

Upgrading of Industrial Structure, Scientific and Technological Innovation, Government Intervention and Coordinated Development of Regional Economy

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Abstract In this paper, an evaluation index system for the coordinated development of regional economy was constructed by considering the aspects of regional development coordination, economic development coordination, economic and social coordination, and resource and environment coordination, which is used to perform comprehensive evaluation of the coordinated development of regional economy. On this basis, the impact of the upgrading of industrial structure, scientific and technological innovation, and government intervention on the coordinated development of regional economy were also investigated. According to the findings of our study, the coordinated development of regional economy in the eastern region was obviously better than that in the central region, while the western region had the lowest coordinated development of regional economy; the upgrading of regional industrial structure promoted the coordinated development of regional economy, while the promoting effect of the scientific and technological innovation on the coordinated development of regional economy were partly achieved by its promotion of the upgrading of industrial structure; the effect of government intervention couldn't be well reflected in the coordination index of regional economy.

Keywords regional economic coordination; upgrading of industrial structure; scientific and technological innovation; influencing mechanism

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1 Introduction

Since the reform and opening up, the strategy for coordinated regional economic development implemented in China has gone through the stages of coordinated development of regional economy, regional economic development under overall planning, and coordinated and balanced development under overall planning. Moreover, the development pattern has been gradually adjusted from all-round opening up and coordinated development of regional economy to promoting the integrated development of the four regions in east, central, west and northeast China under the guidance of the three strategies of coordinated development of Beijing-Tianjin-Hebei Region, Yangtze River Economic Belt and the “the Belt and Road”, so as to develop new economic growth poles, growth belts and growth points, while also promoting the development and exchange of the international and domestic economy, and forming a new pattern of all-round opening up along the coast, river and border^[1]. In the “14th Five Year Plan”, it is proposed to deeply implement the regional coordinated development strategy, profoundly promote the development of the west, the all-round revitalization of the northeast, the rise of the central region, and the eastern region in taking the lead in development, support the accelerated development of special regions, and promote relative balance in development. At present, the regional economic development of China still faces the contradiction of unbalanced development. The economic development in different regions still presents significant differences. The economy of the eastern region is well developed, while the economic development level of the western region is relatively low. The economic development of the Pearl River Delta, the Yangtze River Delta and the Beijing-Tianjin-Hebei Region demonstrates typical high concentration, but their radiation and leading role to the surrounding areas is relatively small. Affected by the net outflow of labor force, the population in the central and western regions has become “hollow”, and the population density difference between regions is large, thus weakening the advantages of industrial transfer factors in the central and western regions. In the process of inter-regional industrial transfer, various prominent problems have shown. For instance, the homogeneous industries are established in different places; the supporting facilities for industrial transfer in some regions are relatively backward; the industrial infrastructure is weak; the economic benefits of industrial transfer cannot be demonstrated. Therefore, the spatial pattern of regional economic development, the gap in regional development and the coordinated regional development in China will remain important topics for regional economic development for a long time in the future^[2,3].

At present, many researches have been carried out on the comprehensive evaluation of the coordinated development of regional economy and the influencing factors on the coordinated development of regional economy. In terms of the evaluation of coordinated development of regional economy, the research is mainly carried out on two aspects. First, the comprehensive evaluation of the coordinated development of regional economy is made, and an evaluation index system for the coordinated development of regional economy is constructed from the perspective of economy, society and ecology^[4–8]. Second, the coordination between the regional economy and the logistics development, scientific and technological innovation and talent development is

measured^[9–11]. The evaluation methods mainly include the principal component analysis, factor analysis, and entropy weight methods. In terms of the influencing factors on the coordinated development of regional economy, these factors can be divided into the categories influencing the macroeconomic development, micro foundation and institutional arrangement of regional development^[12]. Among them, from the perspective of macroeconomic development, the factors that affect the coordinated development of regional economy mainly include the factors influencing the overall development of regional economy, the economic development structure, the balance of regional economic growth, the maturity of regional market, and the characteristics industrial structure^[13–19]. The micro development foundation covers the accumulation of human capital, the technological innovation level, the information level, the ecological environment, the spatial and geographical attributes, the scientific and technological innovation ability, and the education development level^[20–24]. The institutional factors mainly include the support of regional economic policies, institutional dependence, institutional distortion and institutional effectiveness, as well as other factors such as laws and regulations^[25–29]. At present, the evaluation on the coordinated development of regional economy focuses more on analyzing the coordination between economic development and another aspect of development, which lacks the comprehensive evaluation of the coordinated development of regional economy. At the same time, the empirical research on the influencing factors of coordinated regional development is insufficient, and most researches tend to analyze a specific influencing factor. There is a lack of research on the interactions between multiple influencing factors and the degree of their influences, and there are few studies on the influencing factors based on the inter-provincial coordinated development.

Actually, technological innovation, as a crucial internal driver for optimizing and upgrading industrial structures, plays a significant role in achieving high-quality economic development. It not only directly enhances the technological level and competitiveness of industries but also promotes the upgrading of industrial structures in neighboring regions through spatial spillover effects. Optimizing industrial structure serves as a key intermediary in the transition towards innovation-driven economic growth. Moreover, the differentiated classification of technological innovation activities highlights significant disparities in how technological innovation influences regional coordinated development through the optimization and upgrading of industrial structures. The government supports enterprise innovation through tax incentives and R&D subsidies. Tax incentives effectively enhance innovation performance and high-quality innovation outcomes, while R&D subsidies may crowd out innovation performance and quality. Government intervention plays a significant role in promoting regional industrial transformation and upgrading, though its impact varies across different regions.

On the basis of the available researches, this paper constructs the evaluation index system of the coordinated development of regional economy from the aspects of high-quality development of regional economy, regional economic linkage and regional economic gap. On this basis, the impact of the industrial structure upgrading, scientific and technological innovation, government intervention and the interaction between multiple factors on the coordinated development of

regional economy is considered, so as to further reveal the coordinated development pattern of regional economy in China, clarify the key factors affecting the regional economic coordination and their regional heterogeneity, and provide the decision-making basis for the coordinated development of regional economy in China.

2 Variables and Data

2.1 Core Variables

In this study, the core variables include the coordinated development level of regional economy, the upgrading of industrial structure, and the scientific and technological innovation.

The coordinated development level of regional economy (QYXT). Based on the available researches, this paper constructs the evaluation index system for the coordinated development of regional economy from the aspects of high-quality development of regional economy, regional economic linkage and regional economic gap. For the high-quality development of regional economy, the evaluation index system is constructed. Moreover, the factor analysis method is employed to evaluate the high-quality development of regional economy. See Table 1 for specific information.

The level of regional economic linkages is measured by a gravity model with the following expression:

$$R_{ij} = \frac{\sqrt{P_i G_i} \times \sqrt{P_j G_j}}{D_{ij}^2}, \quad (1)$$

wherein, R_{ij} represents the intensity of economic linkage of provinces i and j . P_i and P_j represent the population of province i and j respectively. G_i and G_j represent the GDP of province i and j respectively. D_{ij} represents the shortest path distance between provincial capitals of provinces i and j . Based on the above formula, the intensity of regional economic linkage between province i and the other 30 provinces is measured separately. The regional economic linkage level of province i is obtained by taking the average value.

The problem of unbalanced economic development between regions can be reflected by nighttime lighting data. Therefore, the regional economic gap in this paper is measured by the Gini coefficient calculated from the nighttime lighting data of each province. The nighttime light data are derived from SNPP-VIRS satellite data published by the National Oceanic and Atmospheric Administration.

Effect of industrial structure upgrading (CYSJ). The paper uses the proportion of added value of the three industries in the region, combining the industrial structure hierarchy coefficient^[27] to measure the effect of regional industrial structure upgrading. The specific calculation formula is:

$$\text{CYSJ}_{it} = \sum_{k=1}^3 k * S_{it,k}, \quad (2)$$

wherein, $S_{it,k}$ represents the share of value added for the three industries in region i in year t ,

Table 1 Evaluation index system for high-quality development of regional economy

Target layer	Index
High-quality development of regional economy	R&D investment intensity
	The intensity of financial expenditure on science and technology
	Labor factor input
	R&D projects for industrial enterprises above designated size
	Number of patent applications granted per 10,000 people
	Technical trading active level
	Urban-rural income ratio
	Urban-rural consumption ratio
	Urbanization
	Proportion of tertiary industry
	Industrial Structure Rationalization Index
	Energy consumption per unit of GDP
	Green coverage rate
	Park area per capita
	Waste gas output per unit of GDP
	Foreign trade dependence
	Trade balance
	Foreign capital dependence
	OFDI
	Engel's coefficient for rural residents
	Elasticity of population income growth
	Educational
	Medical service
	Water supply penetration rate
	Cultural service
	Road hardening rate
	Internet penetration rate
	Average road mileage per 10,000 population

where $k = 1, 2, 3$ corresponds to the primary, secondary, and tertiary sectors, respectively. A higher value indicates a stronger effect on the upgrading of regional industrial structures.

Scientific and technological innovation level (KJCX). The existing literature mainly evaluates the level of regional scientific and technological innovation from the aspects of innovation input and output. In fact, innovation input cannot be completely transformed into actual output, while innovation output can better measure the level of regional scientific and technological innovation. This paper uses the ratio of the number of regional patents granted to the resident population to measure the level of regional scientific and technological innovation^[28].

2.2 Regulating Variable

Government intervention level (ZFGY). Local governments can guide the flow of innovative resources through investment, fiscal expenditure and other ways to promote regional coordinated development^[29]. Based on the existing practice, this paper measures the government intervention level by the proportion of regional general fiscal budget expenditure in GDP.

2.3 Control Variables

Human capital (RLZB). This paper measures the level of human capital by the ratio of the number of students in ordinary colleges and universities to the resident population.

Opening up (DWKF). This paper measures the level of opening up by using the ratio of total regional import and export trade to GDP.

Financial development (JRFZ). This paper uses the proportion of the balance of deposits and loans of financial institutions in GDP to measure the level of regional economic development.

Urbanization rate (CZHL). This paper measures the regional urbanization rate by using the ratio of the regional urban population to the total population at the end of the year^[30].

3 Empirical Analysis

3.1 Model Setting

This paper mainly explores the relationship between scientific and technological innovation, industrial upgrading and the coordinated development of regional economy. First, the paper explores the relationship between industrial upgrading and regional coordinated development. The model is set as shown in Formula (3).

$$QYXT_{it} = \alpha_0 + \alpha_1 CYSJ_{it} + \xi_1 X_{it} + \lambda_i + \varepsilon_{it}, \quad (3)$$

wherein, $QYXT_{it}$ is the interpreted variable, $CYSJ_{it}$ is the explanatory variable, and X_{it} is the vector composed of control variables; α_1 is the coefficient of explanatory variable, which is expected to be positive; ξ_1 is the vector composed of estimated coefficients of control variables, λ_i is the regional fixed effect, which representing the difference of coordinated economic development among regions, and ε_{it} is a random error term. i indicates different provinces, and t indicates different years.

On the basis of this model, in order to verify the impact of scientific and technological innovation on promoting regional coordinated development by promoting industrial upgrading, this paper constructs the following intermediary effect model:

$$QYXT_{it} = \gamma_1 + \beta_1 KJCX_{it} + \xi_2 X_{it} + \lambda_{li} + \varepsilon_{1it}, \quad (4)$$

$$CYSJ_{it} = \gamma_2 + \theta_1 KJCX_{it} + \xi_3 X_{it} + \lambda_{2i} + \varepsilon_{2it}, \quad (5)$$

$$QYXT_{it} = \gamma_3 + \varphi_1 KJCX_{it} + \varphi_2 CYSJ_{it} + \xi_4 X_{it} + \lambda_{3i} + \varepsilon_{3it}, \quad (6)$$

wherein, $CYSJ_{it}$ represents intermediary variable, φ_1 is direct effect, $\theta_1 \times \varphi_2$ is indirect effect, and $c = \varphi_1 + \theta_1 \times \varphi_2$ is overall effect. If φ_1 is not significant, which means the full mediation of

c , and the form of Formula (3) remains unchanged; If φ_1 is significant, it is the partial mediation effect. At this time, Formula (3) can be expressed as Formula (6).

In order to further explore the regulatory effect of government intervention, the interactions between government intervention, industrial upgrading and government intervention are introduced, as shown in Formula (7):

$$QYXT_{it} = \alpha_0 + \alpha_1 CYSJ_{it} + \alpha_2 KJCX_{it} + \alpha_3 ZFGY_{it} + \alpha_3 J_{it} + \xi_1 X_{it} + \lambda_i + \varepsilon_{it}, \quad (7)$$

wherein, J_{it} refers to the interaction between industrial upgrading and government intervention.

3.2 Evaluation on the Level of Coordinated Development of Regional Economy

This paper analyzes the index system of regional economic coordinated development and obtains the index of regional economic coordinated development in 30 provinces from 2012 to 2022. Table 2 is the ranking of the coordinated development level of regional economy in 30 provinces and cities in 2012. It can be seen from Table 2 that Beijing and Tianjin along the northern coast, Shanghai and Zhejiang along the eastern coast, and Guangdong along the southern coast, have higher coordinated development of regional economy. These regions being all the eastern regions, have a higher level of high-quality development of regional economy, regional economic linkage and regional economic gap. Henan, Hubei, Hunan, Liaoning, Heilongjiang, Jilin and other provinces and cities have medium coordinated development of regional economy. Xinjiang, Qinghai, Gansu, Ningxia in the northwest, and Guizhou in the southwest have low coordinated development of regional economy. From the regional perspective, the coordinated development of regional economy in the eastern region is obviously better than that in the central region, while the coordinated development of regional economy in the western region is the lowest.

Table 2 Rank of coordinated development of regional economy by province and city in 2013

Province/City	Rank	Province/City	Rank	Province/City	Rank
Shanghai	1	Henan	11	Jiangxi	21
Beijing	2	Fujian	12	Shanxi	22
Jiangsu	3	Hubei	13	Guangxi	23
Zhejiang	4	Hainan	14	Yunnan	24
Tianjin	5	Hunan	15	Qinghai	25
Guangdong	6	Chongqing	16	Xinjiang	26
Shandong	7	Heilongjiang	17	Inner Mongolia	27
Anhui	8	Jilin	18	Guizhou	28
Hebei	9	Shaanxi	19	Ningxia	29
Liaoning	10	Sichuan	20	Gansu	30

Compared with 2012, the coordinated development of regional economy in 30 provinces and cities in 2022 still shows the development trend that the east being the best, the middle the medium and the west the lowest, as shown in Table 3. Some provinces and cities have

changed, such as Shanxi, Shaanxi, Ningxia. They have risen in ranking, mainly because they have made good progress in regional coordinated development, economic development and social development in recent years, such as economic development level, urbanization rate, economic development quality, economic development structure, medical level, etc. Taking Shanxi as an example, we can find that the per capita GDP in 2012 was 12113 yuan/person, which increased to 25643 yuan/person in 2022, with an increase of 84.35%; The proportion of the tertiary industry in GDP increased from 34.58% in 2012 to 40.56% in 2022, with an increase of 17.29%; The number of beds per 10,000 people in medical institutions increased from 46.6 in 2012 to 65.8, with an increase of 38.50%.

Table 3 Rank of coordinated development of regional economy by province and city in 2019

Province/City	Rank	Province/City	Rank	Province/City	Rank
Jiangsu	1	Hainan	11	Ningxia	21
Shanghai	2	Hubei	12	Guizhou	22
Zhejiang	3	Shaanxi	13	Guangxi	23
Beijing	4	Fujian	14	Heilongjiang	24
Tianjin	5	Hunan	15	Jilin	25
Shandong	6	Chongqing	16	Inner Mongolia	26
Anhui	7	Shanxi	17	Qinghai	27
Guangdong	8	Liaoning	18	Xinjiang	28
Hebei	9	Jiangxi	19	Yunnan	29
Henan	10	Sichuan	20	Gansu	30

The coordinated development of regional economy in China's 30 provinces and cities is mainly characterized by the eastern being the best, the central the medium, and the western the weakest. Based on the comprehensive calculation of the coordinated development of regional economy in the past seven years, 30 provinces and cities are divided into five categories: the highest level regions, the higher level regions, the medium level regions, the lower level regions and the lowest level regions. The highest level regions mainly include Shanghai, Beijing, Zhejiang, Tianjin, Fujian and Guangdong; The higher level regions mainly include Liaoning, Jiangsu, Chongqing, Hunan, Hainan and Heilongjiang; The medium level areas mainly include Hubei, Shandong, Inner Mongolia, Jilin, Shaanxi and Jiangxi; The lower level regions mainly include Sichuan, Anhui, Guangxi, Henan, Hebei and Yunnan; The lowest level areas mainly include Shanxi, Guizhou, Gansu, Ningxia, Qinghai and Xinjiang.

3.3 Effect Result

3.3.1 Overall Regression Results

The Hausman test results of cluster robust standard deviation indicate that fixed effects model should be used. The effects of industrial structure upgrading and technological innovation on the coordinated development of regional economy are shown in Table 4. Model (1) used the individual fixed effect model to test the impact of industrial structure upgrading on coordinated

development of regional economy. Model (2) introduced control variables on the basis of Model (1). It can be seen from the empirical results that, in addition to the differences in coefficient size, the upgrading of industrial structure is significantly positive at the level of 1% in both models. The same conclusion can be drawn from Models (3), (4) and (5). It can be inferred that the upgrading of regional industrial structure can promote the coordinated development of regional economy.

Table 4 Impact of industrial structure upgrading on coordinated development of regional economy

Interpreted variable: QYXT					
Explanatory variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
CYSJ	0.820*** (0.0847)	0.556*** (0.122)	0.599*** (0.0762)	0.369*** (0.102)	0.453*** (0.127)
KJCX			0.300*** (0.0656)	0.334*** (0.0647)	0.286*** (0.0637)
ZFGY					-0.0156 (0.125)
CYSJZFGY					-0.429 (0.379)
RLZB		-0.0784 (0.127)		-0.0561 (0.0933)	-0.108 (0.0887)
DWKF		-0.149*** (0.0512)		0.0559 (0.0400)	0.00623 (0.0496)
JRFZ		-0.123 (0.0880)		-0.0847 (0.0597)	-0.0304 (0.0583)
CZHL		0.410*** (0.159)		0.343*** (0.119)	0.375*** (0.107)
Constant	-0.0289 (0.0278)	-0.00840 (0.0303)	0.00340 (0.0240)	-0.0261 (0.0261)	-0.00887 (0.0351)
R^2	0.670	0.724	0.760	0.799	0.813

Note: *, **, and *** represent significant at the significance level of 10%, 5%, and 1% respectively, similarly hereinafter.

Model (3) and Model (4) show the impact of the development of scientific and technological innovation and industrial structure upgrading on the coordinated development of regional economy. Model (4) introduces control variables on the basis of Model (3), in which industrial structure upgrading is an intermediary variable according to Formula (4). The level of scientific and technological innovation in both models is significantly positive at the 1% level, which can be inferred that there are some positive intermediary effects, namely, the promotion of scientific and technological innovation on the coordinated development of regional economy being realized to a certain extent by promoting industrial structure upgrading. According to the em-

pirical results, the direct effect of scientific and technological innovation level on the coordinated development of regional economy is 0.334, the indirect effect is 0.177, and the overall effect is 0.399, namely, each unit of scientific and technological innovation level increase promoting the coordinated development of regional economy by 0.399 units.

Model (5) tests the effect of government intervention, and adds the regulatory variable of government intervention and the interaction between industrial upgrading and government intervention on the basis of Model (4). According to the empirical results, we can find that government intervention and interaction are not significant. It can be inferred that the government's macroeconomic governance focuses on the medium and long-term strategic planning. In a short time, the effect of government intervention is difficult to directly affect the regional economic coordination index.

3.3.2 Regional Heterogeneity Test

1) Basic regression

Table 5 shows the impact of industrial structure upgrading in different regions on the coordinated development of regional economy. From the empirical results, we can see that the coordinated development of regional economy in eastern provinces is most significantly affected by the upgrading of industrial structure. The upgrading of industrial structure in central regions is significant at the level of 5%, while it is not significant in western regions. The coefficient also decreases from east to west. The reason is that the industrial structure upgrading in economically developed provinces will help the less developed regions in the province achieve remarkably

Table 5 Impact of the upgrading of regional industrial structure on the coordinated development of regional economy

Interpreted variable: QYXT			
Explanatory variable	Eastern (1)	Central (2)	Western (3)
CYSJ	1.141*** (0.247)	0.450** (0.202)	0.127 (0.0785)
RLZB	0.212 (0.157)	0.190 (0.188)	-0.222*** (0.0533)
DWKF	-0.129 (0.0823)	0.235 (0.305)	0.210 (0.144)
JRFZ	-0.173 (0.167)	-0.213** (0.0866)	0.0638 (0.0536)
CZHL	0.0629 (0.349)	0.356* (0.206)	0.633*** (0.0926)
Constant	-0.0939 (0.0601)	-0.104 (0.0675)	-0.0544 (0.0396)
R^2	0.809	0.818	0.933

economic development, narrow the gap of economic development in the province, and promote the economically coordinated development in the province. In some underdeveloped provinces, the economic development gap between regions is insignificant, and the role of industrial structure upgrading in accelerating the development of regions is not obvious.

2) Test of intermediary effect of industrial structure upgrading

Table 6 shows the heterogeneity of the impact of technological innovation and industrial structure upgrading in different regions on the coordinated development of regional economy. Although the impact is positive, only two variables in the eastern region pass the significance test. The eastern region is economically developed, and scientific and technological innovation has both direct and indirect impacts on the coordinated development of regional economy.

Table 6 Impact of regional scientific and technological innovation and industrial structure upgrading on the coordinated development of regional economy

Interpreted variable: QYXT			
Explanatory variable	Eastern (1)	Central (2)	Western (3)
CYSJ	0.930*** (0.254)	0.339* (0.177)	0.103* (0.0582)
KJCX	0.173*** (0.0395)	0.404* (0.218)	0.370*** (0.113)
RLZB	0.224 (0.163)	0.0434 (0.174)	-0.178*** (0.0503)
DWKF	-0.00261 (0.0803)	0.223 (0.185)	0.225** (0.115)
JRFZ	-0.151 (0.133)	-0.153** (0.0776)	0.0793 (0.0504)
CZHL	0.0890 (0.328)	0.314** (0.139)	0.478*** (0.0997)
Constant	-0.134* (0.0714)	-0.0354 (0.0545)	-0.0459 (0.0328)
R^2	0.836	0.826	0.939

The economy of the central and western regions is underdeveloped, and the scientific and technological innovation cannot fully affect the coordinated development of regional economy, therefore, the boosting effect of scientific and technological innovation has not been reflected.

3) Effect test of government intervention

From the empirical results in Table 7, we can see that the government intervention and interaction items in the eastern, central and western regions are not significant. The empirical results are consistent with the previous analysis, namely, in a short time, the role of government intervention being difficult to be reflected in the regional economic coordination index.

Table 7 Effect test of government intervention in different regions

Interpreted variable: QYXT			
Explanatory variable	Eastern (1)	Central (2)	Western (3)
CYSJ	0.698** (0.275)	−0.0668 (0.354)	0.175 (0.107)
KJCX	0.0989* (0.0537)	1.598*** (0.474)	0.345*** (0.119)
ZFGY	−0.0452 (0.241)	−0.172 (0.463)	−0.0591 (0.127)
CYSJ*ZFGY	−0.835 (0.737)	0.795 (1.106)	−0.0963 (0.254)
RLZB	−0.0627 (0.130)	−0.471* (0.275)	−0.186*** (0.0461)
DWKF	−0.222* (0.133)	−0.113 (0.322)	0.194* (0.106)
JRFZ	−0.133 (0.102)	0.0492 (0.155)	0.106** (0.0474)
CZHL	0.537 (0.400)	0.119 (0.299)	0.434*** (0.0847)
Constant	−0.000987 (0.0385)	0.263* (0.136)	−0.0245 (0.0556)
R^2	0.815	0.595	0.940

3.3.3 Robustness Test

To verify the robustness of the model, Formula (1) and Formula (4) are tested as follows, shown in Table 8.

1) Replace the regression method

The common mixed regression method ignoring individual heterogeneity is used for regression. The results show that the impact of technological innovation and industrial structure upgrading on the coordinated development of regional economy is still significantly positive after changing regression method, which is consistent with the above. It proves that the model results are relatively robust.

2) Lag the explanatory variables

Considering the time lag of the impact of industrial structure upgrading and scientific and technological innovation on the coordinated development of regional economy, this paper takes industrial structure upgrading lagging for 1 period and scientific and technological innovation lagging for 2 periods as the new independent variables for regression. The results show that the coefficient of the new explanatory variable is still significantly positive, which is consistent with the previous results.

Table 8 Regression results of robustness test

Interpreted variable: QYXT						
Explanatory variable	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
CYSJ	0.601*** (0.0948)	0.354*** (0.0845)	0.525*** (0.0902)	0.339*** (0.0944)	0.556*** (0.122)	0.369*** (0.102)
KJCX		0.455*** (0.0815)		0.485*** (0.115)		0.334*** (0.0647)
RLZB	-0.0613 (0.0602)	-0.0439 (0.0474)	-0.0380 (0.0611)	-0.00672 (0.0508)	-0.0784 (0.127)	-0.0561 (0.0933)
DWKF	0.271*** (0.0836)	0.150** (0.0718)	0.363*** (0.0977)	0.294** (0.116)	-0.149*** (0.0512)	0.0559 (0.0400)
JRFZ	-0.352*** (0.0759)	-0.301*** (0.0647)	-0.338*** (0.0764)	-0.319*** (0.0704)	-0.123 (0.0880)	-0.0847 (0.0597)
CZHL	0.345*** (0.0867)	0.237*** (0.0691)	0.326*** (0.0924)	0.184** (0.0789)	0.410*** (0.159)	0.343*** (0.119)
Constant	-0.0285 (0.0193)	0.0365* (0.0205)	-0.00411 (0.0215)	0.0623** (0.0262)	-0.00840 (0.0303)	-0.0261 (0.0261)
R^2	0.722	0.783	0.725	0.783	0.724	0.799

3) Reduce interference from extreme values

In order to further reduce the interference of extreme values on the accuracy of the results, 5% tail reduction was performed on the research samples according to the regional coordinated development index of the explained variables, and the regression was performed again. After data processing, the estimated coefficients of the core explanatory variables are still significant at the 1% significance level, and the coefficient symbols are consistent with the above results, which confirms the robustness of the regression results.

It can be seen that the model established in this paper has certain robustness.

4 Conclusion

In this paper, an evaluation index system for the coordinated development of regional economy is constructed. On this basis, by considering the impact of the upgrading of industrial structure, the scientific and technological innovation, the government intervention and the interaction between multiple factors on the coordinated development of regional economy, the coordinated development pattern of regional economy in China is further revealed. The following conclusions can be drawn from our study:

1) The following regions have higher level of coordinated development of regional economy: Beijing and Tianjin in the north coast; Shanghai and Zhejiang Province in the east coast; Fujian Province and Guangdong Province in the south coast China. From the regional perspective, the eastern region has significantly better coordinated development of regional economy than the central region, while the western region has the lowest coordinated development level of regional

economy.

2) The upgrading of regional industrial structure can promote the coordinated development of regional economy. The effect of scientific and technological innovation in promoting the coordinated development of regional economy is partly achieved by promoting the upgrading of industrial structure. The macroeconomic governance by government focuses on the medium and long-term strategic planning. Therefore, the effect of government intervention cannot be well reflected in the regional economic coordination index in short term.

3) The upgrading of industrial structure has the most significant influence on the coordinated development of regional economy in the eastern region. The reason could be that the upgrading of industrial structure in economically developed provinces contributes to the economic development of less developed areas in the province, thus narrowing the gap from the developed area in the province in the economic development level and promoting the coordinated development of the economy in the province. The eastern region has relatively developed economy, and the scientific and technological innovation has both direct and indirect influences on the coordinated development of regional economy. The central and western regions have underdeveloped economy. The effect path of scientific and technological innovation on the coordinated development of regional economy is not comprehensive and smooth, so the boosting effect of scientific and technological innovation is not reflected.

In response to the above conclusions, this paper puts forward the following policy recommendations: Continuously promote inter-regional cooperation, especially between the eastern and central and western regions, and utilize the economic and technological advantages of the eastern region to promote the upgrading of the industrial structure and the development of scientific and technological innovation in the central and western regions. Increase support for industrial structure upgrading, especially for the central and western regions, and encourage enterprises to carry out technological innovation and industrial transformation through policy guidance and market mechanisms. In the central and western regions, a perfect science and technology innovation system should be constructed, and the environment for science and technology innovation should be optimized to ensure that the achievements of science and technology innovation can be smoothly transformed into a driving force for economic growth. The government should fully consider the role of the market mechanism when formulating medium- and long-term strategic planning, and optimize the allocation of resources through policy guidance to promote the coordinated development of the regional economy. It should regularly assess and monitor the status of coordinated regional economic development, identify problems in a timely manner and take effective measures to resolve them, so as to ensure the sustained, healthy and coordinated development of the regional economy.

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