Evaluation Model of the Regional Economic Vitality

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Abstract. Regional economic vitality is an important part of regional comprehensive competitiveness. Accurate assessment of regional economic vitality can reflect the state of economic development among different regions and provide reference to the developing policies of regional economic. To measure the regional economic vitality of main Chinese cities, in this paper, we first establish a mathematical index system based on five aspects (i.e., industrial vitality, capital vitality, innovation vitality, talent vitality and humanistic vitality). Then, the evaluation model of regional economic vitality is constructed using entropy method. The result shows that among 19 main cities of China, Guangzhou and Hangzhou have the highest economic vitality in the first-tier and second-tier cities, respectively. Besides, the change of the comprehensive evaluation of economic vitality among the first-tier cities is more obvious than that between second-tier cities. The evaluation results reflect regional differences in Chinese economic development and can provide valuable reference for exploring benign sustainable policies for regional economic development.

1. Introduction

There is a certain difference in the economic vitality among different regions, which plays an important role on reflecting regional economic development and formulating policies to stimulate regional competitiveness. To measure the regional economic vitality of different cities in China, we establish a mathematical evaluation system. Through analysis, the economic vitality of a region is mainly reflected in five aspects: industrial vitality, capital vitality, innovation vitality, talent vitality, and humanistic vitality. Based on this, first of all, we find out the indexes that can measure the regional economic vitality from above five aspects. Then, we establish an evaluation system of regional economic vitality combined with the found indexes using entropy method [1]. Finally, under the established evaluation system, we rank the economic vitality of Beijing, Shanghai, Guangzhou, Shenzhen and other 15 second-tier main cities in China. The result shows that Guangdong has the highest economic vitality in 2017, followed by Beijing, Shenzhen, Hangzhou and Shanghai. The economic vitality of 15 second-tier cities are all lower than these four cities, except Hangzhou.

The contribution of this paper can be summarized as:

(1) We build an index system to measure the economic vitality of a region;

(2) We construct an evaluation model of regional economic vitality to calculate the economic vitality of a region;

(3) We search for related data and rank the regional economic vitality of 19 main Chinese cities based on the constructed index system and the evaluation model, which contributes to reflect the developing statement of regional economy among Chinese cities.
2. Evaluation Model of the Regional Economic Vitality

2.1. Measurement Index System of the Regional Economic Vitality

Relevant data shows that the regional economic vitality can be manifested in five aspects: industrial vitality, capital vitality, innovation vitality, talent vitality and humanistic vitality [2]. Based on this, we find out indexes that can measure the regional economic vitality from these five aspects, and construct the index system of regional economic vitality, shown in Table 1. Each aspect that affects the regional economic vitality includes different indexes. The property of each index can be divided into positive and negative, depending on whether it will promote or inhibit the development of regional economy.

| Index                                      | Index Unit                  | Property |
|--------------------------------------------|-----------------------------|----------|
| Industrial Vitality                        |                             |          |
| Gross Domestic Product                     | 100 million yuan            | Positive |
| Industrial electricity                     | Billion kWh                 | Positive |
| Number of new jobs                         | Ten thousand                | Positive |
| Total loss-making enterprises in national  | 100 million yuan            | Negative |
| development zones                          |                             |          |
| Capital Vitality                           |                             |          |
| Investment in Fixed Assets                 | 100 million yuan            | Positive |
| Foreign Investment Actually Absorbed       | 100 million USD             | Positive |
| Total Tax Revenue of the City              | 100 million yuan            | Positive |
| Total imports                              | 100 million USD             | Positive |
| Total value of securities transactions     | 100 million yuan            | Positive |
| Innovation Vitality                        |                             |          |
| Scientific and Technical Achievements      | Item                        | Positive |
| Talent Vitality                            |                             |          |
| Number of graduated college students       | 10,000 persons              | Positive |
| Policy Vitality                            |                             |          |
| Urban Instructure Investment               | 100 million yuan            | Positive |
| General Budgetary Expenditure              | 100 million yuan            | Positive |

2.2. Measurement Index System of the Regional Economic Vitality

For the influence of different measurement indexes on the evaluation of regional economic vitality is different, it is necessary to give a weight to each index in the evaluation model. In this part, we construct an evaluation model of regional economic vitality based on entropy method, in order to avoid the influence of subjective empowerment and fully reflect the representativeness of measurement indexes to regional economic vitality. The specific construction process is as follows.

2.2.1. Collection and collation of raw data. Annual time series data of main Chinese cities are collected based on the 15 indexes listed in Table 1. For each series of data of one city, the following raw data matrix is constructed as

$$X = (x_{ij})_{m \times n} = \begin{bmatrix} x_{11} & x_{12} & \ldots & x_{1n} \\ x_{21} & x_{22} & \ldots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \ldots & x_{mn} \end{bmatrix}$$

(1)

where \( m \) denotes the number of evaluation objects (i.e., year in this paper); \( n \) denotes the number of evaluation indexes; \( x_{ij} \) denotes the value of index \( j (j = 1, 2, \ldots, n) \) in year \( i (i = 1, 2, \ldots, m) \). The original data matrix \( X \) is standardized to ensure the accuracy of the results [3]. For the property of an index can be positive or negative for improving regional economic vitality, we conduct different
data standardization processing strategies as equation (2) and equation (3) for positive and negative indexes, respectively:

\[ x_{ij}^* = \frac{\max(x_{ij}, x_{i2}, ..., x_{im}) - x_{ij}}{\max(x_{ij}, x_{i2}, ..., x_{im})} \]

\[ x_{ij}^* = \frac{\max(x_{ij}, x_{i2}, ..., x_{im}) - x_{ij}}{\min(x_{ij}, x_{i2}, ..., x_{im})} \]

where \( x_{ij}^* \) is the standardized data; \( x_{ij} \) is the value of index \( j(j = 1, 2, ..., n) \) in year \( i(i = 1, 2, ..., m) \); \( \max(x_{ij}, x_{i2}, ..., x_{im}) \) and \( \min(x_{ij}, x_{i2}, ..., x_{im}) \) is the maximum and minimum value of item \( j \) in \( m \) years, respectively. After data standardization processing, the matrix \( X^* = (x_{ij}^*)_{m,n} \) is obtained.

2.2.2. Calculation of weight of each index. The specific gravity \( p_{ij} \) of the index \( j \) in the year \( i \) in \( X^* = (x_{ij}^*)_{m,n} \) is calculated as:

\[ p_{ij} = \frac{x_{ij}^*}{\sum_{j=1}^{n} x_{ij}} \]

2.2.3. Calculation of entropy of information. In information theory, entropy measures the degree of uncertainty of information. The larger amount of information, the smaller the degree of uncertainty, that is, the smaller the entropy; otherwise, the greater the entropy. Information entropy \( E_j(j = 1, 2, ..., n) \) is calculated as equation (5). Normally, \( K = \frac{1}{\ln m} > 0 \).

\[ E_j = -K \sum_{i=1}^{m} (p_{ij} \ln p_{ij}) \]

2.2.4. Calculation of Information utility value. Information utility value \( D_j \) can be used to measure the difference between indexes and determine the weight of each index in the whole index system. For each index, the greater the difference of time series data, the more information the index can provide and the less uncertain the information, resulting in the larger weight of the index in the whole index system. According to equation (6), information utility value \( D_j(j = 1, 2, ..., n) \) is calculated.

\[ D_j = 1 - E_j \]

2.2.5. Calculation of weight of indexes. Based on the information utility value \( D_j \) of each index, the weight \( W_j \) of each index in the index system is calculated, and the calculation method is shown in equation (7).

\[ W_j = \frac{D_j}{\sum_{j=1}^{n} D_j} \]

2.2.6. Calculation of comprehensive evaluation value. Comprehensive evaluation value of a region \( S_i \) is calculated as equation (8). The higher the value of \( S_i \), the higher the economic vitality of the region.
\[ S_i = \sum_{j=1}^{n_i} W_i P_j \]  

(8)

3. Rank of the regional economic vitality among main Chinese cities

Based on the evaluation model of the regional economic vitality introduced in section 2, we rank the regional economic vitality of 19 main Chinese cities, shown in Figure 1.

As can be seen in Figure 1, the difference of economic vitality between different cities is relatively large, and the economic vitality of the second-tier cities is lower than that of the first-tier cities [4]. In particular, in the first-tier cities, Guangzhou has the highest economic vitality, followed by Beijing, Shenzhen and Shanghai; in the second-tier cities, Hangzhou has the highest economic vitality. In addition, it can be seen from Figure 4 that the change of the comprehensive evaluation value of economic vitality among the first-tier cities is obvious, and the change between the second-tier cities is more gradual. Therefore, we can conclude that the gap between the first-tier cities is relatively large and the gap between the two-tier cities is small. Thus, to further enhance the overall economic vitality of cities in China, economic development policies that promote balanced regional economy are suggested, especially to narrow the gap between the first-tier and second-tier cities, so as to promote the economic prosperity and development in various regions of the country.

Figure 1. Ranking result of Economic viability

To further explore how the indexes listed in Table 1 affect regional economic development, we choose top five cities from the ranking result based on the constructed evaluation model and calculate weight of the evaluation indexes for each city in 2017, shown in Figure 2. Table 2 illustrates the implication of indexes in Figure 2. From Figure 2, we can find that for Shenzhen, Hangzhou and Shanghai, index 4 has largest weights; for Guangzhou, index 9 has largest weights; for Guangzhou and Beijing, index 13 accounts for the biggest proportion, which shows the most influential index for each city. Especially, index 4, 9, and 13 represents how new jobs, industrial electricity and total loss-making enterprises in national development zones, reflecting the viability of regional economy.
Figure 2. Radar map of Economic structure

Table 2. Implication of indexes

| Index  | Meaning                                                                 |
|--------|-------------------------------------------------------------------------|
| Index 1| Investment in Fixed Assets                                              |
| Index 2| Actual amount of foreign direct investment                              |
| Index 3| Permanent population                                                    |
| Index 4| Number of new jobs                                                      |
| Index 5| Number of unemployed                                                    |
| Index 6| Gross Domestic Product                                                  |
| Index 7| The city's total tax revenue                                            |
| Index 8| Total imports                                                           |
| Index 9| Industrial electricity                                                  |
| Index 10| Total transaction value of all securities in the Stock Exchange         |
| Index 11| Achievements in Scientific and Technical Research                      |
| Index 12| Personnel of scientific and technological activities in colleges       |
| Index 13| Total loss-making enterprises in national development zones             |

4. Conclusion
To measure the regional economic vitality, an evaluation model is constructed based on an index system which consists of five aspects (i.e., industrial vitality, capital vitality, innovation vitality, talent vitality and humanistic vitality). With the evaluation model and related data, in this paper, the economic vitality of Beijing, Shanghai, Guangzhou, Shenzhen and 15 second-tier cities are ranked. The result shows that Guangdong has the highest economic vitality in 2017, and Hangzhou has the highest economic vitality in the second-tier cities. This paper makes contributions to reflecting the economic vitality and economic development status of various regions of China, which has reference value in making economic development policies and promoting balanced and coordinated regional economy.

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