Team Number :	APMCM94163

Problem Chosen :	B

2019APMCM summary sheet

Research on the Regional Economic Vitality and Influencing Factors

Abstract

This paper takes Beijing and Xi'an as the research objects, analyzes the correlation between urban population, enterprise vitality and regional economic vitality. We establish the evaluation model of urban economic vitality based on factor analysis and TOPSIS method, and study the role of regional economic policy transformation in promoting the economy, then establish the evaluation model of policy performance from the short-term and long-term.

For question 1, we take Beijing as the research object, collecting the relevant data of population and enterprise vitality in Beijing from 2000 to 2018, processing the missing value and abnormal value with the time series model, then establish the time series analysis model for the population. We use SPSS to fit through the triple exponential smoothing method. For enterprise vitality, we select 9 indexes, establish TOPSIS model to evaluate enterprise vitality, use index smoothing method to fit the change trend of enterprise vitality, and finally establish a linear regression model of economic vitality to enterprise vitality and population change law. Through MATLAB fitting, the goodness of fit reaches 97%. It is concluded that there is a positive correlation between enterprise vitality and population, quantity and economic vitality.

For question 2, we take Xi'an as the research object, and quantitatively analyze the impact of the policy change on Xi'an's economic opening level. We set up the DID Difference-in-Difference model to compare Xi'an and the other cities which did not affect. According to the model, we used STATA programming to fit the curve of economic development under the influence of policies. From the perspective of short-term trend, by 2017, the economic opening level of Xi'an has increased by 124% compared with that of 2013, while the real value of reference data is 128%, and the accuracy of the model is 97%. From the long-term trend of the model, by 2023, the economic opening level of Xi'an will increase by 160%.

For question 3, we select 15 indicators around the economic vitality, recombine these indicators into 5 independent factors through factor analysis, take the information contribution rate of each factor as the weight, establish the TOPSIS urban economic vitality evaluation system based on factor analysis and weighting, and use MATLAB programming to get the economic vitality ranking of 19 cities in Annex 3. According to the model, the top three cities with more developed economic vitality are Guangzhou, Shenzhen and Beijing; the areas with less economic vitality are Shenyang and Kunming. By looking up the ranking results of related research papers, we found that the evaluation model is more accurate.

Finally, according to the model, we give some suggestions for economic development, including improving the level of opening to the outside world, vigorously developing private

enterprises and so on, so as to make Xi'an economic vitality present a benign and sustainable development and regional competitiveness stronger.

Keywords: Factor Analysis TOPSIS Time Series Analysis DID Method

Contents

1 Overview

1.1 Background Investigations

Regional economic vitality is an indispensable part of regional comprehensive competitiveness. In recent years, many regions have introduced policies to attract talents, promote entrepreneurship and improve regional economic vitality. However, because different policies have different effects in different regions, we need to establish appropriate models, and solve three problems according to the five data tables given in the topic and the data obtained from our survey, and propose some policies as local economic decision makers.

The contents of Annexes 1 to 5 are Quantity of Surviving Enterprises in 2019,Changing Trend of Enterprises Increment of Four Economic Zones in 2009-2018, Distribution Data of Enterprise Stock and Cancellation in Beijing, Shanghai, Guangzhou, Shenzhen and Some Other Cities, Distribution Data of Registered Capital of Enterprise Legal Person in 2009-2018, Data of Resident Population and Surviving Enterprises in Some Other Cities in 2019.

Because the data samples given are small and most of the data have indirect impact on local economy, we need to collect more comprehensive and complete data to complete the impact and analysis of economic vitality.

1.2 Problem Analysis

Question 1: Because economic vitality is affected by many factors, the topic requires us to analyze its influence on the change of regional economic vitality from the trend of population change and the trend of enterprise vitality change, and to establish a relationship model of factors affecting economic vitality in a specific region. After investigation, we think that the data of Beijing is more comprehensive and convenient for us to analyze, so we find out the indicators that affect the vitality of enterprises in Beijing and the law of population change, and make fitting regression.

Question 2: The topic requires us to analyze the short-term or long-term impact of economic policy changes on the economic vitality of a region. Through data acquisition we believe that the economic promotion and comparison of the cities along the belt before and after the implementation of the policy is a good research object. Therefore, we chose the starting point of the Silk Road in Xi'an and analyzed the economic vitality indicators before and after the implementation of the policy by DID double difference analysis, and analyzed the short-term and long-term impact of the one belt policy on Xi'an.

Question 3: The topic requires us to continue to select the appropriate index system to build a model to measure the regional economic vitality. We collected more data for the comprehensive evaluation system, used factor analysis algorithm and TOPSIS to quantify the economic vitality of each city, and made the final ranking.

Question 4: The topic hope we could put forward development suggestions to Xi'an from the perspective of policy makers. Combined with the related literature and data, we have made

specific analysis in five different aspects, so as to make Xi'an's economic vitality healthy and sustainable, and regional competitiveness is stronger.

2 Assumptions and Symbol Description

2.1 Assumptions

- Assuming that the data source is reliable and accurate.
- Assuming that the vitality of regional economy is only affected by the population and the vitality of enterprises.
- Assuming that over time, the influence of historical observations on future trends has deepened.
- Assuming that we ignore the impact of the maritime silk road and assume that the cities we choose are completely unaffected by the silk road.
- Assuming that in the absence of One Belt and One Road policy, Xi 'an and the control group city show the same trend of economic opening development.

2.2 Symbol Description

$s_t^{(i)}$	The ith smoothing exponent of period t
y_n	The nth measurement in the time series
α	The weighted coefficient of Measured value
$\overline{s_i}$	The Positive Ideal Solution of ith indicator
$\underline{s_i}$	The Negative Ideal Solution of ith indicator
SST	The sum of the squares of the total deviations
SSE	residual sum of squares
SSR	sum of squares of deviations
R^2	Goodness of fit of regression equation
T	Time decision variable
O	Policy decision variable

3 Problem 1: Modelling and Analysis of Economic Vitality

In this paper, we take Beijing as a research city, and collect data of some economic, business and population indicators in this area. Because these indicators have strong regularity with time, we establish a regression model based on time series analysis to quantitatively analyze the change law of population and business vitality. For the population, we set up three times index smoothing method to predict the future population change; for the enterprise vitality, we selected nine indicators to describe the vitality of local enterprises, and established the enterprise vitality evaluation system based on TOPSIS method. Finally, a multiple regression analysis model of economic vitality is established to quantitatively analyze the impact of population and enterprise vitality on the economy.

3.1 Model of Population Prediction

3.1.1 Model establishment

Beijing is the capital of China, which is convenient for us to query data. We have collected the population of Beijing in 2000-2018 in CSMAR[1]. It is recorded as follows: $y_1, y_2, ...y_n$ the scatter chart of the population of Beijing in 2000-2018 is shown below:

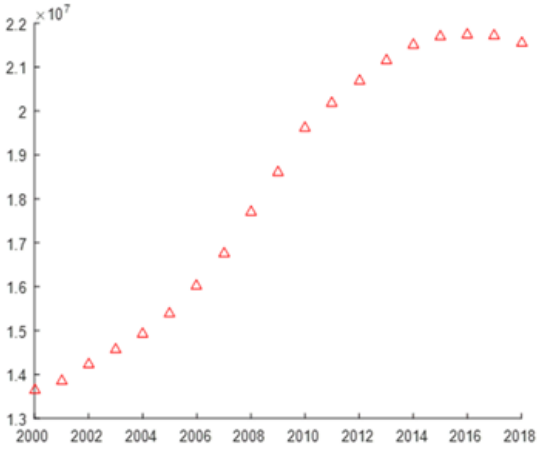

Figure 1.Population Change Law in Beijing from 2009 to 2018

It can be seen from the figure that there is a complex trend of population change with time, so a time series prediction model is established to further study this rule.

- Time Series Model Principle

Time series analysis method is to arrange a group of observation values of a certain index in time order to form a statistical time series, and then use certain mathematical methods to make it extend outwards, predict the future development and change trend, and determine the predicted value. Time series analysis is to predict the market demand trend with the passage of time, which is not affected by other external factors. Its basic principle: first, to recognize the continuity of the development of things. Using the past data, we can infer the development trend of things.

Second, considering the randomness of the development of things. The development of anything may be affected by accidental factors. Therefore, the weighted average method in statistical analysis should be used to process historical data to show the impact of historical data on the future.

The population has a trend of increasing with time, which belongs to non-stationary time series. This method is a simple and smooth prediction technology. It mainly calculates the order time average value including a certain number of items in order to reflect the long-term trend according to the item by item process of time series. The scatter chart of population distribution in Beijing from 2000 to 2018 has a trend of conic curve. The system structure of conic curve is relatively complex. With the passage of time, the influence of sequence on the future is increasing, which is not a simple linear relationship. Exponential smoothing method is an improved method of moving average method, which gives different weights to different historical data. However, the predicted value of the first exponential smoothing method usually lags behind the actual value. In order to eliminate this effect, the third exponential smoothing method is used for time series analysis.

- Time Series Model Based on Cubic Smoothing

For the time series $y_1, y_2, ...y_n$, if $s_t^{(i)}$ is set as the ith exponential smoothing parameter, α is the influence of the observation value of the tth period on the future trend, then the observation value of each period can be weighted in time order as the prediction value, then the recurrence of the three exponential smoothing can be expressed as

$$\begin{aligned} s_t^{(1)} &= \alpha y_t + (1-\alpha) s_{t-1}^{(1)} \\ s_t^{(2)} &= \alpha s_t^{(1)} + (1-\alpha) s_{t-1}^{(2)} \\ s_t^{(3)} &= \alpha s_t^{(2)} + (1-\alpha) s_{t-1}^{(3)} \end{aligned} \tag{1}$$

So the $t+m$th prediction model can be expressed as

$$y_{t+m}^{'} = a_t + b_t m + c_t m^2 \tag{2}$$

Among this

$$\begin{cases} a_t = 3s_t^{(1)} - 3s_t^{(2)} + s_t^{(3)} \\ b_t = \dfrac{\alpha}{2(1-\alpha)^2}[(6-5\alpha)s_t^{(1)} - 2(5-4\alpha)s_t^{(2)} + (4-3\alpha)s_t^{(3)}] \\ c_t = \dfrac{\alpha}{2(1-\alpha)^2}[s_t^{(1)} - 2s_t^{(2)} + s_t^{(3)}] \end{cases} \tag{3}$$

3.1.2 Prediction Result

Using SPSS to predict the population by three times exponential smoothing method, the expression of population prediction is as follows

$$y = -14.1x^2 + 282x - 1274.8$$

The population in the next five years is shown in the table below

Table. 1Growth of population

2019	2020	2021	2022	2023
21377011	21212023	21047034	20882046	20717058

The population change trend from 2019 to 2023 is as follows

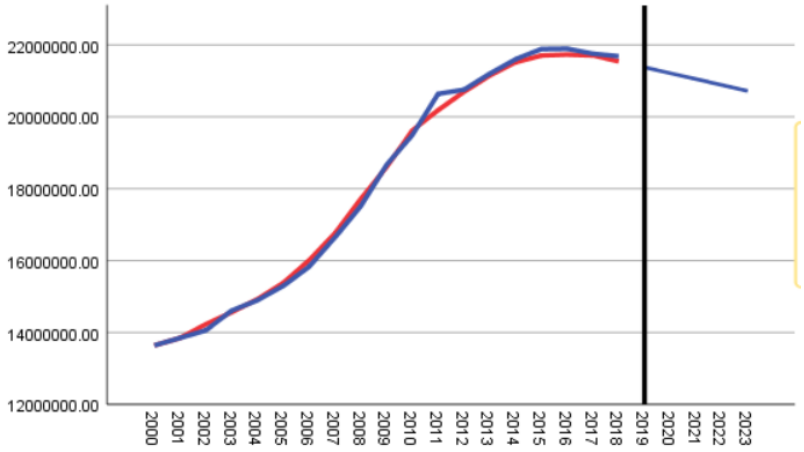

Figure 2 .Population Prediction

It can be seen that in 2016, when the turning point of population was reached, the meaning of the turning point of population was the node where the trend of population change changed. There are many reasons for Beijing to reach the turning point of population. First of all, with the improvement of economic development level and the rise of residents' living standards to a certain stage, the decline of birth rate and aging are inevitable universal laws. However, the main reason is the policy deregulation. With Beijing's strict population control policies in housing, education, business, culture and other aspects, the population growth in the urban area of Beijing slowed down in 2016, and the population in the core area has declined. In the new era, to change the concept and strategic thinking of population development and actively adapt to the changes in the future population structure has become a major trend of Beijing's development.

3.2 Evaluation and Prediction Model of Enterprise Vitality

Enterprise vitality is the power of rapid development of enterprises and operation and production activities. We have selected nine indicators in Beijing, namely, number of enterprises, number of losses, total industrial output value, industrial added value, number of employees, assets (1,000 yuan), liabilities (1,000 yuan), profits (1,000 yuan), proportion of tertiary industry in GDP, and established an evaluation system of enterprise vitality, as shown in the following figure Shown

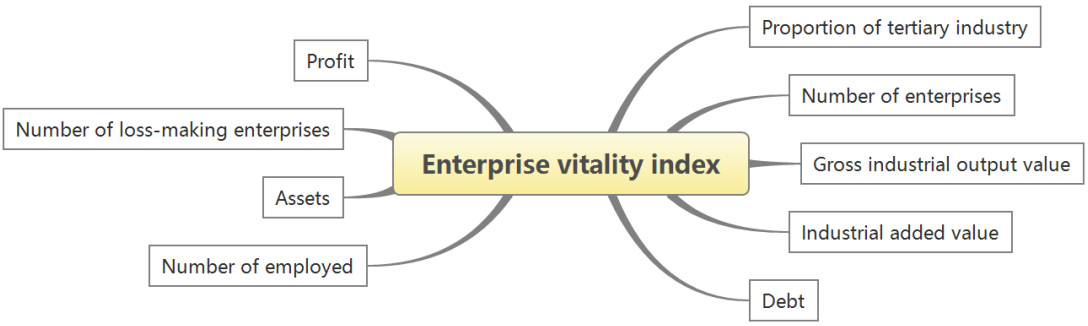

Figure 3 .Enterprise Vitality Index

3.2.1 Time Series Prediction

We collected the data of the nine indicators in Beijing from 2000 to 2011. Observe the scatter chart of annual data distribution of nine indicators, and find that they are all approximately in line with the linear growth trend. Take the number of enterprises as an example, and the number of enterprises in 2000-2012 is shown in the figure below

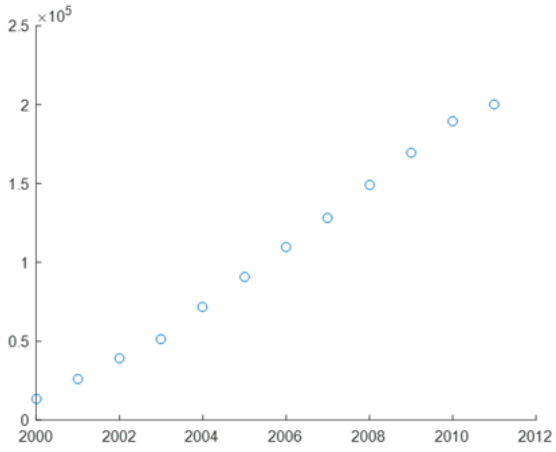

Figure 4 .Number of Enterprises

The exponential smoothing method can be used for prediction. In order to eliminate the lag deviation of the first smoothing, the second exponential smoothing method is used for time series fitting, for time series $y_1, y_2, ...y_n, s_t^{(i)}$ is the fit parameter, α is the weighting coefficient, then the expression of quadratic exponential smoothing method is

$$\begin{aligned} s_t^{(1)} &= \alpha y_t + (1-\alpha) s_{t-1}^{(1)} \\ s_t^{(2)} &= \alpha s_t^{(1)} + (1-\alpha) s_{t-1}^{(2)} \end{aligned} \tag{4}$$

Then we can build the prediction model of the number of enterprises as follows

$$y_{t+m}' = a_t + b_t m \tag{5}$$

$$\begin{cases} a = 2s_t^{(1)} - s_t^{(2)} \\ b = \dfrac{\alpha}{1-\alpha}(s_t^{(1)} - s_t^{(2)}) \end{cases} \tag{6}$$

Using SPSS to carry out secondary index smoothing prediction, using the above methods for all 9 indicators, the prediction results of 9 indicators in 2012-2018 can be obtained, as follows

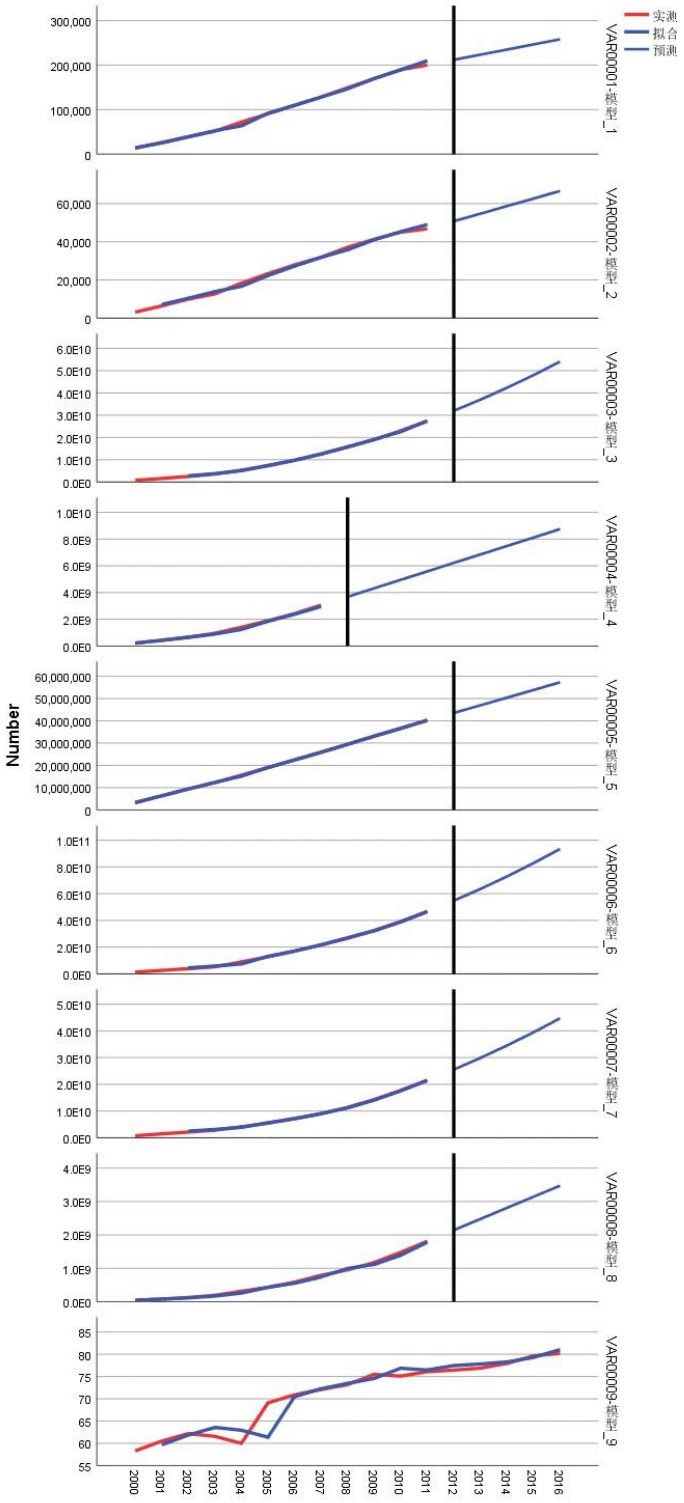

Figure 5. Predictions of 9 Indicators

3.2.2 Evaluation Model Based on TOPSIS

- Background of TOPSIS Method

In order to eliminate this influence, we build an evaluation model based on TOPSIS. TOPSIS is a multi-objective decision-making method in system engineering

When a feasible solution is closest to the optimal solution and far away from the worst solution, the vector set of the solution is the optimal impact evaluation index.

As a comprehensive index evaluation method, TOPSIS is different from fuzzy comprehensive evaluation method and AHP. It has strong subjectivity, does not need objective function, and does not need to pass the corresponding test, that is, the limit requirements are greatly reduced, which makes the scope of application more extensive.

- Specific Steps of TOPSIS Method

Step 1 For the i indicator, set n observation values of the indicator as $[s_{1i}, s_{2i}, ..., s_{ni}]$, and set the ideal "full score" and the ideal "zero score" of the indicator are $\overline{s_i}$ and $\underline{s_i}$.

For the positive correlation index, the ideal full score is the maximum value of all observed values of the index, but for the negative correlation index, because TOPSIS method is a distance based analysis method, in order to unify the values, it is necessary to reverse the ideal full score to the minimum value in the observation value, that is

$$\overline{s_i} = \begin{cases} \max(s_{1i}, s_{2i}, ..., s_{ni}), \textit{when indicators are positively correlated with enterprise vitality} \\ \min(s_{1i}, s_{2i}, ..., s_{ni}), \textit{when Indicators are negetively correlated with enterprise vitality} \end{cases}$$

$$\underline{s_i} = \begin{cases} \min(s_{1i}, s_{2i}, ..., s_{ni}), \textit{when indicators are positively correlated with enterprise vitality} \\ \max(s_{1i}, s_{2i}, ..., s_{ni}), \textit{when Indicators are negetively correlated with enterprise vitality} \end{cases}$$

$$s.t.\ \underline{s_i} < s_{ji} < \overline{s_i} (j = 1, 2, ..., n)$$

Step 2 Calculating the distance from the sample point of index to the ideal value,setting the gap between all indicators in the j year and the ideal "full score" as

$$\Delta\overline{s_j} = \sqrt{\sum_{i=1}^{m} (s_{ij} - \overline{s_i})^2}, j = 1, 2, ..., n$$

The distance to the ideal "zero score" is

$$\Delta\underline{s_j} = \sqrt{\sum_{i=1}^{m} (s_{ij} - \underline{s_i})^2}, j = 1, 2, ..., n$$

Step3 Calculating the final score of enterprise vitality.

The higher the enterprise vitality is, the smaller the value $\Delta\overline{s_j}$ of gap with the ideal "full score" and the larger the value $\Delta\underline{s_j}$ of gap with the ideal "zero score". Then the score f_j of the enterprise vitality in the j th year can be expressed as follows

$$f_j = \frac{\Delta \underline{s}_j}{\Delta \underline{s}_j + \Delta \overline{s}_j} \tag{7}$$

For the year with higher enterprise vitality, its score should be higher.

The specific flow chart of TOPSIS evaluation model is as follows

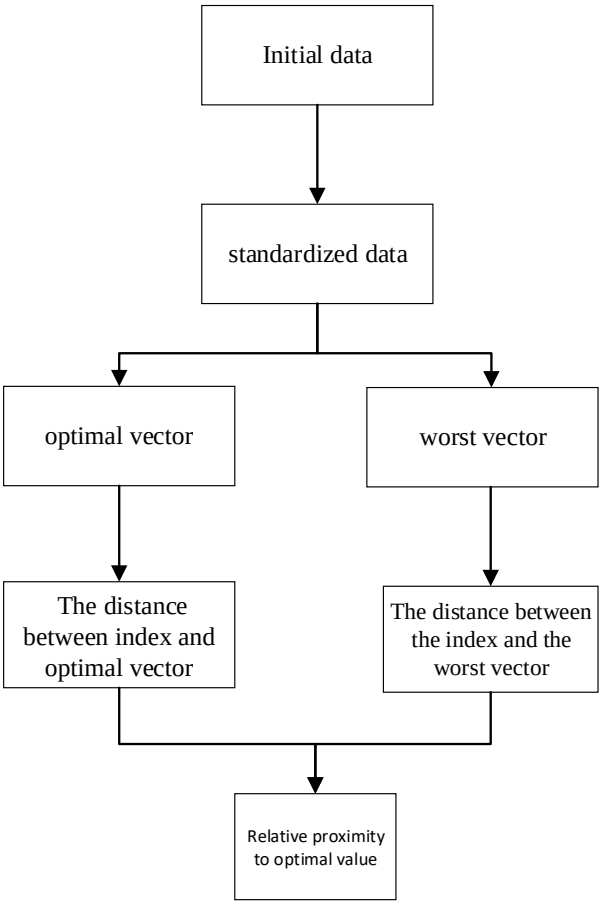

Figure 6. TOPSIS Schematic Diagram

- Result Analysis

By programming with MATLAB, the score and ranking of 2000-2018 enterprise vitality are as follows:

Table2. Rank of fj in Different Years

year	fj	ranking
2000	0.309	17
2001	0.309	18
2002	0.309	15
2003	0.309	16
2004	0.308	19
2005	0.334	14
2006	0.351	13
2007	0.374	12
2008	0.398	11
2009	0.433	10
2010	0.467	9
2011	0.508	8
2012	0.546	7
2013	0.584	6
2014	0.621	5
2015	0.653	4
2016	0.674	3
2017	0.687	2
2018	0.691	1

The trend of enterprise vitality in 2000-2018 is as follows

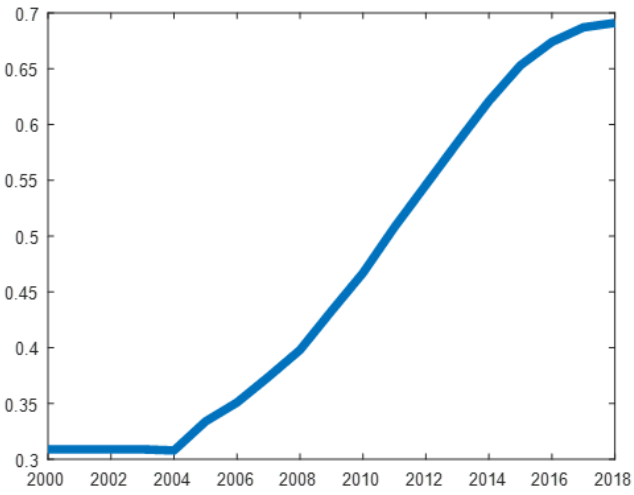

Figure 7. Trend of Enterprise Vitality

It can be seen that with the continuous development of the economy, the overall vitality of enterprises in Beijing is increasing.

3.3 Regression Model of Economic Vitality

We use GDP to measure the economic vitality of a region and collect the GDP data of Beijing

from 2000 to 2018. In order to study the impact of enterprise vitality and population on economic vitality, we establish a regression model of enterprise vitality and population on economic vitality.

3.3.1 Data Standardization

Due to the different dimensions and orders of magnitude of enterprise vitality, population and economic vitality, in order to eliminate this impact, we first standardize the data, and the specific standardization methods are as follows:

$$x_i^{'} = \frac{x_i - b}{|a - b|} \tag{8}$$

$$a = \max(x_1, x_2, ..., x_n)$$
$$b = \min(x_1, x_2, ..., x_n)$$

$x_1, x_2, ..., x_n$ is a set of data without standardized, $x_i^{'}$ are the data after standardization

3.3.2 Regression Model of Economic Vitality

The expression of multiple linear regression model is simple, without cross term, and the regression coefficient has strong economic meaning, which can directly reflect the influence of explanatory variables on economic vitality. And the stability of straight line fitting is strong, which is still applicable to the case of the sudden increase of independent variables. It can be used to predict the long-term trend in economics. Draw the data of economic vitality, population and enterprise vitality from 2000 to 2018 into three-dimensional contour map as follows

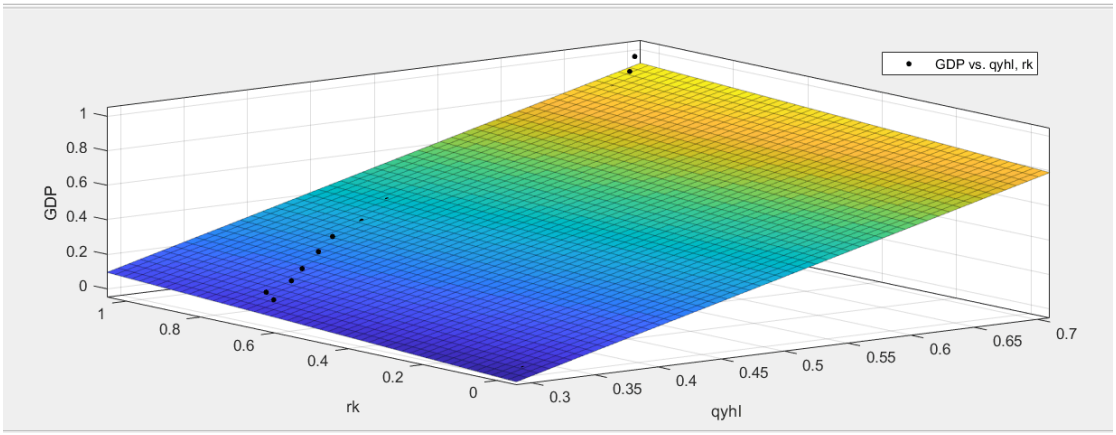

Figure 8. Scatter Distribution in Three-dimensional Space of Enterprise Vitality,Enconimic Vitality and Population

It is found that the scatter points are approximately distributed on an inclined plane, and the covariance is used to test the independence of the explanatory variables x_1 and x_2. The test method is

$$\operatorname{cov}(x_1, x_2) = \frac{\sum_{i=1}^{n}(x_1 - \bar{x})(y_i - \bar{y})}{n-1}$$

Covariance reflects the degree of independence of the two groups of data. The stronger the independence, the greater the covariance of the two groups of data. The covariance of the two explanatory variables in this question is 0.00585, which has strong independence, so it can be fitted with a straight line.

We set x_1 as population, x_2 as enterprise vitality, y' as fitted values, e as residual, obeying the standard normal distribution of variance σ^2, the multiple linear regression model is established as follows

$$\begin{cases} y = b_0 + b_1 x_1 + b_2 x_2 + e \\ s.t. \begin{cases} e = y - y' \\ E(e) = 0 \\ D(e) = \sigma^2 \\ \operatorname{cov}(x_1, x_2) = 0 \\ \min e^2 \end{cases} \end{cases} \tag{9}$$

3.3.3 Analysis of Economic Vitality Prediction Results

- Result Analysis

From the multiple linear regression of SPSS, the linear regression expression of economic vitality is obtained as follows

$$y = -0.5132 + 0.2203x_1 + 1.7013x_2$$

It can be seen from the expression that population and enterprise vitality have a positive impact on economic vitality, and the impact of enterprise vitality is more significant.

The regression curve of economic vitality is shown in the figure below

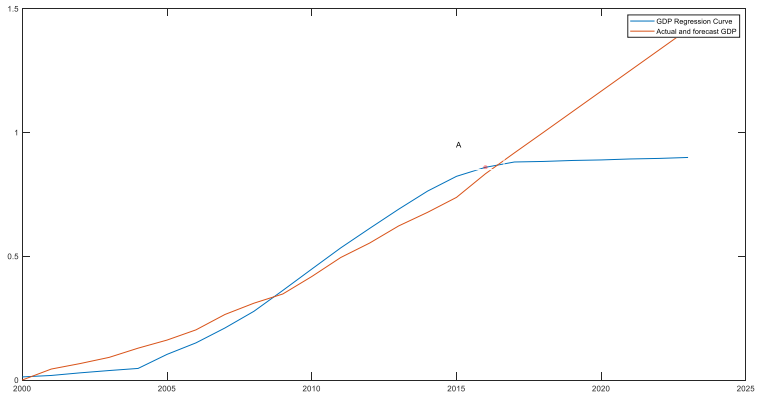

Figure 9. Regression Curve of Encomic Vitality

Based on the regression analysis, we find that before 2016, Beijing's GDP grew rapidly, and after 2016, the GDP growth slowed down. 2016 is a turning point of Beijing's economic growth. The reason for the inflection point is that Beijing's population is too dense. In order to alleviate this pressure, the city's deregulation policy is adopted and only the function of the capital is retained. Therefore, the population of Beijing has declined after 2016, slowing down the growth of GDP.

- Goodness-of-fit Test

We use R^2 significance to test the goodness of fit of regression equation. The significance of R^2 measures the whole fitting degree of regression equation and expresses the overall relationship between dependent variables and all independent variables. The basic idea of R^2 significance test is to decompose the fitting error into residual square sum and regression square sum. R^2 is equal to the ratio of regression square sum in the total square sum, that is, the percentage of dependent variable variability that can be explained by regression equation. Among the total errors between the actual value and the average value, the regression error and the residual error are the relationship between the two. Regression error measures the goodness of fit of the linear model from the front, and the residual error determines the goodness of fit of the linear model from the back. The value of R^2 indicates the goodness of fit. The larger R^2 is, the greater the goodness of fit is.

The specific method of variance decomposition is

$SST=\sum_{i=1}^{n}(y_i-y_i^{'})^2$ Sum of squares of total deviation, representing data stability

$SSE=\sum_{i=1}^{n}(y_i-y_i^{'})^2$ Sum of squares of residuals, representing the fitting stability

$SSR=\sum_{i=1}^{n}(y_i-y_i^{'})^2$ Sum of squares of regression to measure the total deviation between the linear fitting value and its mean value

Then the total variance can be expressed as

$$SST = SSE + SSR$$

R^2 is the ratio of the sum of squares of regression to the total sum of squares,

$$R^2 = \frac{SSR}{SST} \tag{10}$$

The larger R^2 is, the greater the goodness of fit is. Generally speaking, $R^2 \in (0,1)$.

When $R^2 = 1$, it means that the predicted value is the same as the actual value.

When $R^2 = 0$, it means that there is no linear relationship between the predicted value and the actual value.

When $R^2 \geq 0.5$, it means that the general variance of variables can be explained by the model.

Through MATLAB programming, we can get the linear regression model R^2 = 0.9797. So the fitting degree of our model is better than that of other regression models. The following figure shows the fitting results of linear, pure quantitative, quantitative interaction and exponent respectively

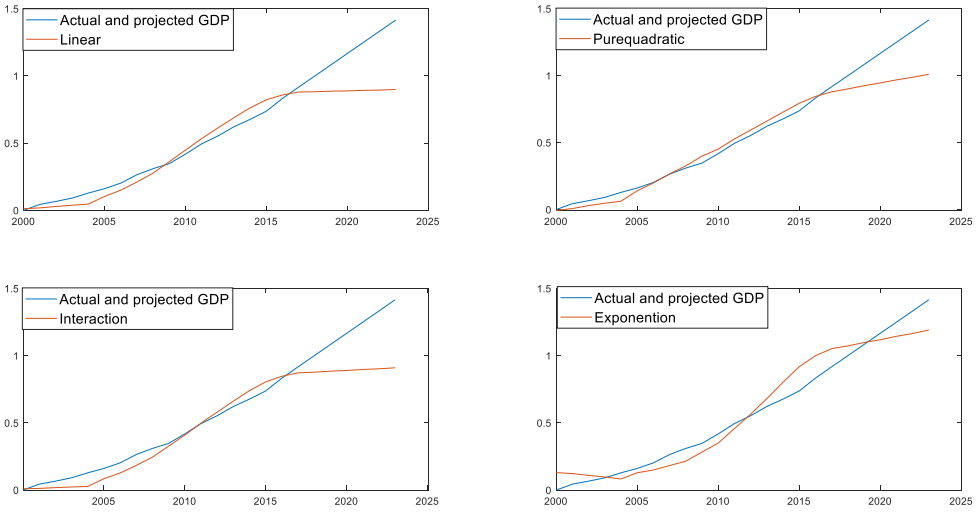

Figure 10. Different Fitting Results

The residuals of the four curves are as follows

Table. 3 residual error

fitted curve	linear	purequadrastic	quadratic interaction	exponention
residual	0.0102	0.0466	0.0487	0.0264

It can be seen from the table that the residual error of straight line fitting is the smallest and the fitting is the most accurate.

3.3.4 Related Suggestions

According to the data collected and the model we have established, the vitality of enterprises and the law of population change can constitute two indicators of urban economic vitality. Compared with the law of population change, the promotion degree of enterprise vitality to economic vitality is more obvious simultaneously. As the sample city of our statistical data, Beijing has experienced a negative population growth from 2017 to 2019, which is due to the excessive development and utilization of environmental resources that enable the population to reach the maximum value within the range of environmental capacity in advance. However, the collected indicators of economic vitality show a growth trend, which leads to the slowdown of the curve growth rate predicted by our fitting equation, which is also in line with the actual situation.

The enterprise vitality is mainly composed of nine indicators, of which the number of employees and the profits of enterprises are the most influential, and all of them are positively correlated. Therefore, we give some suggestions on these two aspects for the local government to improve the local economic vitality

Increase employment:

1. Adhere to the principle of giving priority to talents and people's livelihood, make every effort to promote employment and entrepreneurship, and vigorously promote the high-quality development of human resources

2. At the same time of ensuring the basic life of laid-off workers, a series of policies, such as tax deduction, small amount guarantee loan, training subsidy, employment service and so on, were issued to promote the reemployment of laid-off workers

3. Deeply implement the employment priority strategy and active employment policies, strive to solve the employment structural contradictions, and strive to achieve higher quality and full employment.

4. Adhere to the employment priority strategy and active employment policies, vigorously promote entrepreneurship to promote employment and reduce the unemployment rate

5. Constantly optimize the employment structure and quality, guarantee the labor rights of employees, and standardize the employment of enterprises

6. Improve the legal system of the labor market, strengthen the decisive role of the labor market, and gradually form a public employment service system

Improve enterprise profit:

1. Issue policies, supervise enterprises to change their ideas, strengthen cost awareness, establish a sound cost management mechanism, conduct cost analysis on a regular basis, and strengthen cost accounting.

2. Explore the market and find out its own market positioning, as well as its own product characteristics, and strengthen the ability to attract customers. At the same time, under the premise of ensuring the normal operation of the enterprise, control the cost and find a good supplier, so that the enterprise has a stable supply chain and the product quality can also be guaranteed.

3. In terms of employees, profit is closely related to the working efficiency and ability of all employees. Enterprises should provide employees with competitive wages, welfare and social security, so that employees have a sense of belonging to the enterprise and jointly create enterprise profits.

4 Problem 2: A Study on the Transformation of Economic Policy

The Belt and Road (abbreviated B&R)[2] is the abbreviation of the "Silk Road Economic Belt". In September 2013 and October, Chinese President Xi Jinping put forward the proposal to build a new Silk Road Economic Belt. Relying on the existing dual multilateral mechanisms of China and the relevant countries, with the help of the existing and effective regional cooperation platform, and along the way to borrow the historical symbols of the ancient Silk Road, hold high the banner of peaceful development, actively develop economic cooperation and partnership with the countries along the border, and work together to create a political mutual trust, economic integration, cultural inclusion interest community, and destiny community. Community of responsibility.

The implementation of the "one belt and one way" policy has transformed our inland cities from the hinterland to the westward opening, and the inland cities have ushered in a significant historical opportunity for economic development. Opening to the west is the general trend of

China's deepening reform and opening up, the inevitable choice for inland cities to achieve rapid economic development, and the effective way for inland cities to achieve leapfrog economic development.

2018 was the fifth year of the "one belt and one road" initiative. In the past 5 years, the "one belt and one way" construction has made brilliant achievements. Under the guidance of the national strategy, China's inland cities continue to promote economic development and opening to the outside world, and the level of economic opening has been significantly improved.

As a bridgehead of "one belt and one road", Xi'an has a very important influence on Xi'an. Xi'an has opened a new window for opening to the outside world. In the construction of logistics distribution center, the construction of temporary open ports for railway stations and Multimodal Transport Supervision Center, international cross-border trade e-commerce, international tourism cooperation, cultural heritage protection and exchange have taken on a new look.

The figure below shows the total amount of urban trade of Xi'an and other economically developed cities in the non silk road region in 2013-2017[3][4]

Table 4. Fitting Result of Different Curve

city	2013	2017	cumulative growth rate
Shanghai	27421	32238	18%
Shenzhen	33401	28011	-16%
Beijing	26700	21924	-18%
Guangzhou	7381	9714	32%
Tianjin	7979	7647	-4%
Ningbo	6227	7600	22%
Xiamen	5221	5816	11%
Hangzhou	4036	5085	26%
Qingdao	4834	5024	4%
Dalian	4275	4188	-2%
Nanjing	3461	4143	20%
Fuzhou	1946	2336	20%
Shijiazhuang	870	862	-1%
Haikou	298	210	-29%
Xian	1114	2546	128%
Total	135164	137344	1.50%

The comparison found that: first, the import and export volume of the southeastern coastal cities is much higher than that of Xi'an. In 2013, the average import and export volume of the southeastern coastal cities was 1 trillion and 140 billion yuan, while the total import and export volume of Xi'an was only 110 billion yuan in the same period. Secondly, the gap of the "one belt along the way" was narrowed slightly, but the total import and export volume of Xi'an was faster than that of Southeast Asia. In 2013-2017, the cumulative growth rate of Xi'an was 128% in the coastal cities, while the cumulative growth rate of total import and export of southeast coastal cities in the same period was 0%. In the past 5 years since the construction of "one belt and one road", the development of foreign trade in the Midwest, especially in Xi'an, is catching up.

In order to quantify the impact of the "one belt and one way" policy on Xi'an's economic vitality, we set up a difference-in-difference (DID) model of the one belt policy, and

quantitatively analyze the impact of one belt and one road on Xi'an from a short-term and long-term perspective.

4.1 Difference-in-Difference (DID) Model of the “One Belt and One Way” Policy

Difference in difference (DID) is a mathematical model to study the impact of quantitative policy. The research object is divided into "experimental group" and "control group". By constructing the double difference estimator, the influence of policy can be effectively identified by comparing the before and after intervention with that of the experimental group in terms of comparative time. At the same time, other possibilities are added to the model, the covariates that influence the results supplement the random errors in the sample allocation of "natural experiment", and then get the most real effect of policy intervention.

We chose Xi'an as an object and chose a city with a well-developed economy but no one belt policy. We quantitatively studied the impact of Xi'an's policy on foreign trade and economy. Because of the great difference between Xi'an and coastal cities, it is impossible to fully and accurately reflect the difference of economic opening level by simply comparing the total trade volume. In this paper, the ratio of total trade to total economic volume is used to measure the economic opening level of a city, y

$$y = \frac{Trade}{GDP}$$

$Trade$ represents the total annual trade volume of the city, GDP represents the total economic volume of the city, and the level of economic opening represents the proportion of the total trade volume to the total economic volume, so as to compare the differences in the trade levels of different regions.

- The Establishment of Double Difference Equation Model[5]

The 15 cities are selected as Xi'an x_1, Shanghai x_2, Beijing x_3, Shenzhen x_4, Guangzhou x_5, Fuzhou x_6, Haikou x_7, Xiamen x_8, Ningbo x_9, Tianjin x_{10}, Hangzhou x_{11}, Qingdao x_{12},Dalian x_{13},Nanjing x_{14},Shijiazhuang x_{15} are divided into two groups according to whether there is a policy or not, the experimental group is the city that implements the policy, Xian x_1, $w_1 = \{x_1\}$, The control group is a developed city without a whole area, Shanghai x_2, Beijing x_3, Shenzhen x_4, Guangzhou x_5, Fuzhou x_6, Haikou x_7, Xiamen x_8, Ningbo x_9,remarked as $w_0 = \{x_2, ..., x_{15}\}$.

The introduction of decision variables O_i reflects the implementation of the "one belt road". 1 indicates the implementation of the "one belt" policy and the 0 indicates that there is no one way policy.

$$O_i = \begin{cases} 1, i \in w_1 \\ 0, i \in w_0 \end{cases}$$

The decision variable T_i is introduced to reflect the time course of one belt and one road. In 2013, the 0 represents the policy of not carrying out the "one belt and one road" policy. 1 indicates that the 2017 has indicated that it has implemented the "one belt and one way" policy.

$$T_i = \begin{cases} 1, t = 2017, \textit{One Belt And One Road policy effect period} \\ 0, t = 2013, \textit{One Belt And One Road policy construction base period} \end{cases}$$

To indicate the change of $x_1, x_2, ..., x_n$ in the experimental group and the control group under the belt road policy, we use time variable T_i, development process $T_i O_i$, policy variables O_i as independent variable economic opening level as dependent variable, the double difference model is established as follows

$$y_i = a + b + cT_i + dT_i + e \tag{11}$$

First, the time variable is differentiated,

When $T_i = 1$, $y_{i(T=1)} = a + bO_i + c + dO_i + e$

When $T_i = 0$, $y_{i(T=0)} = a + bO_i + e$

Then the influence of time variable on y_i can be expressed as

$\Delta y_{i(T)} = y_{i(T_i=1)} - y_{i(T_i=0)}$,then $\Delta y_{i(T)} = c + dO_i$

On this basis, the policy variables are differentiated

When $O_i = 1$, $\Delta y_{i(T,O=1)} = c + d$

When $O_i = 0$, $\Delta y_{i(T,O=0)} = c$

Then the total effect Δy_i of policy on the level of economic opening y_i can be expressed as

$$\Delta y_i = y_{i(T,O_i=1)} - y_{i(T,O_i=0)}$$

$$\Delta y_i = d \tag{12}$$

Therefore, the cross term coefficient $T_i O_i$ in the linear regression equation represents the influence of policy on the level of economic openness y_i, while excluding the influence of other random factors y_i.

The specific discussion of this impact is as follows:

$d > 0$, Under the policy of "one belt and one way", Xi'an's economic opening level is higher than that of developed cities, and this policy has a promoting effect.

$d < 0$, The policy of "one belt and one way" has a lower level of opening up to Xi'an's economy than that of developed cities.

$d = 0$, The policy of "one belt and one road" is equal to that of developed cities for Xi'an's economic opening level, and it is impossible to judge the role of the policy.

4.2 Analysis of Policy Results Along the Way

- Short term effect

We select the economic opening level of 36 large and medium-sized cities in China from 2013 to 2017 as the research data[6], as shown in the following table

Table5.Cumulative Growth Rate in 2013-2017 of Different Cities

city	2013	2017	cumulative growth rate
Shanghai	27421	32238	18%
Shenzhen	33401	28011	-16%
Beijing	26700	21924	-18%
Guangzhou	7381	9714	32%
Tianjin	7979	7647	-4%
Ningbo	6227	7600	22%
Xiamen	5221	5816	11%
Hangzhou	4036	5085	26%
Qingdao	4834	5024	4%
Dalian	4275	4188	-2%
Nanjing	3461	4143	20%
Fuzhou	1946	2336	20%
Shijiazhuang	870	862	-1%
Haikou	298	210	-29%
Xian	1114	2546	128%
Total	135164	137344	1.50%

2013 is the base period, and the corresponding time independent variable T = 0, 2017 is the period of effect manifestation, and the corresponding time independent variable T = 1. The influence of other urban policy development O = 0; the influence of Xi'an policy development O = 1. Using STATA programming, the result of double difference model is as follows:

$$y = 0.672 - 0.445O - 0.175T + 1.112TO$$

The cross item value is 1.112, indicating that from 2013 to 2017, the policy of "one belt and one belt" promoted Xi'an's opening to the outside world, an increase of 111.2% over the same period last year.

We put 2013-2017 data of Beijing and Xi'an into the model, and the calculation results are shown in the figure below

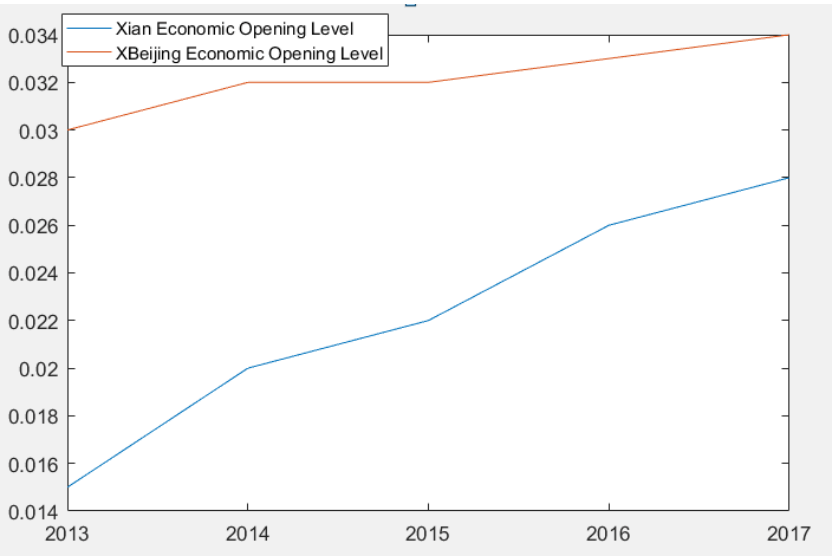

Figure 11. Opening Level of Xian and Beijing

It can be found that the gap between Xi'an and Beijing has been narrowed year by year.

- Short Term Effect Test of the Model

We use the model calculation results to compare with the actual results, and analyze the different situations of T and O

(1) when O = 0 and T = 0, y = 0.672. At this time, the difference between the average value of the economic opening level of the economically developed cities in 2013 and the average value of the economic opening level of the economically developed cities in 2013 in table (3) is the rounding difference.

(2) when O = 0 and T = 1, y = 0.497. At this time, it represents the average value of economic opening level of the economically developed cities in 2017, and the difference between the average value of economic opening level of the economically developed cities in 2017 in Table 7 and 0.4973 is the rounding difference. Therefore, the coefficient of time variable t indicates that the economic opening level of the developed cities has decreased by 0.175 in the past five years.

(3) when O = 1 and T = 0, y = 0.227. At this time, it indicates the average value of Xi'an's economic opening level in 2013 in the base period. The difference between the average value of Xi'an's economic opening level in 2013 in Table 3and 0.2272 is the rounding difference. Therefore, the coefficient of the range variable area shows that the economic opening level of Xi'an is 0.445 lower than that of the developed cities before the construction of "one belt and one road".

(4) when O = 1 and T = 1, y = 0.164. At this time, the construction effect of "one belt and one road" appeared 2017.

The difference between the average value of Xi'an's economic opening level in 2017 and the average value of 0.1641 in (3)is the rounding difference. The coefficient of cross terms indicates that the "one belt and one way" construction promotes the Midwest.

The economic opening level of inland cities increased by 1.12

After testing, we can think that our model has high accuracy and can further carry out long-term prediction.

- Long Term Effect

We fit the economic opening level of 15 cities into the model and get the change of Xi'an's

economic opening level in 2013-2017, as shown in the following figure:

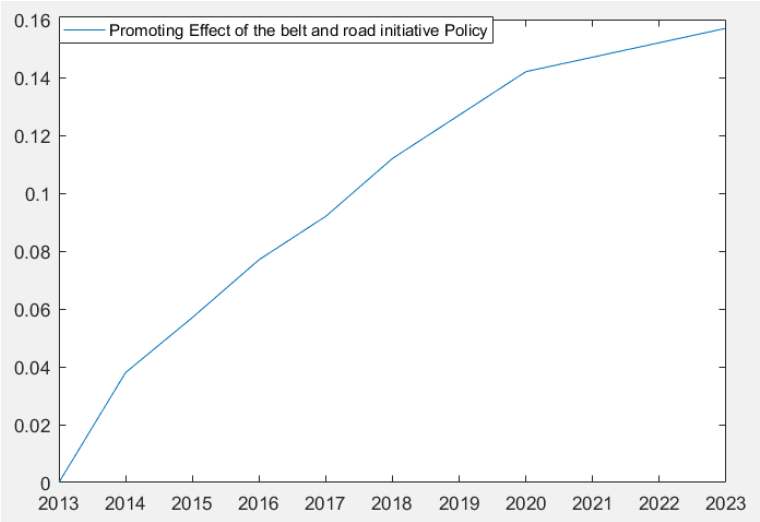

Figure 12. Economic Development Level of Xian in the Future

It can be seen from the figure that the economic development level of Xi'an from 2013 to 2023 increases year by year, with a year-on-year growth of 1.6

5 Problem 3: Evaluation system of urban economic development based on factor analysis

5.1 Data preprocessing

By using the RESSET[7] , CSMAR[3] andChina National Year Book [8]we collected the 15 indicators of economic activity in the city of Beijing, Tianjin, Shenyang, Shanghai, Nanjing, Suzhou, Hangzhou, Ningbo, Qingdao, Zhengzhou, Wuhan, Changsha, Guangzhou, Shenzhen, Dongguan, Chongqing, Chengdu, Kunming and Xi'an from 2000 to 2018. Specific indicators are: total urban GDP x_1, GDP per capita x_2, population (10,000 people) x_3, total import and export x_4, disposable income per capita x_5, surviving enterprises x_6, dead enterprises x_7, fiscal revenue x_8, the number of patent application x_9, GDP growth rate x_{10},total import and export growth rate x_{11}, GDP growth rate per capita x_{12}, students in regular higher educational institutions x_{13}, urban green space area per capita (10,000 people per hectare) x_{14}, the number of scientific research employees (10,000 people) x_{15}, as shown in the following figure:

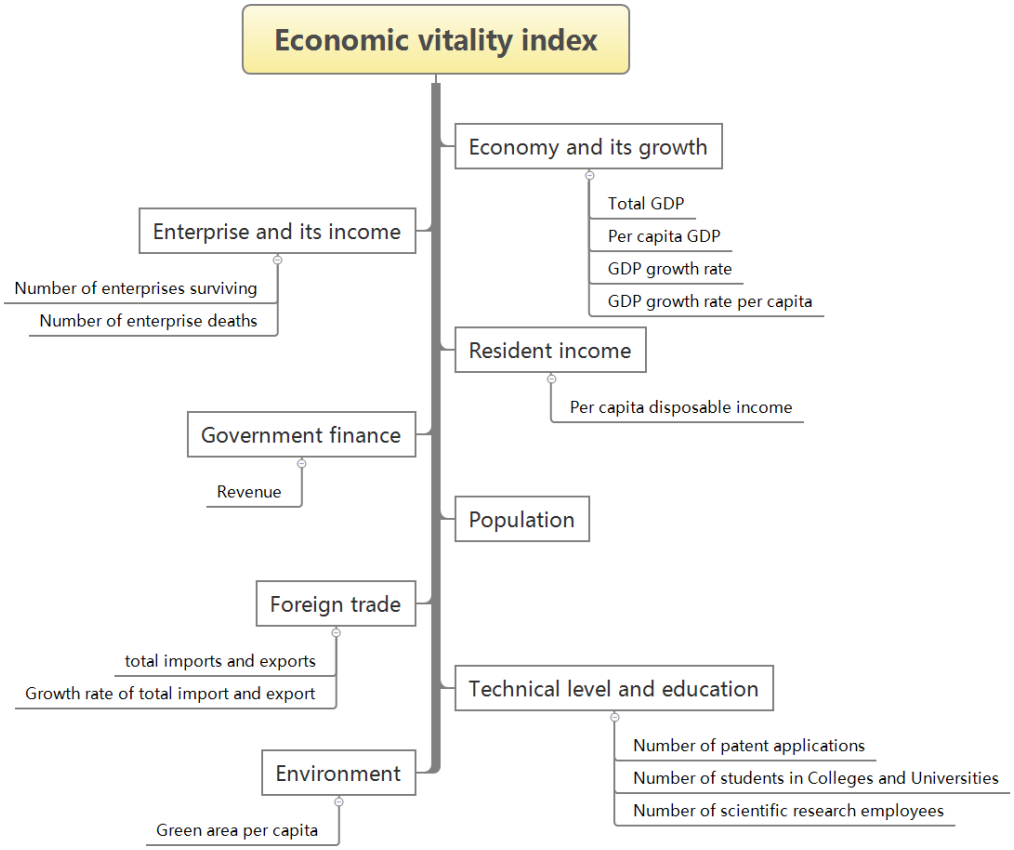

Figure 13. Economic Vitality Index

As for the outliers and missing values in the collected data, we first supplemented them by consulting other data. If we could not find any, we used SPSS to fill them with time series analysis. An example of filling is shown in the figure below:

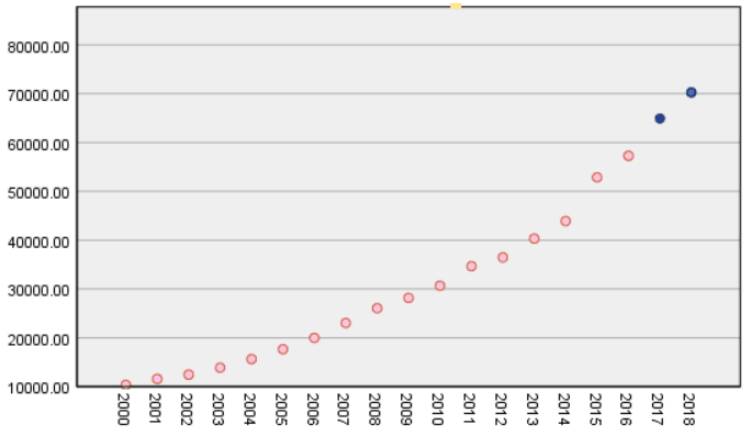

Figure 14. Data supplement example

5.2 Evaluation system based on factor analysis

The 15 indicators we selected have a certain correlation with each other, but direct analysis will reduce the accuracy of the results. Therefore, the first task is to simplify the system structure, hoping to transform the original indicators into fewer independent new indicators. Factor analysis is mainly a linear combination of the original variables. It uses the new variables to explain the

variation of most of the data in the original data, and the variables with high correlation are transformed into independent variables. Through factor analysis, we reduced the dimensions of the original 15 indicators and decomposed them into a few indicators with low correlation, so that the information contained in each indicator has a clear directivity.

- KMO Test

The KMO test is used to analyze whether the selected indicators are suitable for factor analysis. KMO (Kaiser-Meyer-Olkin) test is used to compare simple correlation coefficient and partial correlation coefficient between indicators.

Set m indicators, with n observed values under each indicator, and define the statistics MSA as

$$MSA = \frac{\sum_{i=1}^{j=m}\sum_{j=1}^{n}\sum_{i\neq j} r^2_{ij}}{\sum_{i=1}^{j=m}\sum_{j=1}^{n}\sum_{i\neq j} r^2_{ij} + \sum_{i=1}^{j=m}\sum_{j=1}^{n}\sum_{i\neq j} r^2_{ij\bullet 1,2,...,k}} \tag{13}$$

The value of MSA is between 0 and 1.

When the sum of squares of simple correlation coefficients between all variables is much larger than the sum of squares of partial correlation coefficients, the closer the KMO value is to 1, the stronger the correlation between variables is, the more suitable the original variables are for factor analysis. When the sum of the squares of simple correlation coefficients between all variables approaches 0, it means the closer the KMO value is to 0, the weaker the correlation between variables is, and the less suitable the original variables are for factor analysis.

To conduct the KMO test for the 15 indicators by SPSS in this question, the test results are shown in the following table:

Table 6. Examine of KMO

the Examine of KMO and Bartlett		
KMO		0.743
Bartlett Sphericity test	approxiamate Chi-square	291.001
	df	105
	p	0

It is shown that the value of MSA is 0.743, indicating that the original variable is suitable for factor analysis.

- Construction of factor analysis model

Set $x_i = (x_{i1}, x_{i2}, ..., x_{in})^T, (i = 1, 2, 3, ..., 15)$, $x_{i1}, x_{i2}, ..., x_{in}$ is the year by year data under the index x_i. S refers to the variance of any linear combination of $x_1, x_2, x_3, ..., x_m$. Set $y_1, y_2, ..., y_n$ as the Linear combination of n factors.

Then the factor analysis model can be expressed as:

$$\begin{aligned} y_1 &= u_{11}x_1 + u_{12}x_2 + ... + u_{1m}x_m \\ y_2 &= u_{21}x_1 + u_{22}x_2 + ... + u_{2m}x_m \\ &\vdots \\ &\vdots \\ y_m &= u_{m1}x_1 + u_{m2}x_2 + ... + u_{mm}x_m \end{aligned} \tag{14}$$

$$s.t.\begin{cases} {u_{i1}}^2 + {u_{i2}}^2 + ... + {u_{im}}^2 = 1, (1 = 1, 2, ..., m) \\ a_i y_i + a_j y_j = 0, a_i = 0, a_j = 0, (i, j = 1, 2, ..., m) \\ \max(s) \end{cases}$$

So y_i is the expression for the linear combination of independent variables that have the greatest difference to $y_1, y_2, y_3, .., y_{i-1}$

Next are the specific steps of factor analysis:

- Specific steps of factor analysis

Step1 Data standardization processing

Factor analysis is susceptible to the influence of dimension, so the observed value of the index is firstly standardized. Set x_{ij} as the standardized variable, then

$$X_{ij} = \frac{x_{ij} - e_j}{s_j}$$

$$e_j = \frac{1}{n}\sum_{i=1}^{n} x_{ij}$$

$$s_j = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_{ij} - e_j)^2}$$

e_j is the mean value of n groups of data for each index, and s_j is the standard deviation of n groups of data for each index. At this point, m indicators and the standardized variables of n groups of measurement data under each indicator are obtained. It can be represented as $[X_1, X_2, ..., X_m]$, in which $X_j = [x_{j1}, x_{j2}, ..., x_{jn}]^T, (j = 1, 2, ..., m)$

Step2 Calculate the correlation coefficient matrix

The correlation coefficient matrix can describe the correlation between any two indexes, and the extraction of principal components is based on the correlation coefficient matrix. From normalized variable $[X_1, X_2, ..., X_m]$, we obtained the correlation coefficient matrix.

$$R=\begin{bmatrix} r_{11} & r_{12} & \ldots & r_{1m} \\ \ldots & \ldots & \ldots & \ldots \\ r_{m1} & r_{m2} & \ldots & r_{mm} \end{bmatrix}$$

$$r_{ij}=\frac{\operatorname{cov}(X_i,X_j)}{\sqrt{Var[X_i]Var[X_j]}}\left(i,j=1,2,...,m\right)$$

Step3 Calculation of elementary load matrix

The linear coefficient of the index is called factor loading.The factor load is numerically equal to the eigenvector corresponding to the eigenvalue of the correlation coefficient matrix.

The characteristic root value of the correlation coefficient matrix is numerically equal to the variance of the principal component, which is one of the important criteria for the information contained in the variable data. Therefore, the variance percentage of each principal component can be calculated, that is the every information contribution rate of each principal component b_i , the m eigenvalues of the correlation coefficient matrix $\lambda_1,\lambda_2,...,\lambda_m$, and the corresponding eigenvector $u_i=[u_{1i},u_{2i},...,u_{mi}]^T$. So b_i can be expressed as:

$$b_i=\frac{\lambda_i}{\sum_{i=1}^{m}\lambda_i}(i=1,2,...,m) \tag{15}$$

By using SPSS for factor analysis, the following results were obtained:

Table 7. Variance Interpretstion Rate

Table of Variance Interpretation Rate			
Factor Number	Characteristic root		
	Characteristic root	Rate of Variance Interpretation%	Cumulative value%
1	6.47	43.135	43.135
2	2.525	16.832	59.967
3	1.747	11.649	71.616
4	1.111	7.407	79.024
5	0.865	5.768	84.792
6	0.841	5.607	90.399
7	0.565	3.77	94.169
8	0.412	2.744	96.913
9	0.26	1.736	98.649
10	0.115	0.764	99.413
11	0.046	0.306	99.719
12	0.021	0.141	99.86
13	0.011	0.075	99.935
14	0.006	0.037	99.972
15	0.004	0.028	100

In the initial eigenvalue column, we calculated the results of sorting factors by columns. The information contribution rate of the first five factors has reached 85%, so the first five factors are selected as the main factors for further analysis.

In order to simplify the structure of the factor loading matrix and facilitate the professional interpretation of the main factor, the factor loading matrix is often implemented. We use the orthogonal rotation method with the largest variance to make each column of elements in the rotated factor load matrix as far as possible, that is, to polarize to 0 or 1, so that each major factor only corresponds to a few variables with high load, and the rest of the load is small. And each variable has a high load on only a few principal factors, and the rest of the load is small.

We use SPSS for factor rotation, and the variance interpretation rate of the first five factors was obtained as follows:

Table 8. Interpretation Rate of Variance After Rotation

Factor Number	Interpretation rate of variance after rotation		
	Characteristic root	Rate of Variance Interpretation%	Cumulative value%
1	6.081	40.538	40.538
2	2.255	15.034	55.573
3	1.547	10.313	65.886
4	1.525	10.17	76.055
5	1.311	8.737	84.792

The factor loading matrix after rotation is shown as follows:

Table 9. Factor Loading Coefficient After Rotation

Table of Factor Loading Coefficient After Rotation

Name	Factors Loading Coefficient					Commonality
	1	2	3	4	5	
MMS_GDP	0.931	0.228	0.05	-0.143	0.127	0.958
MMS_Per Capita GDP	0.186	0.902	0.186	0.052	-0.178	0.916
MMS_Population(10,000)	0.616	-0.363	0.039	-0.6	0.149	0.895
MMS_Total Export-Import Volume	0.828	0.378	0.022	0.14	-0.308	0.943
MMS_Per Capita Disposable Income	0.472	0.759	-0.093	0.135	-0.007	0.825
MMS_Quantity of Surviving Interprises in 2019	0.926	0.079	0.056	0.137	-0.096	0.895
MMS_Quantity of Cancelled Interpeises from 2009-2018	0.95	-0.146	-0.019	-0.168	0.004	0.952
MMS_Revenues	0.881	0.265	0.072	0.2	-0.03	0.892
MMS_Quantity of Patent Applications	0.858	0.293	0.156	0.212	0.015	0.891
MMS_Growth Rate of GDP	0.126	-0.084	0.926	0.096	0.208	0.933
MMS_Growth Rate of Total Export-Import Volume	-0.368	0.275	0.128	-0.269	0.241	0.358
MMS_Growth Rate of Per Capita GDP	-0.034	0.479	0.758	-0.208	-0.214	0.894
MMS_Quantity of Students in Colleges and Universities	-0.01	-0.18	0.082	-0.14	0.887	0.846
MMS_Urban Per Capita Green Area(10,000 people / HA)	0.118	0.036	0.004	0.895	-0.123	0.831
MMS_Number of Scientific Research Employees (10,000)	0.674	0.105	-0.103	-0.168	0.431	0.69

Step4 Main factor selection

The significance of the factor load matrix coefficient after rotation is more distinct. The

absolute value of the load reflects the correlation between the index and the main factor. The larger the absolute value is, the stronger the correlation is. Therefore, the five main factors can respectively represent the information of five aspects of economic vitality, namely:

- Factor 1 enterprise vitality factor

This factor mainly explains the influence of dead enterprises, surviving enterprises and financial revenue

- Factor 2 per capita output value factor

This factor mainly explains the influence of per capita GDP, population and per capita disposable income

- Factor 3 GDP growth factor

This factor mainly explains the influence of GDP growth rate, per capita GDP growth rate, total import and export, total import and export growth rate, and total GDP.

- Factor 4 ecological environment factor

This factor mainly explains the influence of urban per capita green area.

- Factor 5 scientific and technological innovation factor

This factor mainly explains the influence of the number of students in Colleges and universities, the number of scientific research employees, and the number of patent applications.

Step5 Selection of factor weights

Take the information contribution rate of the factor as the weight, and get the weight of each factor by normalization, the results are as follows:

Table 10. Weight of Different Factors

Factors Name	Weight
Factor of Enterprise Vitality	0.509
Factor of Per Capita Economy	0.199
Factor of GDP Growth	0.137
Factor of Enviroment	0.087
Factor of Technological Innovation	0.068

- Construction of urban economic evaluation system

To sum up, we establish the evaluation system of urban economic vitality based on factor

analysis and the evaluation structure hierarchy, the hierarchy diagram are as follows:

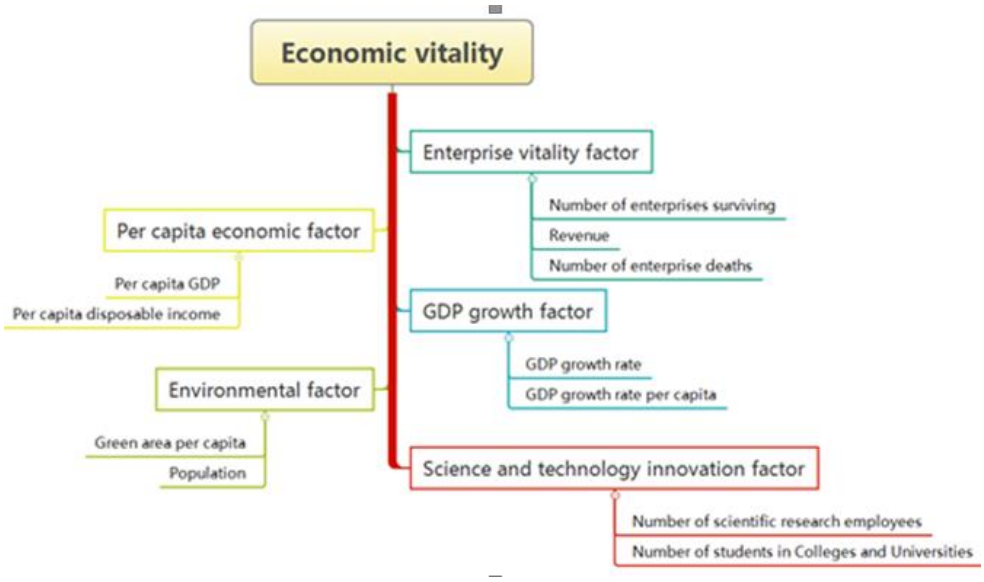

Figure 15. Economic Vitality

5.3 weighted topsis ranking method

In the evaluation process, in order to eliminate the errors caused by the observation differences of cities and to take into account the influence of factor weights, we established a ranking model based on the weighted topsis method, which is similar to problem 2.

- Data standardization

The main factor standardization method is similar to problem 1. The main factor after standardization is $[y_1, y_2, y_3, y_4, y_5] = [a_1, a_2, a_3, a_4, a_5][y_1, y_2, y_3, y_4, y_5]^T$, then the five weighted factors $[a_1, a_2, a_3, a_4, a_5]$, then we get the five weighted factors $[y_1, y_2, y_3, y_4, y_5] = [a_1, a_2, a_3, a_4, a_5][y_1, y_2, y_3, y_4, y_5]^T$.

In order to make the evaluation more objective and cover a wider range of information, we used the mean value of the observed values of the last five years of each indicator as the actual value of the indicator, so as to calculate the value of each factor.

- Choice of ideal point

Similar to question 2, but in this problem, the main factors are positively correlated with economic vitality, so there is no need to reverse the indicators, then the ideal solution of each main factor is as follows :

$$\overline{y_i} = \max(y_{1i}, y_{2i}, ..., y_{ni})$$
$$\underline{y_i} = \min(y_{1i}, y_{2i}, ..., y_{ni}), (i = 1, 2, ..., 5, n = 19)$$

- Evaluate distance construction

The j th city's positive distance and negative distance of the whole city are respectively:

$$\overline{d_j} = \sqrt{\sum_{i=1}^{5}(y_{ij} - \overline{y_{ij}})^2}$$

$$\underline{d_j} = \sqrt{\sum_{i=1}^{5}(y_{ij} - \overline{y_{ij}})^2}, (j = 1,2,...,19)$$

- The ranking function

To sum up, the final ranking function of urban economic vitality is :

$$f_j = \frac{\overline{d_j}}{\overline{d_j} + \underline{d_j}} \tag{16}$$

the bigger the numerical , the higher the rank.

3.4. City ranking and result analysis.

We use MATLAB to compile the ranking function to obtain the final economic vitality ranking results of the 19 cities, as shown below:

Table 11. TOPSIS Result

TOPSIS Result				
city	D	D-	C	Rank
Guangzhou	0.362	0.707	0.661	1
Shenzhen	0.474	0.696	0.595	2
Beijing	0.464	0.679	0.594	3
Nanjing	0.521	0.599	0.535	4
Shanghai	0.587	0.615	0.512	5
Dongguan	0.617	0.611	0.498	6
Wuhan	0.582	0.541	0.482	7
Hangzhou	0.585	0.465	0.443	8
Xian	0.624	0.497	0.443	9
Suzhou	0.711	0.538	0.431	10
Changsha	0.72	0.495	0.408	11
Chengdu	0.664	0.427	0.391	12
Zhengzhou	0.668	0.426	0.39	13
Chongqing	0.775	0.431	0.358	14
Qingdao	0.673	0.372	0.356	15
Tianjin	0.666	0.365	0.354	16
Ningbo	0.701	0.384	0.354	17
Kunming	0.74	0.343	0.317	18
Shenyang	0.784	0.26	0.249	19

According to the analysis in the above table, the most economically dynamic cities in turn are Guangzhou, Shenzhen and Beijing, while the less economically dynamic cities are

Kunming and Shenyang.

5.5 Model Test

We consulted other literatures and found other literatures[9] to rank the economic vitality of these cities based on the clustering method, as shown in the table below, which was not significantly different from our ranking results, indicating that our ranking had a high accuracy. The following figure shows the comparison of literature rankings and model rankings:

Table 12. Comparison of Rank Result

TOPSIS Rank	Specialists' Rank
Guangzhou	Shenzhen
Shenzhen	Shanghai
Beijing	Guangzhou
Nanjing	Dongguan
Shanghai	Suzhou
Dongguan	Beijing
Wuhan	Hangzhou
Hangzhou	Nanjing
Xian	Qingdao
Suzhou	Tianjin
Changsha	Changsha
Chengdu	Chengdu
Zhengzhou	Zhengzhouo
Chongqing	Chongqing
Qingdao	Wuhan
Tianjin	Xian
Ningbo	Ningbo
Kunming	Kunming
Shenyang	Shenyang

- Data visualization

We mapped the economic vitality of 19 cities as shown below：

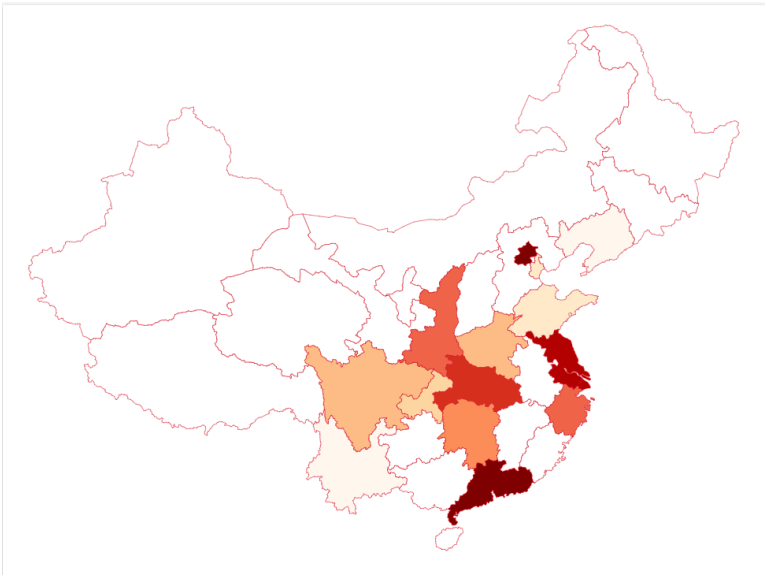

Figure 16. Heat Map of Economic Vitality

From this figure,we can draw a conclusion that the economic vitality of the southeast coastal region is higher than that of the northwest.

6 Policies to Enhance Regional Competitiveness

In question 1, we find that the vitality of urban enterprises is determined by a variety of indicators by studying the data we collected, and the indicators of urban economic vitality are closely related to the urban enterprise vitality and the law of population change. In question 3, we found more index data that can directly affect the economic vitality on the website of the state statistical bureau, and obtained five factors, which jointly affect the economic vitality of the city. In problem 2, we have studied the "one belt and one road" policy specificly. The study of the impact of the implementation of the policy on the economic vitality of Xi'an, the starting place of the Silk Road, has been able to increase the level of opening up to 111.2% in the short term, and gradually reduce the economic differences with the developed regions. In the longer term of the future, Xi'an's economic growth can reach 160%.

As regional policy-makers, we put forward some policies that can make Xi'an economy present benign and sustainable development and stronger regional competitiveness

(1) Accelerating the Construction of an Open Channel for China Unicom's "One Belt, One Road" Economic Belt

Firstly, we will strengthen the construction of international air corridors. Build an international route network with Xi'an as the domestic transit hub, and actively optimize and upgrade the whole freight route network and cross-border e-commerce. Secondly, we should strengthen the construction of major international routes, take the Xi'an international port area as the carrier, strengthen cooperation with the coastal ports and ports, and explore the construction of the "land along the way" central port. Finally, we should strengthen the construction of digital information

channels and build an information industry system with big data, cloud computing and artificial intelligence with Xi'an characteristics. We should strengthen cooperation and exchanges with other countries and regions along the "one belt and one road" in the field of information technology, and build Unicom's global "twenty-first Century numeral Silk Road" to enhance Xi'an's degree of opening to the outside world and increase the volume of import and export trade.

(2) Exploring the Establishment of a Platform for Investment and Trade Liberalization in the "One Belt One Road" Economic Belt.

First of all, take the Xi'an area of China's free trade pilot area as a carrier to explore the establishment of an international free trade port serving the "one belt and one road" construction, investment and trade facilitation, currency convertibility, high-end industry gathering, and legal environment. Secondly, take central Asia and central and Eastern Europe as the key docking areas, give full play to the advantages of Xi'an and Central Asian and central and Eastern European countries, promote the cooperation of customs supervision between countries and regions along the "one belt" road, and strive to build a new platform for international investment and trade liberalization and facilitation. Then, with the construction of Xi'an cross-border e-commerce comprehensive pilot area as the starting point, we will boldly explore, innovate and develop, further simplify the process, promote international trade liberalization, facilitation and business innovation, build a cross-border e-commerce industrial chain and ecosystem, and accelerate the construction of a new highland of opening up in inland areas. Effectively promote the GDP growth rate and per capita disposable income of Xi'an City, so that residents are more interested in using fixed assets for investment and trade.

(3) Building "One Belt One road" Economic Belt Energy Center

Relying on the energy advantages of coal, oil and natural gas in the new Silk Road Economic Belt, we will build an energy resource trading platform based on Shaanxi, radiating to central and Western Asia and Europe, and build an energy financial center of the new Silk Road Economic Belt. Then attract the economic, trade, finance and energy enterprises to settle in, promote the combination of energy and capital market, realize the maximization of energy value, improve the discourse power of energy finance, and radiate the function of energy finance to the surrounding areas. Third, take the coal trading platform as a breakthrough, combine the spot logistics and network logistics, build an electronic trading platform, and strive to build an energy settlement center, investment and financing center, and energy financial product center on the Silk Road Economic Belt. The structural transformation of traditional energy strengthens the environmental protection. While ensuring the urban energy, it can export the surplus to the surrounding areas, drive the economic development of the central and western regions, and promote the economic integration.

(4) Building the "One Belt One Road" Economic Zone

We will vigorously promote the deep integration of science, technology and industry in the new Silk Road Economic Belt. First, build a large platform project for international innovation cooperation and exchange. Build a "one belt and one road" technological innovation, opening, cooperation and sharing platform, effectively improve the number of patent examination and approval in Xi'an, and establish Xi'an's "going global" industrial alliance. The two is to build "one belt and one road" innovation center. Aiming at the world's scientific and technological frontier and industrial innovation and development needs, relying on the resources of colleges

and universities and other units, we will achieve major breakthroughs in aerospace, artificial intelligence and other industries, drive the growth of scientific research funds in Colleges and universities, and increase the proportion of education expenditure in GDP. The three is to create a "one belt and one road" industrial cooperation highland, speed up the construction of industrial parks in Europe and Asia, and constantly expand the new development space of "overseas Xi'an".

(5) Creating "One Belt One Road" Economic and Cultural Financial Center.

Explore the important role of Finance in promoting the development of cultural industry, transform cultural exchanges into monetization, capitalization and securitization, boost the trade and circulation of cultural industry elements and intellectual property rights, such as expanding the influence of platforms such as Eurasian Economic Forum, Silk Road business leaders (Xi'an) summit, etc., and improve the investment and financing capacity and cultural wealth management of Eurasian cultural projects Ability: set up overseas high-end talent project investment fund to achieve financial revenue growth while attracting high-level talents. The introduction of international high-quality educational resources to build a new platform for education cooperation and exchanges along the "one belt and one road" area; to build up a large number of exhibition, art and cultural resources with the "one belt and one way" economic belt, to upgrade the cultural facilities of museums and art galleries, to build an international exhibition cooperation platform, and to run the Western China Cultural Industry Fair and the world cultural tourism conference. We will further enhance our influence and build a creative city along the silk road.

To conclude, under the background of the slowdown of China and the world economy, the "one belt and one way" is a new breakthrough for the long-term development of the Chinese economy. It is also a major opportunity and booster for the western underdeveloped areas to give full play to their late development advantages. We hope that our research and proposed policies can bring constructive help to regional economic development.

Sincerely,
TeamB94163

7 Model Evaluation

7.1Strengths

- In the process of data collection and model building, we used CSMAR, CENSD, National Statistical Yearbook and other databases to efficiently and quickly find the macro-economic data of various regions, and filled in some missing values based on time series method to ensure the correctness and integrity of the data. So that the model we set up in questions 1 to 3 is very close to the actual situation.

- Compared with the traditional mathematical model, the did double difference model we used in question 2 can accurately quantify and calculate the impact of policies on the development of the city, while the impact of separating other variables is more accurate

- For problem 3, before the factor analysis method was proposed to solve the problem of multiple index collinearity, we used principal component analysis and other methods, but the effect was not ideal, so we used the factor rotation of variance maximization method to further simplify the system structure, so that each factor is independent of each other and contains clear information. And take the main factor contribution rate as the weight, which is more objective. Finally, in the ranking, the weighted TOPSIS comprehensive evaluation method is used to calculate the ranking of each city, so that the accuracy of the model is high.

7.2Improvement Needed

- Although we have collected many indicators, there are still some deviations between the final model and the actual situation because the factors that need to be considered to describe the economic vitality of a region are far more than what we put forward.

- Some of the algorithms we selected have unavoidable subjective factors in the use process, which will affect the accuracy of the actual results.

7.3Future Work

In view of the imperfections of our model and work, we hope to complete a more comprehensive and comprehensive analysis of the indicators affecting economic vitality with the help of a larger and more detailed database, so that our research report can truly become a valuable research result for the local government. In this solution, we use not only mathematical model but also economic related model. We hope to have a deeper understanding of the relevant background of economics and establish a more perfect model. Besides, in terms of policy selection, there are still many policies in our country that can promote the economic development and a variety of other indicators in a certain area. The further understanding and analysis of such policies is also a major part of our work.

With the continuous improvement of China's economic development level, it can be predicted that China's enterprise structure and market structure will gradually rationalize. Talents and good enterprise system will jointly promote the development of enterprises, and the development of dynamic enterprises can promote the economic vitality of the city. China's economy will have a bright future.

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Appendix

Program source code of problem1

在 MATLAB 环境中运行：

```
for i = 1: 19
    rk(i)=(rk(i)-min(rk))/(max(rk)-min(rk));
end

subplot(2,2,1)
plot(2000:2023,zongshuju(:,2),2000:2023,-0.5132+0.2203.*rk+1.7013.*qyhl)
legend('Actual and projected GDP','Linear');
subplot(2,2,2)
plot(2000:2023,zongshuju(:,2),2000:2023,-0.6864+0.5180.*rk+2.1107.*qyhl-0.5316.*rk.^2+0.2991.*qyhl.^2)
legend('Actual and projected GDP','Purequadratic');
subplot(2,2,3)
plot(2000:2023,zongshuju(:,2),2000:2023,-0.5945+0.1171.*rk+1.9549.*qyhl+0.0060.*rk.*qyhl)
legend('Actual and projected GDP','Interaction')
subplot(2,2,4)
```

```
plot(2000:2023,zongshuju(:,2),2000:2023,-2.4455+0.7525.^rk+4.3597.^qyhl)
legend('Actual and projected GDP','Exponention')
```

Program source code of problem2

```
在 STATA 环境中运行：
cd G:\Stataex
  use G:\Stataex\ch11.dta,clear
* use "http://fmwww.bc.edu/repec/bocode/c/CardKrueger1994.dta"
  browse
  des
* ssc install diff, replace
diff outcome_var [if] [in] [weight] ,[ options]
  outcome_var

  treated(varname)
cov(varlist)
id(varname)
  bw(#)
ktype(kernel)
cluster(varname)
robust
  bs
  reps(int)
  ----Balancing test----
  test ： 采用 balancing t 检验，检验在基期时，协变量在控制组和实验组的均值是否有差异。
              同时使用 test 和 kernel 选项，执行加权协变量的 balancing t 检验。

  ----报告----
  report ： 当设定选项 kernel 时，显示所包含的协变量的推断或倾向得分的估计。
  nostar ： 去掉 p 值的星号。
--------------------------------------------------------------------------------*/




/*----------【双重】差分法、倍差法、倍分法----------------------*/



/*----1-1--【没有协变量】的双重差分法-----------*/
```

```
   diff fte, t(treated) p(t)
   estimates store DD1

   diff fte, t(treated) p(t) robust
   estimates store DD2

* bootstrapped  稳健标准误:
   quietly diff fte, t(treated) p(t) bs rep(50)
   estimates store DD3


*    ssc install st0085_2                    /*----安装非 Stata 系统软件包----*/
   esttab DD1 DD2 DD3 using testldd.doc, ar2(%8.4f) se(%8.4f) ///
            nogap brackets aic bic    mtitles replace




/*----1-2--用【OLS】估计【没有协变量】的【双重差分】估计量-----------*/

   reg fte c.treated#c.t treated t, robust
   estimates store DDOLS1



*    ssc install st0085_2                    /*----安装非 Stata 系统软件包----*/
   esttab DD2 DDOLS1 using testlddols1.doc, ar2(%8.4f) se(%8.4f) ///
            nogap brackets aic bic    mtitles replace




/*----2-1--【有协变量】的双重差分法-----------*/

   diff fte, t(treated) p(t) cov(bk kfc roys)
   estimates store DDCOV1

*  报告协变量的估计结果
   diff fte, t(treated) p(t) cov(bk kfc roys) report

   diff fte, t(treated) p(t) cov(bk kfc roys) report bs rep(200)
```

```
estimates store DDCOV2

diff fte, t(treated) p(t) cov(bk kfc roys) robust
estimates store DDCOV3


*   ssc install st0085_2                    /*----安装非 Stata 系统软件包----*/
esttab DDCOV1 DDCOV2 DDCOV3 using testlddcov.doc, ar2(%8.4f) se(%8.4f) ///
        nogap brackets aic bic    mtitles replace



/*----2-2--用【OLS】估计【有协变量】的【双重差分】估计量----------*/

reg fte c.treated#c.t treated t bk kfc roys, robust
estimates store DDOLS2


*   ssc install st0085_2                    /*----安装非 Stata 系统软件包----*/
esttab DDCOV3 DDOLS2 using testlddols2.doc, ar2(%8.4f) se(%8.4f) ///
        nogap brackets aic bic    mtitles replace



/*----【检验】----基期，结果变量（协变量）的均值，
                        在控制组和实验组之间是否有显著性差异----------*/

diff fte, t(treated) p(t) cov(bk kfc roys) test
*   estimates store DDCOVTEST1



*   diff fte, t(treated) p(t) cov(bk kfc roys ) test robust
*   estimates store DDCOVTEST2


**   ssc install st0085_2                   /*----安装非 Stata 系统软件包----*/
*   esttab DDCOVTEST1 DDCOVTEST2 using testlddcovtest.doc, ar2(%8.4f) se(%8.4f) ///
*           nogap brackets aic bic    mtitles replace
```

/*----1-3---【分位数】双重差分法----------

diff fte, t(treated) p(t) qdid(0.25)
diff fte, t(treated) p(t) qdid(0.50)
diff fte, t(treated) p(t) qdid(0.75)
diff fte, t(treated) p(t) qdid(0.50) cov(bk kfc roys)
diff fte, t(treated) p(t) qdid(0.50) cov(bk kfc roys) kernel id(id)
diff fte, t(treated) p(t) qdid(0.50) cov(bk kfc roys) kernel rcs

Program source code of problem3

在 MATLAB 环境下运行：

```
k=0;
k1=0;
k2=0;
k3=0;
k4=0;

for i=1:19
    k=0;
    k1=0;
    k2=0;
    k3=0;
    k4=0;
    for j=1:15
        k=k+gyhhsj(i,j).*yzdf1(j);
        k1=k1+gyhhsj(i,j).*yzdf2(j);
        k2=k2+gyhhsj(i,j).*yzdf3(j);
        k3=k3+gyhhsj(i,j).*yzdf4(j);
        k4=k4+gyhhsj(i,j).*yzdf5(j);
    end
    yzl(i,1:5)=[k,k1,k2,k3,k4];

end

zzl=[]
for j=1:19
    for i=1:5
        zzl(i,j)=(GDP(i,j)-GDP(i+1,j))/GDP(i+1,j);
    end
```

```
    zzl(6,j)=mean(zzl(1:5,j));
end
```