The Effect of China's Scientific and Technological Innovation on Improving the Quality of Economic Development Based on Panel Data

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Abstract. Scientific and technological innovation has become an important strategic measure to achieve high-quality economic development under the new development pattern in China. Exploring the mechanism of scientific and technological innovation on economic development quality is of great significance to achieve high-quality economic development and the long-term goal of socialist modernization. Based on the panel data of 30 provinces in China from 2003 to 2019, this paper measures China's economic development quality and analyzes its temporal and spatial evolution trend. With the help of the variable coefficient fixed-effect model, this paper empirically studies the impact of scientific and technological innovation on the quality of economic development. It is found that the quality of China's economic development is improving year by year, and the region with the best quality of economic development is gradually inclined from the southeast coastal region of China to the north China region. Scientific and technological innovation has significantly promoted the quality of economic development, and there are regional differences.

keywords: Quality of economic development; Scientific and technological innovation; SBM super-efficiency model; Variable coefficient fixed effect model

1. Introduction

With the increasing level of economic development, the era of rapid economic growth in China has passed. The future development direction of China's economy will evolve to a more advanced stage, and the economic development mode will change from scale and speed growth to quality and efficiency growth [1]. China's economy has changed from a high-speed growth stage to a high-quality development stage since 2017. China attaches great importance to the role of scientific and technological innovation in future development. In the "14th Five-Year Plan"(2021-2025), the Chinese government clearly states that science and technology should be self-reliant as the strategic support of national development, improve the national innovation system, and accelerate the construction of a strong country in science and technology. China has activated the engine of innovationled growth [3]. Scientific and technological innovation

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has become a strategic measure to achieve high-quality economic development under the new de-elopment pattern in China.

Scholars have done a lot of research on the topic of "technological innovation drives economic development". Cobb and Douglas (1928) jointly proposed using the Cobb-Douglas production function to calculate the contribution rate of technological progress to the new output value [1]. Solow (1956) estimated the contribution of technological progress to economic growth by using the Cobb-Douglas production function and growth rate equation and concluded that technological progress drives permanent economic growth [4]. Denison (1962) put forward the factor analysis method of economic growth and measured the degree of economic growth by using the growth of national income or the average employed national income [5]. Romer (1986) put forward a competitive equilibrium model with endogenous technological change and explained economic growth with endogenous technology [6]. The above research results provide a rich theoretical and model basis for later scholars. In 1990, Romer put forward his second endogenous economic growth model, in which technological innovation, as a specialized input, can enable enterprises to acquire new characteristics of assets. He proposed that the government provide subsidies for scientific and technological innovation activities to promote economic growth [7]. Lucas (1988), with studying the data of American economic growth in the 20th century, proposed that the accumulation of human capital caused technological progress, thus promoting economic growth [8]. Aghion and Howitt (1992) think that technological innovation and technological progress will have positive and normative significance for economic growth. Innovation gives enterprises monopoly advantages in a short time. However, high-level research in the future may limit this monopoly advantage. New innovation will replace old innovation and promote economic growth and cyclical changes through innovation [9]. Becker (1992) thinks that investment in technology and knowledge can promote labor specialization and economic development [10]. Maria (2018) believes that innovation is the main driving force for the growth of more and more economies, and social capital influences technological innovation and then economic growth [11]. In recent years, much research on technological progress and economic growth has been done by deepening the theory of endogenous economic growth. The research results are not fixed to a single conclusion. Alwyn (1995) studied the economic growth in some parts of East Asia. It is considered that capital accumulation and labor participation rate of human capital has a higher driving effect on economic growth than technological progress [12]. Cozza (2012) analyzes the impact of product innovation on the economic performance of enterprises. The results show that innovative products have a positive and significant "innovation premium", and the impact of small companies is more significant [13]. Ngoc (2020) proposes that for achieving the real possibility of endogenous growth, the states must combine capital accumulation with the enhancement of technical progress to offset the decreasing trend of marginal return on capital through continuous technological innovation [14].

As for the quantitative measurement of science and technology investment, scholars mostly use R&D investment to study the impact on science and technology investment and divide R&D into government R&D investment and private R&D investment. Jose (2004) combed 74 papers, and statistics showed that 51.35% of the research conclusions indicated that government R&D investment could reduce the cost and risk of private R&D and jointly promote economic growth [15]. But the scholar Howe (1976) [16], Wallsten (2000) [17], and other scholars hold the opposite view that government R&D investment and private R&D investment cannot promote economic growth together. Lichtenberg (1992) estimated that the investment return rate of private R&D investment is about seven times that of facilities and equipment. Increasing private R&D investment has a noticeable stimulating effect on economic growth [18]. Coe and Helpman (1993) took 22 countries as samples, it is considered that R&D investment affects a country's total factor productivity, and foreign R&D capital stock is a significant factor affecting total factor productivity. The effect is more evident in smaller countries [19]. Charles (1998) thinks that the private R&D investment in the current economic system is too small, and R&D investment is of great significance to long-term economic growth [20]. Wu (2008) confirmed a long-term equilibrium relationship between China's economic growth and R&D investment. Up to 2005, the government's R&D investment has played a particular role in promoting China's economic growth, but the effect is not apparent [21]. Yuen (2016) founds that simply increasing public R&D expenditure can not stimulate economic growth, and active industrial policies are needed to stimulate the generation of innovation activities [22].

Econometrics in the era of big data presents the characteristics of cross-discipline integration when it is used to analyze economic problems. Based on the method of integrating big data analysis and econometrics, this paper demonstrates and analyzes the topic of "scientific and technological innovation to improve the quality of economic development", which is reflected in the the following four aspects: First, information screening: Big data brings a large amount of information to analyze economic problems, but the information presents the characteristics of low value density. Therefore, in the face of various statistical data, it is necessary to fully mine the available data around the research topic to ensure that Data sources are reliable, themes are relevant, and meanings are clear. The analysis and demonstration based on effective data has more practical significance. Second, multi-type data fusion: big data is characterized by the diversification of data types and complex variable relationships. The time-varying, non-linear and non-stationary nature of economic variables limit the selection of models and the characterization of variable relationships. This paper integrates relative and absolute data to provide more metadata for subsequent problem analysis. Third, the comprehensive application of multiple models: In order to objectively describe the relationship between scientific and technological innovation and the quality of economic development, this paper chooses different models for specific problems, and selects models that directly solve problems in evaluation analysis and relationship analysis. The results are combined with the analysis of the development status. Fourth, social network: In the era of big data, data is no longer a flat number, social network and spatial correlation are gradually strengthened, and it is closer to the actual economic operation status. relative level.

Compared with the existing literature, the contributions of this paper are as follows: Firstly, distinguish between economic growth and economic development, and quantify the quality of economic development by clarifying the connotation of economic development; Secondly, this paper constructs the index system of scientific and technological innovation from three angles of scientific and technological input, scientific and technological output and scientific and technological background, and analyzes technological innovation, scientific and technological input and economic development in the same system; Finally, the analysis method chosen in this paper makes the analysis results have both horizontal comparison and vertical comparison, which makes the analysis angle more comprehensive.

Based on the panel data of 30 provinces in China from 2003 to 2019, this paper analyzes the temporal and spatial differences of China's economic development quality to measure the high-quality development of China's regional economy. Through deeply exploring the impact of scientific and technological innovation on the quality of eco-nomic development and the way and degree of impact in different regions, this paper reveals the concrete effects of promoting scientific and technological innovation on the quality of economic development in different countries economic regions.

2. China's provincial economic development quality measurement

2.1 Connotation of economic development quality

Barro (2002) thinks that there are differences between quantity and quality in economic growth. He emphasizes that the quality of economic growth is a complex and broad concept related to economic development, income distribution, and political system [23]. Martinez (2013) believes that high-quality economic growth is a robust, stable, and sustained growth, producing the desired results by improving productivity [24]. High-quality economic development is different from economic development in the ordinary sense. It depends on the typical growth of economic growth and all social residents' livelihood and welfare level [25]. It can be seen that scholars agree that the quality of economic development is a complex and broad concept. Chinese scholars have also extensively explored the connotation of China's economy. Mei Kang (2006) thinks that the quality of economic growth is the efficiency of economic growth [26]. Baoping Ren (2012) defined the quality of economic growth as the quantity of economic growth that reaches higher economic growth efficiency, more reasonable economic growth structure, more reasonable welfare distribution, and long-term stable development of economic growth [27]. Huanming Xiao (2014) believes that the improvement of economic growth quality is reflected in improving resource allocation efficiency. The efficiency of resource allocation needs to consider the input-output efficiency of labor and capital, the consumption of natural resources, and the damage to the environment by the economic system [28]. China’s economy has changed from extensive, high-speed growth realized mainly by increasing the consumption of material resources to a growth mode based on scientific and technological progress, improvement of management level, and improvement of workers' quality and ability. The transformation of China's economic growth mode shows the quality of economic development [29].

Based on the research results of the above scholars, this paper defines the quality of economic development as: on the micro-level, the improvement of production efficiency; on the middle-level, the industrial structure is upgraded to accelerate the transformation of old and new kinetic energy; on the macro level, the state of economic devel-opment with balanced and long-term economic development.

2.2 Research method

2.2.1 Unexpected output SBM model

In 2001, Tone proposed the unexpected output SBM model, which considers the relaxation between the current state of invalid DMU and the target value of strong efficiency [30]. It is supposed that there are n DMUs in total. Each DMU has m inputs, s_1 expected outputs, and s_2 unexpected outputs. Input matrix can be defined as $X=\left[x_1,x_2,...,x_N\right]\in R^{N\times m}$; the expected output matrix and the unexpected output matrix are as follows: $Y^e = \left[y_1^e, \ldots, y_N^e \right] \in R^{N \times s_1}$, $Y^w = \left[y_1^w, \ldots, y_N^w \right] \in R^{N \times s_2}$. $x_i > 0$, $y_i^e > 0$, $y_i^w > 0$. The set of production possibilities under constant scale compensation can be defined as:

$$P = \left\{ \left(x, y^e, y^w \right) \middle| x \geq X\lambda, y^e \leq Y^e\lambda, y^w \geq Y^w\lambda, \lambda \geq o \right\} \tag{1}$$

The linear programming expression of the SBM model with unexpected output is as follows:

$$\min \rho = \frac{1 - \frac{1}{m} \sum_{i=1}^{m} s_i^- / x_{i0}}{1 + \frac{1}{s_1 + s_2} \left(\sum_{r=1}^{s_1} s_r^e / y_{r0}^e + \sum_{r=1}^{s_2} s_r^w / y_{r0}^w \right)}$$

$$s.t. \begin{cases} x_{i0} = X\lambda + S_i^- \\ y_{r0}^e = Y^e\lambda - S_r^e \\ y_{r0}^w = Y^w\lambda + S_r^w \\ S_i^- \geq 0, S_r^e \geq 0, S_r^w \geq 0, \lambda \geq 0 \end{cases}$$

where S^- represents input slack variable; S^e represents the expected output relaxation variable; S^w represents the slack variable of unexpected output; λ represents the weight vector, $0 \leq \rho \leq 1$. The SBM model can effectively solve the efficiency evaluation problem with unexpected output by introducing relaxation variables into the objective function. The improved part of relaxation can be reflected in the measurement of efficiency value.

2.2.2 Window analysis

Window Analysis, proposed by Charnes A, is used to study the efficiency of American air force maintenance units and is suitable for the efficiency analysis of panel data [31]. DEA window analysis method regards the data of different time periods of the same DMU as a relatively independent "decision unit" and selects different reference sets to evaluate the relative efficiency of the "decision unit". Through window analysis, it can meet the efficiency comparison of DMU in time longitudinal direction, the horizontal direction between decision-making units, and overall angle.

Assuming that there are n DMUs and p periods, the number of "decision units" participating in DEA window analysis is np. When the window width is set to $d\left(d \leq p\right)$, the number of windows $Num_{win} = p - d + 1$, the number of "decision-making units" in each window $Num_{DMU} = nd$. When the window width is set to d, a window covers d adjacent time periods. The input matrix and output matrix from time point t are as follows:

$$X_{td} = \left(x_1^t, x_2^t, \ldots, x_n^t, x_1^{t+1}, x_2^{t+1}, \ldots, x_n^{t+1}, \ldots, x_1^{t+d-1}, x_2^{t+d-1}, \ldots, x_n^{t+d-1} \right)$$

$$Y_{td} = \left(y_1^t, y_2^t, \ldots, y_n^t, y_1^{t+1}, y_2^{t+1}, \ldots, y_n^{t+1}, \ldots, y_1^{t+d-1}, y_2^{t+d-1}, \ldots, y_n^{t+d-1} \right)$$

2.3 Indicator selection and data source

The measurement methods of economic development quality can be roughly divided into the following two categories: the first is to build an evaluation index system and use the comprehensive evaluation method or principal component analysis method to evaluate the quality of economic development [32-35]. This method needs a large amount of data as support, so it is challenging to realize objective evaluation with a large time span and wide regional coverage; the second method focuses on total factor productivity and evaluates the quality of economic development by adding different input and output indicators [36-37].

Table 1 Input and output index of economic quality development

	Indicator	Specific indicator	Data
Input	resources	total energy consumption	original data
	capital	investment in fixed assets of the whole society	PIM[1]
	labor force	number of employees at the end of the year	original data
Expected output	economics	gross regional product	actual value[2]
Unexpected output	environment	SO_2 emissions	original data

[1] PIM(perpetual inventory method): refer to paper [38] for data processing method.

[2] Real GDP at constant price in 2003.

Compared with traditional economic development, economic development in the new era pays more attention to the concepts of green development and efficiency im-provement. Therefore, this paper introduces environmental pollution as an unexpected output index based on the total factor productivity index system and selects the SBM model of unexpected output and window analysis method to evaluate the quality of China's provincial economic development. This paper takes 30 provinces (municipalities and autonomous regions) in China from 2003 to 2019 as the research objects and investigates the temporal evolution trend and spatial differences of the quality of provincial economic growth in China. Considering the availability of data, Tibet, Hong Kong, Macau, and Taiwan Province are not included in the study. The data mainly come from the China Statistical Yearbook, China Environmental Statistical Yearbook, and Statistical Yearbooks of various provinces in relevant years. See Table 1 for specific indicators and data processing processes.

2.4 Economic development quality measurement

Figure 1 shows the changing trend of China's economic development quality from 2003 to 2019. The vertical change of economic development quality can be divided into three periods: 2003-

2007; 2008-2014; 2015-2019. The quality of China's economic devel-opment has maintained a growth trend from 2003 to 2019 and has shown an increasing trend in three time periods. The increasing trend is more and more apparent. In a total of 16 years, the growth rate of economic development quality in the first 11 years is consistent with that in the last five years. Although the quality of China's economic development has been growing continuously and the growth trend is gratifying, it can be seen from the analysis of specific numerical values that China's economic development is still in the transition stage from quantitative to quality and has not yet achieved complete high-quality development. There is still much room for improvement.

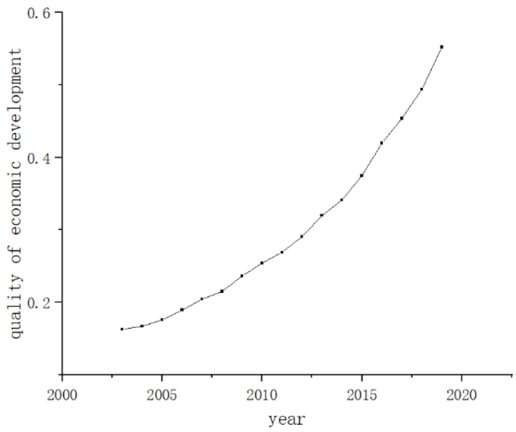

Figure 1 China's economic development quality measurement results from 2003 to 2019

Table 2 shows the measurement results of economic development quality of 30 provinces (municipalities and autonomous regions) in China from 2003 to 2019. Due to space limitations, the table only shows economic development quality calculation results in some years. According to the analysis, all provinces showed the trend of high-quality economic development during the research period. Among them, Beijing, Tianjin, Inner Mongolia, Shanghai and Fujian in 2019 have achieved high-quality economic development.

Analyzing the economic development quality index by province, Beijing, Inner Mongolia, Shanghai, Tianjin, Fujian, Jiangsu, and Guangdong increased rapidly from 2003 to 2019. Although Guizhou, Yunnan, Gansu, Qinghai, Shanxi, Xinjiang, and Ningxia show a trend of high-quality development, this trend is not apparent, compared with other provinces, the improvement of economic development quality is slow.

Table 2 Economic development quality of China's provinces from 2003 to 2019

Region	2003	2010	2017	2018	2019
Beijing	0.196	0.305	0.591	0.829	1.192
Tianjin	0.209	0.368	0.815	0.917	1.035
Hebei	0.139	0.210	0.328	0.345	0.366
Shanxi	0.105	0.169	0.247	0.256	0.266

Inner Mongolia	0.136	0.292	0.774	0.845	1.022
Liaoning	0.177	0.305	0.444	0.461	0.477
Jilin	0.138	0.263	0.483	0.502	0.508
Heilongjiang	0.186	0.292	0.481	0.502	0.535
Shanghai	0.267	0.400	0.727	0.809	1.107
Jiangsu	0.232	0.343	0.587	0.638	0.717
Zhejiang	0.202	0.308	0.518	0.563	0.599
Anhui	0.164	0.272	0.460	0.486	0.511
Fujian	0.265	0.365	0.745	0.898	1.026
Jiangxi	0.178	0.284	0.460	0.482	0.526
Shandong	0.178	0.288	0.492	0.526	0.559
Henan	0.157	0.252	0.465	0.496	0.544
Hubei	0.166	0.263	0.495	0.535	0.564
Hunan	0.180	0.243	0.443	0.471	0.505
Guangdong	0.234	0.341	0.563	0.607	0.665
Guangxi	0.162	0.255	0.429	0.445	0.463
Hainan	0.200	0.273	0.404	0.423	0.450
Chongqing	0.152	0.227	0.479	0.500	0.527
Sichuan	0.134	0.212	0.396	0.417	0.439
Guizhou	0.084	0.141	0.270	0.285	0.302
Yunnan	0.128	0.181	0.313	0.330	0.347
Shannxi	0.125	0.199	0.330	0.349	0.362
Gansu	0.099	0.156	0.254	0.261	0.275
Qinghai	0.092	0.133	0.211	0.220	0.233
Ningxia	0.069	0.114	0.171	0.177	0.183
Xinjiang	0.125	0.169	0.242	0.250	0.260

Figure 2 shows the ranking information of economic development quality of each province in 2003 and 2019. Ranking from high to low in the figure corresponds to filling color from dark to light. From the analysis, we can draw the following conclusions: in 2003, high-quality provinces with economic development were concentrated in the southeast coastal areas of China. The areas with low economic quality development are concentrated in Northwest China. After 17 years of development, by 2019, the areas with high economic quality are gradually inclined to the North China region. However, the areas with low economic development have not developed well in this period and are still at the back end of the ranking.

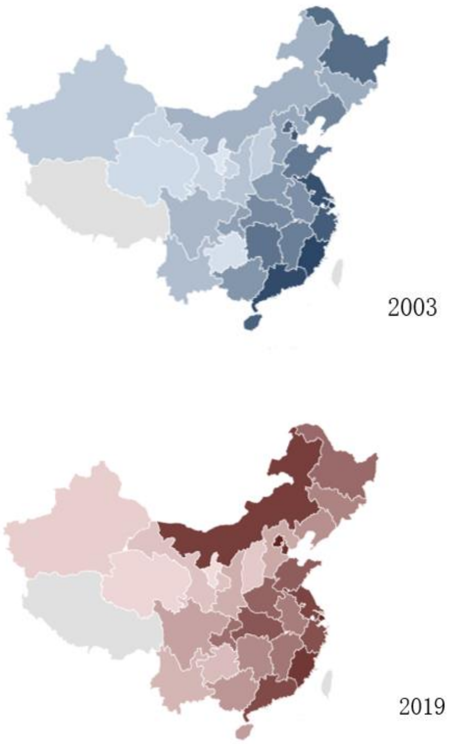

Figure 2 (a) Information chart of economic development quality ranking of China's provinces in 2003; (b) Information chart of economic development quality ranking of China's provinces in 2019

Tracking the ranking information of each province from 2003 to 2019, we can see that Guangdong, Guangxi, Hainan, Hebei, Heilongjiang, Hunan, Jiangxi, and Liaoning have different degrees of ranking decline. Beijing, Guizhou, Henan, Hubei, Jilin, Inner Mongolia, Tianjin, and Chongqing have an upward trend in ranking. The ranking of economic quality development of other provinces remained unchanged from 2003 to 2019. China's 30 provinces can be divided into three categories according to the ranking trend, and the statistical information is shown in Table 3.

Table 3 Regional division of economic development quality

Regions with improved economic development quality	Regions with stable economic development quality	Regions with declined economic development quality

Beijing, Guzhou, Henan, Hubei, Jilin, Tianjin, Chongqing, Inner Mongolia	Anhui, Fujian, Gansu, Jiangsu, Ningxia, Qinghai, Shandong, Shanghai, Shannxi, Sichuan, Xinjiang, Yunnan, Shanxi, Zhejiang	Guangdong, Guangxi, Hainan, Hebei, Heilongjiang, Hunan, Jiangxi, Liaoning

3. Analysis of regional differences in the impact of scientific and technological innova-tion on the quality of economic development

Scientific and technological innovation plays a driving role in the quality of economic development. On the one hand, scientific and technological innovation can im-prove production efficiency, balance the allocation of factors through technological progress, improve the production capacity of social sectors, and reduce the investment of resources and funds. On the other hand, science and technology promote the development of new industries and the transformation of traditional high energy-consuming industries and optimize the industrial structure by accelerating the transformation of new and old economic kinetic energy to improve the quality of economic development.

The impact of scientific and technological innovation on the quality of economic development is noticeable. Still, as the above results show, there are regional differences in the quality of economic development. Therefore, based on the panel data, this paper uses the variable coefficient fixed effect model to deeply explore the impact of scientific and technological innovation on the quality of economic development, as well as the way and degree of impact in different regions, and reveals the specific effects of promoting scientific and technological innovation on the quality of economic development in different economic regions.

3.1 Variable selection and data description

The explained variable is the economic quality development index (Eqd). The data of the explained variables come from the economic quality development index based on the SBM model of unexpected output combined with window analysis. Some data are shown in Table 2.

The explanatory variable is the science and technology innovation index (Tein). The science and technology innovation index has not formed a unified evaluation sys-tem. This paper constructs the science and technology innovation index from the background environment and input-output of science and technology innovation. They explicitly include R & D personnel full-time equivalent, R & D funds internal expenditure, the number of patent applications authorized, technology market turnover, the number of institutions of higher learning, education funds, a total of six indicators. All indicators are positive ones. To make the data comparable, the original data is stand-ardized, and the sum of equal weight is used to represent the sci-tech innovation index. The original data of all indicators are from China Statistical Yearbook and provincial Statistical Yearbooks.

3.2 Panel data stationarity test

The panel data should be tested for stationarity to ensure the effectiveness of the model estimation results and avoid the pseudo-regression phenomenon. The test re-sults of ADF Fisher and PP Fisher are shown in Table 4.

Table 4 Unit root test

Variable	ADF-Fisher Test		PP-Fisher Test		Conclusion
Eqd	48.561	0.855	92.186***	0.005	unstable
ΔEqd	128.675***[3]	0.000	160.333***	0.000	stable
Tein	19.639	1.000	14.884	1.000	unstable
ΔTein	123.244***	0.000	167.424***	0.000	stable

[3] *, **, *** are significant at the levels of 10%, 5%, and 1%, respectively, which are the same below.

The results show that under the two forms of the combined p-value test, the horizontal values of all variables have unit roots, and the original sequences are non-stationary sequences. In the case of first-order difference, all variables reject the original hypothesis at a 1% level, which indicates that all variables are stationary series in the case of first-order difference and meet the basic data conditions for establishing a regression model.

3.3 Panel data cointegration test

The unit root test results show that the panel data of each variable is stable after the first-order difference. To confirm the long-term stable relationship between variables, it is necessary to carry out a cointegration test on variables. This paper uses the Pedroni test in the Engle-Granger two-step method to conduct a cointegration test on variables. The specific test results are shown in Table 5.

Table 5 Estimation results of cointegration test

Test method	Statistics name	Statistics value
Pedroni test (homogeneous panel)	Panel v-Statistic	10.687***
Pedroni test (homogeneous panel)	Panel rho-Statistic	1.177
Pedroni test (homogeneous panel)	Panel PP-Statistic	-1.877**
Pedroni test (homogeneous panel)	Panel ADF-Statistic	-1.590*
Pedroni test (heterogeneous panel)	Group rho-Statistic	2.787
Pedroni test (heterogeneous panel)	Group PP-Statistic	-3.673***
Pedroni test (heterogeneous panel)	Group ADF-Statistic	-3.414***

It can be seen from Table 5 that in the Pedroni test, Panel rho - Statistic and Group rho - Statistic accept the original hypothesis. In contrast, other tests reject the original hypothesis that there is no cointegration relationship between the panel. Comprehensive test results can infer a long-term cointegration relationship between variables, and further panel regression analysis can be conducted.

3.4 Panel data model selection

Before regression analysis of panel data, the form and influence mode of the model should be set. The form of the model was selected by covariance test (F test). The specific test results are shown in Table 6.

According to the F test, the variable coefficient model should be chosen for estimation. In this paper, the members remain unchanged each year, so the fixed effect model is chosen. At the same time, considering the regional differences of science and technology development, the crosssection weighting method is selected to estimate the variable intercept model.

Table 6 F test of model selection

Inspection items	F statistic	$F_{0.05}$ critical value	Conclusion
F_2 test	24.450	1.495	reject mixed model
F_1 test	51.375	1.356	reject variable intercept model

3.5 Panel regression estimation results

Table 7 shows the coefficient value and significance test results of scientific and technological innovation on economic quality development in each province. The R2 of the model is 0.968, which explains the relationship between scientific and technological innovation and economic quality development of each province is 96.8%. The adjusted goodness of fit is 0.964, which shows that the model's goodness of fit is better. F = 217.215, P = 0.000, which indicates that the ability of science and technology innovation to explain the quality of economic development has reached a significant level. The in-creased level of inter-provincial economic development quality is "c=-0.261" which means that China's economic development still has room for improvement. The nega-tive growth is due to the poor quality of economic development in individual provinces. The estimation result of the model can be expressed as the following formula.

$$Eqd_{it} = -0.261 + eTein + \mu$$

By comparing the estimated values of coefficients of scientific and technological innovation in different regions, on the whole, the improvement of China's scientific and technological innovation ability can significantly promote the improvement of economic development quality. In the division of economic development quality, there are also regional differences. The average value of the science and technology innovation coefficient is as follows: the regions with improved economic development quality > the regions with stable economic development quality > the regions with declined economic development quality. And the average value of science and technology innovation coefficient in the region with accelerated economic development quality is higher than the other two. However, there is little difference in the value of science and technology innovation coefficient between regions with flat economic development quality and regions with slow economic development quality. Among them, the provinces with better economic development quality, such as Tianjin, Beijing, Inner Mongolia, Shanghai, Jiangsu, and Fujian, have higher values of science and technology innovation coefficient, while the provinces in northwest China perform poorly in the measurement of economic development quality. The role of science and technology innovation in promoting their economic development quality is relatively insignificant. The ranking of economic development quality in Inner Mongolia in all provinces and autonomous regions has been promoted rapidly, and the corresponding scientific and technological innovation coefficient is the largest; Hainan ranked the most apparent decline, corresponding to the lowest coefficient of scientific and technological innovation. Therefore, it can be analyzed that scientific and technological innovation is prominent for promoting high-quality regional development. To enhance the ability of regional science and technology innovation, increase investment in science and technology, and strengthen the innovation background will help to improve the high-quality development of a re-gional economy.

Table 7 Regression estimation coefficient of the impact of regional scientific and technological innovation on the quality of economic development

Regions with improved economic development quality	
Region	Coefficient value
Tianjin	0.844^{***}
Inner Mongolia	1.139^{***}
Beijing	0.864^{***}
Hubei	0.732^{***}
Jilin	0.840^{***}
Henan	0.772^{***}
Chongqing	0.753^{***}
Guizhou	0.566^{***}
Mean	0.814
Regions with stable economic development quality	
Region	Coefficient value
Shanghai	0.812^{***}
Fujian	0.673^{***}
Jiangsu	0.610^{***}
Zhejiang	0.611^{***}
Shandong	0.614^{***}
Anhui	0.540^{***}
Sichuan	0.621^{***}
Shannxi	0.599^{***}
Yunnan	0.621^{***}
Shanxi	0.545^{***}
Xinjiang	0.646^{***}
Gansu	0.561^{***}
Qinghai	0.503^{***}
Ningxia	0.528^{***}
Mean	0.606
Regions with declined economic development quality	
Region	Coefficient value
Guangdong	0.498^{***}
Heilongjiang	0.679^{***}
Liaoning	0.772^{***}
Jiangxi	0.542^{***}

Hainan	0.374^{***}
Guangxi	0.529^{***}
Hunan	0.732^{***}
Hebei	0.560^{***}
Mean	0.586

4. Conclusions and suggestions

4.1 Conclusions

Time evolution of China's economic development quality: China's economic development quality has maintained a growth trend from 2003 to 2019, and the later growth trend is more prominent. Although the quality of China's economic development has been growing continuously, and the growth trend is gratifying, it can be seen from the analysis of the specific data that China's economic development is still in the transition stage from quantitative type to quality type, and has not yet achieved complete high-quality development, so there is still a lot of room for progress.

Spatial differences in the quality of China's economic development: There are spatial differences in China's economic development quality. The region with high eco-nomic quality development gradually inclines from the southeast coastal region of China to the north China region. The areas with low economic quality development are concentrated in Northwest China, which has not yet shown the trend of regional evolution.

Scientific and technological innovation promotes high-quality economic development: The improvement of China's scientific and technological innovation ability can significantly improve the quality of economic development. The average science and technology innovation coefficient value are highest in the regions with improved economic development quality. In the provinces with rapid economic development quality and top ranking, the driving force of scientific and technological innovation is more vital. To enhance the ability of regional science and technology innovation, increase investment in science and technology, and strengthen the innovation background will help to improve the high-quality development of a regional economy.

4.2 Suggestions

Based on the above conclusions, the paper puts forward the following policy suggestions: China's economic development is still in the process of changing from quantity to quality, and there is still room for progress. China still needs to continue to promote the transformation of new and old kinetic energy and make a longer, balanced, and green development path with the new development concept as the core. We should increase the investment in scientific and technological innovation, give full play to the guidance and incentive role of financial policies on scientific and technological innovation, improve the investment in scientific and technological innovation activities, provide financial support for scientific and technological innovation in essential core areas, and pay attention to improving the utilization rate of scientific research funds. Through improving the mechanism of financial support for scientific and technological innovation, social forces are encouraged to invest in scientific and technological innovation in key core areas and then broaden the financing channels of scientific and technological innovation.

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