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Spatial dynamic co-relations between economic development performances and major factors: evidence of coastal regions in China

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Abstract
The dynamics of coastal economic regions in China need to be studied in the visualized way. Through the data analysis of China's three major coastal economic regions from 1994 to 2014, the authors of the paper utilize the standard deviation ellipse and cosine similarity methods to explore the evolution characteristics of economic barycenter and driving factors. It turns out that the economic barycenter in three economic regions is moving toward inland, matching the trend of the national economic center of gravity. The driving forces of economic regions show diversified spatial trajectories in three economic regions.
Key words: *coastal economic regions; economic barycenter; economic drivers; spatial co-relation*

1 Introduction

Since the reform and opening up in the 1990s, China's economy has continued to develop at a high speed, the economic structure and barycenter have undergone major changes, especially in China's coastal economic zones, which is inextricably linked to the transformation from economic factors. Based on the standard deviation and cosine function, this paper visualizes the excursion of the economic barycenter and the driving level of input factors of three coastal economic zones, expecting to interpret how could China's economic growth pole drives economic restructuring and upgrading under the 'old and new move into' to provide reference for the development of regional policies in coastal economic zones and other areas.

2 Method and Data

2.1 Method

On the question of how to measure economic growth, economists were considered early in *Adam Smith* (1776). In 1987, *Robert Merton Solow* proposed economic growth theory to better address the problem of economic growth, [1] believing that capital and labor are the main factors influencing economic growth. As the share of land in China's economic growth is large, the main factors are capital, labor and land, *i.e.* Eq. (1).

$$Y_t = K_t^{\alpha} L_t^{\beta} N_t^{\gamma} \tag{1}$$

Both sides of the logarithm are available. *i.e.* Eq. (2)

$$\ln Y_t = \alpha \ln K_t + \beta \ln L_t + \gamma \ln N_t \tag{2}$$

However, this theory in the field of spatial economic growth has a low level of visualization, and what drives economic growth in each region cannot be analyzed. In terms of measuring macroeconomic changes, the standard deviation ellipse has been widely used. [2,3] It was first proposed by *Leverville* (1926) to explain the spatial distribution of geographical elements. [4] The average center of the formulas is as follows.*i.e.* Eq. (3).

$$\overline{X} = \frac{\sum_i^N W_i X_i}{\sum_i^N W_i}; \overline{Y} = \frac{\sum_i^N W_i X_i}{\sum_i^N W_i} \tag{3}$$

(x_i, y_i) represents the latitude and longitude coordinates, w_i means the weight of economic factors. If the average center is used to measure the moving trajectory of the economic barycenter, it is possible to observe the continuous development direction of economy in space. The spatial distribution of input factors and output is superimposed on a visualized latitude and longitude map. If a variable M coincides with the direction of the total output Y, the variable can be considered as a significant role in moving the center of the economy.

The center of gravity movement trajectory is a moving distance in the direction.Therefore, $\vec{A}_i(x_i, y_i)$ (i=1,2,3) represents the barycenter trajectory of input factors, $\vec{B}(x, y)$ represents the barycenter trajectory of output. The similarity coefficient of input and output curve is Eq. (4)

$$sim_{\cos(\vec{A},\vec{B})} = \frac{x_i x + y_i y}{\sqrt{x_i^{\,2} + y_i^{\,2}}\sqrt{x^2 + y^2}} \tag{4}$$

The similarity coefficient is closer to 1, the direction of the two vectors is closer to 0. Their direction is more consistent, [5] and the corresponding similarity is higher. Consequently, the factors of high similarity numbers are the main factors that influence the change of the economic barycenter. Conversely, the opposite is true.

2.2 Data

China's three coastal economic circles refer to the Bohai Sea, the Yangtze River Delta and the Pearl River Delta. This paper mainly analyzes the spatial distribution characteristics and the driving factors of economic growth of three coastal economic circles from the perspective of output and input. The GDP (Y) is selected as the output, the total amount of fixed asset

investment (K), the number of employees (L) and the area of construction area (N) as the inputs. Data comes from the 1994-2004 "China Urban Statistical Yearbook".

3 Results

3.1 Drving factors center of gravity trajectories

According to the Solow model, three series of data K, L, N in three coastal economic zones from 1994 to 2014 is analyzed, shown in *Table 1*. Therefore, we can choose these data on behalf of capital, labor and land to explain economic growth in the spatial distribution of factors to do further analysis.

Table 1 –ample regression of three coastal economic circles

V	The Bohai Sea economic circle				The Yangtze River Delta				The Pearl River Delta			
	Coef.	T-Sta.	F-Sta.	R^2	Coef.	T-Sta.	F-Sta.	R^2	Coef.	T-Sta.	F-Sta.	R^2
c	4.74	31.48	2844.97	0.96	3.39	22.07	3998.12	0.97	3.97	13.10	1067.69	0.95
lnk	0.61	45.85			0.68	48.62			0.64	20.70		
lnl	0.20	6.69			0.13	5.99			0.39	8.91		
lnn	0.22	7.81			0.34	14.56			0.12	3.96		

We use the standard deviation ellipse to obtain the barycenter trajectories of three factors and output. As shown in *Fig. 1*, *Fig. 2* and *Fig. 3* respectively, the economic barycenter of three economic circles is moving inland, which is consistent with the national economic barycenter moving inland, [6] indicating the inland economy is growing faster than other areas. It is obvious that the economic barycenters of the Bohai Sea and the Pearl River Delta have shifted to the northwest. And the economic barycenter of the Pearl River Delta shows a large shift eastward. The range of all elements in the Bohai Sea is the largest, while the Pearl River Delta has the smallest range, which is related to their geographical area. Because the Bohai Sea has the largest geographical area in three economic circles, and the Pearl River Delta has the smallest geographical proportion. Apart from that, the scale of output of three economic circles is smaller than capital, labor and land, and the range of capital movement is the maximum.

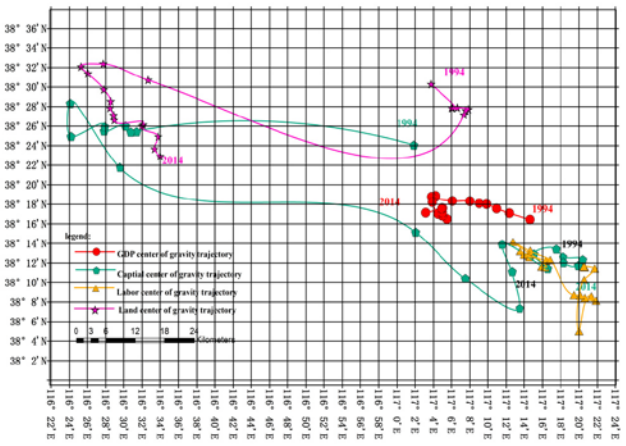

Fig. 1 – inputs and output barycenter moving trajectories in the Bohai Sea, 1994-2014

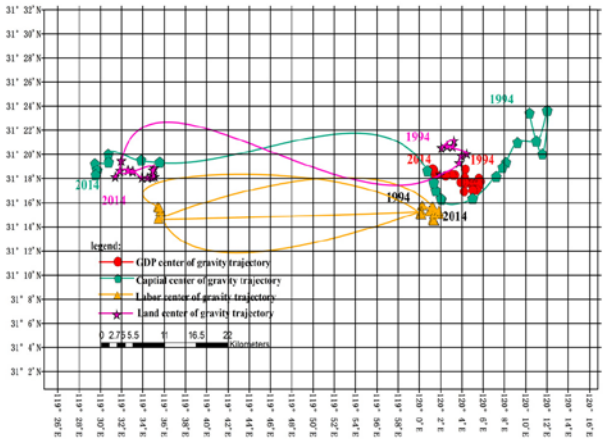

Fig. 2 – inputs and output barycenter moving trajectories in the Yangtze River Delta, 1994-2014

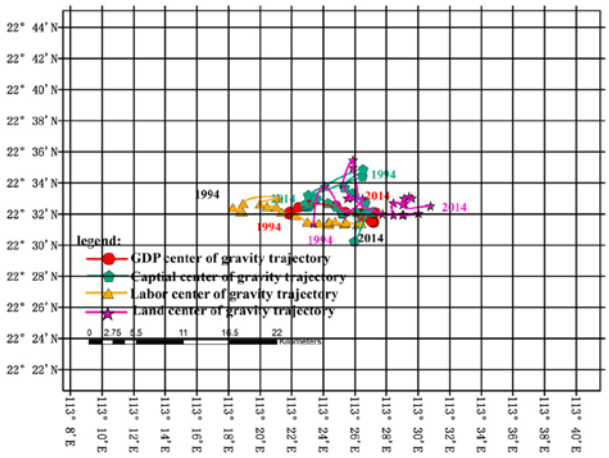

Fig. 3 – inputs and out barycenter moving trajectories in the Pearl River Delta, 1994-2014

3.2 Correlation analysis

According to the cosine similarity method, the similarity coefficients of inputs and outputs center of three coastal economic circles are analyzed, as shown in *Table 2*.

In the Bohai Sea, the similarity between land and output is the highest. It is indicated that land is more consistent with the direction of output. Land is the main driving factor influencing the economic barycenter of the Bohai Sea. In the Yangtze River Delta, the similarity between the capital and output is the highest, indicating that capital is the driving force of the change of economic barycenter. This is consistent with the direction of economic barycenter, moving in three elements of the largest coincidence. In the Pearl River Delta, the similarity coefficient of labor and output is 0.74, which is the highest value in three elements. And it is also the highest combination of three economic circles. Obviously, the input of the labor is the main driving force influencing the economic barycenter. Therefore, the interpretation of trajectory evolution is verified by the cosine similarity coefficient.

In general, it is found that the similarity coefficients of the input factors and the economic barycenter of the Yangtze River Delta are generally higher, but there is the highest level of similarity about the labor with economic barycenter in the Pearl River Delta. The main driving factors in three economic circles are obvious, and the above description of the evolution of the trajectory of the driving force is further verified.

Table 2 – The similarity coefficient of inputs and outputs barycenter trajectories

Coefficients	GDP-K	GDP-L	GDP-N
The Bohai Sea	0.47	0.5	0.66
The Yangtze River Delta	0.72	0.7	0.60
The Pearl River Delta	0.49	0.74	0.64

4 Conclusions

This paper analyzes Spatial dynamic co-relations between economic growth and major factors by visualization methods. To begin with, the economic barycenters are moving inland, which in accordance with the overall inland of China's economic barycenter to move. In addition, the main driving factors of the Bohai sea, the Yangtze river delta and the Pearl river delta are land, capital and labor respectively.

Based on the above conclusions, several policy implications are following: Firstly, We should optimize the investment structure and improve the quality and efficiency of investment to promote the transformation of ‘old and new’. Secondly, in the Bohai Sea, it’s wise to optimize the land using optimization and increase other input factors, such as, capital, technology, *etc.* Finally, not only we pay attention to the scale of labor input, but also we should improve the quality of labor by increasing the training of high-quality personnel in the Pearl River Delta.

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