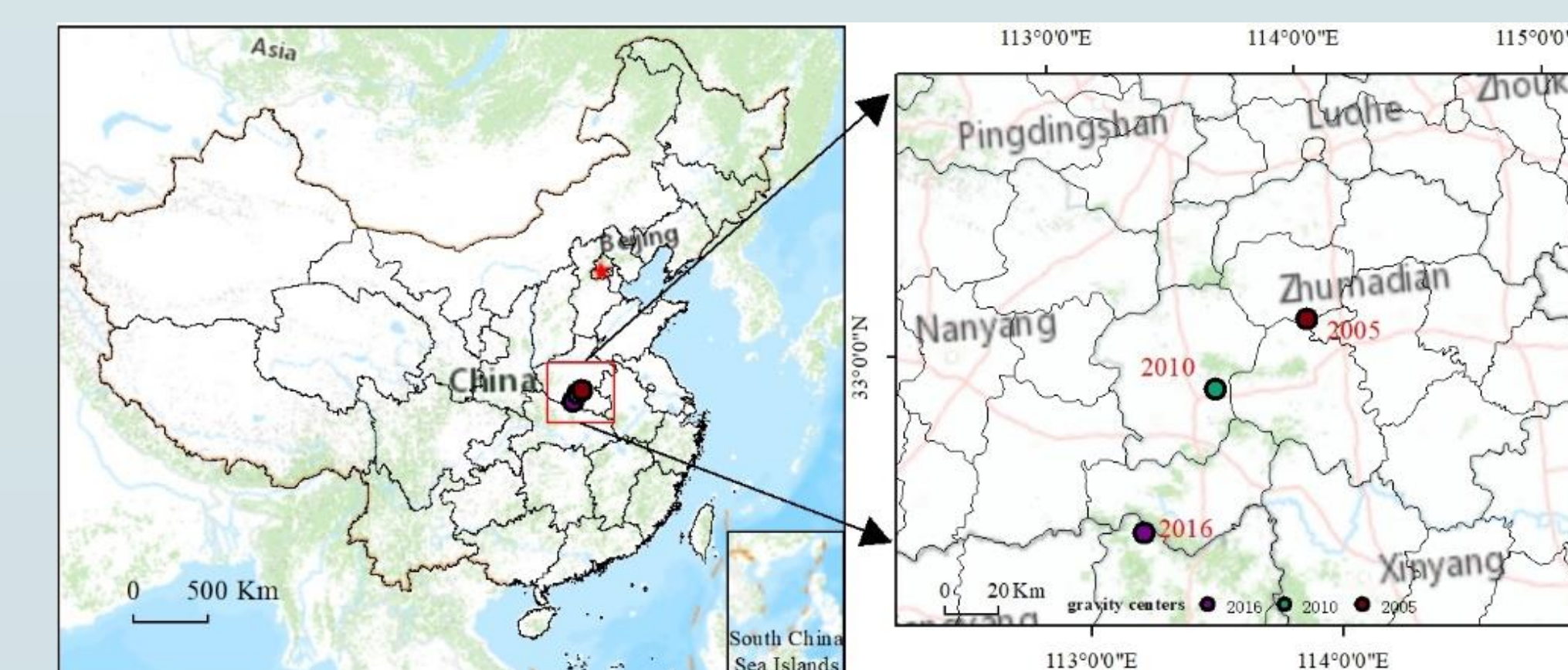- The gravity center moved to the southwest from 2005 to 2010.

Fig. 5. Center of gravity of green growth efficiency

Discussion

Limitation

- The limit of data.
- Not systematically analyzed, only analyzed from the regional level.

Implications

- We should correctly handle the differences among regions and use their comparative advantages.
- Eastern cities can continue to develop and introduce new technologies, and play a leading and radiation-driven role.
- Northeast region should accelerate the transformation and upgrading of its traditional industries.
- Central region should strengthen inter-provincial exchanges and cooperation and promote optimal allocation of resources and cross-regional flows of factors.

Conclusion

- There are obvious spatial differences in the resources investment, social-economic benefits, and environmental impact indexes of China's urban green growth.
- In 2005, 2010, and 2016, the comprehensive evaluation index of green growth of Chinese cities showed a trend of increasing first and then decreasing with overall growth.
- There was a positive spatial correlation of green growth efficiency, but the positive correlation tended to weaken.
- The gravity center moved to the southwest from 2005 to 2010.

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