Operating Mechanism of University Innovation and Entrepreneurship Education and Its Contribution to Regional Economy

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Abstract—China has already ushered in a new economic development stage and its main driving force for the high-quality economic development has gradually shifted to innovation and entrepreneurship and high-level innovative talents. Existing research has ignored to some extent the discussion on regional differences and underdeveloped areas. To this end, this paper studies the operating mechanism of university innovation and entrepreneurship education and its contribution to regional economy. First, based on the theories of human capital and regional economic development, a labor output elasticity estimation model was constructed for regional human resources, to measure the contribution rate of the innovation and entrepreneurship education in regional universities to regional economic development. Considering the complex relationship between university innovation and entrepreneurship education and regional economic development and fluctuations, a suitable VAR model was constructed based on the economic theory to analyze and empirically study the relationship between the two. Finally, the calculation results of the contribution rates of the university innovation and entrepreneurship education in the region and various sub-regions were provided based on the experiment, which verified the effectiveness of the calculation method and analysis model.

Keywords—university innovation and entrepreneurship education, regional economic development, contribution analysis

1 Introduction

After the reform and opening up, China began to implement the development strategy that is centered on economic construction, and as a result, its economic development showed a trend of rapid growth [1-7]. Now that the economic development in China has ushered in a new stage, its main driver has already changed [8-13]. The high-quality economic development has relied more on innovation and entrepreneurship and high-level innovative talents, and no longer on natural resource exploitation and low-cost human resources. This means that the economic output and even the

international competitiveness of China are crucially related to the improvements in the quantity, quality and technology of human capital, rather than the direct accumulation of capital and labor [14-19]. In this sense, innovation and entrepreneurship education, especially relevant education in universities and colleges, has a great impact on the existing economic system of China [20-23]. Strengthening the cultivation of high-quality innovative and entrepreneurial talents in colleges and universities can help transform advanced scientific and technological achievements and promote the development of regional emerging industries and the cultivation of new regional economic growth engines, and thus play a pivotal role in contributing to the regional economy.

Ren [24] aimed to study the relationship between talent design and education and the surrounding regional economy. Through the review, analysis and integration of relevant literatures, the paper formed an understanding of talent training and regional economy. Through questionnaire survey and case analysis of colleges and universities, it gave a full and detailed analysis of the current teaching situation. Gao [25] used the Cobb-Douglas production function model and selected 18 samples from the eastern, central and western regions to study and analyze the relationship between educational investment and economic development. It started with the total education investment, which can be divided by source into fiscal education funds, private education funds and other non-fiscal education funds. At the same time, it also incorporated the employed population and material capital to conduct a more comprehensive analysis of the factors affecting economic growth. Song et al. [26] conducted a quantitative study on the role of vocational education in promoting social and economic development. Taking the people of a village in Tianjin as the samples, it carried out a quantification design on the role of education in the social and economic development of the village in the next 10 years, and concluded that vocational education could significantly promote the economic development there. This study provided scientific data support for the education model adopted for the people in this village in the future. In order to effectively analyze the dynamic relationship between education and economic development, Sun [27] proposed using the PVAR model. It expounded the principles, assumptions, identification and estimation methods of the PVAR model. With education level and economic development as the research objects, it explained the corresponding variables and selected the indicators. With the reform of higher vocational English education as the background, Xin [28] studied the higher vocational English education in Heyuan City and the economic construction and development of the Greater Bay Area with the literature method, data sorting, quantitative analysis method and other research methods. After expounding the theory on the promoting role of higher vocational English education in regional economic development, it also discussed what strategies to take to promote the regional economic development in Heyuan, so as to ensure the position of higher vocational English education in regional economic development.

Through review of the existing relevant literatures, it can be seen that in the research on the relationship between university innovation and entrepreneurship education and regional economic development, the commonly used methods include regression analysis, grey correlation analysis, and causality test. In the research on the con-

tribution of university innovation and entrepreneurship education to regional economic development, more rigorous and scientific methods are used, such as the education benefit method, factor analysis method and the Cobb-Douglas production function model. However, the above studies ignored to a certain extent the discussion on regional differences and underdeveloped areas. Therefore, this research studies the operating mechanism of university innovation and entrepreneurship education and its contribution to regional economy. Section 2 constructs a labor output elasticity estimation model for regional human resources based on the theories of human capital and regional economic development to measure the contribution rate of the innovation and entrepreneurship education in regional universities to regional economic development. Considering the complex relationship between university innovation and entrepreneurship education and regional economic development and fluctuations, Section 3 constructs a suitable *VAR* model based on the economic theory to analyze and empirically study the relationship between the two. The final part of the paper provdes the calculation results of the contribution rates of the university innovation and entrepreneurship education in the region and various sub-regions in combination with an experiment, which verifies the effectiveness of the calculation method and analysis model.

2 Contribution analysis

Figure 1 shows the variation trends of university innovation and entrepreneurship education and regional economic development in the study area during the study period. It can be seen that, although local government has been increasing the investment in university innovation and entrepreneurship education, the investment per capita received by university students is still insufficient due to the huge population in the study area and the great number of college students receiving higher education and university innovation and entrepreneurship education. Nevertheless, during the study period, the investment in university innovation and entrepreneurship education per student in the region showed a growing trend - from 2006 to 2018, the investment per student nearly tripled, and at the same time, the GDP representing the regional economy continuously grew, and the regional GDP per capita also increased, indicating that the regional economic development had a good momentum and the living standards of the people in the region were continuously improving.

Through the analysis of Figure 1, it can be seen that there is a certain correlation between regional university innovation and entrepreneurship education and regional economic development. Increasing the attention to and investment in regional university innovation and entrepreneurship education can help improve the quality of human resources in the region and enhance the level of regional scientific and technological innovation, and thus further promote the sustainable growth of the regional economy. Therefore, measuring the contribution rate of regional university innovation and entrepreneurship education to regional economic development can allow people to better promote the coordinated development of regional university innovation and entre-

preneurship education and economy, and maintain steady progress in regional economy.

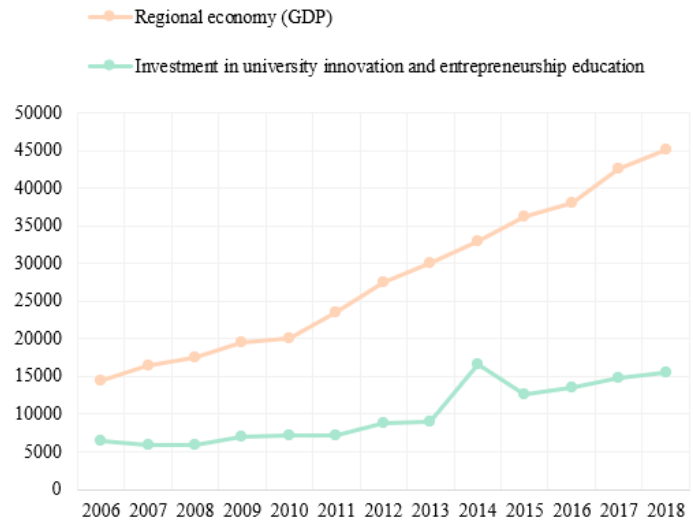

Fig. 1. Changes in university innovation and entrepreneurship education and regional economic development in the study area during the study period

The following section constructs a labor output elasticity estimation model for regional human resources based on the theories of human capital and regional economic development, to measure the contribution rate of regional university innovation and entrepreneurship education to regional economic development.

Suppose that the local capital is represented by ZB, the human resource by DU, the technical level by JS, the time variable by υ, and the economic output by B. If the regional land area is fixed, then ZB, DU and JS can all promote regional economic development. Equation (1) gives the Cobb-Douglas production function model:

$$B_\upsilon = JS_\upsilon ZB_\upsilon^\gamma DU_\upsilon^\lambda \tag{1}$$

Suppose that the output elasticity coefficient of capital is represented by γ, and that of labor by λ, and that $\gamma>0$, $\lambda>0$, and $\gamma+\lambda=1$. To highlight the role of university innovation and entrepreneurship education as part of human resources investment in improving the quality of human resources, the human resources investment DU can be turned into a product of the initial human resources DU_0 and the investment in university innovation and entrepreneurship education SQ. Therefore, Equation (1) can be transformed into:

$$B_\upsilon = JS_\upsilon ZB_\upsilon^\gamma \left(DU_{0\upsilon} SQ_\upsilon\right)^\lambda \tag{2}$$

Take the logarithms of both sides of the above equation, then carry out total differentiation of υ, and finally use the difference equation as the deformation of the pro-

duction function model. Suppose that the annual growth of the regional economy in the study period is represented by b, that of innovation and technological progress by γ, that of capital investment by l, that of the initial human resources quantity by k, and that of the investment in university innovation and entrepreneurship education by t, and there is the equation of economic output growth as follows:

$$b = \gamma + \gamma l + \lambda k_0 + \lambda t \tag{3}$$

Assuming that the factor of university innovation and entrepreneurship education that brings regional economic development is represented by λt, the calculation formula of the contribution rate of university innovation and entrepreneurship education to regional economic development can be obtained from the equation:

$$D_t = \lambda t / b \tag{4}$$

In real practice, it is difficult to calculate the average annual growth of investment in university innovation and entrepreneurship education, and therefore, this paper introduced the composite index S_t of university innovation and entrepreneurship education into the above formula, as follows:

$$D_t = \lambda S_t / b \tag{5}$$

Suppose that the percentage of the average annual growth of the investment in university innovation and entrepreneurship education in the total annual growth of the investment in regional education composite index is represented by SQ_f. The contribution rate of university innovation and entrepreneurship education to regional economic development can be calculated by the following formula:

$$D_f = SQ_f D_t = \lambda SQ_f S_t / b \tag{6}$$

Suppose that the proportions of regional human resources receiving innovation and entrepreneurship awareness training, innovation ability training, entrepreneurial ability training, and practical education of innovation and entrepreneurship abilities are represented by A_1, A_2, A_3 and A_4, respectively. The average years for which a person has received university innovation and entrepreneurship education (including the above four stages) in the region is calculated as follows:

$$O_i = M_i \sum A_i \tag{7}$$

Then, the average years for which regional human resources have received innovation and entrepreneurship awareness training is (A_1+A_2+A_3+A_4), the average years for which they have received innovation ability training is (A_2+A_3+A_4), the average years for which they have received entrepreneurial ability training is (A_3+A_4), and the average years for which they have received practical education of innovation and entrepreneurship abilities is A_4.

The composite index of university innovation and entrepreneurship education can be used to characterize the level of university innovation and entrepreneurship educa-

tion received by regional human resources per capita, and also to measure the increase in human resources input driven by university innovation and entrepreneurship education. Determining the labor simplification rate of regional human resources is the prerequisite for calculating the average growth of the regional university innovation and entrepreneurship education composite index. Assuming that the composite index of regional human resources university innovation and entrepreneurship education is represented by JZ_i, the average years for which the regional human resources have received university innovation and entrepreneurship education by O_i, and the labor simplification rate by SR_j, Equation (8) shows how to calculate the composite index of university innovation and entrepreneurship education for regional human resources:

$$JZ_i = \sum O_i SR_j \tag{8}$$

Assuming that the number of years between the starting year and the ending year is represented by M, the average annual growth of the university innovation and entrepreneurship education composite index for regional human resources from the starting year to the ending year can be calculated as follows:

$$S_t' = \left[\left(JZ_{END} / JZ_{START} \right)^{(1/M)} - 1 \right] \times 100\% \tag{9}$$

Equation (10) gives the formula for calculating the percentage of regional university innovation and entrepreneurship education contributing to the average annual growth of the university innovation and entrepreneurship education composite index:

$$JZ_f = \left[\left(S_t - t_f \right) / S_t \right] \times 100\% \tag{10}$$

In practice, the average annual growth of S_t is usually used to replace the average growth of investment in regional university innovation and entrepreneurship education. According to Equations (5) and (9), let λ be 0.6, and then the contribution rate of regional university innovation and entrepreneurship education to regional economic development is:

$$D_t = \lambda S_t' / b \tag{11}$$

The contribution rate of the corresponding regional higher innovation and entrepreneurship education to regional economic development is:

$$D_f = JZ_f D_t = \lambda JZ_f S_t / b \tag{12}$$

3 Correlation analysis

Due to the complex relationship between university innovation and entrepreneurship education and the regional economic development and fluctuations, the following section constructs a suitable *VAR* model based on the economic theory to analyze and empirically study the relationship between the two.

The *VAR* model can realize the extension of univariate autoregression to multivariate time series autoregression. Assuming that there is a relationship between the variables $b_{1,z}$ and $b_{2,z}$, which are corresponding to university innovation and entrepreneurship education and regional economic development, the following autoregression model can be constructed:

$$\begin{aligned} b_{1,z} &= g\left(b_{1,z-1}, b_{1,z-2}, \cdots\right) \\ b_{2,z} &= g\left(b_{2,z-1}, b_{2,z-2}, \cdots\right) \end{aligned} \tag{13}$$

The autoregression model shown in Equation (13) cannot accurately represent the relationship between the variables $b_{1,z}$ and $b_{2,z}$. Equation (14) gives the simultaneous form of Equation (13):

$$\begin{cases} b_{1,z} = d_1 + \theta_{11,1} b_{1,z-1} + \theta_{12,1} b_{2,z-1} + v_{1z} \\ b_{2,z} = d_2 + \theta_{21,1} b_{1,z-1} + \theta_{22,1} b_{2,z-1} + v_{2z} \end{cases} \tag{14}$$

Where, v_{1z} and v_{2z} and independent and identically distributed, and obey the standard normal distribution *iid* $N(0,\varepsilon^2)$. The matrix form of the above formula is:

$$\begin{bmatrix} b_{1,z} \\ b_{2,z} \end{bmatrix} = \begin{bmatrix} d_1 \\ d_2 \end{bmatrix} + \begin{bmatrix} \theta_{11.1} & \theta_{12.1} \\ \theta_{21.1} & \theta_{22.1} \end{bmatrix} \begin{bmatrix} b_{1,z1} \\ b_{2,z1} \end{bmatrix} + \begin{bmatrix} v_{1z} \\ v_{2z} \end{bmatrix} \tag{15}$$

Let:

$$B_z = \begin{bmatrix} b_{1,z} \\ b_{2,z} \end{bmatrix}, d = \begin{bmatrix} d_1 \\ d_2 \end{bmatrix}, \Psi_1 = \begin{bmatrix} \theta_{11.1} & \theta_{12.1} \\ \theta_{21.1} & \theta_{22.1} \end{bmatrix}, v_z = \begin{bmatrix} v_{1z} \\ v_{2z} \end{bmatrix} \tag{16}$$

Then there is:

$$B_z = d + \Psi_1 B_{z-1} + v_z \tag{17}$$

Assuming that the time series column vector is denoted as B_z, the constant term column vector as d, the parameter matrix as Ψ_j, and the error column vector as v_z, Equation (18) gives the expression of the *VAR* model containing M variables with l lag periods:

$$\begin{aligned} &B_z = d + \Psi_1 B_{z-1} + \Psi_2 B_{z-2} + \cdots + \Psi_l B_{z-l} + v_z, v_z \sim iid\, N\left(0, \varepsilon^2\right) \\ &B_z = \left(b_{1,z}, b_{2,z} \cdots b_{M,z}\right)' \\ &d = \left(d_1, d_2 \cdots d_M\right)' \\ &\Psi_j = \begin{bmatrix} \theta_{11,j} & \theta_{12,j} & \cdots & \theta_{1M,j} \\ \theta_{21,j} & \theta_{22,j} & \cdots & \theta_{2M,j} \\ \vdots & \vdots & \ddots & \vdots \\ \theta_{M1,j} & \theta_{M2,j} & \cdots & \theta_{MM,j} \end{bmatrix}, j = 1, 2, ..., l \end{aligned} \tag{18}$$

In order to measure the changes in the relationship and degree of influence between university innovation and entrepreneurship education and regional economic development caused by the defects in the operating mechanism of university innovation and entrepreneurship education at a certain stage, an impulse response function based on the *VAR* model was constructed in this paper. When the error term changes due to disturbance, the endogenous variable of regional economic development will respond to the error change, and the constructed impulse response function can characterize the effect of the disturbed error term on the present value and trend value of the endogenous variable of regional economic development.

For the following *VAR* model, suppose that $b_{1,z}$ represents regional economy *GDP* and that $b_{2,z}$ the investment in university innovation and entrepreneurship education, and suppose that the error term of $b_{1,z}$ is denoted as $v_{1,z}$, and that of $b_{2,z}$ as $v_{2,z}$, and then there are:

$$\begin{cases} b_{1,z} = d_1 + \theta_{11,1} b_{1,z-1} + \theta_{12,1} b_{2,z-1} + v_{1z} \\ b_{2,z} = d_2 + \theta_{21,1} b_{1,z-1} + \theta_{22,1} b_{2,z-1} + v_{2z} \end{cases} \tag{19}$$

The impulse response function of $v_{2,z}$ is used to measure the impact of one standard deviation of defect in the operating mechanism of university innovation and entrepreneurship education on the present value and trend value of the regional economic development *GDP* and the investment in university innovation and entrepreneurship education. Since any *VAR* model can be characterized by an infinite-order *MA* model, any *VAR*(*k*) model can be rewritten through the companion matrix, that is,

$$\begin{aligned} B_z &= \Psi_1 B_{z-1} + V_z \\ V_z &= \left(SP - K\Psi_1\right) B_z \end{aligned} \tag{20}$$

$$B_z = \left(SP - K\Psi_1\right)^{-1} V_z = V_z + X_1 V_{z-1} + X_1^{\,2} V_{z-2} + \cdots + X_1^{\,r} V_{z-r} + \cdots \tag{21}$$

Rewritten as:

$$B_{z+r} = V_{z+r} + X_1 V_{z+r-1} + X_1^{\,2} V_{z+r-2} + \cdots + X_1^{\,r} V_z + \cdots \tag{22}$$

Let $\psi_j = X_z^j$, j=1,2,3...r, and then there are:

$$\begin{aligned} B_{z+r} &= V_{z+r} + \psi_1 V_{z+r-1} + \psi_2 V_{z+r-2} + \cdots + \psi_r V_z + \cdots \\ \psi_r &= \frac{\partial B_{z+r}}{\partial V_z} \end{aligned} \tag{23}$$

Take the element in row i and column j in ψ_r as a function of the lag period r - $\partial B_{i,z+r} / \partial V_{jz}$, r=1,2,3...

4 Experimental results and analysis

This paper first calculates the contribution rate D_t of university innovation and entrepreneurship education to regional economic development in the region and its sub-regions within the study period according to the derived contribution rate equation (11), and then calculates the contribution rate D_f of higher innovation and entrepreneurship education to regional economic development in the region and its sub-regions within the study period according to the derived contribution rate equation (12). The results are given in Table 1.

Table 1. Contribution rates of university innovation and entrepreneurship education in the region and its sub-regions

Region	C_e	C_k
China	11.52%	2.58%
Beijing	12.95%	3.69%
Liaoning	11.05%	2.18%
Hubei	11.49%	2.58%
Jiangsu	9.63%	2.17%
Shaanxi	12.58%	2.36%
Guangxi	13.26%	1.84%

In order to better analyze the complex relationship between university innovation and entrepreneurship education and the regional economic development and fluctuations, this paper summarized the contribution rates of various factors to regional economic development, and plotted the contribution rate curve in Figure 2. It can be seen from Figure 2 that the contribution rate of innovation and entrepreneurship investment is on a growing trend year by year during the study period, while those of natural resources and human resources input are on a downward trend. Since all input factors of university innovation and entrepreneurship education have certain correlations with each other, to make the analysis results objective and detailed to the greatest extent, this paper analyzed the correlations between the input factors in the four stages of university innovation and entrepreneurship education, which are namely entrepreneurship awareness training (stage I), innovation ability training (Stage II), entrepreneurial ability training (Stage III), and practical education of innovation and entrepreneurship abilities (Stage IV). It can be seen from the results that the input factors in the four stages are all significantly correlated (Table 2).

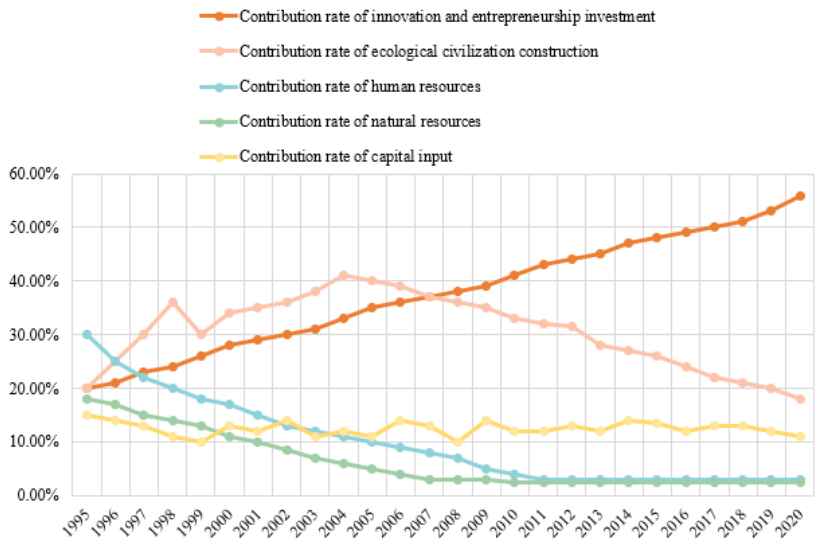

Fig. 2. Contribution rates of various factors to regional economic development

A *VAR* model with regional economic development *GDP* and investment in university innovation and entrepreneurship education as the endogenous variables was constructed for the time series, to study the relationship between university innovation and entrepreneurship education and regional economic development. The model estimation results were obtained, as shown in Table 3. It can be seen that the values of Akaike Information Criterion and Schwartz Criterion of the constructed *VAR* model have reached the minimum, and the R^2 value, F statistic and log likelihood results of the model all show that the model estimation is satisfactory.

In order to better compare the effects of universities' investment in innovation and entrepreneurship education for emerging industries on the regional economic development, Figure 3 was drawn using the influence coefficients of the internal factors of university innovation and entrepreneurship education based on the model results, and the constructed model was also analyzed based on the changing pattern of the regional GDP. The specific emerging industries include new energy, electric automobiles, new medicines and new materials. In addition, this paper added the baseline of the innovation and entrepreneurship information sharing platform, and at the same time introduced the influence coefficients of traditional catering and entertainment services and other service industries for reference and comparison.

From the regional economic development manifested by the GDP growth and the added values of the entrepreneurial costs, technological content and employment activity in emerging industries due to the investment in university innovation and entrepreneurship education, it can be seen that the investment in innovation and entrepreneurship education has positive effects on the development of emerging industries, except the catering and entertainment, and the effects are basically the same. Figure 4 presents the economic changes in the study area. It can be seen that, the added value of entrepreneurial costs in emerging industries grows faster than those of

technological content and employment activity, and its growing trend is most consistent with that of the GDP in the study area due to investment in university innovation and entrepreneurship education. This shows that the economic changes in the study area are mainly driven by the entrepreneurial costs in emerging industries. After comparison of the influence coefficients of the investment in university innovation and entrepreneurship education to the feature industry and the emerging industries, it is found that the investment in university innovation and entrepreneurship education has relatively balanced effects on the added values of entrepreneurial costs, technological content and employment activities in emerging industries.

Table 2. Coefficients of correlation between the input factors in the 4 stages

	Stage I			**Stage II**			**Stage III**			**Stage IV**		
	Pearson correlation	***Significance (two-sided)***	***N***	***Pearson correlation***	***Significance (two-sided)***	***N***	***Pearson correlation***	***Significance (two-sided)***	***N***	***Pearson correlation***	***Significance (two-sided)***	***N***
Stage I	0.927*	0.01	28	0.935**	0.03	23	0.938***	0.01	28	0.854**	0.03	24
Stage II	0.985***	0.03	25	0.981**	0.01	22	0.942***	0.03	26	0.735***	0.01	22
Stage III	0.963*	0.01	27	1	0.03	24	0.815*	0.01	27	0.769**	0.01	25
Stage IV	0.817**	0.02	28	0.752***	0.02	21	1	0.02	25	0.695**	0.02	23

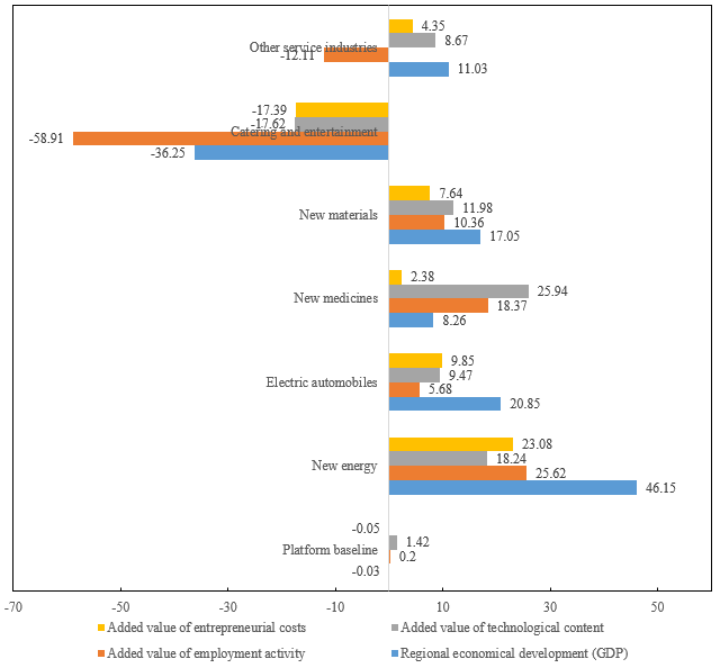

Fig. 3. Influencing coefficients of the internal factors of university innovation and entrepreneurship education

Table 3. *VAR* model estimation

	Regional economic development (*GDP*)	**Investment in university innovation and entrepreneurship education**
Regional economic development (*GDP*) (-1)	0.625814	-0.215238
Regional economic development - (*GDP*) (-2)	(0.015284)	(0.095862)
	[7.485213]	[-3.629584]
	0.021584	0.152953
Investment in university innovation and entrepreneurship education (-1)	(0.084752)	(0.095283)
	[0.326594]	[2.158429]
	0.152842	0.749586
Investment in university innovation and entrepreneurship education (-2)	(0.148529)	(0.058426)
	[1.428456]	[9.362584]
	0.074852	0.3965821
C	(0.135284)	(0.045871)
	[0.849652]	[4.236975]
	0.926352	0.214875
	(0.152695)	(0.142518)
	[5.162937]	[1.854762]
R^2	0.958625	0.965823
F-statistic	5842.584	26325.12
Log likelihood		556.9142
Akaike Information Criterion		-7.142395
Schwartz Criterion		-7.125489

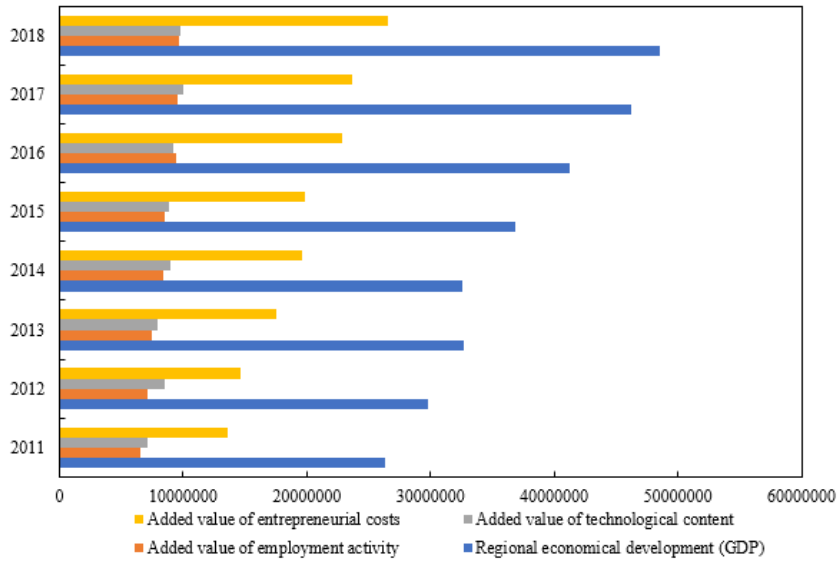

Fig. 4. Economic changes in the study area

5 Conclusions

This paper studies the operating mechanism of university innovation and entrepreneurship education and its contribution to regional economy. First, based on the theories of human capital and regional economic development, a labor output elasticity estimation model was constructed for regional human resources, to measure the contribution rate of the innovation and entrepreneurship education in regional universities to regional economic development. Considering the complex relationship between university innovation and entrepreneurship education and regional economic development and fluctuations, a suitable VAR model was constructed based on the economic theory to analyze and empirically study the relationship between the two. Finally, the calculation results of the contribution rates of the university innovation and entrepreneurship education in the region and various sub-regions were provided based on the experiment. It can be seen that the contribution rate of innovation and entrepreneurship investment is on a growing trend year by year during the study period; and on the other hand, the contribution rates of natural resources and human resources input are on a downward trend.

The results of the correlation analysis between the input factors in the four stages - entrepreneurship awareness training (stage I), innovation ability training (Stage II), entrepreneurial ability training (Stage III), and practical education of innovation and entrepreneurship abilities (Stage IV) were given, which verified that these input factors are all significantly correlated. The estimation results of the *VAR* model were given. Since the values of the Akaike Information Criterion and Schwartz Criterion of the model have reached the minimum, the R^2 value, F statistic and log likelihood results show that the model estimation is satisfactory.

The effects of universities' investment in innovation and entrepreneurship education for emerging industries on the regional economic development were compared, and the influence coefficients of the internal factors of university innovation and entrepreneurship education were summarized, and in addition, the chart of regional economic changes in the study area was drawn, with the corresponding analysis results given.

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