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Review Article

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 establishes a model to solve them. We build panel data model to analyze the influencing factors of economic vitality. Based on the section data of Beijing, the VAR-VEC model is established to analyze the long-term and short-term effects of economic policies on economic vitality. The development strategy of ORT is put forward, and the scheme to promote the growth of economic vitality is given during the COVID-19 epidemic.

For the first problem, the papers pre-process panel data, and tests its independence, and find that each factor is not independent of each other. Through the correlation analysis, we found that there is a strong correlation between the various elements. After Random Effect Test and Fixed Effect Test combined with Hausman Test, the data panel conforms to fixed effect model. Population change and enterprise vitality have a positive impact on economic vitality, the influencing factors 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 selects the section data of Beijing city and constructs the VAR-VEC model. Based on ADF unit root test and Johansen co-integration test, we find that there are at least three co-integration relationships between time series. We use Ais-Sc Criterion to determine the order of delay as the third order. We use OLS estimation method to get the coefficients of VEC Model. Through the IRF response, we find that the long-term impact of economic policy on economic vitality is positive correlation effect. Due to the effect of experience accumulation, the economic vitality presents a W-shaped trend.

For the third problem, the paper uses the minimum average deviation method to pre-process 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 rank first, while Kunming and Dongguan often rank last. Based on the same data, the panel data 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.

Keywords: Panel data model; VAR-VEC model; Factor analysis; Index system

INTRODUCTION

Under the background of new age, China's economic, social, cultural, ecological, political and other fields are coruscate 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 between different regions is the concentrated reflection of 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].

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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 influencing factors of economic vitality, and give the action plan to improve the regional economic vitality. The influence 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.

MODELS

Data analysis and processing: Based on the collected data has certain error and deficiencies, in order to reduce the invalid, the influence of the error data of the following model, improve the reliability of data, need to collect the data pre-treatment, firstly the filtered data, remove abnormal data, secondly, proper supplement of incomplete data, finally, has strong correlation data linear regression analysis forecasting and slight fluctuation data using the moving average method to fill the missing value, to further improve the accuracy and the integrity of the data [8,9].

1. Data selection Principle: This paper needs to collect various indicator data describing economic vitality and influencing economic vitality, and the following classical indicators can be obtained according to the expert method and the literature [10-15] (Table 1).

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 ability Total corporate profitsy Per capita years of education. The inflow of professional and technical personnel

2. Independence Test: In the analysis of the relationship between the factors affecting economic vitality, in order to fully 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.

Firstly, chi-square independence test was conducted and SPSS was used to conduct independent test for each influencing factor to observe whether there was any correlation between each factor. The test results are as follows:

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%
Work loser	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%

It can be seen from Table 2 that the cross relation between each factor and the year, and the cross table shows the availability of different influencing factors, all of which occupy a complete percentage, indicating that the selected data are valid values with high accuracy, which can be further compared in pairs to test the independence of judgment factors. The significance analysis is used to determine whether there is independence between factors. The chi-square significance test results are shown in Table 3.

Table 3: Chi-square significance test results.

	Numerical	Df	Asymptotic significance (2 ends)
Person square test	2753847.871[a]	2745	.000
Likelihood ratio	1416065.1	2745	.000
Linear to linear	13402.742	1	.000
The number of Valid observations	309309		.000

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 null hypothesis is rejected, that is, the influencing factors are not independent of each other.

3. 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:

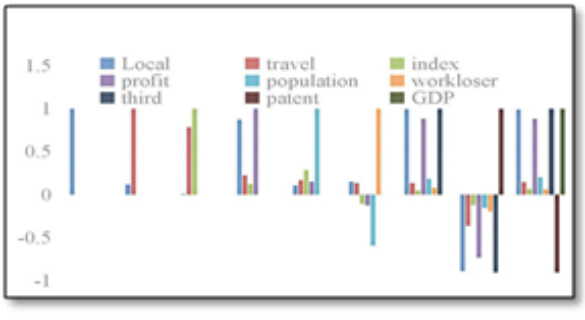

Figure 1: The linear strength relationship between the factors.

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, Consumer price index, Education funds, Total corporate profits, 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.

Correlation coefficients can quantitatively describe the closeness of linear relationships among factors, and SPSS is used for correlation analysis to obtain the correlation coefficients among the influencing factors, as shown in Table 5.

According to the above correlation analysis Table 5, there is a correlation among all factors, and the positive correlation coefficient is distributed between 0.5 and 1, reflecting a strong correlation; and then according to the significance test of the correlation coefficient, the significance values are all less than 0.05, indicating that the correlation coefficient has reached a high level of significance. Therefore, there is a strong correlation between various factors influencing economic vitality.

Establishment of model: This section is based on the panel data of various factors collected from 31 provinces and cities in China from 2009 to 2018. Considering the influence of 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 models, as shown in Table 6.

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 factors affecting economic vitality are 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:

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

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

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

2. **Model determination based on Hausman test:** Because the missing related variables are not excluded, there will be dependent variable-local GDP will change with the same period correlation of random interference items, and the constraint conditions of exogenous variables are not satisfied, so that the OLS estimator is biased and different. OLS is used to test the fixed effect model and GLS is used to test the random effect model. According to the reference [13], the difference between the random effect model and the fixed effect model is that it is difficult to try to make a high degree of distinction on the description of individuals. The

Table 4: Correlation analysis.

	Average	Standard deviation	95% confidence interval (lower bound upper bound)	significant
Local	4047.2789	2473.4606	(3788.2312, 4321.1274)	0.047
travel	2071.1539	3068.7924	(1732.0034, 2455.2115)	0
index	102.306	1.5306	(102.134, 102.473)	0.006
profit	2024.945	2138.7965	(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	8985.1614	(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

fixed effect will cost more degrees of freedom, while the random effect is more universal. The proposed Hausman test can be used to distinguish them to some extent.

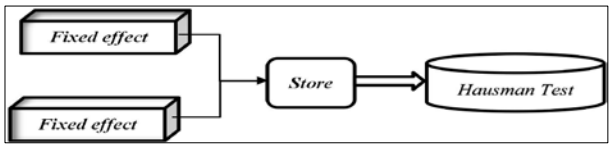

Figure 2: Inspection process.

1. Data stability and reliability analysis: The data of this paper comes from China National Statistical Yearbook, which includes the local government's financial expenditure, the total income of local international tourism, consumer price index, total profits of enterprises, population, unemployment, tertiary industry, total patents and local GDP. The inconsistency of the order of magnitude of each part will cause trouble to the model fitting. According to the statistical yearbook, the city is divided into 1-31, and the distribution of various data is shown in Figure 2.

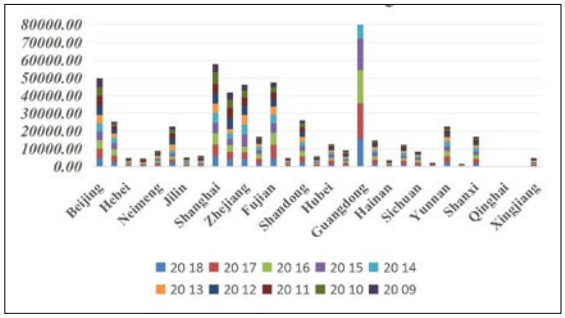

Figure 3: Data distribution of influencing factors in each city.

Take Figure 3 for example, standardize it first. Assume that the original data is X_m, after standardization is X_m.

$$X_m = \frac{x_m}{MAX(Y) - MIN(Y)}$$

After obtaining standardized data, it is shown as follows

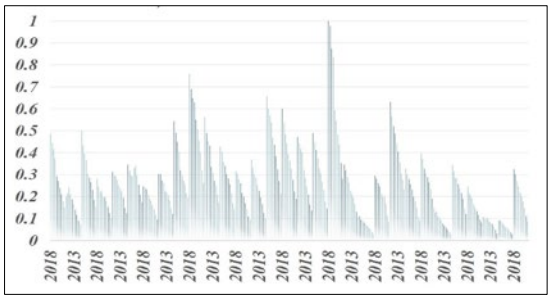

Figure 4: Standardized data distribution.

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.

2. Fixed effect test based on OLS: Panel data has the characteristics of separating long-term variables and short-term variables, while fixed effect model focuses on the relationship between variables within the group, it is necessary to test the fixed effect model. The estimation method is OLS estimation; two assumptions of fixed effect model are made.

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

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

The ξ in Hypothesis 1 is the independent variable interference term. Hypothesis 1: Assume that the ξ has no effect on the observed value, unobserved value and post observed value. Hypothesis **2:** The general test of homo variance, Ensure that the model satisfies the blue estimate of OLS. And organize data into 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 variable is the influencing factor.

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

Table 7: Fixed effect test model.

Variables	GDP	p>|τ| [95% Conf. Interval]
Local	0.0776636	0
travel	0.0481219	0.007
index	0.0104038	0.116
profit	0.1085704	0.001
population	0.0084029	0.011
Work loser	0.0215716	0.083
third	0.7264582	0
Sigma u	0.0362223	F=0 F(30,272)=29.86 Prob>F = 0.0000
rho	0.9181286	
Sigma e	0.0108166	

Local government expenditure, total tourism income, total profits of enterprises, resident population and tertiary industry income all have strong statistical significance. The statistics are shown in Table 8.

Table 8: Indicators passing the fixed effect test.

Variables	GDP
Local	0.0776635
travel	0.0481219

profit	0.1085704
population	0.0084029
third	0.7264581

3. Random effect model test based on GLS estimation: The number of indexes (*N*) is 10, and the time span (*T*) is 10 years. In this case, it is also possible to meet the random effect model; further test of the random effect model is needed.

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

Hypothesis 2: $Cov(a_i, x_{it}) = 0$,

Hypothesis 3: $Cov(a_i, x_{it}) = 0$,

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 influencing factor. Use state software to solve the problem, and get the results as shown in Table 9.

Table 9: Test results of random effect mode.

Variables	GDP	p>|τ| [95% Conf. Interval]
Local	0.0777262	0
travel	0.0325996	0.051
index	0.0062809	0.123
profit	0.145309	0
population	0.0092163	0.332
Work loser	0.0642344	0
third	0.7198721	0
Sigma u	0.0362223	F =0.
rho	0.9181286	F(30,272)=29.86 Prob>F=0.0000
Sigma e	0.0108166	

In 95% confidence interval, p value is 0, that is to say, five hypotheses are passed in this case. This case is suitable for the random effect model.

Table 10: Indicators passing the random effect test.

Variables	GDP
Local	0.0776635
population	0.008403
profit	0.145309
Work loser	0.0642344
third	0.7198721

The third industry has the most significant impact on GDP, and the resident population has the least impact on GDP. We can know that all the selected indicators have positive significance for GDP growth within the statistical range. At the same time, it shows that the test has passed all the hypotheses of panel data and satisfies the random effect (Table 10).

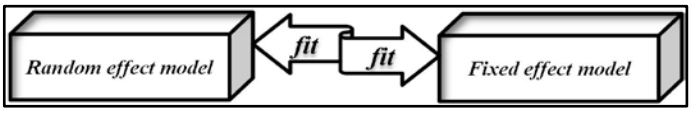

Figure 5: When both tests pass.

Model determination based on Hausman test: According to Alexander GJ et al. [13], the difference between the random effect model and the fixed effect model is that it is very difficult to try to distinguish them in a high degree in the description of individuals (Table 11). The fixed effect will consume a large degree of freedom, while the random effect is more universal on this basis. The proposed Hausman test can be used to distinguish them to some extent (Figure 5).

Table 11: Hausman test results.

Variables	Value
Chi2(7)	382.02
Prob	0.0000

Analysis of model test results: Using Hausman test, the fixed effect model is determined as the interpretation model of economic vitality, and the results are shown in Table 12.

Table 12: Test results of fixed effect model.

Variables	GDP
Local	0.0776635
travel	0.0481219
profit	0.1085704
population	0.0084029
third	0.7264581

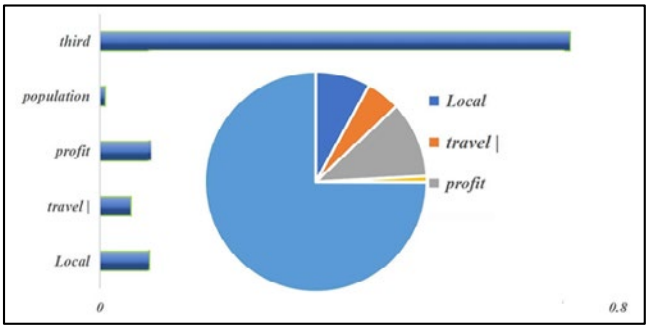

Figure 6: Contribution degree.

Activation scheme proposed based on fixed effect model: According to the fixed effect model shown in Figure 6, the explanation degree of each factor to economic vitality has been given, and the following suggestions are given according to the influence degree.

- To increase the proportion of the tertiary industry in the overall economy, the tertiary industry plays an important role in the influencing factors, so it is necessary to 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.
- In the process of development, the region should combine its resource endowment and industrial foundation to find 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.

- 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.
- Entrepreneurship is encouraged. The government takes the lead in encouraging entrepreneurship, and social practices are carried out to transform enterprises.

The establishment of VAR-VCE dynamic volatility model

Based on the panel data in the first question, this section 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 each factor is verified. Based on Vector Error Correction Model (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.

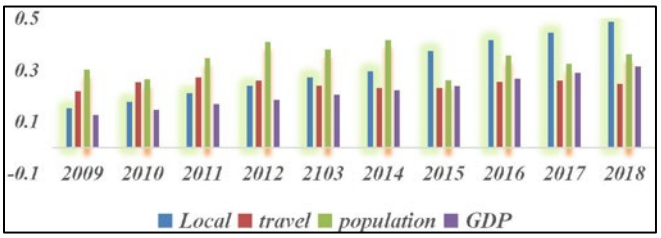

Figure 7: Normalized back view.

It can be seen from Figure 7 that the local government expenditure has a certain increase in each year, basically showing a linear growth; There is no significant change in the local 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.

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

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. B_i Is k-order coefficient B_i is k-row-d-column coefficient matrix, and these matrices need to be estimated by specific methods. The last term is a vector composed of k-dimension random error terms. According to the solution of the following figure, we can get the estimation coefficient.

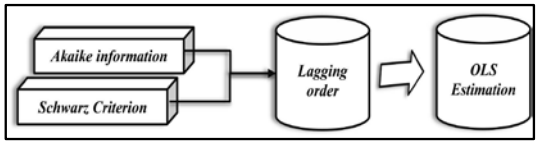

Figure 8: Model inspection process.

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 model, and the coefficient of AVR model can be obtained by OLS estimation (Figure 8).

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

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

ADF unit root test of vector sequence: First, all the time data are tested by ADF test and the difference order is 0. The lag order is 1-2, and the test results are shown in Table 13.

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

	T-Statistic	p	State
lnGDP	-1.679	0.088	Uneven
lnLocal	-2.507	0.012	Uneven
lntravel	0.107	0.745	Uneven
lnindex	-0.058	0.6614	Uneven
lnpopulation	-0.858	0.342	Uneven
lnworkloser	-0.402	0.537	Uneven

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 comparison data under the confidence interval of 95%, shows that the time series of this group of data do not pass the ADF test of the original data, and further differential test is needed. Carry out difference differentiation on the original data, and continue ADF test on the data after difference, and the results are shown in Table 14.

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

	T-Statistic	p	state
LnGDP	-1.911	0.325	Uneven
LnLocal	-2.911	0.049	Uneven
Lntravel	-1.871	0.345	Uneven
Lnindex	-1.785	0.359	Uneven
Lnpopulation	-4.444	0.004	Even
Lnworkloser	-1.608	0.475	Uneven

It can be seen from table 14 that under the ADF time series test, the T value of Lnpopulation t test in six species is less than the comparison data under the confidence interval of 95%.

Carry out the second-order difference differentiation on original data, and continue the ADF test on the data after the difference, and the results are shown in Table 15.

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

	T-Statistic	p	state
LnGDP	-11.634	0.000	Even
LnLocal	-9.1682	0.000	Even

Lntravel	-11.72	0.000	Even
Lnindex	-11.937	0.000	Even
Lnpopulation	-5.342	0.000	Even
Lnworkloser	-11.918	0.000	Even

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

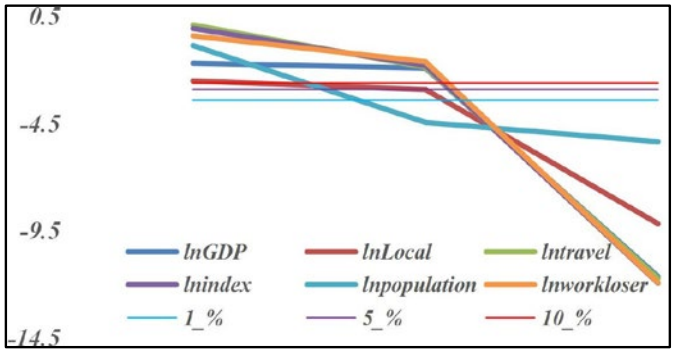

Figure 9: Visualization of three tests.

Figure 9 shows the visual information of three points of each variable fewer than three tests. The confidence intervals of the middle three levels are 1%, 5% and 10% respectively. After the first-order difference, only ln-population passed the test; after the second-order difference, all the data pass the test, that is, the group of data is the second-order zero integer data.

a) 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. First, Johansen co integration test is carried out to find out whether 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 co-integration logarithm is assumed. Table 16 shows the Johansen co integration test results.

Table 16: Co-integration test results.

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	Prob.
None*	255.6213	95.75366	0.0000
At most 1*	161.7542	69.81889	0.0000
At most 2*	100.2905	47.85613	0.0000
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

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

1) Determination of lag period based on AIS-SC minimization criterion: When the model is not integrated and stable, multiple VAR models with different lag periods can be established first.

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.

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

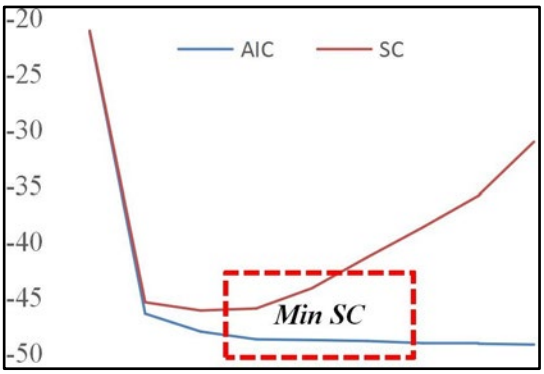

Figure 10: Change with order.

It can be seen from Table 17 that AIs value decreases with the increase of VAR (N) lag period, presenting a monotonic decreasing state; SC has a minimum at VAR (3). According to AIS information standard and SC standard, the optimal lag time is selected as the third- order lag time (Figure 10).

Determination of VEC model parameters: According to the above analysis, through the co integration test, there are at least 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: 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

Table 18 shows the co-integration formula with the maximum log likelihood.

Thus, the final co integration equation can be written as:

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

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

The specific coefficients are described as follows:

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

In the formula

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

The last remainder is

$VECM_{t-1}$=ln gdp-0.73ln 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-term effects of policy implementation on economic vitality are given under certain circumstances.

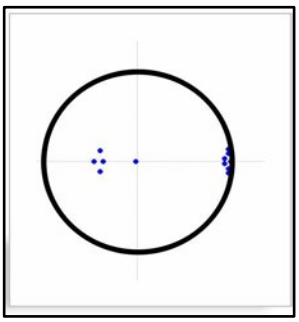

Figure 11: Unit root test.

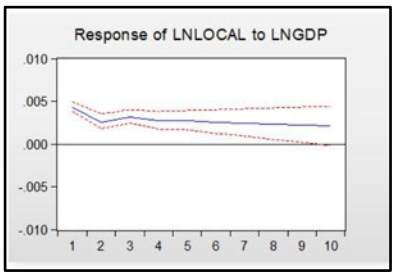

Figure 12: Impulse response.

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 short-term effects of economic policies on economic vitality.

It can be seen from Figure 12 that the promotion effect of economic policies on economic vitality gradually declines after 1-3 periods, and the economic vitality has increased since the third period, Because the experience of implementation after the implementation of economic policies can be applied, which has a secondary effect. After the fourth period, the promoting effect gradually decreased, the decreasing trend was relatively slow, and the long-term positive correlation effect continued.

The model of problem 3

This section aims at question 3. Firstly, we establish a scientific economic vitality index system as the standard of data selection. Secondly, the minimum average difference method is used to screen the data, and the index is initially extracted; Further, the factor analysis method is used to select the main influencing factors, and finally the comprehensive score of each factor is weighted to give the ranking of urban economic vitality.

The construction principle of index system of economic vitality: In order to select effective data to measure the economic vitality of each city, the following five principles are given in this paper, and the general process is as follows:

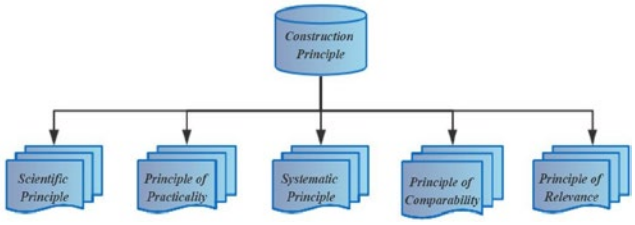

Figure 13: Selection of indicators.

a) Scientific Principle: The selection of measurement indicators must be based on scientific principles, and can truly and objectively reflect the impact of various factors on urban economic vitality. The scientific comprehensive index evaluation system of urban economic vitality is the basis of correct analysis and evaluation of regional economic vitality.

b) Principle of Practicability: The construction of evaluation index system is mainly theoretical analysis, which will be affected 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.

c) Systematic Principle: There should be a certain logical relationship between indicators, which should not only reflect economic vitality from different aspects.

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

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

Data filtering: The minimum mean square deviation method is used to screen the preliminary data. The observation, value is x_{ij}, where i am the number of evaluation objects, i.e. the number of cities, j is the number of evaluation indexes, there are 19 cities, and each city has 14 indexes. First, the average value and mean square deviation of index j are calculated (Figure 13).

$$\begin{cases} \bar{x}j = \frac{1}{n}\sum_{i=1}^{n} x_{ij,} \\ S_j = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(xij - \bar{x}j)^2} \end{cases}$$

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

$$Sj_0 = \frac{\min}{1 \le j \le m}\{Sj\}$$

If the minimum mean square deviation is close to 0, then the index x_j corresponding to S_j be eliminated and calculated in turn.

Factor Analysis: Using factor analysis method, the extracted nine indicators, including 190 sample data from 19 cities in 2009-2018, are dimensioned down, and then the coefficient matrix is multiplied by the standardized factor to calculate the score and find out the factors that have the greatest impact on economic vitality.

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

Where *Fi* is the score of the *i* factor; x_1, x_2, x_p is the standardized value of the index; the corresponding coefficient is the component score coefficient;

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 is the score of the first influencing factor; B_i is the contribution of the first factor, and factor contribution=variance contribution rate/total variance interpretation after the factor rotation.

Measurement of economic vitality of regional cities: Before measuring the economic vitality of each city, the relationship between variables and factor analysis is further verified through the variance of common factors (Table 19).

Table 19: Common factor variance extraction.

	Initial	Extraction
Local GDP	1.000	0.943
Financial expenditure	1.000	0.923
Primary industry	1.000	0.730
The tertiary industry	1.000	0.965
Real estate investment	1.000	0.826
Population size	1.000	0.908
Per capita wage	1.000	0.908
Road traffic noise level	1.000	0.725

Table 20: Total variance.

Component	Total	Cumulative%	Cumulative%
1	4.196	46.618	41.315
2	2.390	73.174	73.174
3	0.940	83.622	-
4	0.859	93.168	-
5	0.403	97.641	-
6	0.147	99.271	-
7	0.048	99.807	-
8	0.017	100.00	-
9	2.134E-16	100.00	-

From Table 20, it can be seen that the cumulative variance contribution rate is 73.174%, indicating that the first two factors contain 73.174% of all indicator information, and the extracted information is large and highly representative. Therefore, it can be seen that factor analysis is effective in extracting original variable information (Table 21).

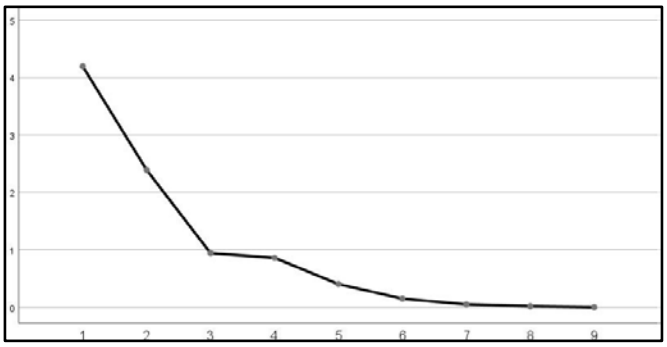

Figure 14: Gravel map.

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	0.700	0.647
Per capita wage	0.700	0.647
Noise level	0.002	-0.475

Table 22: Component transformation matrix.

Component	1	2
1	0.858	0.514
2	-0.514	0.858

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 (Figure 14).

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

According to the component score coefficient matrix, local GDP, fiscal expenditure, tertiary industry, tertiary industry and real estate investment have a positive impact on the ranking; the primary industry has a negative impact on the ranking. The expression of each influence factor is given according to Table 23.

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

$$F_2 = -0.043x_1 - 0.067x_2 + 0.323x_2 - 0.081x_4 + 0.09x_5 + 0.119x_6 + 0.318x_7 + 0.318x_8 - 0.170x_9$$

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:

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

The final weight value of each influencing factor is obtained 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.

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.

It can be seen from Figure 15 that the ranking of Kunming and Ningbo fluctuates greatly. Considering that the local industrial 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.

a) Model Establishment: In order to test the accuracy of the index system established to measure economic vitality, considering that the individual effect of each index is not observable and the time effect is not observable, a panel data model is established 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 rows and K columns. The factors affecting economic vitality can be divided into:

- Social security system: Number of hospitals and Post offices
- Processing and production: The secondary industry
- Consumption level: house price, total retail sales of social goods

b) Descriptive statistics: In order to analyse the regional economic vitality more specifically, it is necessary to understand the distribution 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.

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	10072.94	6383.3838	3442	47936
Total retail sales	190	4194.3943	2340.7614	956.4	12668.7
Number of hospitals	190	402.517	279.872	101	1606
Number of post offices	190	1048.345	1847.4835	131	16374

It can be seen from Table 25 that the average value of eco is close to 0, indicating that the statistical effect is very good. The fluctuation of house price is large, which is in line with China's national conditions. The number of hospitals is quite different, which deserves the attention of local government. The number of post offices is on the high side in some areas, resulting in waste of resources.

c) 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

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

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

of some indicators is too low, it may lead to the low chi square significance value, which needs to be screened. Then, Pearson correlation coefficient is selected to measure the correlation between the variables.

From the correlation analysis results of Table 26, it can be concluded that the correlation coefficients between all explanatory variables and the interpreted variables are significant, and there is no strong correlation between the explanatory variables.

Therefore, there is no multi collinearity 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.

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 multi collinearity 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 is far greater than 1, which shows that the differences among the factors are statistically significant, that is, the interaction effect among the factors is more significant. Fixed effect model and mixed model are tested by F test, random effect model and mixed model are tested by BP test, fixed effect model and random effect model are tested by Hausman test, and they are compared (Table 29).

According to the model test results, if the p value corresponding to the F test is 0, less than 0.05, it means that the fixed effect model is due to the mixed model. If the p value corresponding to the BP test is also 0, less than 0.05, it means that the random effect model is better than the mixed model; If the p value corresponding to the Hausman test is 0, it means that the fixed effect model tends to be selected. See Table 30 for regression results of fixed effect model to be selected after inspection:

From Table 30, we can see the regression results of the model, and the fixed effect model is selected after the test. The correlation coefficients of the first principal component, the second principal component, the second industry, the house price, the retail sales of social goods, the number of hospitals and the number of post offices are all positively correlated with Eco, indicating 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 and number of post offices are all positively related to economic vitality. In these variables, when one variable changes, the other variables remain unchanged, and 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.

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.

Which chose the per capita GDP, fiscal revenue, education 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.

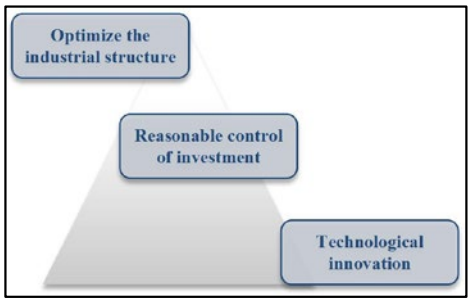

Figure 16: ORT development strategy.

In view of the excessive factors affecting economic vitality, we 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).

Optimizing the industrial structure:

1) 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 of less investment, short cycle, quick effect and high wages of employees. Vigorously developing the tertiary industry can rapidly expand employment fields and jobs, avoid labor surplus, 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 vigorously develop the tertiary industry, which has a significant role in promoting the sustainable development of economic vitality.

2) 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. The first industry is the basic industry of the national economy, strengthening the first industry, and laying the foundation for the development of the second industry and the third industry.

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 related indicators are classified into the same category, each category of indicators becomes a factor, and the economic vitality is measured by a few factors. It simplifies the problem, measures most of the information of economic vitality, and gets more scientific and accurate information at the same time.
- Panel data model: 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 the effectiveness and accuracy of model estimation; Panel data model is more conducive to reflect the randomness of the gap between individuals. In this paper, panel data model can not only reflect the information between the given factors, but also reflect the information of a certain factor through the study of other influencing factors.

Improvements needed

When using panel data model to study influence factors, there are some difficulties in variable design and data collection, some errors in factor prediction, and selection difficulties in influence factors; panel data analysis of time series of factors is short, which can only reflect the data characteristics in the short term, not the long-term changes of factors.

PROMOTION AND APPLICATION OF THE MODEL

In this paper, three models are established: Panel Data Model (fixed effect model and random effect model), Avr-Ave model, and principal component index system model. The Var-Vec model has great generalization. Applicable fields are:

Research on agricultural economic development based on var. Because of its unique ability to test the dynamic fluctuation, AVR can solve the research difficulties in the agricultural economy which are greatly affected by the quarterly seasonality.

International oil has been affected by many aspects, among which the fluctuation of international political 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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