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Construction of Regional Economic Vitality Model

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ABSTRACT

Regional economic vitality reflects the scale and development potential of a region's economy. It largely determines the development of the city, and is also affected by many factors such as population competitiveness, corporate competitiveness, market vitality, innovation vitality, and environmental vitality. A pilot model was constructed with Hebei Province as the inspection area. Quantitative measurement of regional economic vitality was made by finding 21 indicators that indirectly or indirectly affect the economic vitality of Hebei Province. By analyzing the data of 21 indicators for nearly 10 years, the time series clustering is used to achieve the dimensionality reduction of the indicators. After the dimension reduction, it is divided into four categories: overall scale, development potential, market vitality, and innovation vitality. Construct the economic vitality structure model of Hebei Province, and determine the four types of contribution to economic vitality and compare them. On this basis, more accurately grasp the indicators that affect economic vitality and work out reasonable and effective action plans. From the perspective of human resources and corporate vitality, analyze how the action plan accurately affects the economic vitality of Hebei Province^[1]. The 11 cities in Hebei Province are the target of regional economic vitality. The economic vitality structure model constructed uses the required contribution value to select priority indicators. Finally, the six indicators of GPD, GPD growth rate, fiscal revenue, fiscal revenue growth rate, number of industrial enterprises above designated size, and total profit of industrial enterprises above designated size were established for eleven cities in Hebei Province to construct a TOPSIS scoring model, and calculation rankings were conducted through MATLAB. Results The top three cities were Shijiazhuang, Tangshan and Cangzhou.

1. Construction of Quantitative Model of Economic Vitality

1.1 Index Selection

Economic vitality reflects the total supply and demand of the regional economy and its growth rate and potential. When measuring regional economic vitality, it is also necessary to quantitatively measure

economic growth rate, regional development potential, and plastic space while focusing on the overall economic scale^[2]. Here, Hebei Province is selected as the research area, and 21 economic indicators are selected to quantify the economic scale, corporate vitality, human resources, industrial structure, government support, and innovative vitality of Hebei Province in combination with the economic vitality of Chinese cities^[3].

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Selected Hebei Province’s GDP, GDP growth rate, CPI, total profits of large-scale enterprises, growth rate of large-scale enterprises’ profits, current number of enterprises, growth rate of number of enterprises, annual per capita disposable income growth rate, annual per capita disposable income growth rate, government fiscal expenditure Proportion of GDP, fiscal revenue, fiscal revenue growth rate, per capita park green space, population, number of patent applications for enterprises above designated size, total exports, total imports, tertiary industry’s share of GDP, insurance income, year-end farmland hectares A total of 21 indicators are used to quantitatively measure the economic vitality of Hebei Province [4].

1.2 Data Preprocessing

Dimensionless processing was performed on the collected 21 indicators. Dimensional data is transformed into scalar data through normalization, which facilitates the application and analysis of the data (shown here are data from 21 indicators measuring economic vitality in the past five years, also we omitted some of the parameter data and the whole data are shown in the appendix).

Table 1. Economic vitality index data

	2014	2015	2016	2017	2018
GDP(100 million CNY)	29421.15	29806.11	32070.45	34016.32	36010.27
GDP growth rate	6.50%	6.80%	6.80%	6.60%	6.60%
CPI	101.7	100.90	101.50	101.70	102.40
.....
Proportion of tertiary industry in GDP	37.25%	40.19%	41.54%	44.21%	46.19%
Amount of insurance income (100 million CNY)	931.90	1163.11	1495.27	1714.93	1790.60
Cultivated land area (thousand hectares)	6537.74	6525.47	6520.45	6518.86	6380.19

Data source: Statistical Yearbook of Hebei Province.

Normalize the above indicators:

$$y = \frac{(x - MinValue)}{(MaxValue - MinValue)} \tag{1}$$

The results of the normalized data are shown in the attached file.

1.3 Time Series Clustering Dimension Reduction based on Morphological Features

Because the surveyed economic vitality index data of Hebei Province is time series data, the traditional clustering method for point clustering of data cannot solve the problem of time series data clustering. The improvement is

based on the existing clustering method.

First, use the Mikowski gap of each indicator as an evaluation indicator to evaluate the similarity of the two indicators:

$$d_L = \sqrt[q]{\sum_{k=1}^p (x_{ik} - t_{jk})^q} \tag{2}$$

The normalized index data was processed by Python, and 21 indicators that affected the economic vitality of Hebei Province were clustered by revealing similar trend fluctuations, turning points or abnormal points in the time series. The indicators that have a high degree of correlation and consistent trends are synthesized into a category, and the results are shown in the following figures.

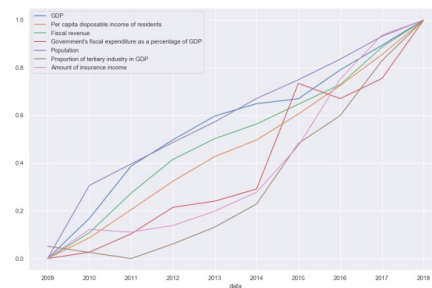


Figure 1. Overall scale

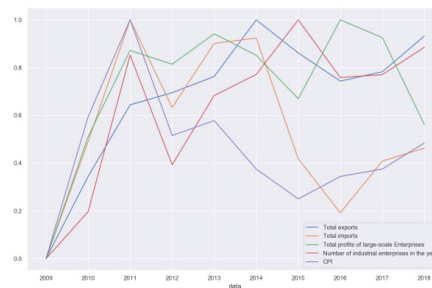


Figure 2. Market vitality

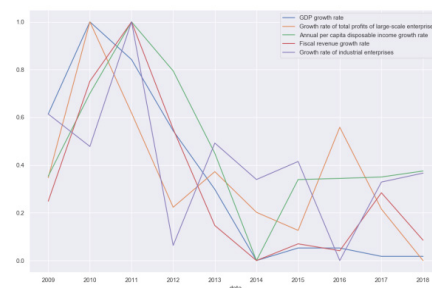


Figure 3. Development potential

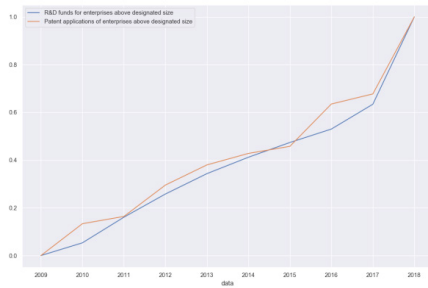


Figure 4. Vitality of innovation

The operation results are divided into four major parts according to the morphological characteristics, as the four major factors that constitute the interpretation of the economic vitality of Hebei Province. According to the common characteristics of the four categories, they are divided into four parts: overall scale, market vitality, development potential, and innovation vitality. The indicators under the overall scale are: total GDP, annual per capita disposable income, fiscal income, population, and fiscal expenditure as a percentage of GDP; the market vitality indicators are CPI imports, total profits of export-scale enterprises, and the number of enterprises; development potential The following indicators are: GDP growth rate, disposable income growth rate, fiscal revenue growth rate, total profit growth rate of large-scale enterprises, and growth rate of industrial enterprises. The innovation vitality is under the number of enterprise patent applications and R & D expenditures.

1.4 Construction of Hebei’s Economic Vitality Model

From this, the economic vitality structure map is constructed:

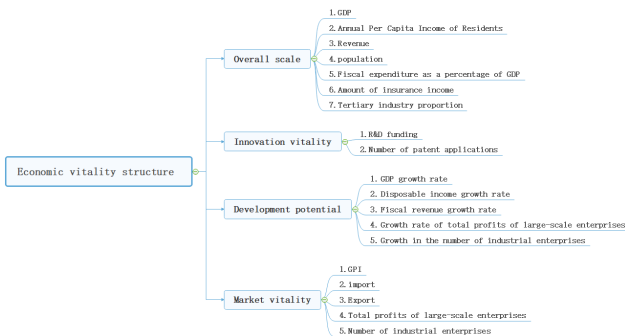


Figure 5. Composition of economic vitality indicators

Construct the economic vitality structure of Hebei Province, and mark the overall scale, innovation vitality, development potential and market vitality of the four layers of the target layer as A、 B、 C、 D. Measure the

economic vitality of Hebei Province from different angles. Mark the subordinate indicators of the overall scale layer as $A_1、 A_2...A_7$; mark the indicators of innovation vitality as $B_1、 B_2$; mark the indicators of development potential as $C_1、 C_2...C_5$; mark market vitality indicators as $D_1、 D_2...D_5$.

Take $Q_i、 Q_j$ two types of metrics, the e_{ij} indicator indicates the ratio of the effects of Q_i and Q_j on the economic vitality of Hebei Province.

Table 2. Factors

Factor	Q_1	Q_2	Q_3
Q_1	e_{11}	e_{12}	e_{13}
Q_2	e_{21}	e_{22}	e_{23}
Q_3	e_{31}	e_{32}	e_{33}

Comparison results are expressed as a pairwise comparison matrix:

$$F = (e_{ij})_{n \times n}, e_{ij} > 0, e_{ji} = \frac{1}{e_{ij}} \tag{3}$$

Combined with the actual data of each factor, the pairwise comparison matrix can be obtained after comparison.

$$F = \begin{bmatrix} e_{11} & e_{12} & e_{13} \\ e_{21} & e_{22} & e_{23} \\ e_{31} & e_{32} & e_{33} \end{bmatrix}$$

The maximum feature root and feature vector can be obtained by MATLAB.

According to formula:

$$\omega_{ij} = \frac{\omega_{ij}}{\sum_{j=1}^6 \omega_{ij}} \tag{4}$$

The feature vector is normalized to obtain a weight vector through a formula.

1.5 Consistency Inspection

Because the importance index of constructing the comparison matrix is affected by human subjective factors, even if you consult the literature and use expert conclusions, you will still get low consistency in the process of obtaining the importance of pairwise comparisons of complex factors, resulting in certain deviations.

When $CI = 0$, the consistency is complete. When the value of CI is getting larger, it shows that the degree of consistency is getting smaller and smaller, and the subjective factors that influence the model produce more and

more errors, leading to inaccurate results.

In order to determine the range of acceptable consistency to evaluate the degree of consistency, the CR ratio of consistency is introduced, namely:

$$CR = \frac{CI}{RI}$$

When $CR \leq 0.1$, it is considered to be within the acceptable level of consistency.

1.6 Solving the Model

By studying the GDP, annual disposable income per capita, fiscal revenue, population, fiscal expenditure as a percentage of GDP, insurance income, and tertiary industry as a proportion of the overall scale, this article further explores the indicators' economic impact on Hebei Contribution of vitality. According to the scale table of Table 2, combined with the analysis of expert literature, we get:

Table 3. The indicators' economic impact on Hebei Contribution of vitality

A	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆	A ₇
A ₁	1	3	1	4	2	5	3
A ₂	1/2	1	1/2	1	1	2	1
A ₃	1	3	1	4	2	5	3
A ₄	1/4	1/2	1/4	1	1/2	1	1/2
A ₅	1/2	2	1/2	2	1	3	2
A ₆	1/5	1/2	1/5	1	1/2	1	1/2
A ₇	1/3	1	1/3	1	1/2	2	1

The normalized eigenvectors solved by MATLAB (see the appendix for the code) are: $CI=0.0323$ $CR=0.0237 < 0.1$.

The consistency of this matrix is acceptable.

By studying the ratio of R & D funds and patent applications in Hebei Province to the innovation vitality, this paper further explores the contribution of indicators to the economic vitality of Hebei Province. According to Table 3 scale table, combined with expert literature analysis:

Table 4. The contribution of indicators to the economic vitality of Hebei Province

B	B ₁	B ₂
B ₁	1	2
B ₂	1/2	1

The normalized eigenvector is: , and it passes the consistency check.

Through researching the GDP growth rate, disposable income growth rate, fiscal revenue growth rate, growth rate of total profits of large-scale enterprises, and the growth rate of the number of industrial enterprises in the proportion of development potential to further explore the contribution of indicators to the economic vitality of He-

bei value. According to Table 3 scale table, combined with expert literature analysis:

Table 5. The contribution of indicators to the economic vitality of Hebei value

C	C ₁	C ₂	C ₃	C ₄	C ₅
C ₁	1	3	1	2	2
C ₂	1/2	1	1/2	1	1
C ₃	1	3	1	2	2
C ₄	1/2	2	1/2	1	1
C ₅	1/2	1	1/2	1	1

The normalized eigenvectors solved by MATLAB (see the appendix for the code) are: $CI=0.0931$ $CR=0.0831 < 0.1$.

The consistency of this matrix is acceptable.

By studying the five indicators of Hebei Province's CPI, imports, exports, total profits of large-scale enterprises, and the number of industrial enterprises in the market vitality to further explore the contribution of the indicators to the economic vitality of Hebei Province. According to Table 3 scale table, combined with expert literature analysis:

Table 6. the contribution of the indicators to the economic vitality of Hebei Province

D	D ₁	D ₂	D ₃	D ₄	D ₅
D ₁	1	1/2	1/2	1/3	1/4
D ₂	2	1	1	1/2	1/2
D ₃	2	1	1	1/2	1/2
D ₄	3	2	2	1	1
D ₅	4	2	2	2	1

The normalized eigenvectors solved by MATLAB (see the appendix for the code) are: $CI=0.0481$ $CR=0.0430 < 0.1$.

The consistency of this matrix is acceptable.

By analyzing the total indicators: the overall scale, innovation vitality, development potential, and market vitality's contribution to the economic vitality of Hebei Province, the importance of each aggregate indicator is determined. According to Table 3 scale table, combined with expert literature analysis:

Table 7. The importance of each aggregate indicator

M	A	B	C	D
A	1	3	2	2
B	1/3	1	1/2	1/2
C	1/2	2	1	1
D	1/2	2	1	1

The normalized eigenvectors solved by MATLAB (see the appendix for the code) are: $CI=0.0035$ $CR=0.0039 < 0.1$.

The consistency of this matrix is acceptable.

Finally, it is concluded that the contribution value that affects the economic vitality of Hebei Province is .

Above, a structural indicator system for measuring the economic vitality of Hebei Province was constructed, and 21 indicators were included in total. The regional economy is quantified through the aspects of overall economic scale, development potential, innovation vitality and market vitality of Hebei Province^[5]. Quantify the contribution value of 21 indicators to the economic vitality of Hebei Province, build a Hebei Province economic vitality scoring system on this basis, and score 11 cities in Hebei Province.

2. Construction of Economic Vitality Evaluation Model

2.1 Data Processing

Because in the first question, the economic vitality composition model of Hebei Province was constructed, and the contribution values of 21 indicators affecting economic vitality to regional economic vitality were determined. On this basis, several indicators that contributed more to regional economic vitality were determined As an effective indicator of the economic vitality of the eleven largest cities in Hebei Province. The selected indicators are the six indicators of GDP, GDP growth rate, fiscal revenue, fiscal revenue growth rate, number of industrial enterprises above designated size, and total profit of industrial enterprises above designated size in eleven cities in Hebei Province^[6].

After standardization, the Table 8:

Table 8. Main indicators affecting economic vitality

City	GDP	GDP GR	Fiscal revenue	Fiscal revenue GR	Number of companies	Corporate profit
Shi Jiazhuang	0.5243	0.3091	0.5561	0.4720	0.5213	0.7633
Tang Shan	0.5542	0.2649	0.4448	0.2065	0.3215	0.5159
Qin Huangdao	0.1273	0.3091	0.1386	0.3835	0.0712	0.0772
Han Dan	0.2868	0.3091	0.2574	0.0590	0.2651	0.2188
Xing Tai	0.1774	0.3091	0.1482	0.3835	0.2649	0.1142
Bao Ding	0.2928	0.2649	0.3256	0.4720	0.3606	0.1491
Zhang Jiakou	0.1211	0.3091	0.1588	0.1180	0.0880	0.0400
Cheng De	0.1244	0.3091	0.1043	0.2655	0.0852	0.0448
Cang Zhou	0.3092	0.3091	0.2801	0.2655	0.4767	0.2252
Lang Fang	0.2445	0.3091	0.3876	0.0590	0.2327	0.0637
Heng Shui	0.1293	0.3091	0.1210	0.2360	0.2300	0.0603

2.2 Integration of TOPSIS Economic Vitality Scoring Model

Construct the normalized data into a matrix D:

$$D = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix}$$

Construct a weighted judgment matrix based on the weight vector obtained above and the normalized D.

$$d = \begin{bmatrix} x'_{11} & x'_{12} & \dots & x'_{1n} \\ x'_{21} & x'_{22} & \dots & x'_{2n} \\ \dots & \dots & \dots & \dots \\ x'_{m1} & x'_{m2} & \dots & x'_{mn} \end{bmatrix}$$

Through the obtained weighted judgment matrix, the positive ideal connection and negative ideal solution are determined. The positive ideal solution is the solution with the strongest economic vitality in all cities, and the negative ideal solution is the solution with the worst economic vitality in all cities.

Solved by MATLAB:

Table 9. Results

City	Shi Jiazhuang	Tang Shan	Qin Huangdao	Han Dan	Xing Tai	Bao Ding
Stand	0.2390	0.1583	0.0602	0.0726	0.0750	0.1097
Rank	1	2	8	6	5	4
City	Zhang Jiakou	Cheng De	Cang Zhou	Lang Fang	Heng Shui	—
Stand	0.0194	0.0406	0.1099	0.0673	0.0479	—
Rank	11	10	3	7	9	—

References

- [1] Huixia Jin, Yunqin Mao. The new normal of economic growth and supply-side structural reforms[J]. Taxation, 2019, 13 (04): 2019-220.
- [2] Yejun Wang, Jingkui Zhou. The Impact of Entrepreneurial Vitality on Urban Industrial Economic Growth: An Empirical Study Based on Multidimensional Perspectives[J]. Scientific Decision, 2019 (01): 25-46.
- [3] Na Wang. Analysis and Evaluation of Urban Vitality in Jiangxi Province[J]. Time-honored Brand Marketing, 2019 (03): 17-18.
- [4] Mengqi Zhang. Analysis and Evaluation of Urban Vitality[D]. Wuhan University, 2018.
- [5] Fei Wang, Wang Gui. Innovation drive stimulates the vitality of county economy [J]. Contemporary County Economy, 2019 (08): 60-61.
- [6] Ruqun He. Research on Evaluation of Urban Economic Vitality in Pearl River-Xijiang Economic Belt[D]. Guangxi Normal University, 2019.