

Ministry of Education and Science of Ukraine
**ODESSA NATIONAL ACADEMY OF
FOOD TECHNOLOGIES**

International Competition of
Student Scientific Works

**BLACK SEA
SCIENCE 2020**
PROCEEDINGS



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Ministry of Education and Science of Ukraine
Odessa National Academy of Food Technologies

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2020

Proceedings

Odessa, ONAFT 2020

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2. ECONOMICS AND **ADMINISTRATION**

ANALYSIS AND DECISION OF REGIONAL ECONOMIC VITALITY AND ITS INFLUENCING FACTORS**Author:** Wang Yining**Supervisor:** Lihui Tu*Ningbo Institute of Technology, Zhejiang University (China)*

Abstract. *Regional economic vitality is an important component of regional comprehensive competitiveness. Therefore, how to grasp the key factors and effectively improve the regional economic vitality is a research direction with practical value.*

Through researching a large number of related literatures, this article proposes two issues for research: 1. Taking a region as an example, establishing a relationship model of regional economic vitality influencing factors, proposing action plans, and analyzing regional economic vitality from the perspective of population and corporate vitality trends Impact of change. 2. Select a suitable index system to establish a mathematical model for measuring regional economic vitality, and rank regional economic vitality in Beijing, Shanghai, Guangzhou, Shenzhen, and some second-tier cities.

For the first question, this article starts from five aspects of economic aggregate, corporate benefits, government regulation, residents' situation and environment, selects 22 indicators, uses correlation analysis method to select 8 optimal indicators, and then uses subjective weighting method and The model combined with objective weighting method obtains the weight of each indicator, scores the regional economic vitality, and obtains the relationship model of the factors that influence the regional economic vitality, and proposes an action plan. Finally, it uses regression analysis to find that the population growth rate negatively affects the regional economy. Vitality, the growth rate of the number of enterprises is positively affecting regional economic vitality.

For the second question, this paper tests the relational model given in the first question. It is found that there is an error from the actual test, so it needs to be corrected. This article uses hypothesis testing model ideas and adds two correction coefficients based on a mathematical model of normal distribution, and then performs linear programming on the correction factors, and then tests the relative error to determine whether it makes the probability histogram follow a normal distribution image The relative error is less than 0.05, and then the hypothesis is justified based on the conclusion. After correction, it was found that it was indeed within the acceptable range, and the top three cities that got the economic vitality were Shanghai, Beijing, and Shenzhen.

Based on the previous conclusions, this article puts forward a series of suggestions for promoting the development of talents, informatization, technological innovation, and industrial upgrading in Beijing. It provides a reference for the sustainable development of regional economic vitality and the improvement of regional competitiveness. Value.

Keywords: *Regional economic vitality; Correlation analysis method; Normal distribution model*

1 Introduction

Against the background of the current deepening reforms, the booming new technological revolution around the world has pushed the world economy to move forward at a faster pace. Under the pressure of huge international competition, how to strengthen the economic system of a region Vitality has become an urgent issue at this time. In this paper, by scoring major cities in China, establishing related mathematical models, analyzing and researching regional economic vitality, asking and solving problems, and seeking solutions to the problem.

2 Literature analysis

Although economic vitality has long been proposed to be of great significance to the economic development of a country or region, there is little relevant literature on the study of regional economic vitality. The index system used by different scholars in the same region is different. The index system used is also different, which has caused the economic vitality research index system to be ununiform.

Regarding regional vitality, Zhou Tianbao first, Yang Anqin (1985) proposed that urban vitality is manifested as the ability to self-development and improvement of urban production relations. In addition, urban vitality is also manifested as meso-economic control, regulation, and organization of coordinated macroeconomic development. The ability of the overall economic system to operate ^[1]. Lu Mingyang (2011) and others believe that the city's competitiveness is the best reflection of urban vitality, and the two have a positive correlation. When selecting the index system, mainly refer to the city competitiveness index system, and use the principal component analysis method for the Inner Mongolia Autonomous Region. Twelve prefecture-level cities were evaluated for vitality to obtain a city ranking ^[2].

Regarding economic vitality, Cui Jian (2008) believes that high-efficiency investment is the main way to improve the economic vitality of the country ^[3]; Cao Yongfu (2017) proposed the impact of the decline in the economic vitality of the United States in "U.S. economic vitality decline: facts, causes and consequences" The strength of the medium and long-term economic growth in the United States is mainly reflected in the slowdown of new company establishment, the decline of listed companies, the shrinking growth potential of SMEs, the company's aging, and the decline in power market liquidity. It also explains the causes and consequences of this phenomenon. However, no data model has been used to prove which indicators are affected, and to what extent ^[4].

Regarding regional economic evaluation, Wang Shenglan (2013) used a combination of fuzzy comprehensive evaluation and information entropy to evaluate the vitality of major cities in Hubei Province, and analyzed economic vitality as the primary factor. He believed that economic vitality affected urban vitality. The key is to enhance the vitality of the city's economy and play an important role in urban development ^[5]. Yi Wei (2016) measured the economic vitality of various urban areas in Sichuan Province in the "Study on the Economic Vitality of Sichuan", and concluded that there is a positive correlation between the social production and human resource factors that affect economic vitality and economic synergy ^[6].

Scholars at home and abroad have adopted a variety of analytical methods, and in-depth research from all aspects on the necessity of improving the economic vitality of the city for the development of the city's economy. At the same time, it is also of

great significance to the modernization, vitality and vitality of China's urban development. The vitality evaluation laid the theoretical foundation.

3 Object, subject and methods of study

The research object of this article is the vitality of regional economy, and the research subject is the field of economics and administration. By establishing a suitable mathematical model to analyze and study the regional economic vitality, this paper proposes the following questions to solve:

1. Take a region as an example, establish a relationship model of the factors affecting regional economic vitality, propose an action plan, and analyze the impact on regional economic vitality changes from the perspective of population and corporate vitality trends.

2. Select a suitable index system to establish a mathematical model for measuring regional economic vitality. Select Beijing, Shanghai, Guangzhou, Shenzhen, and some second-tier cities to rank their urban economic vitality.

In addition, this article proposes the following model assumptions:

Assumption 1: Assume that the selected city index screening results can be completely analogized to other cities.

Assumption 2: It is assumed that the errors between the factors studied in this article are irrelevant.

Assumption 3: Assume that only systematic errors occur during data mining and processing research in this paper, and no random errors.

Assumption 4: Assume that the data scoring system is normally distributed.

Assumption 5: Assume that the distribution of the histogram intervals in Problem 3 is reasonable.

3.1 Establishment and Solution of Problem One Model

This article starts from the five aspects of economic aggregate, corporate benefits, government regulation, residents' situation and environment, selects 22 indicators, uses correlation analysis method to select 8 optimal indicators, and then uses subjective and objective weighting methods. The weight of each indicator is obtained, the regional economic vitality is scored, and the relationship model of the regional economic vitality influencing factors is obtained, and then an action plan is proposed. Finally, the regression analysis method and the gray prediction model are used to analyze the changes in population and corporate vitality trends. Impact. The specific analysis process is shown in the figure:

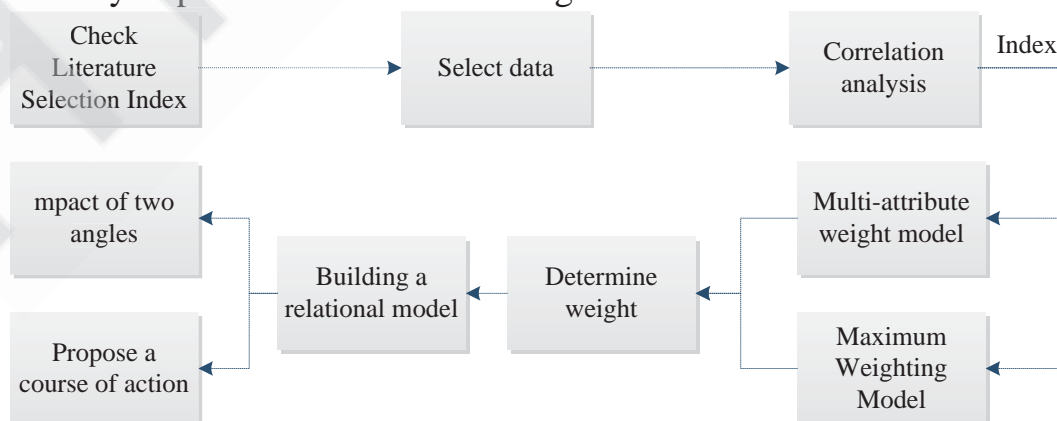


Figure 1 Problem-Idea flowchart

3.1.1 Selection of Evaluation Indicators for Regional Economic Vitality

(1) Index selection

Economic vitality is the extent to which a region supports its economy and society, and it is the ability to sustain economic growth. Drawing on the research of experts and scholars, this article takes Beijing as an example, starting from five aspects of economic aggregate, corporate benefits, residents, government regulation and environment, and selects 22 indicators based on the principles of scientificity, comprehensiveness and evaluability as follows:

Table 1 Selection of original indicators

| First-level indicators | Secondary indicators |
|------------------------|---|
| Economic aggregate | GDP per capita (yuan / person) |
| | Regional GDP (100 million yuan) |
| | Per capita GDP growth rate (%) |
| Business efficiency | Number of corporate entities (a) |
| | Growth rate of corporate legal entities (%) |
| | Funds for the development of new products by industrial enterprises above designated size (10,000 yuan) |
| | Total import and export of business units |
| | Total export of the location of the business unit (trillion US dollars) |
| Government regulation | Local fiscal revenue (100 million yuan) |
| | Local fiscal revenue growth rate (%) |
| | Local fiscal expenditure (100 million yuan) |
| | Proportion of local fiscal expenditure to GDP (%) |
| | Number of people participating in urban basic medical insurance at the end of the year (10,000 persons) |
| | Revenue of Urban Employee Medical Insurance Fund (10,000 yuan) |
| Residents | Household consumption level (yuan) |
| | Per capita disposable income of residents (yuan) |
| | Per capita disposable income growth rate of residents (%) |
| | Permanent population at the end of the year (10,000 people) |
| | Permanent population growth rate at the end of the year (%) |
| Surroundings | Urban green space (10,000 hectares) |
| | Per capita green space (10,000 hectares / person) |
| | Harmless treatment rate of domestic garbage (%) |

(2) Data preprocessing

The data in this article comes from the National Bureau of Statistics, which selected 22 indicators of Beijing from 2009 to 2018. Because the data units are not uniform and the values are too large, direct processing will cause large errors. This paper uses normalization to standardize the data. The formula is as follows:

$$X^* = \frac{X - \min}{\max - \min}$$

The standardized results are detailed in the appendix.

The 22 indicators are analyzed by the correlation matrix method, and the determination rule is that the absolute value of an element above (or below) the main diagonal is very large (above 0.8), then the variables are considered to have more severe multicollinearity.

Based on this, this article removes the variables above 0.8, and selects 8 optimal indicators, which are the per capita GDP growth rate, the growth rate of the number of corporate entities, the total import and export of the business unit location, the total export of the business unit location, and the local fiscal revenue growth rate, Per capita disposable income growth rate, year-end resident population growth rate, harmless treatment rate of domestic waste. There is no serious collinear relationship among the above 8 variables, and their correlation can be found in the appendix. The specific indicator system of regional economic vitality evaluation is shown in the following figure: [7]

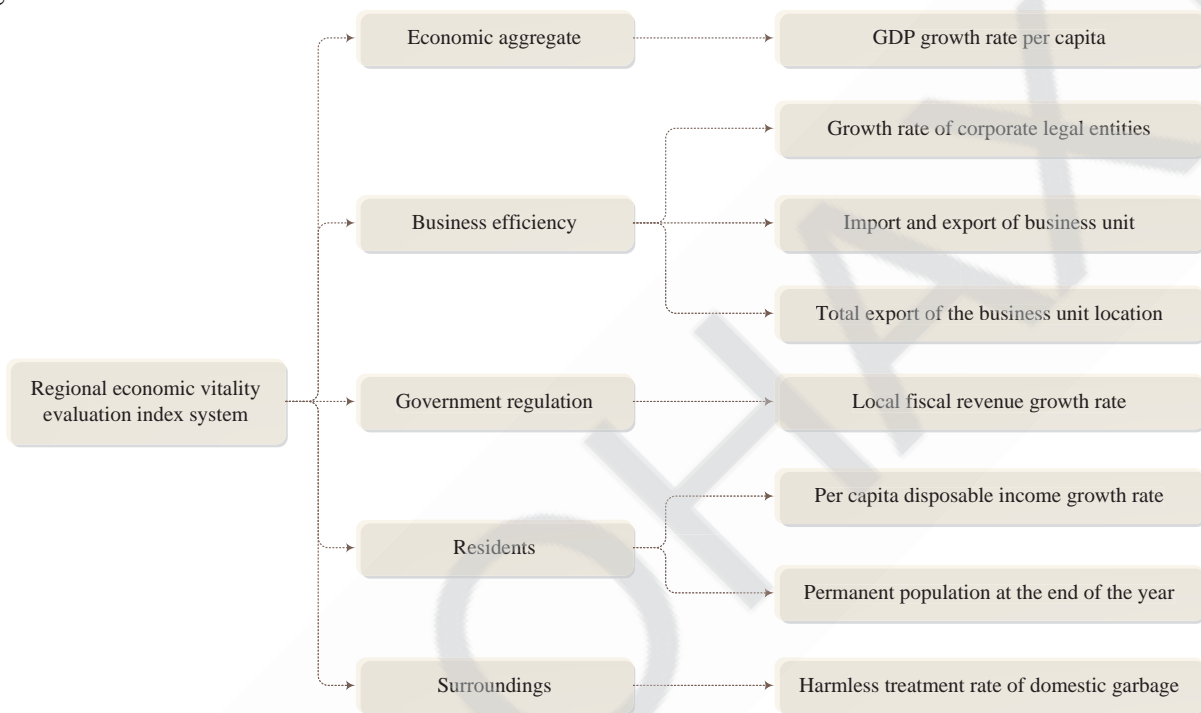


Figure 2 Evaluation indicators of regional economic vitality

3.1.2 Determining Weights with Subjective and Objective Weighting

Methods

From the above, in the case of excluding multiple indicators, there are still multiple indicator quantities, and the complexity of decision-making is still high. Facing this kind of multi-attribute decision problem, weight analysis is obviously a good solution. Therefore, the determination of the weight of each indicator is obviously a very important link. The distribution of attribute weights will directly affect the final evaluation results. Therefore, in the process of comprehensive evaluation of multiple indicators, this article uses the subjective weighting method and the objective weighting method. The combined method combines qualitative analysis and quantitative analysis to make the weight values more reasonable and practical.

(1) Multi-attribute fuzzy comprehensive decision weight model^[8]

Assume $C = \{c_1, c_2, \dots, c_m\}$ for a solution to a problem, $U = \{u_1, u_2, \dots, u_m\}$ is the attribute set, to evaluate and compare each scheme through the attribute set U, choose the best scheme. That is, each plan is comprehensively judged by a model, and then the results of different plans are compared to make a decision.

The flowchart of the multi-attribute comprehensive decision-making process is shown in the following figure:

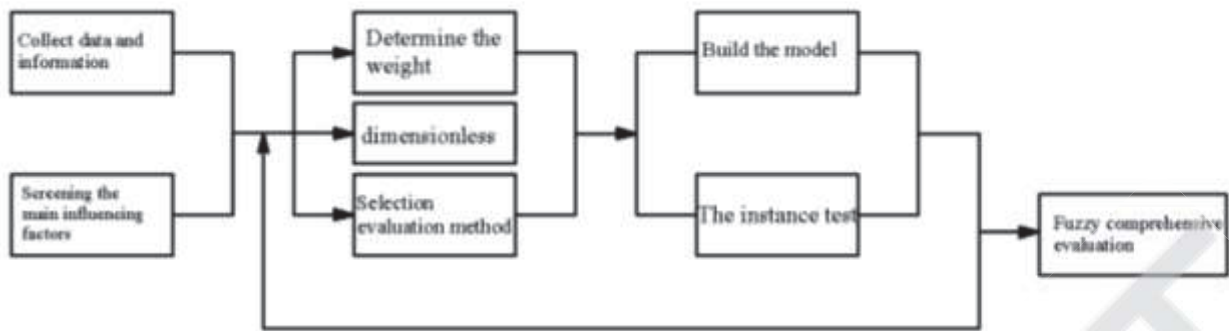


Figure 3 Multi-attribute comprehensive decision-making flowchart

The multi-attribute fuzzy comprehensive decision-making model, as a subjective weighting method, has the advantage that its weights are given by professionals considering actual conditions. However, its shortcomings are strong randomness. It does not link the actual numerical characteristics of the indicator with the method of determining the weight, and it does not show the dynamic change of the indicator weight with time.

Therefore, this paper combines it with the weighting model of dispersion maximization method, and uses a large amount of data to quantitatively analyze the ordering of weight values in accordance with the actual reasonable ordering weights, so as to make the weights change dynamically with time.

(2) Weighting model with dispersion maximization method

The dispersion maximization method is based on quantitative and qualitative analysis, and makes a quantitative evaluation of each index in a manner that maximizes dispersion, so that the results have mathematical and statistical characteristics.

Steps to maximize dispersion:

First, let the factor set be $U = \{u_1, u_2, \dots, u_m\}$, The k given factors are $u_i (i=1, 2, \dots, k)$ of weight assignment value, secondly set V_j as the maximum deviation of the j -th indicator:

$$V_j = \max(X_j) - \min(X_j)$$

$$\max(X_j) = \max(X_{ij})$$

$$\min(X_j) = \min(X_{ij})$$

Then take the average of each factor's weight as its weight:

$$a_i = \frac{1}{k} \sum_{j=1}^k a_{ij} (i=1, 2, \dots, n)$$

The following restrictions exist in the calculation of weights:

$$\sum_{i=1}^n a_{ij} (j=1, 2, \dots, k) = 1$$

$$\sum_{j=1}^k a_{ij} (i=1, 2, \dots, n) = 1$$

Calculate each weight value under the above conditions.

(3) Determine the weight

Table 2 Determine the weight

| Index | Weights |
|---|---------|
| GDP growth rate per capita | 0.0778 |
| Growth rate of corporate legal entities | 0.2585 |
| Total import and export of the business unit location | 0.1194 |
| Total export of the business unit location | 0.1130 |
| Local fiscal revenue growth rate | 0.1559 |
| Per capita disposable income growth rate | 0.0811 |
| Year-end resident population growth rate | 0.1099 |
| Harmless treatment rate of domestic garbage | 0.0875 |

3.1.3 Establish the Relationship Model and Determine the Action Plan

(1) Establish the relationship model of the factors affecting economic vitality

Because the weight is the result of standardizing the data based on Beijing, if you want to apply it to different data in other cities, you need to modify the formula. And because the values of the weights are all positive, the positive and negative relationship between the index and the function value y cannot be reflected, so this article considers using the correlation analysis to calculate the positive and negative coefficients. The main method is to divide each coefficient by its data before normalization, and then modify the formula based on positive or negative correlation.

The relationship model of the factors affecting economic vitality is as follows:

$$y = -0.8969x_1 + 0.4216x_2 + 0.5573x_3 + 4.3814x_4 - 0.7363x_5 + 0.2275x_6 - 1.8920x_7 + 0.4150x_8$$

It can be seen that the growth rate of per capita GDP, the growth rate of local fiscal revenue, and the growth rate of resident population at the end of the year negatively affect the regional economic vitality. The growth rate of dominating income and the rate of harmless treatment of domestic garbage are positively affecting the regional economic vitality.

The 2009-2018 regional economic vitality score was calculated, and the score was modified. For comparison, this article enlarges the score by 100 times, as follows:

Table 3 Regional economic vitality scores

| Years | Original rating | 100x score |
|-----------|-----------------|------------|
| 2018 year | 0.8829221 | 88.29221 |
| 2017 year | 0.7453814 | 74.53814 |
| 2016 year | 0.5795811 | 57.95811 |
| 2015 year | 0.6786326 | 67.86326 |
| 2014 year | 0.7882847 | 78.82847 |
| 2013 year | 1.0000670 | 100.0067 |
| 2012 year | 0.7524676 | 75.24676 |
| 2011 year | 0.5634553 | 56.34553 |
| 2010 year | 0.6099048 | 60.99048 |
| 2009 year | 0.5284320 | 52.8432 |

(2) Action plan

In terms of economy, use policies to lower the threshold for the development of enterprises, and support and subsidize them, thereby promoting the growth of the number of enterprises; in foreign trade, reduce tariffs, vigorously support import and export trade, and implement mutually beneficial and win-win agreements with other countries Foreign policy; in terms of government regulation, relax local taxation

requirements to maximize local fiscal revenue; in terms of residents, reducing taxes and housing prices has significantly improved people's living standards and enriched people's lives; in the environment In terms of increasing investment in the environment and sorting waste, the city's environmental quality has been significantly improved.

3.1.4 Two-angle effect

Regression analysis is a method used to study the relationship between a phenomenon and its influencing factors. According to the number of independent variables, it can be divided into univariate regression and multiple regression. Based on the multiple regression model obtained above, it is concluded that the population growth rate negatively affects the regional economic vitality, and the growth rate of the number of corporate legal entities positively affects the regional economic vitality. This article uses a univariate regression model to analyze the impact of changes in population and corporate vitality on regional economic vitality.

(1) Trend of population change

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|--------------------|-------------|-----------------------|-------------|----------|
| X | -326.2972 | 239.1558 | -1.364371 | 0.2096 |
| C | 77.65575 | 6.527493 | 11.89672 | 0.0000 |
| R-squared | 0.918765 | Mean dependent var | | 71.29128 |
| Adjusted R-squared | 0.907361 | S.D. dependent var | | 15.11416 |
| S.E. of regression | 14.43889 | Akaike info criterion | | 8.354583 |
| Sum squared resid | 1667.851 | Schwarz criterion | | 8.415100 |
| Log likelihood | -39.77292 | Hannan-Quinn criter. | | 8.288196 |
| F-statistic | 1.861508 | Durbin-Watson stat | | 1.396607 |
| Prob(F-statistic) | 0.209592 | | | |

Figure 4 Impact of population growth rate on regional economic vitality

The relationship between regional economic vitality Y and population growth rate X with a high degree of fitting is obtained:

$$Y = -326.2972X + 77.6558$$

$t = -1.36, p = 0.2096 > 0.05$. This shows that at a significance level of 0.05, the linear effect of population growth rate on regional economic vitality is not significant. On the whole, the population growth rate negatively affects the regional economic vitality.

(2) Changes in corporate vitality

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|--------------------|-------------|-----------------------|-------------|----------|
| X | 52.71410 | 21.02562 | 2.507137 | 0.0365 |
| C | 66.85770 | 4.185541 | 15.97349 | 0.0000 |
| R-squared | 0.940001 | Mean dependent var | | 71.29128 |
| Adjusted R-squared | 0.930001 | S.D. dependent var | | 15.11416 |
| S.E. of regression | 11.99648 | Akaike info criterion | | 7.983961 |
| Sum squared resid | 1151.325 | Schwarz criterion | | 8.044478 |
| Log likelihood | -37.91980 | Hannan-Quinn criter. | | 7.917574 |
| F-statistic | 6.285736 | Durbin-Watson stat | | 1.090627 |
| Prob(F-statistic) | 0.036534 | | | |

Figure 5 The impact of the growth rate of the number of enterprises on regional economic vitality

The relationship between the regional economic vitality Y and the corporate vitality change X with a high degree of fitting is obtained:

$$Y = 52.7141X + 66.8577$$

$t = 2.51, p = 0.0365 < 0.05$. This shows that at a significance level of 0.05, the growth rate of the number of enterprises has a significant linear effect on the regional economic vitality. When other conditions remain the same, the regional economic vitality score increases by an average of 52.7141 points for each unit increase in the number of enterprises. On the whole, the growth rate of the number of enterprises is positively affecting the regional economic vitality.

(3) Inspection

From the comparison of the incremental changes in the number of enterprises in each region and the number of surviving companies in each province in 2019, it can be obtained that the number of surviving companies in the city will increase with the changes in the vitality of enterprises. It can be seen that the change trend of enterprises is positively correlated with the change of regional economic vitality. In the analysis of the weights requested in this article, it is seen that the growth rate of the number of corporate legal entities is higher, and the weight of the growth rate of the resident population at the end of the year is lower. This is also in line with the conclusions obtained by using the linear fitting mentioned above in this article, so it shows that the method and conclusion used in this article are correct.

3.2 Model Establishment and Solution of Problem 2

The second question asked to rank the economic vitality of cities. These cities occupy a certain position in China's regional economy and have strong representation. Although the relational model given in Question 1 is universal, measuring regional economic vitality is a complex issue. Therefore, to use the relational model of Question 1, you need to test the model. If the test finds that it is reasonable, then Question 3 remains. You can use the model from question one. However, when using the relational model given in Question 1 to conduct a scoring test, a great deviation from the actual situation was found. After re-examining this question, it was found that the score determined in this way did not take into account factors such as the geographical location of the east and west, and lacked enforceability. Therefore, in order to make it reflect the real performance as much as possible, the calculation formula of the above relational model will be processed, and correction coefficients will be added to ensure that it has the ability to reflect the real performance. The specific flowchart is as follows:

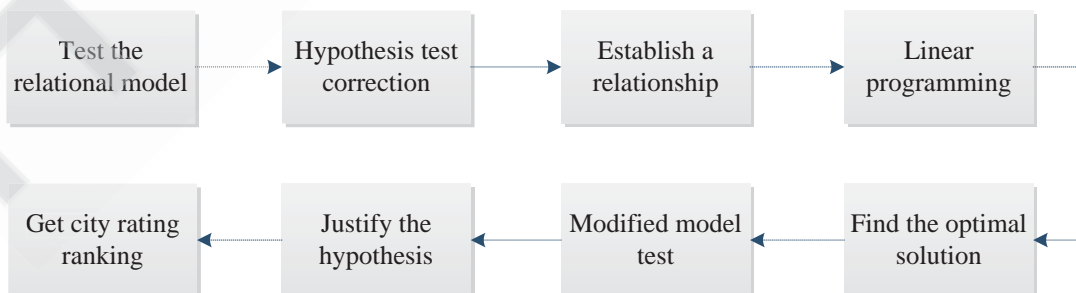


Figure 6 Flow chart of question 2

3.2.1 Test of Relational Model

Substitute the data into the relational model, and then draw the probability histogram of the score at intervals of 0.05. According to mathematical knowledge, most of the laws of nature are normally distributed. After comparing the two images with errors, we find that: two images There is a large gap between them, which cannot be used directly, as shown in the following figure:

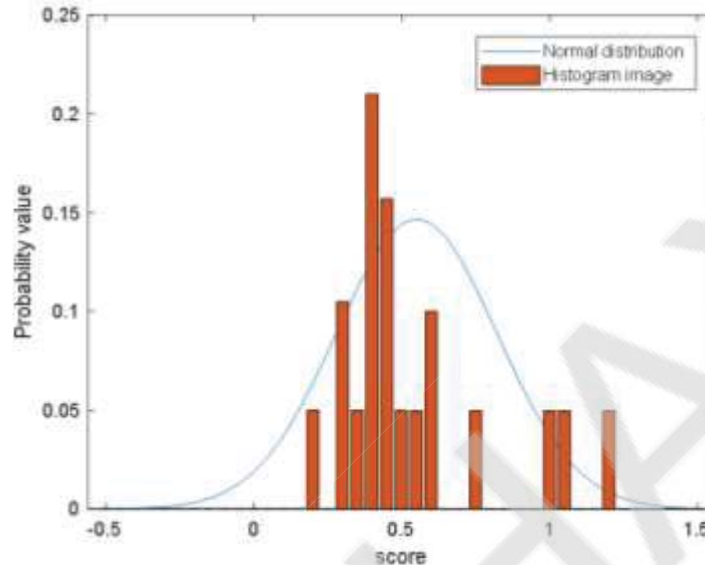


Figure 7 Error comparison of probability histogram before correction

From the above, the state of the original relation model fitting with reality is not as expected. To enhance its ability to reflect the real performance, it is necessary to use the knowledge in physics and increase the corresponding correction coefficients to modify the model. However, in the absence of experimental data, the most sophisticated experiments cannot be performed on the model. Therefore, the number of correction factors and their classification standards have become the biggest problems.

This article introduces a hypothesis testing model in probability theory on this issue. The main idea is to use hypotheses to draw conclusions, and then to prove the hypotheses based on the rationality of the conclusions.

3.2.2 Establishment and Solution of Hypothesis Testing Model

(1) Model establishment

Hypothesis testing is a method for inferring the population from a sample based on certain assumptions in mathematical statistics. The basic steps are as follows:

- a. Establish hypothesis H_0 and consider it correct.
- b. Then accept or reject the hypothesis H_0 based on the sample .
- c. If the sample observations cause a "small probability event", hypothesis H_0 should be rejected, otherwise hypothesis H_0 should be accepted. Among them, the small probability event represents that the relative error with the normal distribution image is too large.

(2) Solving the preliminary relationship model

To solve this problem, first consider the correction factors. The basic steps are as follows:

- a. Look for factors that need correction.

From the five attachments given in the title, it is not difficult to find that the title has a special reflection on the geographical location of the eastern and western regions and the registered capital of the corporate entity. This article may consider these two factors.

b. Modification.

According to previous research results, most of the laws in nature are normally distributed. It may be useful to set the scoring system constructed in this article to also be normally distributed. When the error between the corrected result and the normal distribution is within the allowable range Think the amendment is reasonable .

c. Fit the scores obtained from the relationship model.

According to mathematical knowledge, there are only two variables in the normal distribution function, which are only related to the mean and standard deviation. Therefore, the data obtained in the National Bureau of Statistics is substituted into the relational model and the result $U = \{u_1, u_2, \dots, u_m\}$.

The formulas that fit the mean σ and standard S deviation are as follows:

$$\sigma = \frac{u_1 + u_2 + \dots + u_n}{n}$$

$$S = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (u_i - \sigma)^2}$$

d. Inspection.

Compare the scored histogram with the normal distribution function graph, and use the following formula to determine whether there are major discrepancies. If there are major discrepancies, consider modifying the correction factors. The correction factors are in line with reality, thereby improving the scope and accuracy of the formula.

$$\Delta t = \frac{t - t'}{t'}$$

Where t represents the value of the score, t' the value of the function of the normal distribution, and the relative error Δt . According to daily experience, it can be known that when $\Delta t \leq 0.05$, the two images can be considered to be within the allowable error.

(3) Solving further relational models

Therefore, based on the above analysis, we can define further relational models regarding scoring:

$$t = k_1 k_2 y$$

Among them, k_1, k_2 represents the correction factor of the geographical location and the registered capital, respectively, and y represents the relationship indicated in Question 1.

In considering k_1 , this article classifies the four economic regions divided in the question.

When considering k_2 , we should first define a new classification standard for it, according to the appendix 4 of the title: in terms of enterprise size distribution, the differences between second-tier cities and Beijing, Shanghai, Guangzhou and Shenzhen are not as imagined. Large, so this article does not intend to use the size of

the registered capital as a classification criterion. Therefore, this article directly considers the number of enterprises with capital distribution > 10,000,000 when classifying.

When calculating the size of the registered capital, we can clearly find that there is an obvious classification trend in the data (see the attachment at the end of the article). The size of most of the registered capital is 50,000, only Shanghai, Shenzhen, Beijing, and Guangzhou. The city has reached more than 100,000. Therefore, the classification criterion is 100,000.

In order to compensate for the different influences of the above geographical locations, use k_1 to modify. The k_1 values in different cases are as follows:

In the eastern region : $k_1 = t_1$

In the central region : $k_1 = t_2$

In the western region : $k_1 = t_3$

In the northeast region : $k_1 = t_4$

In order to compensate for the above-mentioned different effects of the number of capital distribution companies, use k_2 to make corrections. The value of k_2 in different cases for the number of enterprises with a capital distribution greater than 10,000,000 is as follows:

Number of companies is greater than 10 : $k_2 = t_5$

Number of companies is less than 10 : $k_2 = t_6$

According to the characteristics of the normal distribution, the changes in mean σ and standard deviation S are as follows:

$$\sigma' = \frac{k_1 k_2 u_1 + k_1 k_2 u_2 + \dots + k_1 k_2 u_n}{n}$$

$$S' = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (k_1 k_2 u_i - \sigma')^2}$$

3.2.3 Analysis of Images before and after Correction

By observing the image before correction, it can be found that the place with the highest frequency is different from the image with the normal distribution, and by studying the position with the highest frequency, most other cities in the middle can be found. The most intuitive response of the correction coefficient on the image: histogram Graph of movement. Therefore, it may be useful to move it to σ' , which is both realistic and an interpretation of the image.

At the same time, it can be seen in the image that the values of the four cities of North, Shanghai, Guangzhou, Shenzhen are leading the country, which is expected. This is expected, and their distribution is more in line with the trend of normal distribution. Therefore, in order to reduce The error makes the model more convenient. It will be used as a standard to distinguish it from other coefficients, and its related coefficients will not be modified.

From the above, the following relations can be obtained:

$$t_1 = 1, \quad t_5 = 1$$

$$t_2 \times t_6 = \frac{\sigma'}{\mu}$$

Where μ is the score of the highest frequency of the image before correction.

From the above, it can be found that there are already three relations. In the face of four unknowns to find the optimal solution, according to mathematical knowledge, it can be known that linear programming can be used for processing. get:

$$t_1 = 1, \quad t_2 = 1.235, \quad t_3 = 1.054, \quad t_4 = 1.138, \quad t_5 = 1, \quad t_6 = 0.958$$

Substituting the calculated correction coefficient into the original expression gives the following figure:

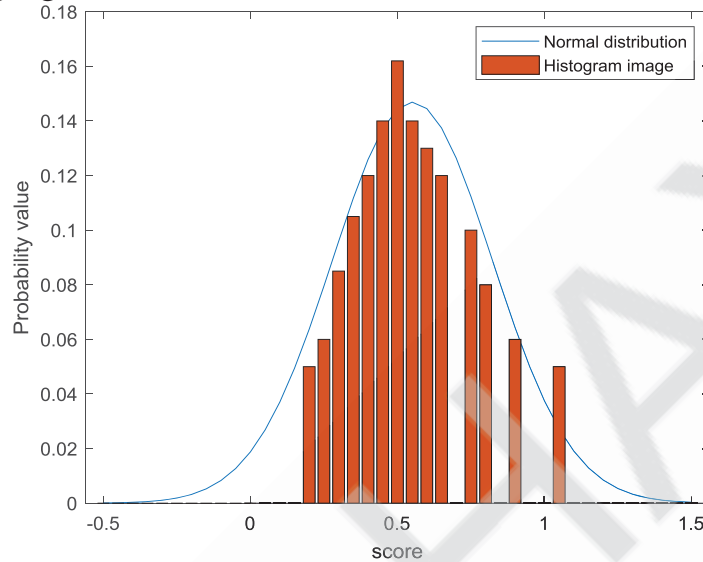


Fig. 8 Error comparison of probability histogram after correction

After testing, it can be found that the modified scoring function has a more normal distribution and a smaller $\Delta t = 3.283\%$ than the function before the correction. Therefore, the assumptions given in the previous analysis can be considered to be all true. The scoring function can be widely applied to this problem.

4 Results

4.1 Ranking results of regional economic vitality question 2

From the above analysis, the scores and rankings of the urban regional economic vitality (100 times magnification) are as follows:

Table 4 Scoring and ranking of regional economic vitality

| | | | | | | | | | | |
|---------|-----------|---------|----------|-----------|----------|----------|-----------|---------|---------|-----------|
| City | Shanghai | Beijing | Shenzhen | Guangzhou | Tianjin | Hangzhou | Chongqing | Nanjing | Ningbo | Wuhan |
| score | 111.65 | 103.65 | 100.55 | 87.99 | 79.25 | 78.44 | 64.61 | 59.61 | 57.96 | 57.15 |
| ranking | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| City | Zhengzhou | Suzhou | Dongguan | Chengdu | Shenyang | Qingdao | Changsha | Xi'an | Kunming | Zhengzhou |
| score | 56.92 | 50.58 | 50.58 | 50.33 | 50.21 | 46.61 | 41.42 | 40.02 | 29.38 | |
| ranking | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | |

It can be seen that the top three cities in terms of economic vitality are Shanghai, Beijing and Shenzhen, followed by the second tier cities.

5 Conclusions

After the establishment, application and derivation of the problem model, this article establishes a perfect relationship model of the factors affecting the economic vitality. Through the study of the model, it is found that the growth rate of per capita GDP, the growth rate of local fiscal revenue, and the growth rate of resident population at the end of the year negatively affect the regional economic vitality, the growth rate of the number of corporate units, the total import and export of business units, the total

export of business units, and residents. The growth rate of per capita disposable income and the rate of harmless treatment of domestic waste are positively affecting regional economic vitality. Based on this, this article makes the following suggestions for the development of Beijing:^[9]

(1) Pay attention to human capital and improve the flow of talents.

Human resources are the first resource for regional economic development. In a knowledge economy society, the progress of a city depends on human capital, and knowledge spillovers require human capital. Therefore, Beijing should give full play to human capital, play a role in promoting corporate growth and regional economic growth, establish a sound mechanism for the free movement of talents, and realize the huge role of talent resources in promoting the regional economy. It is necessary to seize opportunities, make good use of talents, and maximize To the maximum extent stimulate their potential and vitality, improve their use efficiency, and promote the local scientific culture and economic prosperity and development.

(2) Accelerate the process of informatization and promote sustained economic growth.

Information, as the most critical factor in today's social productivity, plays an important role in socio-economic growth. Informatization is also an important driving force for investment, capital and talent flow, and it plays an important role in promoting the generation, exchange, release and transmission of information between regions. Therefore, in order to increase the positive impact of Beijing's investment in enterprises, the level of informatization must be improved.

(3) Utilize geographical proximity to form the diffusion of technological innovation.

Technological innovation can improve the nuclear and competitiveness of enterprises, increase the operating efficiency of enterprises, and promote the transformation of the economic growth mode of enterprises. It is necessary to create a macro environment for technology diffusion, make good use of the convenience of geographical proximity, and increase the imitation and diffusion of new technologies. In order to strengthen the regional positive impact of enterprises, promote the economic development of Beijing, and improve the economic competitiveness of Beijing.

(4) Strengthen enterprise support and promote industrial upgrading.

Small businesses are at a disadvantage in local competition. Therefore, the Beijing Municipal Government should increase its support for small enterprises, use capital support, technological innovation support, broaden financing channels, help market development, and other methods to improve the living environment of small enterprises and strengthen their competitiveness. In addition, while focusing on supporting the development of advantageous industries, we must actively develop high-tech industries and use high-tech to transform traditional industries, promote the upgrading of the industrial structure, and increase the number of enterprises in Beijing.

(5) Increase investment in poor areas and increase per capita disposable income of residents in poor areas.

At the same time as Beijing's rapid economic growth, the gap between regions is also growing, which is not only detrimental to social stability, but also restricts Beijing's economic development to a certain extent. To reduce regional disparities, it

is necessary to increase investment in areas with poor economic development. Therefore, it is necessary to increase investment in less developed regions, create an excellent investment environment, enhance the attractiveness of regional economies, lift these regions out of poverty, and then rely on their own driving forces to promote economic development. In addition, at the same time, the per capita disposable income of residents in poverty-stricken areas must be increased to achieve the chain effect of first being rich and then being rich, so that the economic vitality of Beijing can be developed sustainably.^[10]

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7 Appendix

(1) Correlation analysis

Table 5 Correlation analysis

| | x1 | x2 | x3 | x4 | x5 | x6 | x7 | x8 |
|----|---------|---------|---------|---------|---------|---------|---------|---------|
| x1 | 1.0000 | -0.1971 | -0.7151 | -0.5094 | -0.0133 | 0.8334 | 0.6166 | -0.2421 |
| x2 | -0.1971 | 1.0000 | 0.3885 | 0.1956 | -0.0354 | -0.3848 | 0.0525 | 0.1559 |
| x3 | -0.7151 | 0.3885 | 1.0000 | 0.8216 | 0.1232 | -0.6753 | -0.3444 | 0.3628 |
| x4 | -0.5094 | 0.1956 | 0.8216 | 1.0000 | -0.1569 | -0.5223 | -0.5135 | 0.4013 |
| x5 | -0.0133 | -0.0354 | 0.1232 | -0.1569 | 1.0000 | 0.0009 | 0.2745 | 0.1380 |
| x6 | 0.7334 | -0.3848 | -0.6753 | -0.5223 | 0.0009 | 1.0000 | 0.7988 | 0.0912 |
| x7 | 0.6166 | 0.0525 | -0.3444 | -0.5135 | 0.2745 | 0.7988 | 1.0000 | 0.2074 |
| x8 | -0.2421 | 0.1559 | 0.3628 | 0.4013 | 0.1380 | 0.0912 | 0.2074 | 1.0000 |

(2) Standardized treatment

Table 6 Standardized data

| Particular year | X_1 | X_2 | X_3 | X_4 | X_5 | X_6 | X_7 | X_8 |
|-----------------|--------|--------|--------|--------|--------|--------|--------|--------|
| 2018 year | 0.0941 | 0.0183 | 0.2787 | 0.2724 | 0.0968 | 0.0000 | 0.0727 | 1.0000 |
| 2017 year | 0.0924 | 0.0116 | 0.1487 | 0.1268 | 0.0905 | 0.0000 | 0.0698 | 1.0000 |
| 2016 year | 0.2500 | 0.1393 | 0.0000 | 0.0749 | 0.2214 | 0.1294 | 0.2121 | 1.0000 |
| 2015 year | 0.2414 | 0.2461 | 0.0000 | 0.0881 | 0.2611 | 0.1956 | 0.3294 | 1.0000 |
| 2014 year | 0.0858 | 0.0503 | 0.0000 | 0.0189 | 0.1181 | 0.0477 | 0.1283 | 1.0000 |
| 2013 year | 0.0697 | 0.6233 | 0.0382 | 0.0453 | 0.0000 | 0.0086 | 0.0927 | 1.0000 |
| 2012 year | 0.0623 | 0.0267 | 0.0380 | 0.0000 | 0.1115 | 0.0144 | 0.0946 | 1.0000 |
| 2011 year | 0.0904 | 0.0000 | 0.2855 | 0.0468 | 0.1214 | 0.0098 | 0.2708 | 1.0000 |
| 2010 year | 0.0864 | 0.0000 | 0.0375 | 0.0398 | 0.1415 | 0.0360 | 0.1468 | 1.0000 |
| 2009 year | 0.1443 | 0.0152 | 0.0000 | 0.0030 | 0.3759 | 0.0466 | 0.1010 | 1.0000 |

(3) Number of enterprises

Table 7 Number of enterprises with registered capital greater than 10000000

| | | | | | | | | | | |
|-----------------------|----------|----------|-----------|-----------|----------------|--------------|----------|----------|---------|---------|
| City | Shanghai | Shenzhen | Beijing | Guangzhou | Chongqing City | Chengdu City | Nanjing | Hangzhou | Suzhou | Tianjin |
| Number of enterprises | 14.17 | 13.93 | 15.38 | 8.06 | 6.28 | 5.45 | 5.02 | 4.38 | 4.82 | 3.93 |
| City | Qingdao | Dongguan | Zhengzhou | Wuhan | Xi'an | Ningbo | Changsha | Shenyang | Kunming | |
| Number of enterprises | 3.69 | 3.91 | 3.88 | 3.58 | 3.38 | 2.80 | 2.57 | 1.96 | 2.12 | |

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