Modelling of index system of economic vitality during the COVID-19 epidemic.

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Abstract

Economic vitality is an important indicator to measure the level and potential of economic development. The paper puts forward three social problems about economic vitality and HVWDEOLVKHV D PRGHO WR VROYH WKHP :H EXLOG SDQHO GDWD of economic vitality. Based on the section data of Beijing, the VAR-VEC model is established WR DQDO\]H WKH ORQJ WHUP DQG VKRUW WHUP HuHFWV RI HFRQ development strategy of ORT is put forward, and the scheme to promote the growth of economic vitality is given during the COVID-19 epidemic.

)RU WKH ¿UVW SUREOHP WKH SDSHU SUHSURFHVV SDQHO GDWD each factor is not independent of each other. Through the correlation analysis, we found that there LV D VWURQJ FRUUHODWLRQ EHWZHHQ WKH YDULRXV HOHPHQWV 7HVW FRPELQHG ZLWK +DXVPDQ 7HVW WKH GDWD SDQHO FRQIRU FKDQJH DQG HQWHUSULVH YLWDOLW\ KDYH D SRVLWLYH LPSDFW are 0.01 and 0.07 respectively. We put forward the strategy of adjusting the overall structure of enterprises to improve economic vitality.

For the second problem, the paper select the section data of Beijing city and construct the VAR-9(& PRGHO %DVHG RQ $') XQLW URRW WHVW DQG -RKDQVHQ FRLQ least three cointegration relationships between time series. We use Ais-Sc Criterion to determine WKH RUGHU RI GHOD\ DV WKH WKLUG RUGHU :H XVH 2/6 HVWLPD 9(& 0RGHO 7KURXJK WKH ,5) UHVSRQVH ZH ¿QG WKDW WKH ORQJ HFRQRPLF YLWDOLW\ LV SRVLWLYH FRUUHODWLRQ HuHFW 'XH W economic vitality presents a W-shaped trend.

For the third problem, the paper use the minimum average deviation method to preprocess the index data, and get 9 representative indexes. We extract two main factors by factor analysis and build an index system of economic vitality. The economic vitality of each city from 2009 to 2017 is calculated according to the index system. Beijing, Shanghai, Guangzhou and Shenzhen often UDQN ¿UVW ZKLOH .XQPLQJ DQG 'RQJJXDQ RIWHQ UDQN ODVW % model test results are similar to index system.

For the fourth problem, we review the previous conclusions and put forward the ORT development strategy to improve economic vitality based on the established model.

.H\ZRUGV Panel data model, VAR-VEC model, Factor analysis, Index system.

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Introduction

Under the background of new age, China's economic, social, FXOWXUDO HFRORJLFDO SROLWLFDO DQG RWKHU ¿HOGV DUH FRUXVF gives new vigor and vitality, at the same time the good life is people's increasing need to inadequate and imbalance of the contradiction between the development of become the main social contradiction, and the unbalanced economic development EHWZHHQ GLuHUHQW UHJLRQV LV imbalance is not fully developed; To accelerate the narrowing of the gap in regional economic development, promote the vitality of regional economic development, and promote the coordinated development of regional economy is the basis and key to solve the main social contradictions in the new age, and is also the driving force of economic and social development axis [1-5].

Regional economic vitality is an important part of regional comprehensive competitiveness. In recent years, in order to improve economic vitality, some regions have introduced a lot of preferential policies to stimulate economic vitality, such as UHGXFLQJ WKH DSSURYDO VWHSV IRU support for entrepreneurship, and lowering the threshold for settling down in order to attract talents. However, due to

GLuHUHQW UHVRXUFH HQGRZPHQW HuHFWV LQ GLuHUHQW UHJLRQV + HuHFWLYHO\ LPSURYH WKH UHJLRQ research topic [6].

In order to study how to improve regional economic vitality, given some data. Based on these data and my own survey data, this paper established an appropriate model to solve the following problems:

Problem 1, it is necessary to take a certain region (or city or province) as an example, and combine the data collected in the attachment to establish the appropriate relationship model of the LQÀXHQFLQJ IDFWRUV RI HFRQRPLF WR LPSURYH WKH UHJLRQDO HFRQ of population change trend and enterprise vitality change on regional economic vitality change is analyzed.

Problem 2, selecting a region (or city or province) and investigating the appropriate data analyze the short-term and long-term impact of economic policy transformation on the economic vitality of the region (or city or province).

Problem 3, this paper collects relevant data, selects appropriate indicator system, establishes mathematical model to analyze and measure regional (or city or provincial) economic vitality, and ranks urban economic vitality [9-12].

Models

The model of problem 1

Based on the panel data model, collects data from various provinces and cities performs correlation test and principal FRPSRQHQW DQDO\VLV RQ WKH GD UDQGRP HuHFW WHVW ZHUH FDUUL DQG WKH LQÀXHQFH RI SROLF\ DQG vitality was analyzed based on the established relationship model between each factor and economic vitality during the COVID-19 epidemic.

Data analysis and processing: Based on the collected data has FHUWDLQ HUURU DQG GH¿FLHQFLHV WKH LQÀXHQFH RI WKH HUURU GDW the reliability of data, need to collect the data pretreatment, ¿UVWO\ WKH ¿OWHUHG GDWD VXSSOHPHQW RI LQFRPSOHWH GDW GDWD OLQHDU UHJUHVVLRQ DQDO\V GDWD XVLQJ WKH PRYLQJ DYHUDJH to further improve the accuracy and the integrity of the data.

Data selection principle: This paper needs to collect various LQGLFDWRU GDWD GHVFULELQJ H economic vitality, and the following classical indicators can be obtained according to the expert method and the literature [10,11,13,14].

Dependent variable, in the existing economic vitality research and analysis, more choose gross domestic product (GDP) as a measure of regional economic vitality. In this paper, in order to measure regional economic vitality, main factors from the HuHFWV RI WKH HFRQRPLF YLWDOLW\ WKDW UHÀHFWV WKH *'3 JURZWK rate as the level of economic development during the period of change degree of dynamic indexes, namely whether a national economic basic index of the dynamic, and USES the linear regression analysis and panel data model analysis, the main measures for regional economic vitality. IDFWRUV DQG HFRQRPLF YLWDOLW\ LV D ZRUWK

Independent variables: Based on the existing literature research results and the aforementioned analysis, this paper selects 9 DVSHFWV LQFOXGLQJ SRSXODWLRQ J HPSOR\PHQW UDWH PDLQO\ XVHG WR factors of regional economic vitality and its growth trend).

The employment rate is expressed by the number of unemployed; at the same time, in the establishment of the model, for the negative value of population growth rate, in order to reduce the error in the large number region, dummy variables can be used instead of the original statistical samples, which are set to zero in this paper. YLWDOLW\ > @ 7KH LQÀXHQFH

Control variables: Based on the analysis of the comprehensive evaluation index system of urban economy, and considering the availability of data, this paper introduces independent innovation ability, per capita length of education, professional and technical WDOHQW LQÀRZ DQG RWKHU LUUHOHY Through certain analysis, the variables other than independent YDULDEOHV WKDW FDQ DuHFW WKH should be well controlled and regarded as constants, so as to obtain appropriate causal relationship and obtain the most true and accurate value (Table 1).

Independence test: In the analysis of the relationship between WKH IDFWRUV DuHFWLQJ HFRQRPLF understand whether there is an internal relationship between the factors, according to the processed data, this paper carries out an independence test for each factor.

The data source is the national bureau of statistics, and the independence test is conducted on the pre-processed data. 6HH WKH DSSHQGL[IRU WKH VSHFL assumptions about the research hypothesis:

1XOO +\SRWKHVLV WKH IDFWRUV WK independent of each other.

$OWHUQDWLYH +\SRWKHVLV WKH I vitality are not independent.

Firstly, chi-square independence test was conducted and SPSS ZDV XVHG WR FRQGXFW FKL-VTXDUH LQGHSHQGHQFH WHVW to observe whether there was any correlation between each factor. The test results are as follows:

It can be seen from Table 2 that the cross relation between each factor and the year, and the cross table shows the availability RI GLuHUHQW LQÀXHQFLQJ IDFWRUV percentage, indicating that the selected data are valid values with high accuracy, which can be further compared in pairs WR WHVW WKH LQGHSHQGHQFH RI MX

Table 1. *Variable definition.*

Variable Name	Definition
Dependent variable	The local GDP, Added value of tertiary industry, Education funds, LGE, Government expenditure, Gross income from international tourism, Consumer price index, Population, Unemployment, Number of patents filed
Independent variables	Population growth rate, Fiscal spending
Control variables	Independent innovation abilitTotal corporate profitsy, Per capita years of Education, The inflow of professional and technical personnel

analysis is used to determine whether there is independence EHWZHHQ IDFWRUV 7KH FKL VTXDUH shown in Table 3.

It can be seen from Table 3 that the degree of freedom is the probability of Person chi-square, which is less than 0.05, so the QXOO K\SRWKHVLV LV UHMHFWHG independent of each other.

Correlation analysis: Each factor in the collection is the indicator data of each city in the country, which belongs to the panel data. There may be a certain correlation between the data. Considering the correlation among various factors, the linear strength relationship diagram of each factor is obtained based on the data as follows:

As can be seen from the observation in Figure 1, there is a correlation among all factors, as well as the expression form and strength of the relationship among all factors. The closer the data is to 1, the stronger the correlation is.

Local GDP is positively correlated with Government expenditure, Gross income from international tourism, &RQVXPHU SULFH LQGH[(GXFDWLRQ IXQGV Population, Unemployment and added value of the tertiary industry, and negatively correlated with the number of patent applications. SPSS was used to conduct correlation analysis on the data, and the results were shown in Table 4.

&RUUHODWLRQ FRHvFLHQWV FDQ TXD of linear relationships among factors, and SPSS is used for FRUUHODWLRQ DQDO\VLV WR REWDLQ

According to the above correlation analysis Table 5, there is a correlation among all factors, and the positive correlation FRHvFLHQW LV GLVWULEXWHG EHWZ VWURQJ FRUUHODWLRQ $QG WKHQ D RI WKH FRUUHODWLRQ FRHvFLHQW W WKDQ LQGLFDWLQJ WKDW WKH D KLJK OHYHO RI VLJQL¿FDQFH 7KHUH EHWZHHQ YDULRXV IDFWRUV LQÀXHQFL

Establishment of model: This section is based on the panel data of various factors collected from 31 provinces and cities LQ &KLQD IURP WR &RQVLG multiple factors on economic vitality, a variety of methods can be used, such as multiple linear regression and panel data model. Here, a rough comparison is made before further model establishment. Compare the panel data model with the multiple linear regression model, as shown in Table 6.

Table 2. Independence test results.

	Observations					
	Effective		Missing			
	N	Percentage	N	Percentage	N	Percentage
Local	309309	100.00%	0	0.00%	309309	100.00%
Travel	309309	100.00%	0	0.00%	309309	100.00%
Index	309309	100.00%	0	0.00%	309309	100.00%
Profit	309309	100.00%	0	0.00%	309309	100.00%
Population	309309	100.00%	0	0.00%	309309	100.00%
Workloser	309309	100.00%	0	0.00%	309309	100.00%
Third	309309	100.00%	0	0.00%	309309	100.00%
Patent	309309	100.00%	0	0.00%	309309	100.00%
GDP	309309	100.00%	0	0.00%	309309	100.00%

Table 3. *Chi-square significance test results.*

	Numerical	Df	Asymptotic significance (2 ends)
Person square test	2753847.871[a]	2745	0
Likelihood ratio	1416065.09	2745	0
Linear to linear	13402.742	1	0
The number of Valid observations	309309		0

Figure 1. The linear strength relationship between the factors.

Table 4. Correlation analysis.

	Average	Standard deviation	95% confidence interval (lower bound upper bound)	significant
Local	4047.2789	2473.46062	（3788.2312，4321.1274）	0.047
travel	2071.1539	3068.79243	（1732.0034，2455.2115）	0
index	102.306	1.5306	（102.134，102.473）	0.006
profit	2024.945	2138.79648	（1793.7463，2264.6996）	0.011
population	5.42268	2.847803	（5.12150，5.74611）	0.017
Work loser	24.8066	14.06292	（23.3868，26.4238）	0
third	9627.7616	8985.16139	（8672.1902，10640.3587）	0.007

Table 5. *Correlation coefficient result.*

	Local	travel	index	profit	Pop	Work	third	patent
Local	1	0.602	-0.113	0.777	-0.155	0.57	0.921	0.911
travel	0.602	1	-0.022	0.592	-0.034	0.217	0.709	0.656
index	-0.113	-0.02	1	0.011	0.034	-0.057	-0.092	-0.073
profit	0.777	0.592	0.011	1	-0.145	0.589	0.875	0.935
pop	-0.155	-0.034	0.034	-0.145	1	-0.478	-0.153	-0.16
Work	0.57	0.217	-0.057	0.589	-0.478	1	0.515	0.625
third	0.921	0.709	-0.092	0.875	-0.153	0.515	1	0.972
GDP	0.911	0.656	-0.073	0.935	-0.16	0.625	0.972	1
patent	0.399	0.656	-0.034	0.662	-0.108	0.39	0.566	0.608

Table 6. Model comparison.

	Multiple linear regression	Panel data model
Independent variable Selection	Independent variables must be mutually exclusive	No special requirements
Observations	Less description	More description
Analysis of the dimension	One-dimensional	Two-dimensional
Predictive accuracy	Accurately	Relatively accurate
Information contained	Less	More
Controllability	No	Yes

Based on the data and problem in this question, it is obvious that the panel data model is a better choice. The panel data model includes both the cross-section and the time dimension. Here, the individual is taken as the cross-section, and the year is taken as the time dimension. Among them,i(i=1…8)represents the following linear model set for the year:

$$y_{it} = \alpha_i + \lambda_t + \beta x_{it} + \varepsilon_{it}.$$

The panel data model can be divided into fixed effect model and random effect model.

Fixed effect model: The individual effect is regarded as a fixed factor that does not change with time, then equation 1 can be expressed as a vector

$$y_{it} = \alpha_i A_T + \lambda_t + \beta x_{it} + \varepsilon_{it}.$$

In the formula, A_T is a column direction where all elements are 1, and the others have the same meaning as the original model.

Random effect model: The individual effect is regarded as a random factor that changes with time. By using the random effect model, the long-term and short-term variance can be separated. The basic setting of the model is as follows:

$$y_{it} = \alpha_{it} + \lambda_t + \beta x_{it} + \varepsilon_{it}.$$

Model determination based on Hausman test: Because the missing related variables are not excluded, there will be correlation of random interference items, and the constraint conditions of explanatory variables and random interference items will change with the same period. The proposed Hausman test can be used to distinguish them to some extent (Figure 2).

Model solving process:In this section, stability analysis is conducted on the existing panel data, Hausman test is used to determine the applicable model for the panel data. Finally, the analysis results

Figure 2. Inspection process.

are obtained based on the panel regression model.

Data stability and reliability analysis: The data of this paper comes from China National Statistical Yearbook, which includes WKH ORFDO JRYHUQPHQW V ¿QDQFLDO H[SHQGLWXUH WKH WRWDO LQFRP ORFDO LQWHUQDWLRQDO WRXULVP FRQVXPHU SULFH LQGH[WRWDO SU of enterprises, population, unemployment, tertiary industry, total patents and local GDP. The inconsistency of the order of PDJQLWXGH RI HDFK SDUW ZLOO FDXVH WURXEOH WR WKH PRGHO ¿WWL According to the statistical yearbook, the city is divided into 1-31, and the distribution of various data is shown in Figure 3.

Figure 3. Data distribution of influencing factors in each city.

7DNH)LJXUH IRU H[DPSOH VWDQGDUGL]H LW ¿UVW $VVXPH WKDW WKH original data is x_m, after standardization is X_m.

$$X_{ni} = \frac{X_{ni}}{MAX(Y) - MIN(Y)}.$$

After obtaining standardized data, it is shown as follows (Figure 4).

It can be seen from the observation Figure 4 that after the standardization, the feature expression is more clear, which is conducive to the next model inspection work.

Figure 4. Standardized data distribution.

Fixed effect test based on OLS: Panel data has the characteristics of separating long-term variables and short-term variables, while ¿[HG HuHFW PRGHO IRFXVHV RQ WKH UHODWLRQVKLS EHWZHHQ YDULDEO ZLWKLQ WKH JURXS ,W LV QHFHVVDU\ WR WHVW WKH ¿[HG HuHFW PRGH The estimation method is OLS estimation, Two assumptions of ¿[HG HuHFW PRGHO DUH PDGH

Hypothesis 1 $E[\xi_i \mid x_i, a_i] = 0$.

Hypothesis 2 $Var[\xi_i \mid x_i, a_i] = \sigma^2 I_T$

The ξ in Hypothesis one is the independent variable interference term.

Hypothesis 1 Assume that the ξ KDV QR HuHFW RQ WKH REVHUYHG value, unobserved value and post observed value.

Hypothesis 2 The general test of homovariance, Ensure that the PRGHO VDWLV¿HV WKH EOXH HVWLPDWH RI 2/6 $QG RUJDQL]H GDWD LQW long data types.

The year (2009-2018) is the cross-section marker, the province (1-31) is the research individual, and each type of independent YDULDEOH LV WKH LQÀXHQFLQJ IDFWRU

The solution is based on Stata software, and the results are shown in Table 7.

Table 7. *Fixed effect test model.*

Variables	GDP	P>|t|[95% Conf. Interval]
Local	0.07766356	0
travel	0.04812193	0.007
index	0.01040376	0.116
profit	0.10857042	0.001
population	0.00840291	0.011
workloser	0.02157164	0.083
third	0.72645815	0
sigma_u	0.03622232	F =0 F(30,272)=29.86 Prob > F = 0.0000
rho	0.91812864	
sigma_e	0.01081659	

Table 8. *Indicators passing the fixed effect test.*

Variables	GDP
Local	0.0776635
travel	0.0481219
profit	0.10857042
population	0.0084029
third	0.7264581

Among them, the F value is very close to 0, indicating that the ¿[HG HuHFW LV YHU\ VLJQL¿FDQW LQ WKLV FDVH $PRQJ WKHP WKH independent variables, the consumer index and unemployment UDWH DUH QRW VLJQL¿FDQW ZLWKLQ WKH FRQ¿GHQFH LQWHUYDO

$PRQJ WKHP WKH WKLUG LQGXVWU\ on GDP, and the consumer index has the least impact on GDP.

We can know that all the selected indicators have positive VLJQLI¿FDQFH IRU $*L3 JURZWK YLWKL shows that this test has passed hypothesis one and hypothesi two for panel data, and both of them are true.

Local government expenditure, total tourism income, total SURJWV RI HQWHUSULVHV UHVLGHQW SRSXODWLRQ DQG WHUWLDU LQFRPH DOO KDYH VWURQJ VWDWLVWLFDO VLJQL¿FDQFH shown in Table 8.

Random effect model test based on GLS estimation: The number of indexes(N) is 10, and the time span(T) is 10 years, QWKLV FDVH LV DQVRSYLEOH IXUWKHU WHVW RI WKH UDQGRP HuHF

Hypothesis 1: $E[\xi_i | x_i, a_i] = 0$,

Hypothesis 2: $Var[\xi_i | x_i, a_i] = \sigma^2 I_T$,

Hypothesis 3: $a_i \sim IID(0, \sigma_a^2)$,

Hypothesis 4: $Cov(a_i, x_{it}) = 0$,

Hypothesis 5: $u_i | x_i \sim IID(0, \sigma^2 I_T + \sigma_a^2 A_T A_T')$.

According to the above assumption, suppose that the distribution RI HDFK LQGHSHQGHQW YDULDEOH DQG WKH HuHFW RI HDFK LQGHSHQGHQW value of 0. The second is the description of random interference, which has no correlation with explanatory variables. The third WHUP PDNHV WKH WZR FRHvFLHQWV LQGHSHQGHQW RI HDFK RWKHU

Based on the above description, GLS estimation method can be used to obtain whether the panel data model conforms to the UDQGRP HuHFW WHVW ZKHQ WKH FROOHFWHG YDULDEOHV time span.

Organize data into long data types. The year (2009-2018) was used as the cross-section marker, the province (1-31) as the study individual, and each type of independent variable as the LQÀXHQFLQJ IDFWRU 8VH 6WDWD VRIWZDUH WR VROYH get the results as shown in Table 9.

,Q FRQ¿GHQFH LQWHUYDO WKDW hypotheses are passed in this case. This case is suitable for the UDQGRP HuHFW PRGHO 7DEOH

7KH WKLUG LQGXVWU\ KDV WKH PRVW VLJQL¿FDQW LPSDFW RQ *'3 DQG the resident population has the least impact on GDP. We can NQRZ WKDW DOO WKH VHOHFWHG LQGLFDWRUV KDYH SRVLWLYH VLJQL¿F for GDP growth within the statistical range. At the same time, it shows that the test has passed all the hypotheses of panel data DQG VDWLV¿HV WKH UDQGRP HuHFW)LJXUH

The number of indexes (K) selected in this paper is 10, and the time span (T) LV \HDUV ,Q WKLV FDVH ERWK WKH ¿[HG HuHFW PRGHO DQG WKH UDQGRP HuHFW PRGHO DUH VDWLV¿HG DQG IXUWKHU PRGHO is needed. At this time, Hausman test should be taken.

***Table 9**. Test results of random effect mode.*

Variables	GDP	*P*>|*t*| [95% Conf. Interval]
Local	0.07772621	0
travel |	0.03259963	0.051
index	0.00628094	0.123
profit	0.14530897	0
population	0.00921631	0.332
workloser	0.06423435	0
third	0.71987214	0
sigma_u	0.03622232	F=0. F(30,272)=29.86 Prob > F = 0.0000
rho	0.91812864	
sigma_e	0.01081659	

***Table 10**. Indicators passing the random effect test.*

Variables	GDP
Local	0.07766353
population	0.00840295
profit	0.14530897
workloser	0.06423435
third	0.71987214

Model determination based on Hausman test: According to WKH UHIHUHQFH > @ WKH GLuHUHQ PRGHO DQG WKH ¿[HG HuHFW PRGHO try to distinguish them in a high degree in the description of LQGLYLGXDOV 7KH ¿[HG HuHFW ZLO IUHHGRP ZKLOH WKH UDQGRP HuHF basis. The proposed Hausman test can be used to distinguish them to some extent.

7KH FRQVWUDLQWV RI WKH DQ YDQFHG UDQGRP UHVXOWV WKDW WKH ¿[HG HuHFW +DXVPDQ WHVW LV XVHG WR JHW WKH to test the two models simultaneously is established (Table 11).

It is known from the output that the variance of parameter HVWLPDWLRQ RI UDQGRP DQG ¿[HG H SRVLWLYH GH¿QLWH PDWUL[ZKLFK V FRQ¿GHQFH LQWHUYDO 3 YDOXH WK ZH VKRXOG FKRRVH ¿[HG HuHFW PRG of economic vitality.

Analysis of model test results: 8VLQJ +DXVPDQ WH HuHFW PRGHO LV GHWHUPLQHG DV economic vitality and the results are shown in Table 12.

Among them, the factors that have a positive impact on economic YLWDOLW\ DUH WKH ORFDO JRY WKH WRWDO DQQXDO UHYHQXH RI OR of local enterprises, the local permanent population and the GDP of the tertiary industry. *'3 DQG ¿YH $FFRUGLQJ WR)LJXUH EDVHG RQ V

Figure 5. When both tests pass.

Table 11. Hausman test results.

Variables	Value
Chi2(7)	382.02
Prob	0

***Table 12**. Test results of fixed effect model.*

Variables	GDP
Local	0.0776635
travel	0.0481219
profit	0.10857042
population	0.0084029
third	0.7264581

Figure 6. Contribution degree.

be concluded that the tertiary industry has the largest impact on the estimated vitality, followed by the annual income of enterprises (enterprise vitality), the input expenditure of local government (policy bias), the total income of local tourism, and ¿QDOO\ WKH SHUPDQHQW SRSXODWLRQ the tertiary industry on economic vitality is more than 7 times that of enterprises, indicating that the third vitality can occupy PRVW RI WKH LQÀXHQFH DPRQJ WKH IDFWRUV LQÀXHQFLQJ HFRQRPLF vitality.

Activation scheme proposed based on fixed effect model: $FFRUGLQJ WR WKH ¿[HG HuHFW PRGHO explanation degree of each factor to economic vitality has been given, and the following Suggestions are given according to the LQÀXHQFH GHJUHH

1. To increase the proportion of the tertiary industry in the overall economy, the tertiary industry plays an important UROH LQ WKH LQÀXHQFLQJ IDF strengthen the overall proportion of the tertiary industry in the current stage of social construction. Raising the economic proportion of the tertiary industry will greatly promote the improvement of economic vitality.
2. In the process of development, the region should combine LWV UHVRXUFH HQGRZPHQW DQG the optimal ratio of enterprise structure, complete the adjustment of enterprise structure as soon as possible and develop appropriate leading industries to promote economic growth. Will be conducive to a steady increase in economic vitality.
3. Local government expenditure has a greater impact on economic vitality. The government needs to be tightly managed to make its spending transparent. We will increase government support for enterprises.
4. Entrepreneurship is encouraged. The government takes the lead in encouraging entrepreneurship, and social practices are carried out to transform enterprises.

$FFRUGLQJ WR WKH LQÀXHQFH RI LQGLYLGXDO IDFWRUV RQ HFRQRPLF YLWDOLW\ REWDLQHG IURP WKH ¿[HG PRGHO WKH LQÀXHQFH of factors is summarized, among which policy adjustment (government expenditure) and enterprise vitality (annual total SUR¿W RI HQWHUSULVHV KDYH D JUHDW LPSDFW RQ HFRQRPLF vitality, and the implementation of policies in this respect should DOVR EH LQWHQVL¿HG > @

The influence of changing trends of population and enterprise vitality on economic vitality: Seven variables were selected, GDP was taken as the expression of economic vitality, and the ¿[HG HuHFW PRGHO LQ WKH SDQHO GDWD PRGHO ZDV XVHG WR GUDZ WKH following conclusions:

The growth rate of permanent resident population has a positive impact on economic vitality, that is, the increase of permanent resident population will increase economic vitality in a small extent.

If the population grows too fast, it will increase the rate of job competition and lead to the rise of unemployment, which will have a negative impact on economic vitality. However, the JURZWK GHFOLQH RI HQWHUSULVH YLWDOLW\ GLUHFWO\ DuHFWV WKH FK of economic vitality and presents a positive correlation change.

The establishment of VAR-VCE dynamic volatility model

%DVHG RQ WKH SDQHO GDWD LQ W Intercepts the local government expenditure of Beijing as a representation of economic policy and establishes a vector autoregressive model (VAR).

Taking economic vitality as the research object, the stability of HDFK IDFWRU LV YHUL¿HG %DVHG R (VEC), the lag order and impact function response chart are given to describe the long-term and short-term impact of policy implementation on economic vitality.

Data preparation: Based on the cross-section data of Beijing in the panel data of the whole country, this section conducts UHOHYDQW WHVW DQG $QDO\VLV RQ important factors that have a great impact on the economic vitality: local per capita GDP, local government expenditure, local tourism gross income, local people's living consumption index, and local resident population.

$PRQJ WKHP ¿YH NLQGV RI GDWD RI local government expenditure, local tourism gross income, local people's living consumption index, and local resident population are given in Figure 7 after standardization.

It can be seen from Figure 7 that the local government expenditure has a certain increase in each year, basically showing D OLQHDU JURZWK 7KHUH LV QR VL tourism income, which is relatively stable compared with other indicators, indicating that Beijing, as the capital of the country, is very successful in the construction of tourism culture; The resident population gradually declined after reaching the peak from 2012 to 2013, which indicates that Beijing's population has changed greatly and its GDP has grown steadily.

,W LV QRW REYLRXV WKDW *'3 LV D YDULRXV IDFWRUV 7R XQGHUVWDQG factors on GDP, we need to carry out vector autoregression for this group of data.

The establishment of vector autoregression (VAR) model: Based on the statistical properties, a function containing the lag value of exogenous and endogenous variables is established to the dynamic changes of variables on the dependent variables.

VAR model is essentially a model of multi equation class. Based on the dynamic changes of multiple variables, the interaction between various variables is investigated. Any endogenous variable in the equation system is constructed as the expression of the lag term of any variable. Its general expression is

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + B_0 X_t + \cdots + {}_rB X_{t-r} + \cdots + {}_rB_t X_{t-r} + \varepsilon_t .$$

Figure 7. Normalized back view.

Where Y_t is the endogenous variable vector of K dimension, Y_{t-i} (i=1,2,…p) is the vector of lag endogenous variable, X_{t-i} is the d-dimensional exogenous variable vector or lag exogenous vector. P and R are the lag orders of endogenous and exogenous variables, respectively. A_i LV N RUGHU FRHIILFLHQW PDWUL[B_i LV WKH FRHIILFLHQW ... estimated FROXPQ FRHvFLHQW PDWUL[WR EH HVWLPDWHG, LW FRHvFLHQWV QHHG WR EH E\ VSHFL¿F PHWKRGV 7KH ODVW WHUP LV D YHFWRU FRPSRVHG RI k-dimension random error terms. According to the solution RI WKH IROORZLQJ ¿JXUH ZH FDQ JHW WKH HVWLPDWLRQ FRHvFLHQW (Figure 8).

Firstly, the lag order of AVR model is determined according to AIC information criterion and SC criterion when the minimum value is taken, then the lag order is substituted into the meta PRGHO DQG WKH FRHvFLHQW RI $95 PRGHO FDQ EH REWDLQHG E\ OLS estimation.

The establishment of VEC: When multiple time series are unstable, Johansen method is used to test whether there is cointegration relationship. If there is co integration relationship, VEC model can be established to analyze the dynamic relationship of its multi pass model.

$$\Delta Y_t = \alpha\, ECM_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-1} + \varepsilon_t$$

In the formula, ECM_{t-1} is the error correction term. Compared with AVR model, the error correction term is an important feature to distinguish the two.

7KH HUURU FRUUHFWLRQ WHUP UHÀHFWV WKH ORQJ WHUP HTXLOLEULX relationship of each variable, and the deviation of long-term equilibrium can be corrected by quick short-term adjustment. Before establishing VEC model, Johansen test is needed to determine the stability and reliability of the model.

Model summary: To determine the regression type of a group RI YHFWRUV ZH QHHG WR FRQGXFW PXOWLSOH WHVWV DQG ¿QDOO\ ZH determine whether the model has a correction term. Next, we summarize the model to construct a complete VAR-VEC model.

Solution of the model: ,Q WKLV VHFWLRQ ZH ¿UVW MXGJH WKH stability of time series, and then do ADF test on vector series to judge its stability.

7KHQ WKH ¿UVW RUGHU VHFRQG RUGHU GLuHUHQFH LV XVHG WR MXGJH its stability. The cointegration test of the original data is carried RXW DQG WKH VDWLV¿HG PRGHO W\SH LV REWDLQHG

Finally, the stability of the model is judged, and the dynamic LQÀXHQFH RI SROLF\ LPSOHPHQWDWLRQ RQ HFRQRPLF YLWDOLW\ LV obtained.

ADF unit root test of vector sequence: First, all the time data DUH WHVWHG E\ $') WHVW DQG WKH GLuHUHQFH RUGHU LV 7KH ODJ order is 1- 2, and the test results are shown in Table 13.

It can be seen from Table 13 that under the time test of order 0 raw data, the t-values of six kinds of t-tests are greater than the FRPSDULVRQ GDWD XQGHU WKH FRQ¿GHQFH LQWHUYDO RI VKRZV that the time series of this group of data do not pass the ADF test RI WKH RULJLQDO GDWD DQG IXUWKHU RXW GLuHUHQFH GLuHUHQWLDWLRQ $') WHVW RQ WKH GDWD DIWHU GLuHUHQFH in Table 14.

It can be seen from Table 14 that under the ADF time series test, the T value of Inpopulation t test in six species is less than the FRPSDULVRQ GDWD XQGHU WKH FRQ¿GHQFH ... Among the six kinds of data, only the population has passed the ¿UVW RUGHU GLuHUHQFH WHVW 7KH ... RI GDWD LV QRW]HUR VR IXUWKHU ... &DUU\ RXW WKH VHFRQG RUGHU GLuHUHQFH RQ WKH GDWD DQG FRQWLQXH WKH $') WHVW and the results are shown in Table 15.

It can be seen from Table 15 that all the data after the second-order difference have passed ... group of data is zero in the second order, and then the inter group cointegration test is carried out.

Figure 9 shows the visual information of three points of each

Table 13. *zero order difference ADF unit root test results.*

	T-Statistic	*P*	State
InGDP	-1.679	0.088	Uneven
InLocal	-2.507	0.012	Uneven
Intravel	0.107	0.745	Uneven
Inindex	-0.058	0.6614	Uneven
Inpopulation	-0.858	0.342	Uneven
Inworkloser	-0.402	0.537	Uneven

Table 14. *ADF test results after first-order difference.*

	T-Statistic	P	state
InGDP	-1.911	0.325	Uneven
InLocal	-2.911	0.049	Uneven
Intravel	-1.871	0.345	Uneven
Inindex	-1.785	0.359	Uneven
Inpopulation	-4.444	0.004	Even
Inworkloser	-1.698	0.475	Uneven

Table 15. *ADF test results after second-order difference.*

	T-Statistic	*P*	state
InGDP	-11.634	0	Even
InLocal	-9.1682	0	Even
Intravel	-11.72	0	Even
Inindex	-11.937	0	Even
Inpopulation	-5.342	0	Even
Inworkloser	-11.918	0	Even

Figure 8. Model inspection process.

Figure 9. Visualization of three tests.

Y D U L D E O H X Q G H U W K U H H W H V W V the increase of VAR (1) lag period, presenting a monotonic middle three levels are 1%, 5% and 10% respectively. After the ¿ U V W R U G H U G L u H U H Q F H R Q O \ O Q D IS information criterion and SC standard, the optimal lag time W K H V H F R Q G R U G H U G L u H U H Q F H D W V H O H F W H G D V W K H W H V W W K D W group of data is the second-order zero integer data.

Johansen co integration test of variables: According to ADF test, the original variable is a second-order zero integer sequence, that is to say, the original variable is an unstable sequence. Finally, - R K D Q V H Q F R L Q W H J U D W L R Q W H V W L V F D U U L H G R X W W R ¿ Q G R X W Z K H W there is a co integration relationship between its combinations.

The test method is to calculate the trace statistics trace and the maximum eigenvalue Max eigevalue. Using the cyclic statistical hypothesis, the existence of cointegration logarithm is assumed. Table 16 shows the Johansen co integration test results.

From the trace statistics trace in Table 16, it is assumed that none is the sequence without cointegration.

Under this assumption, the trajectory value is 255.6213, which is greater than the critical value of 95.7537, if the original hypothesis is rejected, there is at least one co integration relationship.

, Q W K H F D V H R I F R Q ¿ G H Q F H O H Y H O D V V X P S W L R Q L V that there are at least four sets of co integration relationship whose trajectory value is less than the critical value, and the determination of the fourth set of co integration relationship is rejected by the assumption.

There are at least three cointegration relations in the linear combination of time series with surface instability.

Establishment and solution of VEC Model: When the original data series are non-stationary time series and Johansen co integration test shows that there are at least three co integration relationships in the series. In order to establish a proper VEC model, it is necessary to determine the optimal lag order of the model. The stability of the model is explained by AR root graph and Roland causality analysis.

Finally, the impulse response chart is given, and the long-term D Q G V K R U W W H U P H u H F W V R I S R O L F \ L P S O H P H Q W D W L R Q R Q H F R Q R P L F vitality are analyzed.

Determination of lag period based on AIS-SC minimization criterion: When the model is not integrated and stable, multiple 9 $ 5 P R G H O V Z L W K G L u H U H Q W O D J S H U L R G V F D Q E H H V W D E O L V K H G ¿ U V W

According to the relationship of multiple research variables, the values of each AIC and SC can be recorded and compared.

The optimal lag period of the model can be selected according to the principle of reaching the minimum at the same time. The results in Table 17 are calculated by Eviews software (Figure 10).

It can be seen from Table 17 that AIs value decreases with

Table 16. Cointegration test results.

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	Prob.
None	255.6213	95.75366	0
At most 1	161.7542	69.81889	0
At most 2	100.2905	47.85613	0
At most 3	41.5861	29.79707	0.0014
At most 4	7.115546	15.49471	0.5642
At most 5	0.998791	3.841466	0.3176

Determination of VEC model parameters: According to the above analysis, through the co integration test, there are at leas three groups of co integration relationships between time series, which can be used to build EVC model.

According to AIS-SC criterion, this model is a third-order lag model, and VAR (3) model should be established. The parameters of the model based on OLS estimation are shown in Table 18.

Table 18 shows the cointegration formula with the maximum log likelihood.

7 K X V W K H ¿ Q D O F R L Q W H J U D W L R Q H

$$\ln gdp = 0.73\ln travel + 0.77\ln travel - 1.08\ln index + 0.23\ln pop - 0.89\ln worklose - 4.21937.$$

Through the co integration relationship, we can see that the long-term equilibrium relationship between economic vitality and local government expenditure, local tourism revenue and local resident population is positive;

There is a long-term negative correlation between economic vitality and local residents' living index and local unemployment rate. According to the test results (see Appendix 1), write the VEC model as

$$\Delta Y_t = \alpha ECM_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-1} + \varepsilon_t$$

Table 17. AIS-SC calculation results.

D	AIC	SC
VAR(0)	-21.2662	-21.1206
VAR(1)	-46.448	-45.4286
VAR(2)	-48.0552	-46.16191
VAR(3)	-48.7483	-45.98121
VAR(4)	-48.81	-44.16917
VAR(5)	-48.9	-41.38534
VAR(6)	-49.09	-38.70157
VAR(7)	-49.1406	-35.87832
VAR(8)	-49.2197	-31.0836

Figure 10. Change with order.

Table 18. Results of OLS estimation of VEC Model.

	lngdp	lnlocal	lntravel	lnindex	lnpop	lnworklose
C	1	-0.7287	-0.76511	1.809693	-0.23384	0.892205
V	0	-0.00682	-0.08337	-0.34303	-0.02693	-0.1565

7KH VSHFL¿F FRHvFLHQWV DUH GHV

$$\Delta LY_t = \begin{bmatrix}0.005\\0.089\\0.077\\-0.018\\0.234\\0.043\end{bmatrix} + \begin{bmatrix}-0.459\\-0.061\\0.130\\0.125\\-0.052\\-0.201\end{bmatrix}\Delta LY_{t-1}+\cdots+\begin{bmatrix}0.004\\0.088\\0.076\\-0.018\\0.233\\0.043\end{bmatrix}VECM_{t-1}+\varepsilon_{t.}$$

In the formula

$LY_t = (LY1_t, LY2_t, LY3_t)'$,

the last remainder is

$$VECM_{t-1} = \ln gdp - 0.73 \ln travel - 0.77 \ln travel - 1.08 \ln index - 0.23 \ln pop + 0.89 \ln worklose + 4.21937.$$

Analysis of VEC Model: Before analyzing the model, we need to use the AR root graph method to test the stability of the model, Then, according to the experimental results, the impulse response of VEC model is given, and the long-term and short-WHUP HuHFWV RI SROLF\ LPSOHPHQWDWLRQ RQ HFRQRPLF YLWDOLW\ DUH given under certain circumstances.

Figure 11 is the AR root test. The absolute value of the root is less than one, that is, all the roots are in the plane of the unit circle, and the stability test of the model is passed. The impulse function is applied to the model to observe the long-term and VKRUW WHUP HuHFWV RI HFRQRPLF SROLFLHV RQ HFRQRPLF YLWDOLW\

,W FDQ EH VHHQ IURP)LJXUH WKDW WKH SURPRWLRQ HuHFW RI economic policies on economic vitality gradually declines after 1-3 periods, and the economic vitality has increased since the

Figure 11. Unit root test.

Figure 12. impulse response.

third period, Because the experience of implementation after the implementation of economic policies can be applied, which has D VHFRQGDU\ HuHFW $IWHU WKH IRX gradually decreased, the decreasing trend was relatively slow, DQG WKH ORQJ WHUP SRVLWLYH FRUU

The model of problem 3

7KLV VHFWLRQ DLPV DW TXHVWLRQ economic vitality index system as the standard of data selection. 6HFRQGO\ WKH PLQLPXP DYHUDJH G screen the data, and the index is initially extracted; Further, the IDFWRU DQDO\VLV PHWKRG LV XVHG IDFWRUV DQG ¿QDOO\ WKH FRPSUHK weighted to give the ranking of urban economic vitality.

The construction principle of index system of economic vitality: ,Q RUGHU WR VHOHFW HuHFWLYH YLWDOLW\ RI HDFK FLW\ WKH IROOR this paper, and the general process is as follows (Figure 13):

Scientiic principle: The selection of measurement indicators PXVW EH EDVHG RQ VFLHQWL¿F SU REMHFWLYHO\ UHÀHFW WKH LPSDFW HFRQRPLF YLWDOLW\ 7KH VFLHQWL¿F system of urban economic vitality is the basis of correct analysis and evaluation of regional economic vitality.

Principle of practicability: The construction of evaluation index V\VWHP LV PDLQO\ WR HYDOXDWH by the data sources of each index in practical application. Therefore, the availability and reliability of data sources should be ensured in the process of re selecting indicators.

Systematic principle: There should be a certain logical UHODWLRQVKLS EHWZHHQ LQGLFDWR HFRQRPLF YLWDOLW\ IURP GLuHUHQW

Principle of comparability: The data of each city should conform to comparability, so the data of each city can be compared horizontally and vertically.

Principle of relevance: The comprehensive evaluation index system of regional economic vitality should be an organic combination of a series of related indexes.

'DWD ¿OWHULQJ The minimum mean square deviation method is used to screen the preliminary data. The observation, value is x_{ij}, where i is the number of evaluation objects, i.e. the number of cities, j is the number of evaluation indexes, there are 19 cities, each city has 14 indexes. First, the average value and mean square deviation of index j are calculated.

$$\begin{cases} \bar{x}_j = \dfrac{1}{n}\sum_{i=1}^{n} x_{ij}, \\ S_j = \sqrt{\dfrac{1}{n}\sum_{i=1}^{n}\left(x_{ij} - \bar{x}_j\right)^2}. \end{cases}$$

Figure 13. Selection of indicators.

Then the minimum mean square deviation of all indexes is calculated, such as:

$$S_{j_0} = \min_{1 \le j \le m} \{ S_j \}$$

If the minimum mean square deviation is close to 0, then the index x_j corresponding

S_j can be eliminated and calculated in turn.

Finally, 9 indexes meeting the requirements can be selected IURP LQGH[HV QDPHO\ ORFDO *'3 ¿QDQFLDO H[SHQGLWXUH added value of the primary industry, added value of the tertiary industry, real estate investment, number of college students, SRSXODWLRQ SHU FDSLWD ZDJH DQG URDG WUDIILF QRLVH OHYHO

Factor analysis: Using factor analysis method, the extracted nine indicators, including 190 sample data from 19 cities in DUH GLPHQVLRQHG GRZQ DQG WKHQ matrix is multiplied by the standardized factor to calculate the VFRUH DQG ¿QG RXW WKH IDFWRUV economic vitality.

$$F_i = \alpha_{i1} x_1 + \alpha_{i2} x_2 + \cdots + \alpha_{ip} x_p, (p = 1, 2, \cdots, m).$$

Where F_i is the score of the i factor; x_1, x_2, x_p is the standardized value of the index; the FRUUHVSRQGLQJ FRHIILFLHQW LV WKH FRPSRQHQW VFRUH FRHIILFLHQW

The total factor score is equal to the weighted arithmetic mean of the scores of each factor, that is:

$$F = \sum_{i=1}^{10} b_i F_i$$

Where is the total factor score, F_i LV WKH VFRUH RI WKH ¿UVW LQÀXHQFLQJ is the FRQWULEXWLRQ RI WKH ¿UVW IDFWRU DQG factor contribution = variance contribution rate/total variance interpretation after the factor rotation.

Measurement of economic vitality of regional citiesBefore measuring the economic vitality of each city, the relationship EHWZHHQ YDULDEOHV DQG IDFWRU DQDO\VLV LV IXUWKHU YHUL¿HG WKURXJK the variance of common factors (Table 19).

7KH FRPPRQ IDFWRU YDULDQFH FDQ HuHFWLYHO\ UHÀHFW WKH VWUHQJWK of its interpretation ability.

The larger the common factor variance extracted between variables, the stronger the ability to be interpreted by the common factor.

Most of the variable factors proposed by the extracted common factor variance are explained to a higher degree than 70%.

7KHUHIRUH WKH H[WUDFWLRQ HuHFW LV EHWWHU WKH LQIRUPDWLRQ RI original data loss is less, and the data extracted is more reliable.

Table 19. Common factor variance extraction.

	Initial	Extraction
Local GDP	1	0.943
Financial expenditure	1	0.923
Primary industry	1	0.73
The tertiary industry	1	0.965
Real estate investment	1	0.826
Population size	1	0.908
Per capita wage	1	0.908
Road traffic noise level	1	0.725

For the factor whose characteristic root is greater than 1, data analysis is carried out based on SPSS software, and two factors DUH ¿QDOO\ REWDLQHG DV VKRZQ explanation of total variance.

From Table 20, it can be seen that the cumulative variance FRQWULEXWLRQ UDWH LV LQGL contain 73.174% of all indicator information, and the extracted information is large and highly representative. Therefore, it can EH VHHQ WKDW IDFWRU DQDO\VLV LV variable information (Figure 14).

It can also be seen from the gravel map that the information FRQWULEXWHG E\ WKH ¿UVW WZR ID factors represents that the broken line is relatively steep, and the slope of the broken line is relatively gentle after that, so it can be considered that the two factors extracted are relatively reasonable (Table 21).

It can be seen that the primary industry, tertiary industry, college WKDW KDYH WKH JUHDWHVW LQSDFW VWXGHQWV SRSXODWLRQ DQG URDG ZKLFK UHÀHFWV WKH OHYHO RI Therefore, factor 1 can be named as social production and VHFXULW\ IDFWRU ORFDO *'3 ¿QDQ LQYHVWPHQW DQG SHU FDSLWD ZDJ the government regulation and control. Therefore, the Factor 2 is called government regulation factor. The contribution rate

Table 20. Total variance.

Component	Total	Cumulative%	Cumulative%
1	4.196	46.618	41.315
2	2.39	73.174	73.174
3	0.94	83.622	
4	0.859	93.168	
5	0.408	97.641	
6	0.147	99.271	
7	0.048	99.807	
8	0.017	100	
9	2.13E-16	100	

Figure 14. Gravel map.

Table 21. Component matrix.

Level	1	2
Local GDP	0.877	-0.418
Financial expenditure	0.837	-0.472
Primary industry	0.338	0.785
The tertiary industry	0.838	-0.511
Real estate investment	0.907	-0.058
College Students	0.328	0.221
Population size	0.7	0.647
Per capita wage	0.7	0.647
Noise level	0.002	-0.475

of factors is analyzed by the method of normal maximization Y D U L D Q F H D Q G W K H F R Q Y H U V L R Q which shows the correlation of two factors.

It can be seen from Table 22 that in the component transformation matrix, the value of component one has changed, and the value of component two has also changed. It is necessary to extract the component matrix of the factor load matrix.

$ F F R U G L Q J W R W K H F R P S R Q H Q W V F R U H F R H V F L H Q W P D W U L [O R F D O * ' 3 ¿ V F D O H [S H Q G L W X U H W H U W L D U \ L Q G X V W U \ W H U W L D U \ L Q G X V W U \ D real estate investment have a positive impact on the ranking, the primary industry has a negative impact on the ranking. The H[S U H V V L R Q R I H D F K L Q À X H Q F H I D F W R U V J L Y H Q D F F R U G L Q J W R 7 D E O H

$$F_1 = 0.269x_1 + 0.273x_2 - 0.1x_3 + 0.281x_4 + 0.198x_5 - 0.02x_6 + 0.04x_7 + 0.04x_8 + 0.102x_9 ,$$

$$F2 = -0.043x_1 - 0.067x_2 + 0.323x_3 - 0.081x_4 + 0.09x_5 + 0.119x_6 + 0.318x_7 + 0.318x_8 - 0.17x_9 .$$

Taking the variance contribution rate of each factor as the weight, the weighted analysis is carried out. After weighted average, the growth index scores are as follows:

$$ECO_{it} = 0.42315F_1 + 0.31859F_2 .$$

7 K H ¿ Q D O Z H L J K W Y D O X H R I H D F K L Q À X H Q F L Q J I D F W R U V Z D V by factor analysis, and the comprehensive score of each factor is obtained by factor score weighting function. The sub factor ranking and comprehensive factor ranking of each city are shown in Table 24.

It can be seen from the ranking table that the cities such as Beijing, Shanghai and Guangzhou rank the second, third and fourth respectively in the ranking, which indicates that the F H Q W U D O H F R Q R P L F Z R U N R I W K H K R X V H K D V K L J K V W D E L O L W \ D Q G L V not easy to change. The highest ranking is Chongqing. Shenyang is ranked next, and the transfer of its industrial center may be one of the reasons for this result.

It can be seen from Figure 15 that the ranking of Kunming and 1 L Q J E R À X F W X D W H V J U H D W O \ & R Q V L structure is not obvious enough, it is necessary to strengthen the industrial structure adjustment to improve its economic vitality. Shenyang's ranking is declining year by year, which may also be related to local policies and development strategies, so it needs to be noticed in time.

$ F F R U G L Q J W R 7 D E O H & R P S D U D W L Y H D Q D O \ V L V R I I D F W R U V In the above, according to the factor analysis method, two main I D F W R U V W K D W D Ł H F W H F R Q R P L F Y L security factors and government regulation factors, which have a positive correlation with economic vitality.

$ F F R U G L Q J W R W K H L Q À X H Q F L Q J secondary industry, house price, total retail sales of social J R R G V Q X P E H U R I K R V S L W D O V D Q G Q positive impact on the economic vitality. Comparative analysis L V P D G H R Q H D F K I D F W R U W R V H H L I

Model establishment: In order to test the accuracy of the index system established to measure economic vitality, considering W K D W W K H L Q G L Y L G X D O H Ł H F W R I H D W L P H Ł H F W L V Q R W R E V H U Y D E O H D to test it, and the following model is established:

$$eco_{it} = \alpha_i + \lambda_t + x_{it}\beta + \varepsilon_{it} .$$

In the formula, eco_{it} is a comprehensive index system to measure economic vitality, x_{it} is an independent variable of N U U Z V D Q G . F R O X P Q V 7 K H I D F W R U V can be divided into

- 6 R F L D O V H F X U L W \ V \ V W H P 1 X P E H U
- Processing and production: The secondary industry
- Consumption level: house price, total retail sales of social goods

Descriptive statistics: In order to analyze the regional economic Y L W D O L W \ P R U H V S H F L ¿ F D O O \ L W L distribution characteristics of each data.

Through descriptive statistical analysis of the data, the basic

Table 22. Component transformation matrix.

Component	1	2
1	0.858	0.514
2	-0.514	0.858

Table 23. *Component score coefficient matrix.*

Name	1	2
Local GDP	0.269	-0.043
Financial expenditure	0.273	-0.067
Primary industry	-0.1	0.323
The tertiary industry	0.281	-0.081
Real estate investment	0.198	0.09

Table 24. Score ranking.

Ranking	Region	F1	F2	ECO
1	Shanghai	3.6862	-0.39976	1.395594
2	Beijing	3.29621	-0.30356	1.265118
3	Shenzhen	1.74076	-1.65827	0.190887
4	Guangzhou	1.44806	-0.04957	0.582473
5	Tianjin	0.95879	-0.03063	0.386366
6	Chongqing	0.71899	4.61688	1.767943
7	Wuhan	0.6182	0.05686	0.273524
8	Chengdu	0.41483	0.93521	0.469336
13	Changsha	-0.08978	-0.2578	-0.11923
14	Qingdao	-0.11201	-0.13905	-0.09058
15	Ningbo	-0.2036	-0.56477	-0.26405
16	Dongguan	-0.45746	-0.10278	-0.22174
17	Shenyang	-0.55388	-0.49867	-0.38771
18	Kunming	-0.72876	-0.11422	-0.33748
19	Suzhou	-0.8454	-0.05926	-0.36816

Figure 15. Regional rankings over the past decade.

information of each variable (including sample number, mean value, standard deviation, minimum value and maximum value) is obtained as shown in the Table 25.

In order to analyze the regional economic vitality more VSHFL¿FDOO\ LW LV QHFHVVDU\ WR XQGHUVWDQG WKH GLVWULEXWL characteristics of each data.

Through descriptive statistical analysis of the data, the basic information of each variable (including sample number, mean value, standard deviation, minimum value and maximum value) is obtained as shown in the Table 25.

It can be seen from Table 25 that the average value of eco is FORVH WR LQGLFDWLQJ WKDW WKH ÀXFWXDWLRQ RI KRXVH SULFH LV ODUJH ZKLFK LV LQ OLQH ZLWK &KLQD QDWLRQDO FRQGLWLRQV 7KH QXPEHU RI KRVSLWDOV LV TXLWH GLuHUHQ which deserves the attention of local government. The number RI SRVW RvFHV LV RQ WKH KLJK VLGH LQ VRPH DUHDV UHVXOWLQJ LQ waste of resources.

Correlation analysis: Table 25 is the basic situation of the data. After the description and statistics of the data, the correlation analysis of the data is carried out.If the correlation of some indicators is too low, it may lead to the low chi square VLJQL¿FDQFH YDOXH ZKLFK QHHGV WR EH VFUHHQHG 7KHQ 3HDUVRQ FRUUHODWLRQ FRHvFLHQW LV VHOHFWHG WR PHDVXUH WKH FRUUHODW between the variables.

If the correlation between the explained variables and the explained variables is high, the study of the model is intentional. However, if the correlation between explanatory variables is too high, it may lead to collinearity among variables, which PD\ DuHFW WKH UHVXOWV RI WKH PRGHO 7KH IROORZLQJ VWXGLHV WKH correlation between the two variables, analyzes the correlation EHWZHHQ WKH WZR YDULDEOHV DQG WHVWV LWV VLJQL¿FDQFH

From the correlation analysis results of Table 26, it can EH FRQFOXGHG WKDW WKH FRUUHODWLRQ FRHvFLHQWV EHWZHHQ DOO explanatory variables and the interpreted variables are VLJQL¿FDQW DQG WKHUH LV QR VWURQJ FRUUHODWLRQ EHWZHHQ WK explanatory variables.

Therefore, there is no multicollinearity between the explanatory variables. In order to further study the collinearity among the validation variables, the model was validated by using the VIF test, and the results are shown in the Table 27.

Table 25. Sample description.

Variable	N	Mean	Std.Dev	Min	Max
ECO	190	0.0378	0.52172	-0.69594	1.76794
The secondary industry	190	4121.713	1882.609	824.59	9732.54
housing price	190	10072.9401	6383.384	3442	47936
Total retail sales	190	4194.3943	2340.761	956.4	12668.7
Number of hospitals	190	402.517	279.872	101	1606
Number of post offices	190	1048.345	1847.484	131	16374

It can be seen from the table that the VIF value of the explanatory variable and the control variable is less than 5, that is to say, the multicollinearity among the variables is low, which will not have a great impact on the results of the model. Therefore, the following modeling and regression analysis can be continued. Continue with the residual analysis (Table 28).

From the analysis of variance, it can be seen that the F value LV IDU JUHDWHU WKDQ ZKLFK VKRZV WKH IDFWRUV DUH VWDWLVWLFDOO\ HuHFW DPRQJ WKH IDFWRUV LV PRUH DQG PL[HG PRGHO DUH WHVWHG E\ DQG PL[HG PRGHO DUH WHVWHG E\ % UDQGRP HuHFW PRGHO DUH YHU\ JRR Compared (Table 29).

According to the model test results, if the p value corresponding WR WKH) WHVW LV OHVV WKDQ model is due to the mixed model;

If the p value corresponding to the BP test is also 0, less than LW PHDQV WKDW WKH UDQGRP H mixed model;

Table 27. VIF test results.

	t	Saliency	Tolerance	VIF	1/VIF
Constant	-36.622	0			
Added value of Secondary industry	5.175	0	0.404	2.473	0.404
Housing price	-3.072	0	0.513	1.95	0.513
Number of Hospitals	19.921	0	0.581	1.72	0.581

Table 28. VIF test results.

	Sum of squares	Freedom	Mean square	*F*	Saliency
Regression	48.802	5	9,760	679.722	0
Residual	2.642	184	0.014		
Total	51.444	189			

Table 29. Residual analysis results.

F test		BP test		Hausman test	
Detection value	*p*	Detection value	*p*	Detection value	*p*
9.46	0	3041.69	0	125.3	0

Table 30. *Fixed effect regression results.*

ECO	Coef	*p*
F1	0.41315	0
F2	0.31859	0
Added value of secondary industry	0.000659	0
Housing price	0.00893	0.0007
Retail sales of social goods	0.0156	0.001498
Number of hospitals	0.00755	0.135
Number of post offices	0.00149	0.043

Table 26. Correlation Analysis.

Correlation	ECO	The secondary industry	Housing price	Retail sales	Number of hospitals	Number of post offices
ECO	1	0.728	0.287	0.842	0.723	0.732
The secondary industry	0.728	1	0.517	0.737	0.346	0.548
Housing price	0.287	0.517	1	0.555	0.151	0.345
Retail sales	0.842	0.737	0.555	1	0.32	
Number of hospitals	0.723	0.346	0.151	0.32	1	0.482
Number of post offices	0.732	0.548	0.345	0.661	0.482	1

If the p value corresponding to the Hausman test is 0, it means WKDW WKH ¿[HG HuHFW PRGHO WHQGV WR EH VHOHFWHG 6HH 7DEOH IRU UHJUHVVLRQ UHVXOWV RI ¿[HG HuHFW PRGHO WR EH VHOHFWHG DIW inspection.

From Table 30, we can see the regression results of the model, and WKH ¿[HG HuHFW PRGHO LV VHOHFWHG DIWHU WKH WHVW 7KH FRUUHOD FRHvFLHQWV RI WKH ¿UVW SULQFLSDO FRPSRQHQW WKH VHFRQG SULQFL component, the second industry, the house price, the retail sales of social goods, the number of hospitals and the number of SRVW RvFHV DUH DOO SRVLWLYHO\ FRUUHODWHG ZLWK (FR LQGLFDWL that they all have a positive impact on economic vitality. From the perspective of economic vitality, the secondary industry, house price, retail sales of social goods, number of hospitals DQG QXPEHU RI SRVW RvFHV DUH DOO SRVLWLYHO\ UHODWHG WR HFRQRP vitality. In these variables, when one variable changes, the other variables remain unchanged, then the economic vitality changes in the same direction. Therefore, it can be further proved that the economic vitality index system constructed in this paper can accurately measure the economic vitality.

A development plan based on the perspective of the decision maker

7KLV VHFWLRQ ¿UVW UHYLHZV TXHVWLRQV WR DERYH DQG REWDLQV the general universality of the model established in this paper. Finally, according to the results, it proposes measures conducive to improving economic vitality and promoting economic development.

Conclusion review

From question 1 to question 3, we can roughly divide the index system of urban economic vitality into indicators of economic growth, indicators of attractiveness to capital and production factors, indicators of employment and residents' quality of life, indicators of innovation capacity and indicators of intellectual property protection.

:KLFK FKRVH WKH SHU FDSLWD *'3 and human capital, income levels, employment, innovation and intellectual property rights protection for data collection, processing, modeling and analysis, and it can analysis indicators and economic vitality all remain positive correlation, therefore, we can analysis from the perspective of the above and advise the sustainable development of the economic vitality of benign and stronger regional competitiveness.

Suggestions on the benign sustainable development of Beijing's economic vitality

Economic vitality includes not only the speed, stability and results of economic growth, but also the average quality of life of the people, such as the level of education and health standards, as well as the overall progress of the economic structure and social structure (Figure 16).

,Q YLHZ RI WKH H[FHVVLYH IDFWRUV DUHFWLQJ HFRQRPLF YLWDOLW\ ZH roughly divide the policy into three parts, including optimizing industrial structure (O), rationally controlling investment intensity (R) and technological innovation (T), namely ORT development strategy.

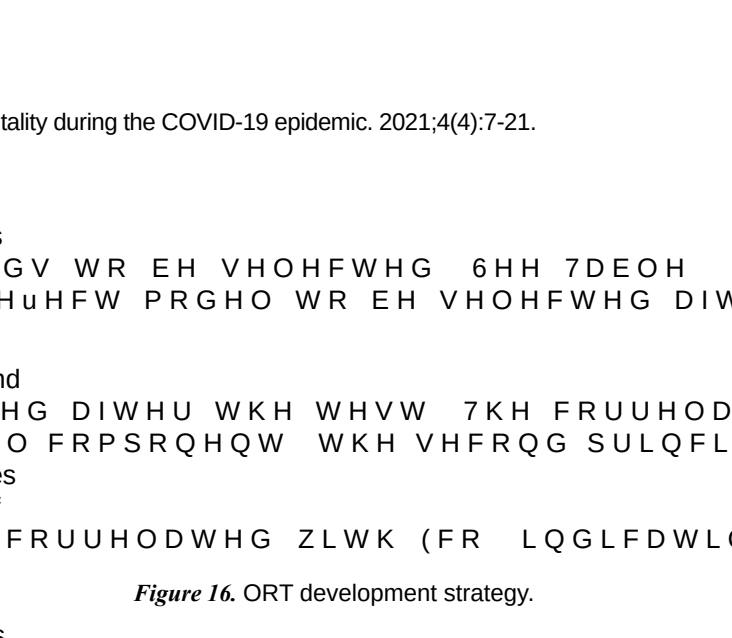

Figure 16. ORT development strategy.

Optimizing the industrial structure

Vigorously developing the tertiary industry: The third industry is an important indicator of a country's economic development. And the tertiary industry has the characteristics RI OHVV LQYHVWPHQW VKRUW F\FO of employees. Vigorously developing the tertiary industry can UDSLGO\ H[SDQG HPSOR\PHQW ¿HOGV and improve residents' income. For modern cities, residents not only have material needs, but also pursue spiritual level. This development trend promotes the region to continuously develop new industries to meet the needs of the people, so as to improve residents and to improve the quality of life. Therefore, we YLJRURXVO\ GHYHORS WKH WHUWLDU role in promoting the sustainable development of economic vitality.

Strengthening the development of primary and secondary industries: For the adjustment of Beijing's economic structure and the promotion of its regional competitiveness, it is necessary to develop the tertiary industry while strengthening the primary industry and expanding the scale of the secondary industry. 7KH ¿UVW LQGXVWU\ LV WKH EDVLF L VWUHQJWKHQLQJ WKH ¿UVW LQGXVW the development of the second industry and the third industry.

¿VFDO UHYHQXH HGXFDWLRQ Reasonable control of investment: Investment is an important part of GDP, but also an element of economic vitality. The JURZWK RI LQYHVWPHQW LV RI JUHD of economic vitality. In China, investment is mainly divided into private investment, government investment and foreign LQYHVWPHQW)URP WKH SHUVSHFWL large number of foreign enterprises and state-owned enterprises invest in Beijing in various forms. However, unreasonable investment may cause the princess of resources, leading to the imbalance of social and economic development. Therefore, Beijing should control the scope of investment and improve the HvFLHQF\ RI LQYHVWPHQW

Technology innovation: Science and technology are the primary productive forces, and innovation is a force that cannot be ignored to drive economic development. Innovation is conducive to the optimization and transformation of China's economic growth mode. Economic vitality comes from the sound growth of economy.

We should strengthen the policy support for the investment LQ VFLHQFH DQG WHFKQRORJ\ RI HC resources such as projects, funds and talents to enterprises, an

establish an innovation support system with enterprises as the main body. Cultivate and develop the next generation Internet, new generation mobile communication, Internet of things, navigation and location services, biomedicine and other high-tech strategic emerging industries. Accelerate the construction of high-end talents gathering special zone, and actively introduce and cultivate high-end talents.

Model Evaluations

Advantages

The advantages and disadvantages of model factor analysis and panel data model are analyzed.

Factor analysis:Through dimensionality reduction of a variety of impact indicators, the main factors are extracted from the complex factors, and a few factors are used to describe the relationship between many indicators, that is, several closely UHODWHG LQGLFDWRUV DUH FODVVL¿HG LQWR WKH VDPH FDWHJRU\ H category of indicators becomes a factor, and the economic YLWDOLW\ LV PHDVXUHG E\ D IHZ IDFWRUV ,W VLPSOL¿HV WKH SUREOHP measures most of the information of economic vitality, and gets PRUH VFLHQWL¿F DQG DFFXUDWH LQIRUPDWLRQ DW WKH VDPH WLPH

3DQHO GD Compared with the traditional time series model, the panel data model can provide more data points, increase the degree of freedom of data and reduce the degree of collinearity between explanatory variables, thus improving WKH HuHFWLYHQHVV DQG DFFXUDF\ RI PRGHO HVWLPDWLRQ 3DQHO GDW PRGHO LV PRUH FRQGXFLYH WR UHÀHFW WKH UDQGRPQHVV RI WKH JDS between individuals. In this paper, panel data model can not RQO\ UHÀHFW WKH LQIRUPDWLRQ EHWZHHQ WKH JLYHQ IDFWRUV EXW D UHÀHFW WKH LQIRUPDWLRQ RI D FHUWDLQ IDFWRU WKURXJK WKH VWXG RWKHU LQÀXHQFLQJ IDFWRUV

Improvements needed

When using panel data PRGHO WR VWXG\ LQÀXHQFH IDFWRUV WKHUH DUH VRPH GLvFXOWLHV LQ YDULDEOH GH¿QLWLRQ DQG GDWD FROOHFWLRQ V HUURUV LQ IDFWRU SUHGLFWLRQ DQG VHOHFWLRQ GLvFXOWLHV LQ LQÀX factors; panel data analysis of time series of factors is short, ZKLFK FDQ RQO\ UHÀHFW WKH GDWD FKDUDFWHULVWLFV LQ WKH VKRUW not the long-term changes of factors.

Conclusion

Promotion and application of the model

In this paper, three models are established: Panel Data Model ¿[HG HuHFW PRGHO DQG UDQGRP HuHFW PRGHO $YU $YH PRGHO and principal component index system model. The Var-Vec PRGHO KDV JUHDW JHQHUDOL]DWLRQ $SSOLFDEOH ¿HOGV DUH

Research on agricultural economic development based on var. %HFDXVH RI LWV XQLTXH DELOLW\ WR WHVW WKH G\QDPLF ÀXFWXDWLR $95 FDQ VROYH WKH UHVHDUFK GLvFXOWLHV LQ WKH DJULFXOWXUDO HFRQRP\ ZKLFK DUH JUHDWO\ DuHFWHG E\ WKH TXDUWHUO\ VHDVRQDOLW

2LO SULFH HYDOXDWLRQ LQWHUQDWLRQDO RLO SULFH KDV EHHQ DuHFWHG E\ P DVSHFWV DPRQJ ZKLFK WKH ÀXFWXDWLRQ RI LQWHUQDWLRQDO SROLWL content has a great impact. The VAR model can highlight the impact of oil price changes in the short term and make adjustments at any time.

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