

Analysis of Urban Economic Vitality Index based on Principal Component Analysis

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Abstract: With the continuous development of economy and the deepening of urbanization, while the city construction has made remarkable achievements, some deep-seated problems are gradually emerging. The high energy consumption, high pollution and low output of traditional cities have caused the urban environment pollution, old urban facilities and unreasonable urban management planning, which have hindered the urban development vitality and rising space. In order for a city to break through numerous obstacles and regain its life, it is necessary to understand the factors influencing the economic vitality of the city, know the advantages and disadvantages of the city, and define the development direction of the city in the future. This paper aims to select several representative cities and representative indicators, use principal component analysis to explore the factors affecting urban economic vitality, from qualitative and quantitative aspects to build the index system of urban economic vitality, and give corresponding Suggestions to help the city to develop more healthy and sustainable.

Keywords: Index system of urban economic vitality; Economic vitality; Principal component analysis

1. Introduction

With the deepening of urbanization, many cities are paying more and more attention to their sustainable development potential and recognizing their position in urban coordinates. Therefore, the development ranking of cities has attracted more and more attention. After the rapid development of various cities, many cities limited to the traditional mode have developed, resulting in high pollution, low production capacity, unscientific management system and backward urban planning, which have greatly reduced the potential of urban economic development and narrowed the room for sustainable urban economic development. Urban economic vitality is an important factor affecting city ranking, which can measure the ability and potential of a city's economic development. To correctly analyze and evaluate the economic vitality of a city, the establishment of a more scientific comprehensive evaluation index system of urban economic vitality is its basic link.

In 2004, the organization for economic vitality and sustainable development defined economic vitality as: a community's economic competitiveness, adaptability, and attraction to private and public enterprises. Economically dynamic communities provide residents with economic activities such as satisfactory employment and a long-term sustainable quality of life; Be able to find opportunities and seize opportunities at any time, committed to the increase of residents' welfare; To encourage and recognize the creativity, hard work, integrity, and involvement

of people and businesses in the community. Urban economic vitality can reflect a city's economic development potential, attraction to foreign capital and foreign factors of production, full employment and quality of life, and innovative development capacity. Through the analysis of the indicators of urban economic vitality, the factors affecting urban economic vitality can be explored, so as to help cities better understand their own positioning, clearly perceive some advantages and shortcomings of cities, identify the future development direction of cities, and improve the vitality and competitiveness of cities. The purpose of this paper is to study the influencing factors of urban economic vitality, and to construct the index system of urban economic vitality through qualitative and quantitative analysis, so as to inject more vitality into urban economic development.

2. Literature Review

With the demand for high-quality urban development, many scholars have studied the urban economic vitality. He ruqun [1] proposed a comprehensive factor analysis method to measure urban economic vitality based on the factors and evaluation model of urban vitality and competitiveness. Then by using principal component analysis, it is concluded that the per capita GDP, the ratio of fiscal expenditure to GDP and the disposable income of urban residents are the main factors affecting the urban economic vitality. Zhang Keyuan [2] measured the economic vitality of each city based on the amount of enterprise

registration and the registered capital of each city, combined with the gross product of each city, demonstrated the influence of enterprises on the economic vitality of the city from the perspective of enterprises by using the grey relational method, and finally found that enterprises had a certain influence on the economic vitality of the city. Zhang Hongdong and Qin Zhenyan [3] qualitatively discussed urban economic vitality from seven aspects: economic aggregate and its growth, enterprises and their earnings, residents' income, finance and social security, foreign trade and foreign capital, technical level, education and environment. Qin Yangyang [4] used principal component analysis and cluster analysis to analyze the relevant index system established by the economic development level of all provinces and autonomous regions in China, and put forward Suggestions for alleviating the current situation of unbalanced regional economic development.

Based on the research of many scholars on urban economic vitality, most scholars conduct theoretical exploration on the factors affecting urban economic vitality from a qualitative perspective, or use quantitative analysis to study economic indicators. In this paper, economic indicators and environmental education indicators are included in the scope of study to comprehensively explore the impact of various indicators on urban economic vitality, and give relevant Suggestions.

3. Analysis of Indicators of Urban Economic Vitality

3.1. Selection of indicators and data sources

In this paper, four representative cities of Beijing, Shanghai, Tianjin and Chongqing in 2017 were selected as indicators, including their economy and growth, enterprises and their income, residents' income and expenditure, finance and social security, foreign trade and foreign investment, environment, science and technology education and other factors.

Economy and growth can reflect the aggregate of economies of scale and the aggregation of economic factors, which can improve the output efficiency of a city and thus enhance its economic vitality. The enterprise and its income reflect the enterprise's quality, capital, industrial organization structure and degree of specialization, which have certain influence on the urban economic vitality. Enterprises are the microcosmic basis and economic cell of urban economic vitality, and they have made a great

deal of contributions to the expansion of investment, the expansion of productivity development scale and the improvement of productivity development level. To some extent, residents' income reflects the quantity and quality of the labor force and the income of the labor force. The sustained and steady growth of labor force can promote the continuous growth of urban economic vitality, and the inflow of external population can also help the growth of urban labor force, thus having a certain impact on the urban economic vitality. Financial and social security is the guarantee of normal operation of a regional economic activity, also determines the degree of various factors of production to a city, the role of the government mainly depends on the city government's intervention in the market, policy, government affairs openness and efficiency of the government, and one of the important measure is the financial and social security. Foreign trade and foreign capital are important indicators to measure the degree of the city's opening to the outside world. Capital can boost the sustainable growth of urban economy. Only with advanced technology can urban economy develop with high quality, so it is also an important source of urban economic growth. On the one hand, technological progress provides technical support for the development of urban economy, on the other hand, it also forms a huge attraction to high-quality factors of production outside the city, so as to further promote the development of urban economy. Education level is the foundation of urban economic vitality, and excellent educational conditions can help a city cultivate a steady stream of high-quality talents, and then transform them into the creativity and technical level of urban economy. The urban environment includes natural landscape and social environment. Beautiful environment and healthy cultural life atmosphere can attract more talents and production factors, and are also important factors to improve the quality of urban life, thus affecting the vitality of urban economy.

Among them, the per capita GDP, at the end of the resident population, the per capita disposable income, the enterprise legal person units number, the number of industrial enterprises above designated size, the scale of enterprise profit, local fiscal revenue, the total import and export, the urban green space area, road area, education funds and technology market turnover data on 11 indexes such as the annual data from the national bureau of statistics, as table 1:

Table 1. Evaluation factors and indicators

The evaluation factors	Indicators
Residents' income and expenditure	Gross Domestic Product per capita
	Per capita disposable income
	Year-end resident population
Enterprises and their earnings	Total profits of scale enterprises
	Number of enterprise legal person units

	Number of industrial enterprises above the scale
Finance and social security	Local fiscalrevenue
	Education funding
	Technology market turnover
Foreign trade and foreign capital	Total import and export volume
Urban environment construction	Road area
	Urban green space

3.2. The data processing

Excel was used to sort out the collected data, and SPSS was used to process the variable data. The descriptive

statistics after the variable processing are shown in table 2:

Table 2. Descriptive statistics

	The minimum	The maximum	The average	The standard deviation
Gross Domestic Product per capita	65933	140211	113372.25	32662.57903
Number of enterprise legal person units	414784	676829	516380	115542.3168
Number of industrial enterprises above the scale	3231	8122	5580.75	2226.56797
Total profits of scale enterprises	1061.37	3243.8	1957.6775	943.32633
Year-end resident population	1557	3075	2305.25	627.99383
Local fiscalrevenue	2252.38	6642.26	4158.9475	2223.86298
Total import and export volume	66601107	476196649	244933586	190584310.3
Per capita disposable income	24152.99	58987.96	44348.2775	16750.85911
Urban green space	4.43	13.63	8.1425	3.99452
Road area	10896	19015	14653.25	3348.14689
Education funding	5850624	12512746	9987863	3067383.563
Technology market turnover	51.36	4486.89	1475.0775	2032.45304

3.3. The establishment and solution of the model

3.3.1. Correlation test

The 12 indexes selected in this paper are both relatively independent and correlated to some extent. Table 3 is the correlation coefficient matrix after the normalization of each index.

Table 3 (a). Correlation matrix

Correlation matrix						
	Gross Domestic Product per capita	Number of enterprise legal person units	Number of industrial enterprises above the scale	Total profits of scale enterprises	Total profits of scale enterprises	Local fiscalrevenue
Gross Domestic Product per capita	1	0.223	-0.418	0.366	-0.717	0.661
Number of enterprise legal person units	0.223	1	-0.52	0.057	0.232	0.295
Number of industrial enterprises above the scale	-0.418	-0.52	1	0.598	0.577	0.243
Total profits of scale enterprises	0.366	0.057	0.598	1	0.257	0.922
Total profits of scale enterprises	-0.717	0.232	0.577	0.257	1	0.006
Local fiscalrevenue	0.661	0.295	0.243	0.922	0.006	1
Total import and export volume	0.679	0.163	0.295	0.931	-0.064	0.99
Per capita disposable income	0.88	0.311	-0.052	0.748	-0.321	0.938
Urban green space	0.371	0.041	0.603	1	0.245	0.921
Road area	-0.837	0.116	-0.144	-0.733	0.469	-0.837
Education funding	0.297	0.649	0.207	0.786	0.451	0.834
Technology market turnover	0.667	0.87	-0.673	0.143	-0.231	0.487

Table 3 (b). Correlation matrix

Correlation matrix						
	Total import and	Per capita	Urban green	Road	Education	Technology

	export volume	disposable income	space	area	funding	market turnover
Gross Domestic Product per capita	0.679	0.88	0.371	-0.837	0.297	0.667
Number of enterprise legal person units	0.163	0.311	0.041	0.116	0.649	0.87
Number of industrial enterprises above the scale	0.295	-0.052	0.603	-0.144	0.207	-0.673
Total profits of scale enterprises	0.931	0.748	1	-0.733	0.786	0.143
Total profits of scale enterprises	-0.064	-0.321	0.245	0.469	0.451	-0.231
Local fiscal revenue	0.99	0.938	0.921	-0.837	0.834	0.487
Total import and export volume	1	0.937	0.932	-0.895	0.756	0.396
Per capita disposable income	0.937	1	0.748	-0.907	0.675	0.632
Urban green space	0.932	0.748	1	-0.741	0.775	0.133
Road area	-0.895	-0.907	-0.741	1	-0.398	-0.288
Education funding	0.756	0.675	0.775	-0.398	1	0.574
Technology market turnover	0.396	0.632	0.133	-0.288	0.574	1

3.3.2. Principal component analysis solution

Calculate the correlation coefficient of each index.
 Calculate the characteristic value and the contribution rate of each main factor.
 The eigenvalue I_j is obtained by the vector inner product of the correlation coefficient matrix (R), and the corres-

ponding eigenvector I_{ij} is obtained by the inverse compact transformation. Then the number of principal factors is determined according to the cumulative percentage of eigenvalues and the contribution rate of each principal factor is calculated.

Table 4. Total variance explanation

Total variance explanation						
Composition	Initial eigenvalue			Extract the sum of the squared loads		
	Total	Percentage of variance	The cumulative%	Total	Percentage of variance	The cumulative %
1	6.804	56.701	56.701	6.804	56.701	56.701
2	3.075	25.628	82.329	3.075	25.628	82.329
3	2.121	17.671	100	2.121	17.671	100
4	4.57E-16	3.81E-15	100			
5	3.44E-16	2.86E-15	100			
6	2.08E-16	1.74E-15	100			
7	1.79E-16	1.49E-15	100			
8	5.55E-17	4.62E-16	100			
9	-1.12E-16	-9.31E-16	100			
10	-1.64E-16	-1.37E-15	100			
11	-2.51E-16	-2.09E-15	100			
11	-2.51E-16	-2.09E-15	100			
12	-3.42E-16	-2.85E-15	100			

SPSS software was used for principal component analysis, and the contribution rate of the principal factor was shown in table 4. The top two primary factor contribution amount to 82.329%, the principle of combining with eigenvalues greater than 1 to extract the two principal components, its characteristic values were 6.804, 3.075, each principal components variance contribution rates were 56.701% and 25.628% respectively, the accumulation contribution rate of 82.329%, representing the two principal components can represent the measured 12 cities of dynamic economic indicators, so choose the first

two principal components as the main factor to represent the city's economic vitality 82.329% of the information. Calculate the factor load
 Calculate R analysis factor load quantity (L): $L_{ij} = \sqrt{I_i} I_{ij}$ of main factor (P_k) and evaluation factor (X_j), and further consider factor load quantity: $H_{ij} = L_{ij} P_j (j=1,2,3,...,12)$ of the case of relative importance of main factor. The factor load quantity is shown in table 4.

Table 5. Component matrix

Component matrix		
	1	2
Gross Domestic Product per capita	0.724	-0.598
Number of enterprise legal person units	0.308	-0.476

Number of industrial enterprises above the scale	0.168	0.977
Total profits of scale enterprises	0.888	0.46
Year-end resident population	-0.075	0.697
Local fiscal revenue	0.996	0.082
Total import and export volume	0.988	0.119
Per capita disposable income	0.965	-0.235
Urban green space	0.887	0.462
Road area	-0.862	0.067
Education funding	0.806	0.149
Technology market turnover	0.534	-0.723

According to table 5, the indicators that determine the size of the first principal component are local fiscal revenue, total import and export volume and per capita disposable income of residents. The indexes that determine the size of the second principal component are the number of industrial enterprises above the scale and the resident population at the end of the year respectively. Based on the comprehensive analysis of the two principal components, under the premise of following the establishment principle of the index system and the principle of causality, the first principal component can be named as urban economic income and the second principal component as enterprise activity.

3.4. The establishment of evaluation system of urban economic vitality

By dividing the principal component load of each index variable by the eigenvalue of the principal component by the square root of the square root, the corresponding coefficients of each index of the two principal components are obtained, and the two principal component factor expressions are constructed by taking the obtained coefficients as the weight:

$$Z1 = 0.278X1 + 0.382X2 + 0.379X3 + 0.370X4 \quad (1)$$

Where Z1 is the first principal component of urban economic income, X1 represents per capita GDP, X2 represents local fiscal revenue, X3 represents total imports and exports, and X4 represents residents' per capita disposable income.

$$Z2 = 0.557X1 + 0.262X2 + 0.397X3 \quad (2)$$

Where, Z2 is the activity degree of the second principal component enterprise, Y1 is the number of industrial enterprises above the scale, Y2 is the total profit of scale enterprises, and Y3 is the resident population at the end of the year.

With the variance contribution rate corresponding to each principal component as the weight, the evaluation system model of urban economic vitality can be obtained by weighted summation:

$$F = 0.567Z1 + 0.256Z2 \quad (3)$$

In the formula (3), F is the urban economic vitality, while Z1 and Z2 are the urban economic benefits of the first principal component and the activity degree of the second principal component enterprises, respectively. In the formula, the urban economic vitality can be mainly

measured by the urban economic income of 57.7% and the enterprise activity degree of 25.6%.

4. Summary and Evaluation of Indicators of Urban Economic Vitality

4.1. Appropriate absorption of population

A modest increase in population density has a positive impact on economic vitality. In a densely populated city, more economic value can be created, the business circle can be active, a steady stream of vitality can be injected into enterprises, and opportunities and vitality can be created for the economy of a city. But high population density may be detrimental to the development of social and cultural vitality. An appropriate increase in population can activate the economic and cultural market and promote the exchange of economic and cultural activities. However, the excessive population in the limited space will cause certain consequences such as resource shortage, excessive unemployment rate, traffic inconvenience and so on, which will affect people's life and even the heavy burden of urban functions. Therefore, an appropriate amount of population density is helpful to improve urban vitality and competitiveness.

4.2. Proper introduction of enterprises, improve the quality of enterprises

Enterprises are the blood of a city's economy. The economic value created by enterprises can provide more economic vitality for the city. Enterprises can provide the materials needed for the operation of a city, attract foreign investment and promote the flow of capital; The existence of a large number of enterprises can provide more jobs and job opportunities for cities, but too many enterprises may cause negative effects. The operation of agricultural and industrial enterprises requires a large amount of urban land and various resources of water and electricity, and even causes a lot of pollution. Therefore, it will have a certain impact on the urban environment and people's life, and aggravate the resource shortage. Only high-tech enterprises, service enterprises will better increase the economic activity of the city. In addition, the government should promote favorable policies suitable for the development of enterprises to help the healthy growth of urban enterprises. Only by streamlining the

number of enterprises and improving their quality can we better promote the dynamic development of cities and enhance their competitiveness.

4.3. The government implements appropriate economic policies

The government can through long-term steady economic transition policy, promoting urban economic vitality and competitiveness of long-term growth and development, economists can take advantage of the economic transformation and upgrading of related indicators and growth factors, to make long-term prediction in economic vitality and competitiveness, based on the relevant factors of theory with practice, set up for the city suitable for their future development direction, make up a short board, play advantage, better promote the economic vitality of the city.

4.4. Pay attention to environmental protection and sustainable development

In the process of rapid development, the city should not only promote the high speed and high quality development of economy, but also pay attention to the rational

use of resources, the protection of resources and the protection of ecological environment. In the process of urban development, human pollution emissions and resource use will almost always cause irreversible harm, which requires us to combine economic development and environmental protection, to get along harmoniously with nature, and to achieve sustainable economic development. Healthy and sustainable urban development will increase the development potential of urban economy, enhance the competitiveness of cities, and enhance the vitality of high-quality urban economy.

References

- [1] He R.Q. Evaluation of urban economic vitality in the pearl river - Xijiang economic belt. Guangxi Normal University. 2019.
- [2] Zhang K.Y. Analysis of the dynamic development status of Beijing-Tianjin-Hebei city based on enterprise influence. Industry and Technology Forum. 2019, 18(16), 87-88.
- [3] Zhang H.D., Qin Z.Y. Analysis of urban economic vitality. Heilongjiang Science and Technology Information. 2011, (21), 155.
- [4] Qin Y.Y. Research on regional economic development based on principal component analysis and k-means cluster analysis. China Business Theory. 2020, (04), 214-215.