

Green Development, Technological Innovation and High-quality Economic Development

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Abstract

Green development and technological innovation are two important measures to realize High-quality economic development under the new "double cycle" development pattern in China. Exploring the action mechanism of green development and technological innovation on High-quality economic development is of great significance to realize High-quality economic development. Firstly, this paper analyzes the theoretical mechanism of technological innovation and green development affecting High-quality economic development, and puts forward the theoretical hypothesis that technological innovation, green development and their interaction can promote High-quality economic development. Secondly, based on the new development concept, this paper constructs the measurement index system of High-quality economic development level, measures the High-quality economic development level, and finds that the national High-quality economic development level shows an upward trend year by year, with great regional differences, showing the characteristics of eastern region > central region > western region; Thirdly, the fixed effect model is used to explore the impact of green development and technological innovation on High-quality economic development at the national level and in the eastern, central and western regions. The results show that green development and technological innovation not only have independent effects on High-quality economic development, but also have synergistic effects on mutual promotion, and there is regional heterogeneity in their impact on High-quality economic development. Finally, it puts forward countermeasures and suggestions: increase investment in technological innovation and improve the efficiency of green development. At the same time, we should pay attention to the coordinated development of green development and technological innovation, and promote High-quality economic development.

Keywords

Green Development; Technological Innovation High Quality Economic Development; Fixed Effect Model.

1. Introduction

Today's world is experiencing great changes that have not been seen in a century. The international environment is complex and changeable, rising against the trend of globalization, and the world economic development has entered a period of turbulence and change. At the same time, China proposes to unswervingly implement the new development concept, build a new development pattern, and constantly promote High-quality economic and social development. The Fifth Plenary Session of the 19th CPC Central Committee pointed out that China is in the stage of High-quality development, with long-term economic improvement, strong development toughness and overall social stability. However, the problem of unbalanced and insufficient development in China is still prominent. Therefore, how to speed up the

construction of a new development pattern and strive to promote High-quality economic development is the focus of the government and academia.

Both green development and technological innovation are important factors affecting High-quality economic development. Green development can effectively solve external problems such as environmental pollution, and technological innovation can solve internal problems such as quality change, efficiency change and power change [1]. For a time, the country set off an upsurge of green production, low-carbon travel and green consumption. The role of technological innovation in promoting High-quality economic growth has been raised to a new level. The first discharge of the new generation of "artificial sun", the research and development of new crown vaccine, the successful development of "Chapter 9" of quantum computer, 5g technology and other scientific and technological achievements have further promoted High-quality development. The report of the 19th CPC National Congress mentioned that adhering to green development and strengthening innovation drive are important magic weapons to promote High-quality economic development and achieve new results. With the continuous development of green innovation technology system, green industries such as energy conservation and environmental protection industry and clean energy industry begin to rise, and the requirements of new industries for technology are also increasing, which forms a negative force on technological innovation. Technological innovation and green development promote each other and jointly promote High-quality economic development. At the same time, there are great differences in resource endowments in various regions of China, resulting in uneven economic development and different driving effects of High-quality economic development factors. Therefore, it is necessary to clarify the relationship among green development, technological innovation and High-quality economic development. Does green development and technological innovation promote High-quality economic development? Do they have synergistic effects on High-quality economic development? Is there regional heterogeneity? This has important practical guiding significance for promoting the High-quality development of regional economy.

At present, the relevant research on green development, technological innovation and High-quality economic development mainly includes the following three aspects. The first is the research on the connotation, path and evaluation system construction of High-quality economic development. Jin Bei (2018) believes that achieving sustainable development is the essential feature of High-quality economic development [2]. Pu Xiaoye et al. (2018), Yu Yongze, Hu Shan (2018) and Zhang Junkuan (2018) believe that technological progress is the core driving force of High-quality economic development, factor investment is the fundamental driving force, institutional innovation is the driving force of development, market-oriented reform is the main focus, and accelerating the improvement of the system and policy environment is the key [3,4,5]. Chen Deming (2018) believes that China's economic development is in a critical period, which can provide strong support for High-quality economic development by vigorously promoting the rapid development of new technologies and industries, promoting the integration of old and new kinetic energy, expanding the scale of the domestic market and developing green industries [6]. Ren Baoping and Song Xuechun (2020) pointed out that there are a series of problems in China's High-quality economic development, such as the lack of independent innovation ability, the gradual expansion of regional development gap, the serious burden on the environment caused by industrialization and urbanization, the trade pressure caused by the rise of anti-globalization and trade protectionism, and the imbalance in the supply of public services [7]. In the future, we need to stimulate the vitality of innovative development, promote regional coordinated development, improve the construction of green development system, form a higher level of opening pattern, and improve the supply capacity of public services, so as to create a new thrust for High-quality economic development. S. Y. Chen (2021) constructed a comprehensive evaluation system of High-quality economic development level from the five

dimensions of innovation, coordination, green, openness and sharing. The study found that the High-quality economic development level of China is on the rise, and there are great differences in the High-quality economic development level of each province [8]. M. Chen M and H. B. Wang (2021) used the five dimensions of green development, people's life, innovation ability, economic vitality and coordinated development to measure the High-quality economic development of 233 prefecture level cities from 2003 to 2016 by using the principal component analysis method, and found that the High-quality economic development level of China is characterized by high in the East and low in the West [9]. Based on the relevant data from 2002 to 2017, Zhang Xia and Xu Qifa (2021) objectively weighted and measured China's High-quality economic development index by using entropy weight method. The study found that, on the whole, China's High-quality economic development is mainly distributed in the eastern region, while low-quality economic development is mainly distributed in the central and western regions [10].

The second is the research on the impact of technological innovation on High-quality economic development. How technological innovation drives High-quality economic development is a hot issue in academic circles. Ren Baoping and Wen Fengang (2018) believe that innovation is the first driving force to drive High-quality economic development and the first pillar to improve labor productivity and achieve coordinated development [11]. D. Li and S. M. Hu (2021) pointed out that technological innovation has strengthened the coordination between China's industrial economy and environment and is the main driving factor for achieving High-quality economic development [12]. Jia Hongwen et al. (2021) empirically found that scientific and technological innovation not only has a direct effect on High-quality economic development, but also has an indirect effect on High-quality economic development through industrial structure upgrading [13]. When exploring the driving mechanism of scientific and technological innovation on High-quality development, Sun Yixuan et al. (2021) found that the driving effects of various elements of scientific and technological innovation on High-quality economic development are relatively strong, and the driving effects of various elements of scientific and technological innovation on High-quality economic development vary greatly in different regions [14].

Third, research on the impact of green development on High-quality economic development. Existing studies basically agree that technological innovation can promote High-quality economic development, but High-quality economic development requires not only High-quality output, but also High-quality green and sustainable development. Y. Liu et al. (2021) believe that environmental regulation is an important means to solve economic development and environmental pollution, and plays an important role in High-quality economic development [15]. Li Mengxin and Ren Baoping (2019) pointed out that green development is the path guidance of High-quality development in the new era and the top-level design of efficiency improvement, harmonious coexistence and sustainable development [16]. Wei Zhenxiang and Shi Xiangguo (2021) combined the coupling degree of ecological sustainability and High-quality economic development, analyzed the coupling and interactive development between the two systems through PVAR model, and found that the development between ecological sustainability and High-quality economic development will promote each other [17]. 50. M. Chen et al. (2020) discussed the impact of environmental regulation on High-quality economic development according to the average human development index (HDI) of China's provinces, and found that environmental regulation can promote the upgrading of industrial structure, so as to promote High-quality economic development [18]. Li Kai and Shangguan Xuming (2021) found that environmental governance not only has a significant direct role in promoting the High-quality development of local economy, but also has a negative spatial spillover effect [19]. S. Y. Chen (2021) et al. Studied the spatial impact of green investment on China's High-quality economy by using the Dobbins model and found that the High-quality economic development

level has the spatial spillover effect of green investment in terms of geographical proximity and presents spatial agglomeration [8].

By combing the existing literature, it is found that the academic research on the connotation, path and evaluation and measurement system of High-quality economic development has been relatively rich, but the research on green development, technological innovation and High-quality economic development mostly focuses on the relationship between two of the three, and few literature studies the three together. There are few studies on the independent and synergistic effects of technological innovation on High-quality economic development. Therefore, this paper brings green development and technological innovation into the same analysis framework for analysis, which not only systematically expounds the respective effects of green development and technological innovation on High-quality economic development, but also explores the synergy and regional heterogeneity of green development and technological innovation on High-quality economic development. Compared with the existing literature, this paper has two contributions: (1) in theory, this paper brings green development, technological innovation and High-quality economic development into the same analysis framework, and systematically analyzes the relationship between green development, technological innovation and High-quality economic development. (2) Empirically, the independent and synergistic effects of technological innovation and green development on High-quality economic development are investigated with the help of fixed effect model.

2. Theoretical Analysis

Clarifying the impact mechanism of green development and technological innovation on High-quality economic development will help to speed up the process of High-quality development in China. Therefore, this paper analyzes the impact of green development and technological innovation on High-quality economic development and their synergistic effect on High-quality economic development.

2.1. The Impact of Green Development on High-quality Economic Development

Green development leads High-quality economic development. Green development characterized by resource conservation and environmental friendliness is an effective means to alleviate environmental pollution caused by extensive growth mode [20]. The Fifth Plenary Session of the 19th CPC National Congress stressed that at present, China's ecological problems are still serious, ecological environmental protection has a long way to go, and the quality and stability of the ecosystem need to be improved. Therefore, we should accelerate the promotion of green and low-carbon development, constantly improve the quality of the ecological environment and promote High-quality economic development. Green development requires high polluting enterprises to increase investment in pollution control, reduce pollution emissions, and even shut down and eliminate some high polluting enterprises, while some unqualified polluting enterprises are transferred to other areas with relatively loose policies [1], so as to strengthen environmental governance and promote High-quality economic development; Under the concept of green development, some enterprises produce by introducing green production technology and high-tech production mode, so as to achieve the effect of reducing environmental pollution and resource consumption, and constantly carry out industrial upgrading to promote High-quality economic development. Based on this, hypothesis 1 is put forward. H1: green development plays a significant role in promoting High-quality economic development

2.2. The Impact of Technological Innovation on High-quality Economic Development

Technological innovation drives High-quality economic development. Technological innovation can transform production factors and knowledge factors in High-quality economic development into production achievements, promote the diversification of products and services, and stimulate the upgrading of residents' consumption structure; Technological innovation can also operate effectively in the economic field, change the direction of resource allocation and improve the allocation efficiency of economic development factors, so as to improve total factor productivity [21]. At the same time, technological innovation also plays an important role in promoting the transformation and upgrading of traditional industries and the transformation of economic development mode. Technological innovation can give birth to a new economic structure, reduce pollution emissions and energy consumption in production, and promote enterprises to carry out green and low-carbon circular development [16], so as to promote High-quality economic development. Based on this, hypothesis 2 is proposed. H2: technological innovation plays a significant role in promoting High-quality economic development.

2.3. The Influence of Green Development and Technological Innovation on High-quality Economic Development

Technological innovation can promote High-quality economic development by promoting green development. Technological innovation can catalyze the increasing returns to scale effect and substitution effect, make the industrial structure more reasonable, effectively promote the upgrading of industrial structure [22], reduce the energy consumption intensity and pollution emissions in the production process of enterprises, improve the green development level of economy, and then promote the High-quality development of economy; Green development will also force technological innovation. According to Porter hypothesis, appropriate environmental regulation can promote enterprises to carry out innovation activities, improve enterprise production efficiency, promote industrial upgrading [23], and promote High-quality economic development. Technological innovation is the driving force of green development, and green development is the guidance of technological innovation. They promote each other and jointly promote High-quality economic development. Based on this, hypothesis 3 is put forward. H3: the synergy between green development and technological innovation plays a significant role in promoting High-quality economic development.

3. Measurement and Analysis of High-quality Economic Development Level

3.1. Construction of Measurement System of High-quality Economic Development Level

High quality economic development is the development to meet the needs of people's better life. The economic and social structure and proportion are coordinated, innovation and efficiency are continuously improved, the ecological environment is continuously optimized, the level of opening to the outside world is continuously improved, and people's life is to achieve common prosperity [24]. The new development concept embodies the main characteristics of High-quality economic development and provides a scientific theoretical basis for measuring the level of High-quality economic development. The economic High-quality development index contains multi-dimensional comprehensive indicators. Therefore, based on the new development concept, this paper constructs an economic High-quality development measurement index system of 5 primary indicators, 13 secondary indicators and 21 tertiary indicators.

(1) Innovation and development. Innovative development is the core driving force of High-quality development. The Fifth Plenary Session of the 19th CPC Central Committee proposed to "adhere to the core position of innovation in the overall situation of China's modernization". Innovation, as the power source of High-quality economic development, constantly stimulates the potential of High-quality development. At present, the "neck" of the core key technology is still a very difficult problem. In order to achieve High-quality economic development, the state vigorously invests funds and human capital to support the development of scientific research and innovation, and strives to seize the development opportunity through technological innovation to ensure that China's economic and social development has continuous power support. This paper measures the level of innovation development from the social environment, investment and output of innovation. Technological activity is used to measure the social environment of innovation, R & D personnel of Industrial Enterprises above designated size are converted into full-time equivalent and R & D expenditure of Industrial Enterprises above designated size are used to measure the level of innovation input, and patent applications per 10000 people are used to measure the level of innovation output.

(2) Coordinated development. Coordinated development is a stable guarantee for High-quality development. Coordinated economic and social development is the basis for sustainable development and the inevitable choice of modernization. Coordinated development can effectively solve the problem of unbalanced development. At present, there are still great differences in the level of economic development among regions in China. The development gap between urban and rural areas continues to increase, the contradiction between economic development and environmental protection intensifies, and unbalanced and insufficient development has become the main contradiction hindering economic development. This paper measures the level of coordinated development from regional coordination, Urban-Rural Coordination and economic and social structure coordination. The level of regional coordinated development is measured by per capita GDP, the level of urban-rural coordinated development is measured by urban-rural consumption ratio, and the level of coordinated development of economic and social structure is measured by urbanization rate, population aggregation and inflation rate.

(3) Green development. Green development is a universal form of High-quality development. Since the reform and opening up, China has always insisted that development is the key to solving all problems. Earth shaking changes have taken place in economic development, realizing the transformation from factor driven to innovation driven, scale expansion to structural upgrading, and becoming the second largest economy in the world. However, with the rapid economic growth, there are a series of problems such as resource waste and environmental damage, which hinder the sustainable development of the economy. This paper measures the level of green development from the level of green input, resource conservation and green output. The intensity of pollution control is used to measure the level of green input, the green coverage rate of built-up areas and the harmless treatment rate of domestic waste are used to measure the level of green output, and the power consumption per unit of regional GDP is used to measure the level of resource conservation.

(4) Open development. Open development is the only way for High-quality development. The great achievements of reform and opening up over the past 40 years have confirmed the necessity and importance of opening up to the outside world. At present, accelerating the construction of a new domestic and international dual cycle development pattern is a major strategic measure to promote the High-quality development of China's economy. We should not only open to the outside world, but also build a higher-level opening-up pattern to solve the problem of internal and external linkage.

Table 1. Measurement system of High-quality economic development level

Primary index	Secondary index	Tertiary indicators	Index calculation method	Attribute
Innovation-driven development	Innovative social environment	Technical activity	Total turnover of technology contracts / GDP	+
	Innovation investment	Full time equivalent of R & D personnel in Industrial Enterprises above Designated Size	—	+
		R & D expenditure of Industrial Enterprises above Designated Size	—	+
	Innovation output	Patent applications per 10000 people	Number of patent applications / number of permanent residents in the region	+
Coordinated development	Coordination of economic and social structure	Urbanization rate	Urban permanent population / total population	+
		Population aggregation	Expression of population density in municipal districts	+
		Inflation rate	Expressed by consumer price index	-
	Urban Rural Coordination	Urban-rural consumption ratio	Per capita consumption expenditure of urban residents / per capita consumption expenditure of rural residents	+
	Regional coordination	Per capita GDP	Per capita GDP	+
Green development	Green output	Greening coverage rate of built-up area	—	+
		Harmless treatment rate of domestic waste	—	+
	Green input	Pollution control intensity	Expressed by industrial pollution control investment	+
	Resource conservation	Power consumption per unit of GDP	Electricity consumption / GDP	-
Development for global progress	Degree of openness	Dependence on foreign trade	Total import and export volume / GDP	+
		Intensity of utilizing foreign capital	Actual paid in capital of utilizing foreign capital this year / GDP	+
	Open results	Export volume	—	+
		Import volume	—	+
Development for the benefit of all	Social public service supply	Number of health technicians per unit population	—	+
		Highway Length	—	+
	People's living conditions	the registered urban unemployment rate	—	-
		Number of students in Colleges and universities per 10000 people	Students in higher education institutions / total population	+

This paper measures the development level of openness from the degree and achievements of openness. The degree of openness is measured by the degree of dependence on foreign trade and the intensity of foreign capital utilization, and the results of openness are measured by the number of exports and imports.

(5) Shared development. Shared development is the ultimate goal of High-quality development. "People-oriented" is the basic idea of China's current economic and social development. Economic development needs the participation and efforts of the whole people, and the development achievements are shared by the whole people. This paper measures the level of shared development from the supply of social public services and people's living conditions. The number of health technicians and highway mileage per unit population are used to measure the supply of social public services, and the urban registered unemployment rate and the number of ordinary colleges and universities per 10000 people are used to measure people's living conditions. The measurement system of High-quality economic development level is shown in Table 1.

3.2. Analysis of High-quality Economic Development Level

Using the High-quality development measurement index system, this paper analyzes the High-quality development level of China's economy from 2011 to 2017. Firstly, the positive and negative indicators in Table 1 are standardized by different methods, and the original data in the High-quality development measurement system are de dimensioned. The calculation formula is as follows:

$$Y_{ij}^t = \begin{cases} \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})}, & X_{ij} \text{ is a positive indicator} \\ \frac{\max(X_{ij}) - X_{ij}}{\max(X_{ij}) - \min(X_{ij})}, & X_{ij} \text{ is a reverse index} \end{cases} \quad (1)$$

Formula (1) represents the value of the j-th evaluation index of the i-th evaluation object after standardized treatment in the t-th year. Then, the entropy weight method is used to calculate the information entropy of each index and determine the weight of each index. The calculation formula is as follows:

$$E_j = -\frac{1}{\ln m} \sum_{i=1}^m p_{ij}^t \ln p_{ij}^t \quad (2)$$

$$w_j = \frac{1 - E_j}{n - \sum_{j=1}^n E_j} \quad (3)$$

In formula (2) $p_{ij}^t = \frac{Y_{ij}^t}{\sum_{i=1}^m Y_{ij}^t}$ $i=1, 2, \dots, m; j=1, 2, \dots, n$ is the proportion of the i-th evaluation object in

the j-th index in the t-th year, E_j is the information entropy of the matrix of $(P_{ij})_{m \times n}$, and formula (3) w_j is the entropy weight of index J.

Finally, the linear weighting method is used to calculate the comprehensive index of High-quality economic development. The results are shown in Table 2.

Table 2. Comprehensive index of High-quality economic development in China

Region	2011	2012	2013	2014	2015	2016	2017	Mean value
Beijing	0.4705	0.5021	0.5342	0.5334	0.4987	0.5173	0.5282	0.5135
Tianjin	0.2554	0.2718	0.2921	0.3119	0.3256	0.3359	0.3066	0.2999
Jiangsu	0.4214	0.4639	0.4845	0.4820	0.4877	0.4967	0.5215	0.4797
Zhejiang	0.2848	0.3229	0.3530	0.3601	0.3732	0.3956	0.4054	0.3564
Anhui	0.1179	0.1563	0.1320	0.1795	0.1885	0.2036	0.2149	0.1761
Xinjiang	0.1047	0.1157	0.1183	0.1365	0.1342	0.1342	0.1362	0.1257
Guangdong	0.4924	0.5409	0.5834	0.5702	0.5684	0.5825	0.6318	0.5678
Guizhou	0.0817	0.1033	0.1102	0.1163	0.1196	0.1274	0.1409	0.1142
Shanghai	0.3765	0.3936	0.3949	0.3952	0.3965	0.4079	0.4377	0.4003
Yunnan	0.0906	0.1182	0.1130	0.1252	0.1280	0.1335	0.1467	0.1222
Qinghai	0.0701	0.0898	0.0944	0.1029	0.1140	0.1399	0.1345	0.1065
Ningxia	0.0539	0.0833	0.0856	0.1047	0.1035	0.1153	0.1201	0.0952
Hebei	0.1164	0.1384	0.1474	0.1731	0.1709	0.1635	0.1741	0.1548
Shanxi	0.1064	0.1287	0.1435	0.1497	0.1496	0.1505	0.1615	0.1414
Inner Mongolia	0.0950	0.1227	0.1260	0.1454	0.1430	0.1469	0.1473	0.1323
Liaoning	0.1939	0.2142	0.2260	0.2185	0.2015	0.2011	0.2186	0.2105
Jilin	0.1025	0.1208	0.1193	0.1298	0.1356	0.1416	0.1479	0.1282
Heilongjiang	0.1218	0.1409	0.1482	0.1571	0.1573	0.1530	0.1570	0.1479
Fujian	0.2040	0.2301	0.2347	0.2390	0.2378	0.2421	0.2541	0.2346
Jiangxi	0.1387	0.1473	0.1500	0.1566	0.1640	0.1683	0.1805	0.1579
Shandong	0.2632	0.2931	0.3148	0.3381	0.3278	0.3410	0.3600	0.3197
Henan	0.1386	0.1683	0.1820	0.2010	0.2041	0.2175	0.2273	0.1913
Hubei	0.1339	0.1604	0.1755	0.1992	0.2128	0.2200	0.2350	0.1910
Hunan	0.1195	0.1520	0.1514	0.1581	0.1680	0.1685	0.1902	0.1582
Guangxi	0.0903	0.1091	0.1167	0.1272	0.1441	0.1453	0.1547	0.1268
Hainan	0.1244	0.1374	0.1364	0.1320	0.1313	0.1200	0.1220	0.1291
Chongqing	0.1398	0.1674	0.1788	0.2211	0.2039	0.1899	0.2010	0.1860
Sichuan	0.1279	0.1519	0.1607	0.1782	0.1695	0.1788	0.2002	0.1667
Shaanxi	0.1507	0.1853	0.2070	0.2277	0.2431	0.2354	0.2397	0.2127
Gansu	0.0823	0.1175	0.1237	0.1383	0.1408	0.1492	0.1524	0.1292
National average	0.1756	0.2017	0.2126	0.2236	0.2248	0.2307	0.2419	0.2158
Eastern mean	0.2912	0.3194	0.3365	0.3412	0.3381	0.3458	0.3609	0.3333
Central mean	0.1224	0.1468	0.1553	0.1664	0.1725	0.1779	0.1893	0.1615

It can be seen from table 2 that since 2011, the High-quality economic development level of all provinces in China has been continuously improved, and the growth rate is stable. In order to reflect the High-quality economic development level of each province, 2011, 2014 and 2017 are selected as representative years for analysis. In 2011, Guangdong had the highest level of High-quality economic development, indicating that it played a leading role in High-quality economic development. Other provinces with High-quality economic development level include Beijing, Jiangsu, Zhejiang, Shanghai, Tianjin, Fujian, Shandong, etc; Ningxia has the lowest level of High-quality economic development, indicating that it is relatively backward in the process of High-quality economic development. Other lower provinces include Qinghai, Guizhou, Yunnan, Gansu, Guangxi and Inner Mongolia. In 2014, Guangdong remained the province with the highest level of High-quality economic development, and other High-quality provinces include Beijing, Tianjin, Fujian, Shanghai, Jiangsu, Zhejiang, Shandong, etc; Qinghai has become the province with the lowest level of High-quality economic development. Other provinces with

low level of High-quality economic development are mainly Jilin, Guangxi, Guizhou, Yunnan and Ningxia. In 2017, Guangdong still maintained a leading position in High-quality economic development. Other High-quality provinces include Shandong, Zhejiang, Jiangsu, Beijing, Shanghai and Tianjin). With a comprehensive index of 0.1201, Ningxia has once again become the province with the lowest level of High-quality economic development. Other provinces with low level of High-quality economic development are mainly Hainan, Guizhou, Yunnan, Qinghai and Xinjiang. Provinces with high economic quality and high development level are mainly located in economically developed areas, with high degree of opening to the outside world, strong scientific and technological innovation ability, developed transportation infrastructure, high economic development efficiency and relatively high quality of economic development. The provinces with low High-quality economic development are mainly located in economically underdeveloped areas. The development of scientific research and innovation is relatively backward, the degree of opening to the outside world is relatively low, the foundation of economic development is weak, and the quality of economic development is not high.

In terms of regions, the High-quality economic development level of the eastern, central and western regions is increasing year by year, but there are great differences among regions. The comprehensive index of High-quality economic development in the eastern region was 0.2912 in 2011, 0.3412 in 2014 and 0.3609 in 2017; The comprehensive index of High-quality economic development in Central China was 0.1224 in 2011, 0.1664 in 2014 and 0.1893 in 2017; The comprehensive index of High-quality economic development in the western region was 0.0988 in 2011, 0.1476 in 2014 and 0.1613 in 2017. Over the years, the eastern region has always been in a leading position in High-quality economic development. The reason is that the eastern region is close to the sea, which is convenient for foreign trade, and the terrain is flat and convenient for transportation. The higher scientific research investment makes the regional innovation ability continuously strengthened, a large amount of human capital is transferred to the eastern region, the population aggregation is high, the economic development speed is fast, the efficiency is high, and the High-quality economic development level is relatively high. The High-quality economic development of the central and western regions lags behind that of the eastern regions. The central and western regions are mainly located inland, with relatively backward resources and environment, inconvenient foreign trade and relatively small population. Therefore, the High-quality economic development level is low.

4. Empirical Analysis

Using panel data, this paper makes an empirical study on the impact of technological innovation and green development on High-quality economic development. Firstly, the fixed effect panel model is established by using the selected variables; Secondly, through the econometric analysis of the whole sample, we can get the overall situation of the impact of green development and technological innovation on High-quality economic development; Finally, through the econometric analysis of the data of the East, middle and west regions, the impact of green development and technological innovation on High-quality economic development in different regions is obtained.

4.1. Model Setting, Variable Selection and Data Description

4.1.1. Model Setting

According to the above theoretical analysis, the impact of green development and technological innovation on High-quality economic development not only has an independent effect, but also has a synergistic effect of mutual promotion. Therefore, using the methods of Ren Xiaoyan and Yang Shuili (2020), we add the interaction term of green development and technological innovation into the model and establish a fixed effect panel model to empirically test the impact

of green development and technological innovation on High-quality economic development [25]. The construction model is as follows:

$$hqed_{it} = \beta_0 + \beta_1 gl_{it} + \beta_2 tech_{it} + \beta_3 R\&D_{it} + \beta_4 fa_{it} + \beta_5 csl_{it} + \beta_6 lcf_{it} + \varepsilon_{it} \quad (4)$$

$$hqed_{it} = \beta_0 + \beta_1 gl_{it} \times tech_{it} + \beta_3 R\&D_{it} + \beta_4 fa_{it} + \beta_5 csl_{it} + \beta_6 lcf_{it} + \varepsilon_{it} \quad (5)$$

In equations (4) and (5), t represents the year, i represents the region, $hqed$ represents the High-quality economic development level, gl represents the green development level, $tech$ represents technological innovation, $gl \times tech$ represents the interaction between green development and technological innovation, $R \& D$ represents the R & D investment intensity, fa represents the investment intensity of fixed assets, csl represents the development level of commercial service industry, and lcf represents the level of communication facilities. $\beta_1, \beta_2, \dots, \beta_6$ is the model parameters to be estimated, ε_{it} is a random perturbation term.

4.1.2. Variable Selection

(1) Explained variable. High quality economic development level ($hqed$). The comprehensive index of High-quality economic development calculated above is used to measure the High-quality economic development of all provinces.

(2) Core explanatory variables. Green development level and technological innovation level are used as the core explanatory variables. ① Green development level (gl). The measurement of green development level in academic circles mainly considers two dimensions: environmental regulation and environmental quality. Environmental regulation is mainly a series of policies and measures taken by regional governments to achieve green development, and environmental quality mainly reflects the degree of green development in a region. This paper mainly explores the impact of the status of green development in all provinces on High-quality economic development. Therefore, the level of green development in all provinces is measured from the perspective of environmental quality. Environmental quality is mainly measured by pollution discharge, pollution treatment and environmental self-healing ability. Pollution discharge is the biggest obstacle in the process of green development, and pollution treatment is the key step, and the environmental self-healing ability is the foundation. Therefore, select the corresponding indicators from the three environmental quality aspects of pollution discharge, pollution treatment and environmental self-healing ability to calculate the level of green development. The selection of indicators refers to the research of Zhang Jie et al. (2020), Zhang Xu et al. (2020) and Li Danqi et al. (2020). The pollution emission indicators include total wastewater discharge (TWD), sulfur dioxide emission in waste gas (SO₂), removal and transportation of municipal solid waste (MSW), use of chemical fertilizer (converted into pure) (Fu) and smoke (powder) dust emission in waste gas (SG); The pollution treatment indicators include the completed investment amount (WI) of wastewater treatment project, the completed investment amount (GI) of waste gas treatment project, the harmless treatment amount of domestic waste (HW) and the comprehensive utilization amount of general industrial solid waste (RE). The total afforestation area (TA) and per capita water resources (PW) at the end of the year are selected as the indicators of environmental self-healing ability [26, 27, 28]. Based on the above indicators, the green development level is calculated. Firstly, the original data of each indicator is processed by z-score standardization. Secondly, the applicability of principal component analysis is tested on the data. The results show that the KMO value is 0.670 and the p value of Bartlett sphericity test is 0, indicating that the data is suitable for principal component analysis. Finally, through the linear combination coefficient matrix, variance interpretation rate and cumulative variance interpretation rate, the comprehensive score coefficient is calculated, and the comprehensive score coefficient is

normalized to obtain the index weight. Each index is multiplied by the corresponding weight and summed to obtain the calculation result of green development level. The calculation formula is as follows:

$$gl_{it} = 0.1033TWD + 0.1022SO2 + 0.1014SG + 0.1028MSW + 0.0662FU + 0.093HW + 0.0974RE + 0.0836WI + 0.0994GI + 0.0705TA + 0.0803PW \quad (6)$$

② Technological innovation (Tech). In the context of innovation driven development strategy, technological innovation is the key factor to promote High-quality economic development. The higher the level of technological innovation, the more conducive to promoting High-quality economic development. At present, scholars mainly use innovation input and innovation output to measure the level of technological innovation. Innovation input refers to the input of human, material and financial resources needed for technological innovation, such as R & D expenditure, scientific research personnel, etc; Innovation output refers to the relevant achievements generated through technological innovation, such as the number of invention patent applications, the number of patent application authorizations, science and technology business incubators, etc. Based on the dimension of innovation output and referring to the practices of Liu Hong et al. (2019) and Li Juan et al. (2017), this paper uses the number of patent applications authorized to measure the level of technological innovation [29, 30].

(3) Control variables. In addition to green development and technological innovation affecting High-quality economic development, R & D investment intensity, fixed asset investment intensity, development level of commercial service industry and communication facilities are also important factors affecting High-quality economic development. Therefore, the following control variables are selected: ① R&D investment intensity (R&D). The increase of R&D investment intensity can effectively promote the development of scientific research and innovation, so as to promote High-quality economic development. It is expressed by the ratio of R&D expenditure of Industrial Enterprises above Designated Size to regional GDP. ② Investment intensity of fixed assets (fa). Fixed asset investment promotes social and economic growth by bringing effective supply and demand, and plays a positive role in promoting High-quality economic development. It is measured by the proportion of fixed asset investment of the whole society in regional GDP. ③ Development level of business service industry (csl). The development of commercial service industry has effectively promoted the development and improvement of the market system, and promoted the development of social economy by stimulating the consumption demand of residents, so as to promote the High-quality development of economy. Select the ratio of retail sales of social consumer goods to regional GDP. ④ Communication facility level (lcf). Communication facilities are the cornerstone of the development of Internet economy in the network era. The higher the level of communication facilities, the more conducive it is to the development of Internet economy and the more effective it is to promote High-quality economic development. It is measured by telephone penetration (including mobile phones).

4.1.3. Data Description and Descriptive Statistics

The sample data in this paper are mainly from the 2012-2018 China Statistical Yearbook, China Environmental Statistical Yearbook, China economic network statistical database and the statistical yearbooks of various provinces over the years. The panel data of 30 provinces from 2011 to 2017 were selected, with a total of 210 sample observations. The descriptive statistical results of each variable are shown in Table 3.

Table 3. Definition of each variable and descriptive statistical results

Variable	Meaning	Measure or description	Observed value	Average value	Standard deviation	Minimum value	Maximum
hqed	High quality economic development	High quality development index	210	0.2159	0.1279	0.0539	0.6318
gl	Green development level	Green development index	210	1.26E-08	0.3486	-0.4578	1.2996
tech	technological innovation	Number of patent applications authorized	210	4.4301	6.2420	0.0502	33.2652
R&D	R & D investment intensity	R & D expenditure of Industrial Enterprises above Designated Size / GDP	210	109.1245	61.7757	16.6346	324.1569
fa	Investment intensity of fixed assets	Total fixed asset investment / GDP	210	0.8594	0.2857	0.2201	1.5965
csl	Development level of commercial service industry	Retail sales of social consumer goods / GDP	210	0.4002	0.0680	0.2545	0.7390
lcf	Communication facilities	Telephone penetration	210	110.9999	29.2312	67.1400	228.0900
gl*tech	Interactive item	Product of green development and technological innovation	210	0.1653	1.6778	-2.9293	8.0638

4.2. Empirical Results and Analysis

In order to explore the impact of green development and technological innovation on China's High-quality economic development and regional heterogeneity, this study introduces the fixed effect model to explore the impact of green development and technological innovation on High-quality economic development from the national and subregional perspectives.

4.2.1. Full Sample Regression Analysis

In the selection of random effect model and fixed effect model, Hausmann test method is used to test. The test results show that the impact of green development and technological innovation on High-quality economic development is estimated by fixed effect model. The full sample regression results are shown in Table 4.

Based on the full sample regression results, this paper analyzes the impact of core explanatory variables and control variables on High-quality economic development.

(1) The impact of core explanatory variables on High-quality economic development. The regression results of (1) ~ (5) in Table 4 show that the influence coefficient of green development variables on High-quality economic development is 0.0211, and there is a significant positive correlation at the level of 1%, indicating that the High-quality economic development level increases by 0.0211 units for every increase in green development level.

The positive impact of green development on High-quality economic development is consistent with the above theoretical analysis, that is, strengthening environmental governance and protection can promote green development by eliminating polluting industries, transferring

polluting industries and industrial upgrading, so as to achieve High-quality economic development.

Table 4. Regression results of national samples

Explanatory variable	Explained variable (hqed)					
	(1)	(2)	(3)	(4)	(5)	(6)
gl	0.0298**	0.0280**	0.0253**	0.0261***	0.0211**	
	(0.0124)	(0.0112)	(0.0104)	(0.0095)	(0.0088)	
tech	0.0076***	0.0059***	0.0056***	0.0047***	0.0042***	
	(0.0009)	(0.0009)	(0.0008)	(0.0007)	(0.0007)	
R&D		0.0007***	0.0004***	0.0004***	0.0003***	0.0004***
		(0.0001)	(0.0001)	(9.62e-05)	(8.92e-05)	(9.30e-05)
fa			0.0513***	0.0334***	0.0238***	0.0241***
			(0.0093)	(0.0090)	(0.0085)	(0.0090)
csl				0.2320***	0.1630***	0.2010***
				(0.0397)	(0.0387)	(0.0404)
lcf					0.0008***	0.0010***
					(0.0001)	(0.0002)
gl*tech						0.0049***
						(0.0008)
Constant	0.1820***	0.1180***	0.1030***	0.0337**	-0.0150	-0.0391**
	(0.0042)	(0.0106)	(0.0102)	(0.0151)	(0.0164)	(0.0168)
N	210	210	210	210	210	210
Within R ²	0.390	0.507	0.580	0.649	0.702	0.663
Hausma value	16.03	10.58	54.73	53.14	50.10	56.56

Note: the figures in brackets are the estimated t (z) value of each variable coefficient, * * *, * *, * respectively represent significant at the level of 1%, 5% and 10% (the same as the following table).

Therefore, the model supports hypothesis 1. The influence coefficient of technological innovation variables on High-quality economic development is 0.0042, and there is also a significant positive correlation at the level of 1%, indicating that every unit of technological innovation level increases, the level of High-quality economic development increases by 0.0042 units. This may be because technological innovation can promote the transformation and upgrading of traditional industries by stimulating the upgrading of consumption structure, effectively improving the efficiency of resource allocation and changing the mode of economic development, so as to promote High-quality economic development. Therefore, the model supports hypothesis 2. In addition, (6) in Table 4 is the regression result of introducing the interaction term of green development and technological innovation. The estimated coefficient of the interaction term is significantly positive, indicating that green development and technological innovation not only have independent effects on High-quality economic development, but also have synergistic effects on High-quality economic development, that is, green development will strengthen the promotion effect of technological innovation on High-quality economic development, Technological innovation will also further strengthen the role of green development in promoting High-quality economic development, so the model supports hypothesis 3.

(2) The influence of control variables on High-quality economic development. R & D investment intensity (R & D) has passed the significance test of 1%, and the coefficient is positive, indicating that increasing R & D investment intensity is conducive to promoting the High-quality

development of China's economy. The reason may be that the increase of R & D investment can improve the innovation output level of high-tech industry, which is the key carrier of innovation driven development strategy and can promote the sustained and healthy development of economy. Therefore, the increase of R & D investment intensity can effectively promote the High-quality development of economy. The coefficient of fixed asset investment intensity (FA) is positive, indicating that the increase of fixed asset investment can promote High-quality economic development. The reason may be that the implementation of fixed asset investment can bring effective supply and effective demand, so as to promote High-quality economic development. In terms of supply, investment can bring new productivity, increase the supply of social products, and then lead to the increase of national income; In terms of demand, investment will bring demand for human and material resources, which will generate corresponding demand for upstream products, and thus pass on, forming a complete demand chain with investment as the top, increasing the total demand of the society. The coefficient of the development level of commercial service industry (CSL) is positive, which shows that the improvement of the level of commercial service industry is conducive to the improvement of High-quality economic development level. The possible reason is that in areas with high development level of commercial service industry, residents have high consumption demand, and consumption is one of the troikas driving economic growth. Therefore, the increase of consumption demand can drive economic growth, which is conducive to promoting High-quality economic development. The coefficient of communication facility level (LCF) is also significantly positive, indicating that the improvement of communication facility level plays a significant role in promoting High-quality economic development. Because of the application of Internet communication technology, commodity transactions are gradually transferred to online, the cost of commodity transactions is reduced and consumer demand is increased, which promotes economic growth and High-quality development.

4.2.2. Analysis of Regional Regression Results

Table 5. Regional regression results

Explanatory variable	Explained variable (hqed)					
	(1)	(2)	(3)	(4)	(5)	(6)
gl	0.0267*	0.0290**	0.0760***	0.0547**	-0.0059	-0.0388**
	(0.0145)	(0.0115)	(0.0218)	(0.0228)	(0.0170)	(0.0158)
tech	0.0061***	0.0038***	0.0184***	0.0143***	0.0207***	0.0045
	(0.0010)	(0.0008)	(0.0020)	(0.0027)	(0.0028)	(0.0032)
R&D		0.0005***		0.0001		-9.98e-05
		(0.0001)		(0.0002)		(0.0002)
fa		-0.0197		0.0042		0.0382***
		(0.0158)		(0.0131)		(0.0119)
csl		0.2850***		0.0457		0.2150**
		(0.0917)		(0.0367)		(0.0986)
lcf		0.0007***		0.0007***		0.0011***
		(0.0002)		(0.0002)		(0.0002)
Constant	0.2760***	0.0143	0.1300***	0.0324	0.1090***	-0.0925***
	(0.0331)	(0.0466)	(0.0097)	(0.0289)	(0.0087)	(0.0334)
N	77	77	56	56	77	77
Within R ²	0.483	0.718	0.801	0.858	0.431	0.765
Hausmanvalue	4.48	13.33	5.17	0.95	0.78	5.35

Due to the differences in the dynamic mechanism, economic development level and policies of various regions in China, in order to test whether the impact of green development and technological innovation on High-quality economic development has regional heterogeneity, the full sample data are further divided into eastern, central and western regions. The estimated results are shown in (1) ~ (6) in Table 5.

The regression results show that the coefficient between green development and High-quality economic development in eastern and central China is significantly positive, indicating that the improvement of green development level can promote the High-quality economic development in eastern and central China. For each unit of green development in eastern and central China, the High-quality economic development level will rise by 0.0290 and 0.0547 units respectively. The level of economic development in the eastern region is relatively high, and the speed of industrial upgrading is relatively fast. The efficient utilization of resources and energy and the effective treatment of environmental pollution make the green development in the eastern region effective, and play a significant role in promoting the High-quality economic development. The central region has accelerated the process of green development after undertaking the industrial transfer in the eastern region, alleviating the pressure of resources and environment on regional economic development, so as to promote High-quality economic development. The variable coefficient of green development is negative in the western region, indicating that green development has a certain hindering effect on High-quality economic development in the western region. For each unit of increase in green development level, the High-quality economic development level will decrease by 0.0388 units. The possible reason is that since the western development in the early 21st century, the industrialization of the western region has started. Although the large-scale development strategy has brought economic growth, due to the long-term dependence on the high consumption of non-renewable resources such as minerals, it has posed a serious threat to the ecological environment, and the overall ecological environment in the western region is deteriorating. The economic development of the western region is relatively backward, and the economic development is highly dependent on resources and heavy chemical enterprises. Green development may require the closure of most enterprises, which is unfavorable to the High-quality economic development of the western region [31].

The technological innovation variables and the High-quality economic development coefficients of the eastern, central and western regions of China are significantly positive. For each unit of increase in the level of technological innovation, the High-quality economic development level of the eastern, central and western regions will increase by 0.0038, 0.0143 and 0.0045 units respectively. The investment in scientific research and innovation in the eastern region is relatively high and develops early. According to the law of diminishing marginal return, although the level of technological innovation plays a significant role in promoting High-quality economic development, compared with the central and western regions, the level of technological innovation in the eastern region has less impact on High-quality economic development. The central region urgently needs the development of technological innovation to speed up industrial transformation and industrial structure upgrading. Therefore, the improvement of technological innovation level in the central region has a greater impact on the improvement of High-quality economic development level. The economic development of the western region is relatively backward. Although the state vigorously supports the development of the western region through the western development strategy, and the investment in scientific research funds has increased, the lack of scientific and technological talents makes the promotion effect of the level of technological innovation in the western region on High-quality economic development relatively low.

Among the control variables, R&D investment intensity and commercial service industry development level have a significant positive effect on High-quality economic development in

the eastern region, and the influence coefficient is the largest, indicating that R&D investment intensity and commercial service industry level have the greatest impact on High-quality economic development in the eastern region. The possible reason is that with the economic development in the eastern region, more and more people pursue a more advanced and High-quality life and pay more attention to the quality and level of commercial service industry. Enterprises begin to increase capital investment and develop High-quality products and services to meet consumers, stimulate consumption and promote High-quality economic development. The investment intensity of fixed assets and the level of communication facilities have a significant positive impact on High-quality economic development in the western region, and the impact coefficient is the largest. The western region is located inland, the level of opening to the outside world is low, and the economic development urgently needs capital investment. Therefore, the increase of the investment intensity of fixed assets has the greatest impact on the High-quality economic development of the western region. At the same time, the western region has high mountains and plateaus, rugged terrain, relatively backward infrastructure level and restricted economic development. The improvement of communication infrastructure plays an important role in stimulating effective investment and promoting the modernization of cities, towns and rural areas in the western region. Therefore, the improvement of communication facilities plays the most obvious role in promoting the High-quality economic development of the western region.

5. Conclusions and Suggestions

This paper theoretically analyzes the independent and synergistic effects of green development and technological innovation on High-quality economic development. Taking the panel data of 30 provinces from 2011 to 2017 as samples, this paper measures the level of High-quality economic development, and empirically uses the fixed effect model to explore the impact mechanism of green development and technological innovation on High-quality economic development. The study found that the overall level of High-quality economic development showed an upward trend, with great regional differences, among which the eastern region was the highest, the central region was the second, and the western region was the lowest; Technological innovation, green development and their interaction have a significant role in promoting High-quality economic development, that is, green development and technological innovation have independent and synergistic effects on High-quality economic development; There are regional differences in the impact of green development and technological innovation on High-quality economic development. Based on the research conclusions, the following policy suggestions are put forward:

First, increase investment in technological innovation and improve the ability of independent innovation. The core of High-quality economic development is to rely on innovation to promote development. Increasing innovation investment and improving innovation ability are of great practical significance for realizing innovation driven economic development. Increasing technological innovation is mainly achieved by improving the training of scientific research and innovation talents and the investment intensity of R & D funds. The shortage of talents is the biggest obstacle to the development of high-tech in China, especially the shortage of high-level scientific research and innovation talents, which affects the process of High-quality economic development to a certain extent. Therefore, we should strengthen the training of capable and highly contributing technical talents and give a certain reward mechanism to stimulate the creativity and enthusiasm of scientific researchers. R&D expenditure is the support for the development of technological innovation. The development of technology and the transformation of achievements are inseparable from the investment of funds. The government should reasonably arrange the expenditure of scientific research funds to ensure sufficient

financial support in the development stage of technological innovation. To improve the ability of independent innovation, we should support qualified regions to vigorously develop high-tech industries and build scientific and technological innovation centers. At the same time, we should deepen the supply side reform in the field of technological innovation, reform the system that hinders technological innovation, constantly improve the supporting mechanism of technological innovation, and continuously strengthen the protection of intellectual property rights, so as to promote High-quality economic development.

Second, adhere to the path of giving priority to ecology and improve the efficiency of green development. The essence of green development is to solve the contradiction between economic development and environmental protection. Economic growth must be controlled within the range that the ecosystem can carry, and we should adhere to the road of ecological priority. The government established and improved the corresponding green development policies, laws and regulations, adhered to the one vote veto system, and strengthened the supervision of ecological environment. In the direction of green circular development, enterprises introduce green technology, promote green supply chain production, reduce the damage to the ecological environment caused by resource mining and processing, and improve the efficiency of green development. Individuals should strengthen environmental awareness, clarify their rights and obligations for environmental protection, participate in the supervision and evaluation of environmental protection, actively corresponding green lifestyle, low-carbon travel, diligence and thrift.

Third, pay attention to the coordinated development of green development and technological innovation. In the process of High-quality economic development, it is limited to emphasize the role of green development or technological innovation in promoting High-quality economic development. Only by promoting the coordinated development of the two can we better promote High-quality economic development. Promote green development through technological innovation, encourage enterprises to introduce green innovative technologies and develop towards energy conservation and environmental protection; Green development forces technological innovation, constantly improve the legal system of ecological and environmental protection, and strengthen the monitoring of ecological and environmental management, so as to encourage enterprises to carry out technological innovation to adapt to the green development policy.

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