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Study on the Impact of Clean Power Investment on Regional High-Quality Economic Development in China

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Abstract: In 2017, the 19th CPC National Congress proposed to "establish a sound economic system of green, low-carbon and circular development", which indicates the direction of high-quality economic development in the new era of China. Clean power investment is a powerful way to promote high-quality economic development by adopting non-fossil-energy utilization and low-emission technologies, as well as creating new jobs. Meanwhile, large-scale investment and a long investment return period result in negative effects on local economies. To better understand the effect of clean power investment, this paper selects panel data of thirty provinces in China from 2010 to 2019 to establish a spatial Durbin model to explore the impact of clean power investment on regional high-quality economic development. The results show that inter-regional high-quality economic development shows significant spatial auto-correlation characteristics. Clean power investment has not only a positive direct effect on high-quality economic development but also generates positive spatial spillover effects. Human capital, degree of government intervention, and urbanization rate have positive effects on regional high-quality economic development, while they play a suppressed role on neighboring regions.

Keywords: clean power investment; high-quality development; spatial Durbin model

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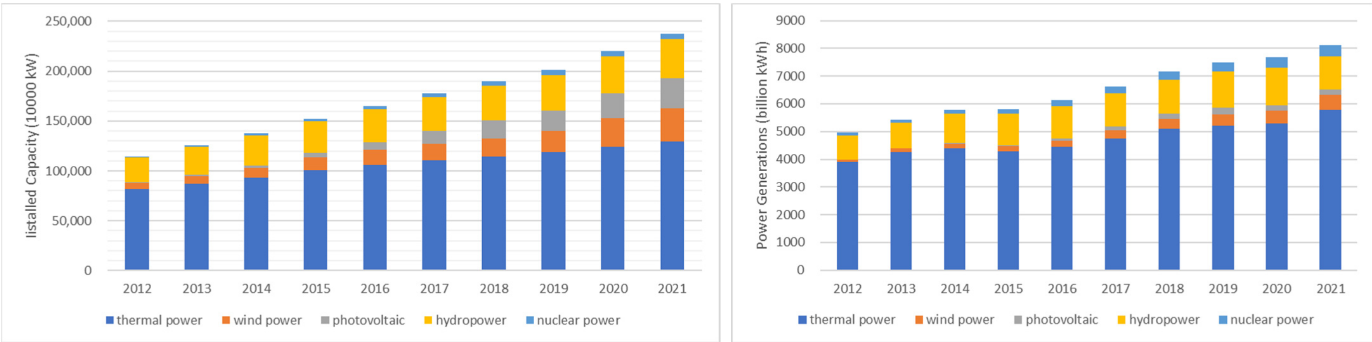
1. Introduction

In September 2020, President Xi Jinping made a solemn commitment at the United Nations General Assembly that China will strive to peak CO_2 emissions by 2030 and achieve carbon neutrality by 2060, reflecting China's determination and confidence in restructuring the relationship between the environment and the economy [1]. It is necessary to improve energy technology and optimize energy structure to achieve carbon peaking and carbon neutrality goals [2]. While making efficient use of coal for cleaning, we should vigorously develop clean energy, promote the optimal combination of traditional fossil and clean energy, build a diversified energy production and consumption structure, and constantly improve the green development ability of energy. Clean energy development and utilization can significantly reduce fossil energy consumption, increase the proportion of clean energy consumption, and change the energy supply structure in which fossil energy accounts for the vast majority. With fossil energy, clean energy can reduce greenhouse gas emissions, reduce the emissions of various pollutants such as industrial smoke and solid waste, and play a significant and positive role in the environment and society. Thus, the state has issued several policies to encourage governments at all levels, large state-owned enterprises, small and medium-sized enterprises, and private individuals to vigorously develop clean energy industries, and has achieved remarkable results. From the perspective of power generation structure, according to the data from *China Electricity Statistics Yearbook*, clean energy power generation accounts for about 34.5% in 2021 (mainly including hydropower, wind power, photovoltaic, biomass power generation, and nuclear power), among which hydropower accounts for 16.00% of the national power generation, wind power accounts for 7.83%, and solar power accounts for 3.9% (see Figure 1). The "Fourteenth Five-Year Plan for Renewable

Energy Development" released in 2022 pointed out the direction of renewable development: optimizing the development mode and development of renewable energy on a large scale; promoting storage and consumption, and use of renewable energy in a high proportion; adhering to innovation drive and developing renewable energy with high quality.



(**a**) (**b**)

Figure 1. Installed power capacity and power generation in China (2012–2021). (**a**) The installed capacity of thermal power, wind power, photovoltaic, hydropower and nuclear power by years from 2012 to 2021. (**b**) The power generation from 2012 to 2021.

Green development is an essential part of high-quality economic development in the new era which requires a lot of clean power investment. All kinds of government enterprises' investment in the clean power industry will bring the upgrading of equipment, technical personnel, technology, management, and product. Clean power investment has a considerable impact on the adjustment, transformation, upgrading, and optimization of national industrial structure and guiding green consumption, and it provides an impetus for accelerating and leading high-quality economic development. Therefore, based on sorting out the previous literature, clarifying the profound connotations, interactions, mechanisms, and effects of clean power investment and high-quality economic development, this paper puts forward the countermeasures of clean power investment leading to high-quality economic development, which has vital practical significance for realizing high-quality economic development.

2. Literature Review

Some studies have examined clean power investment and its impact on high-quality economic development. The main research directions are as follows: first, the definition, quantification, and influencing factors of high-quality economic development; second, the economic and social effects of clean power investment; third, some scholars have explored the impact path and empirical research of clean power investment on high-quality economic development.

2.1. Definition, Quantification, and Influencing Factors of High-Quality Economic Development

High-quality economic development was put forward for the first time by President Xi Jinping at the 19th Party Congress, which means that China's economy will pay more attention to balance, effectiveness, sustainability, and sharing, thus triggering an upsurge in studying high-quality economic development [3].

High-quality development is the combination of effectiveness, sufficiency, coordination, innovation, sharing, and stability of economic development with improving total factor productivity and realizing economic endogenous, ecological, and sustainable development [4–6]. Yu et al. (2018) summarized the reality and predicament of China's high-quality economic development from the four dimensions of industry development, innovation, openness, and people's lives [7]. It is the advanced state of economic development quality and the upgraded version of China's economic development. The measurement of high-quality economic development needs to establish a relatively complete index system to measure the level of high-quality economic development. Scholars put forward a series of index systems according to their respective understanding of the connotation of high-quality economic development. Wang (2020) calculated the total factor productivity of 108 cities in the Yangtze River Economic Belt by the Malmquist-Luenberger index and Dagum Gini coefficient method, and analyzed the temporal and spatial evolution law and regional gap of economic quality, efficiency change, and technological change. It was concluded that technological progress is the power source of economic quality optimization and promotion [8]. Yu (2022) defines high-quality development in terms of technological innovation, system reform, industrial transformation, upgrading, and development efficiency. The research shows that all the above factors have spatial spillover effects, and technological innovation, system reform, transformation, and upgrading have significant direct and indirect effects on high-quality economic development [9]. Li et al. (2022) constructed 12 secondary and 22 tertiary evaluation indexes from five aspects: economic growth rate, economic growth stability, innovation efficiency, sharing of economic development achievements, and green development, and formed the evaluation index system of high-quality economic development level in China [6]. Wei (2021) subdivided the meaning of high-quality development into economic development, innovation efficiency, environmental impact, ecological services, and people's livelihood. In addition, the direct effect of technological innovation, transformation, and upgrading is stronger than the indirect effect [10]. According to former literature, although the specific indicators chosen by each scholar to measure the high-quality development level of the economy are different, they can be generally summarized into five basic dimensions: "innovation, coordination, green, openness, and sharing". Li (2019) and Wei (2018) both measure the high-quality development level of the local economy from these five basic dimensions [11,12]. There are plenty of factors that affect high-quality economic development, and many scholars have studied it from the perspectives of the digital economy [13,14], environmental regulation [15], foreign direct investment [16], and green innovation [17].

2.2. Research on the Economic and Social Effects of Clean Power Investment

According to the definition of the Energy Law of the People's Republic of China (draft) (2020), clean energy is defined as energy with zero or low emissions of environmental pollutants and greenhouse gases such as carbon dioxide in the process of development, utilization, and use, mainly including hydro-energy, nuclear energy, wind energy, solar energy, biomass energy, geothermal energy, hydrogen energy, and ocean energy. As far as "clean power investment" is concerned, there is no consistent definition in existing studies. Man et al. (2013) pointed out that energy investment meets the following conditions: "In order to obtain future benefits, investors invest in fixed assets in the fields of energy production, circulation and consumption" [18]. Considering the central role of enterprises in social production and economic growth, most of the research focuses on the perspective of enterprises. Specifically, Xu and Bai (2009) defined renewable energy investment as "enterprise investment in the field of renewable energy" [19]. Zhang et al. (2015) defined it as "cash paid by renewable energy enterprises for the construction of fixed assets, intangible assets and other long-term assets" [20]. These definitions are different in the subject and object of renewable energy investment. Considering that the role of government and enterprises in clean power investment cannot be ignored, this paper defines clean power investment as the sum of government investment and investment of listed clean power companies.

Scholars focus on the role that clean power investment plays in economic development. Green technology investment can have long-term or short-term positive effects on economic development [21]. It is suggested that the government should increase investment in clean energy [22]. The green investment will promote not only clean energy consumption but also economic growth [23]. Clean power development can boost the local economy by creating employment opportunities, increasing taxes, and reducing energy costs [24]. However, some scholars have come to the opposite conclusion through research. Green investment and renewable energy policies are not conducive to improving the sustainability of enterprises in highly market-oriented areas, especially electronic companies, labour-intensive companies, and companies with low equity concentration. Clean power investment will improve environmental sustainability at the expense of economic growth [25].

Besides the economic effect, clean power investment also has a very positive effect on the social dimension. In terms of improving the environment, clean power investment will inhibit carbon emissions [26] and greenhouse gas emissions, helping to improve environmental quality [27,28]. In the early stage of clean power investment, carbon emissions will increase. In the medium term, clean power investment will begin to play a role in emission reduction. In the later period, clean power investment may lead to an increase in carbon emissions again [29].

The process of replacing fossil fuels with clean energy can increase employment opportunities for many unemployed people. In 2018, about 15% of all jobs created globally came from the clean energy sector, which will create 84 million jobs worldwide by 2050 [30,31]. China's effective clean power investment and green projects will help the Belt and Road Initiative's neighboring countries optimize energy structure, enhance energy security, promote global low-carbon construction, and have a far-reaching impact on the human long-term living environment [32,33]. The results show that, with traditional fossil energy, clean energy power generation will create more jobs, and the global energy transformation will have a comprehensive positive impact on the future stability and growth of the world economy [34,35]. A large number of research results show that clean power investment not only has a positive effect on the environment, but also plays a positive role in creating jobs, increasing taxes, reducing energy costs, optimizing energy structure, and other social effects.

However, there are risks in clean power investment, including economic and commercial risks, market, policy, technological, environmental, and social risks [36]. Organizational efficiency and cost efficiency are the most important factors in clean power investment projects. On the other hand, moderate risks should be considered in these projects. To reduce risks, necessary measures should be taken to improve communication and cost control among departments [37].

2.3. Clean Power Investment on High-Quality Economic Development

At present, there are few articles about the impact of clean power investment on high-quality economic development. The existing literature mainly studies the relationship between green finance, green credit, and green investment and high-quality economic development, and few studies focus on the factor of clean power investment. Minna et al. (2018) pointed out that the combination of green investment and innovation will have a positive impact on high-quality economic development [38]. Ana et al. (2018) takes the incident of insufficient power supply in sub-Saharan Africa as an example, and analyzes that green investment has a positive impact on high-quality economic development [39]. Zhang (2020), based on Durbin's model test, found that green investment can promote the high-quality economic development in the process of marketization, and the effect is remarkable [40]. Shahani et al. (2020) refers to the European Green Investment Agreement of EUR 1 billion published by the European Union, and comes to the conclusion that green investment has a positive effect on high-quality economic development [41]. Chen et al. (2021) studied the relationship between green financial investment, industrial structure upgrading, and high-quality economic development, and found that both green financial investment and industrial structure upgrading are the direct driving forces of high-quality economic development, and that industrial structure upgrading has some intermediary effects between green financial investment and high-quality economic development [42].

Former literature has provided abundant information and help for the research of this paper. Scholars' research focuses on the measurement and influencing factors of high-quality economic development and the economic and social effects of clean power investment, but seldom refine the research object into clean power investment and bring it into a unified analysis structure to analyze the relationship between it and high-quality economic development. Therefore, this paper comprehensively evaluates the high-quality economic development level of each province with entropy TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method from the five dimensions of innovation, coordination, greenness, openness, and sharing, and further empirically analyzes the impact of clean power investment on high-quality economic development with the spatial Durbin model.

3. Impacting Mechanism

At the Fifth Plenary Session of the 18th Central Committee of the Communist Party of China, President Xi Jinping systematically discussed the five development concepts of innovation, coordination, greenness, openness, and sharing. This paper intends to subdivide high-quality economic development into five development concepts. This chapter will explain how clean power investment acts on the five development concepts to promote high-quality economic development.

3.1. Clean Power Investment on Innovative Development

Innovative development is the primary driving force for high-quality development, and science and technology are the primary productive forces. The development of the modern world economy is more and more dependent on innovation. The achievements of scientific and technological innovation act on various factors such as production, sales, and management, and exert a "multiplier effect" to promote high-quality economic development. Clean power-related technologies are relatively new, challenging, and promising, with the possibility of overtaking on corners. Currently, China's innovative achievements are mainly concentrated at the level of enterprise and university. Investment in the clean power industry can inject a large number of funds into clean power companies and enhance their vitality. To enhance competitiveness, clean power companies will use the funds for technology research and development to attract high-caliber talents, and produce more energy-saving and low-consumption products. The scientific and technological innovation results generated by clean power investment can provide cleaner and greener production for further production and provide a driving force for high-quality economic development. This paper selects three indicators: R&D investment intensity, R&D personnel equivalent, and the number of domestic invention patents granted per 10,000 people to measure the level of innovative development in each province.

3.2. Clean Power Investment on Coordinated Development

Coordinated development is the endogenous characteristic of high-quality economic development. China is striving to build a situation of industrial coordination, regional coordination, and urban-rural coordination. The demand for clean and low-carbon energy structure with government enterprises will guide the funds invested in clean energy from high-pollution and energy-consuming industries to more environmentally friendly and energy-saving industries. It will increase the scale and business scope of environmental protection industries, drive the rationalization and upgrading of the whole industrial structure, promote the integration and development of advanced manufacturing industries related to clean power technologies with the digital economy and real economy, and promote high-quality economic development. Due to different natural endowments, western regions such as Qinghai, Gansu, and Xinjiang are rich in wind energy and solar energy. Compared with the middle and eastern regions, they are more suitable for developing clean power industries, such as wind energy and solar energy. Most of the investment in clean energy will flow into underdeveloped regions such as the western region to build more power bases, thus increasing local employment, creating tax revenue, and narrowing the economic gap between undeveloped and developed regions. Clean power investment not only plays a role in power supply construction, but also in infrastructure construction such as power grid construction, building a modern clean energy system in rural areas, meeting the needs of agricultural water conservancy machinery and farming equipment, narrowing the gap between urban and rural areas, and improving the lives of rural residents. Therefore, this paper chooses the income gap between urban and rural areas, the rationalization of industrial structure, and the upgrading of industrial structure as indicators to measure coordinated development.

3.3. Clean Power Investment on Green Development

Green development is a common form of high-quality economic development. Decades of rapid economic development and the accumulation of low-carbon technologies can restore the destroyed ecological environment, and people's demand for green life is becoming stronger and stronger. The process of clean power investment will form brand-new green productivity. The production process shows the characteristics of clean production, such as saving energy and raw materials, and producing less waste. The produced products are recyclable and low in pollution, and environmental protection is carried out at the same time of production. The increase of clean power investment can significantly reduce the consumption of high-emission fossil energy such as coal combined with improving the energy structure, reducing the discharge of all kinds of industrial wastes, and improving the living environment and the air quality. Therefore, this paper selects five indicators: per capita industrial waste gas emissions, per capita coal consumption, forest coverage, per capita solid waste production, and the ratio of total environmental pollution control to GDP to comprehensively measure the green development level.

3.4. Clean Power Investment on Open Development

Open development is the necessary way for an economy to develop with high quality. To achieve high-quality economic development, domestic enterprises should not only actively go abroad but also vigorously introduce outstanding enterprises from other countries to supplement the problems of insufficient domestic investment and low investment quality and give full play to their catfish effect. It is also necessary to actively develop foreign investment, give full play to comparative advantages, expand markets, and accumulate experience in developing regions such as Asia, Africa, and Latin America, which can not only increase employment, expand labor export, and transfer some backward production capacity, but also enhance the value of domestic brands, expand national influence, and lay a solid foundation for future product export. Concerning clean power and low-carbon technologies, Western developed countries started earlier and domestic related industries caught up and realized the advantage of backwardness. At present, domestic companies in clean power fields such as photovoltaic, large hydropower station construction, nuclear power station, offshore wind energy, etc.. have a technical level no less than that of foreign countries. More and more Chinese clean power companies set up factories and build large clean power projects abroad. Therefore, this paper selects the ratio of total import and export of goods to GDP and the ratio of foreign direct investment to GDP as two indicators to measure the level of open development.

3.5. Clean Power Investment on Shared Development

Shared development is the fundamental purpose of high-quality development. The achievements of economic development should be shared by all people and the life quality of all people should be improved. China is establishing a public service system integrating urban and rural areas, speeding up the construction of water, electricity, gas, network, and other infrastructure in rural areas, and moderately tilting to rural areas in education, medical care, old-age care, culture, sports, etc. Clean power investment is a part of social public service investment and is concentrated in underdeveloped areas such as the west, which can effectively narrow the difference between urban and rural public facilities. In this paper, the loop length of 35 KV and above transmission lines and the ratio of social service expenditure to GDP are selected as two indicators to measure shared development level.

Through the research on the mechanism of clean power investment in five aspects of high-quality economic development, we know that clean power investment plays a positive role in five aspects: innovation, coordination, greenness, openness, and sharing. The present situation of high-quality economic development and clean power investment will be further introduced below.

4. Materials and Methods

As mentioned in the third chapter, this paper plans to build a comprehensive index system based on the five development concepts to measure the high-quality economic development level of 30 provinces (excluding Tibet, Hong Kong, Macao, and Taiwan). This paper chooses the Entropy Weight Method to calculate the weights of specific indicators. Its basic idea is to determine the objective weight according to the variation degree of indexes. Specifically, the smaller the information entropy of an index, the greater the variation of the index, the more information it provides, the greater its role in the comprehensive evaluation system, and the greater its corresponding weight. The specific calculation steps are as follows:

Firstly, we should standardize the original data. The corresponding data dimensions of each index layer are different. In order to make each index comparable, the data should be standardized first, and the calculation formula is as follows:

$$U_{\mathrm{ij}} = \frac{x_{ij} - \mathrm{min}x_{ij}}{\mathrm{max}_{ij} - \mathrm{min}x_{ij}}(i = 1, \ldots, n; j = 1, \ldots, m) \quad (1)$$

Secondly, we can calculate the proportion of x_{ij}:

$$U'_{ij} = \frac{U_{ij}}{\sum_{i=1}^{n} U_{ij}} \quad (2)$$

Thirdly, we calculate information entropy, and the formula is as follows:

$$E_j = -\ln(n)^{-1} \sum_{i=1}^{n} U'_{ij} \ln(U'_{ij}) \quad (3)$$

Finally, we calculate the corresponding weight of each indicator according to the index weight formula:

$$W_j = \frac{1 - E_j}{\sum_{j=1}^{m} (1 - E_j)} \quad (4)$$

The final results and positive and negative attributes (the positive attribute indicate that the higher the indicator value, the better, while the negative attribute is the opposite) are shown in Table 1:

Table 1. Measurements of high-quality economic development.

The First Layer	The Second Layer	Positive or Negative	Weights
Innovative development	R&D investment intensity	+	0.066
	Domestic invention patents granted per 10,000 people	+	0.194
	R&D personnel full-time equivalents	+	0.119
Coordinated development	Urban-rural income gap	−	0.031
	Rationalization of industrial structure	+	0.059
	Premiumization of industrial structure	+	0.068
Green development	Industrial waste gas emissions per capita	−	0.030
	Coal consumption per capita	−	0.021
	Forest coverage	+	0.055
	Solid waste generation per capita	−	0.022
	Total environmental pollution control to GDP ratio	+	0.047
Open development	Ratio of total exports and imports of goods to GDP	+	0.120
	FDI to GDP ratio	+	0.067
Shared development	Loop length of 35 KV and above transmission lines	+	0.047
	Ratio of social service expenditure to GDP	+	0.056

The weight calculated according to the entropy weight method is further passed through the TOPSIS method to get the scores of high-quality economic development.

Firstly, we calculate the weighting matrix of evaluation indicator Z_{ij}:

$$Z_{ij} = (z_{ij})_{n*m} = W_j * x_{ij} \quad (5)$$

Then, we find the best ideal solution A_j^+ and the worst ideal solution A_j^-:

$$A_j^+ = (\max z_1, \ldots, \max z_m) \quad (6)$$

$$A_j^- = (\min z_1, \ldots, \min z_m) \quad (7)$$

Next, we calculate the distance to the best and worst ideal solution to each evaluation object, and the calculation formula is as follows:

$$D_i^+ = \sqrt{\sum_{j=1}^{m} \left(A_j^+ - z_{ij}\right)^2} \quad (8)$$

$$D_i^- = \sqrt{\sum_{j=1}^{m} \left(A_j^- - z_{ij}\right)^2} \quad (9)$$

Lastly, we can calculate the score of each object:

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (10)$$

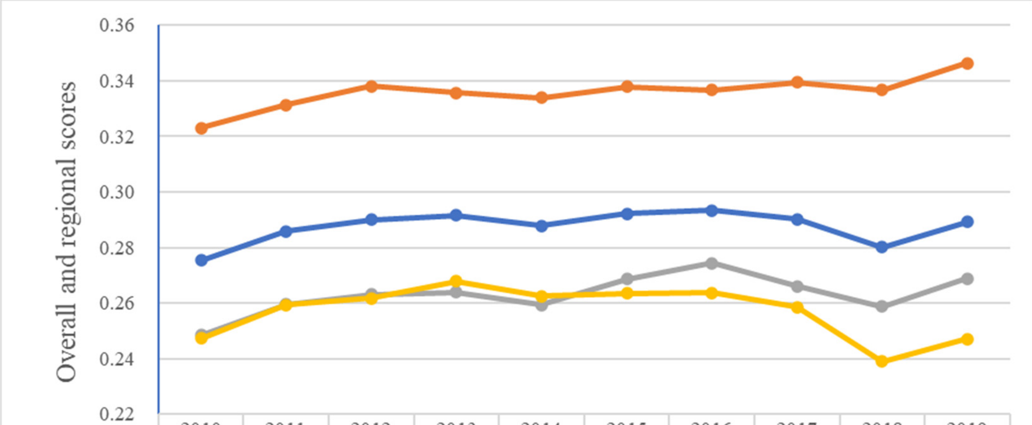
After the above calculations, we get the scores of high-quality economic development level of each province from 2010 to 2019. Due to the space limitation, only odd-numbered year results and ten-year average scores are displayed. The specific results are shown in Table 2.

Table 2. Score of economic high-quality development by province.

Region	2011	2013	2015	2017	2019	Average
Beijing	0.478	0.485	0.517	0.552	0.543	0.506
Tianjin	0.320	0.335	0.349	0.289	0.283	0.313
Hebei	0.248	0.240	0.248	0.266	0.273	0.252
Shanxi	0.207	0.220	0.238	0.209	0.224	0.220
Inner Mongolia	0.236	0.242	0.247	0.251	0.241	0.240
Liaoning	0.311	0.303	0.237	0.257	0.254	0.278
Jilin	0.251	0.245	0.240	0.243	0.248	0.244
Heilongjiang	0.280	0.270	0.266	0.263	0.251	0.264
Shanghai	0.379	0.369	0.378	0.377	0.381	0.376
Jiangsu	0.334	0.346	0.352	0.357	0.372	0.349
Zhejiang	0.328	0.339	0.360	0.362	0.386	0.352
Anhui	0.259	0.285	0.288	0.287	0.282	0.276
Fujian	0.301	0.303	0.300	0.298	0.299	0.298
Jiangxi	0.297	0.290	0.297	0.298	0.299	0.295
Shandong	0.269	0.284	0.291	0.300	0.301	0.285
Henan	0.240	0.249	0.256	0.262	0.268	0.251
Hubei	0.274	0.275	0.282	0.279	0.282	0.276
Hunan	0.268	0.276	0.283	0.288	0.297	0.280
Guangdong	0.385	0.398	0.390	0.391	0.432	0.399
Guangxi	0.273	0.287	0.292	0.289	0.291	0.283
Hainan	0.293	0.289	0.293	0.284	0.285	0.288
Chongqing	0.282	0.289	0.253	0.253	0.259	0.264
Sichuan	0.280	0.287	0.290	0.286	0.290	0.285
Guizhou	0.291	0.281	0.262	0.252	0.251	0.266
Yunnan	0.272	0.273	0.277	0.259	0.244	0.265
Shaanxi	0.245	0.307	0.282	0.280	0.296	0.281
Gansu	0.277	0.291	0.279	0.271	0.252	0.272
Qinghai	0.242	0.214	0.218	0.228	0.199	0.217
Ningxia	0.216	0.216	0.234	0.214	0.178	0.209
Xinjiang	0.240	0.260	0.265	0.260	0.217	0.245

From Table 2, it is obvious that Beijing has a distinctive leading edge in high-quality economic development, ranking first for ten consecutive years in China. The dominant position of Beijing is mainly due to its innovation, environmental protection, and optimization of industrial structure [43–45]. Innovation is the primary power source for Beijing's high-quality economic development. In 2019, the investment intensity of R&D funds in Beijing was 6.3%, which has a good lead over 4.01% of the second place in Shanghai. Thanks to numerous well-known universities and research institutions, the number of invention patents granted per 10,000 people in Beijing increased from 5.71 in 2010 to 24.26 in 2019, 4.24 times that of a decade ago, further expanding Beijing's dominant position in innovation. Beijing is the capital of China, which has high requirements for ecological environment, and some enterprises with high energy consumption and high pollution have moved to other places, so its green development level is high. Beijing's tertiary industry accounted for 83.52% of GDP, and the ratio of the tertiary industry to the secondary industry was 5.17 in 2019, ranking both first in China, with the most optimized industrial structure. Other provinces can increase investment in innovation, strengthen environmental protection, and promote the upgrading of industrial structure from the experience of Beijing.

According to the division of China's Ministry of Finance, this paper divides 30 provincial administrative regions into three regions: East, Middle, and West. The eastern region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan, and the middle region includes Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan, while the western region includes Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. And the scores of high-quality economic development in the three major regions of China are shown in Figure 2:



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
all	0.275	0.286	0.290	0.292	0.288	0.292	0.293	0.290	0.280	0.289
east	0.323	0.331	0.338	0.336	0.334	0.338	0.337	0.339	0.337	0.346
middle	0.249	0.260	0.263	0.264	0.259	0.269	0.274	0.266	0.259	0.269
west	0.247	0.259	0.262	0.268	0.262	0.264	0.264	0.259	0.239	0.247

Figure 2. Scores of regional high-quality economic development from 2010 to 2019.

By observing the data in Table 2 and Figure 2, it can be seen that the level of high-quality economic development in the eastern region during the decade from 2010 to 2019 was significantly higher than the national average and the middle and western regions. The score of the eastern region increased from 0.323 in 2010 to 0.346 in 2019, with an increase of 7.2%. In the eastern part of China, Beijing scored more than 0.5, ranking first among 30 provinces and cities, and Jiangsu, Zhejiang, Shanghai, and Guangzhou also performed very well. The eastern region was the first to implement the policy of reform and opening-up; the central government's introduction of a series of policies and measures is conducive to the development of the eastern coastal areas and towns. After decades of reform and opening-up, the eastern region has a high degree of marketization. Additionally, private enterprises which have the most innovations in the eastern region are growing vigorously, so it has developed industrial industries, talent reserves, education and medical care, advanced management experience, and technology.

From 2010 to 2014, the level of high-quality economic development in the middle and western regions was almost similar, rising slowly; from 2015 to 2019, the gap between the middle region and the western region began to widen. During this period, the middle region developed rapidly, and the level of high-quality economic development improved, while the level of high-quality economic development in the western region even declined slightly. In 2010, the average score of the eastern region was 0.323, which was higher than the national average of 0.275, the western average of 0.247, and the middle average of 0.249. This shows that the eastern region has always been ahead of other regions, not only at an economic level but also at the national leading level in the five major developments [46–49]. As is clear from Figure 2, after several years of steady improvement the level of high-quality economic development decreased significantly for the middle and western regions in the years from 2016–2018. The western region, since the adoption of the strategy of developing Western China in 1999, was developing rapidly with abundant natural resources and national policies. However, limited by resource endowment, economic foundation, weak private enterprises, and institutional environment, western high-quality economic development has stagnated or even declined. From 31 December 2015 to 4 February 2016, the central environmental protection inspector pilot was launched in Hebei. In the next two years, the action will have achieved full coverage across China. The policy of environmental regulation forced the transformation or closure of high-pollution and high-emission enterprises. Inevitably, this will have a short-term shock on the economy, especially in the west, whose economic structure is dominated by the energy industry [50]. In any case, the low level of industrial structure, lack of innovation motivation, low level of education, and high emission of pollutants have led to the decline of high-quality economic development from 2016 to 2018. As for the middle region, the strength of large population and low labor cost once brought advantages to the development of agriculture and heavy industry. However, after entering the new era, the labor cost is constantly increasing and the development space of labor-intensive industries is gradually shrinking. In addition, the middle region is rich in mineral resources such as coal, oil, iron, nonferrous metals, etc., which have brought advantages to the development of heavy industries, such as metal smelting, machinery, chemical industry, etc. However, high-quality development requires more environmental protection and energy efficiency; the importance of primary energy and raw materials in industrial development is decreasing, and the resource advantages of the middle region are weakening. Weak innovation ability, low level of urbanization, large income gap between urban and rural residents, poor level of openness, and a large number of rural poverty have all led to the fact that the high-quality economic development level of the middle region cannot be steadily improved.

In order to further improve the regional economic high-quality development level, the middle and western regions can implement the innovation-driven strategy vigorously by strengthening the capacity of scientific and technological innovation, intensifying the dominant position of enterprise innovation, and promoting the transformation of scientific and technological achievements. In addition, accelerating industrial transformation and upgrading is an efficient way to promote high-quality development. They can build characteristic industrial clusters with competitive advantages according to local conditions, and promote the common development of surrounding areas through the diffusion effect and correlation effect of leading cities, so as to solve the problem of uneven development in various parts of the region and enhance the coordination of regional development.

Developing clean power is the core of future energy investment. Clean technologies such as wind power and photovoltaic power generation are still the most economical power generation options in many countries. The focus of wind power is shifting to offshore. Last year, more than 20 GW of offshore wind power was put into production, with an investment of about USD 40 billion. China still ranks first, accounting for more than half of the newly added wind energy. It is worth mentioning that from 2019 to 2021, wind power investment soared due to the impact of the affordable access policy. China's clean power investment in recent years is shown in Figure 3.

Liu (2011) divided green investment into fixed assets investment, industrial pollution control investment, and financial environmental protection expenditure [51]. The renewable energy investment data selected by Chen (2020), Pan (2020), and Yang (2020) are the cash paid for the construction of fixed assets, intangible assets, and other long-term assets of renewable energy enterprises [52–54]; Zhu (2019) selected electric power companies listed on Shanghai Stock Exchange or Shenzhen Stock Exchange with clean power investment business to analyze their investment [55]. The author observes that the measurement of clean power investment by other scholars is mostly based on the cash paid by listed clean energy companies to build fixed assets, intangible assets, and other long-term assets, ignoring the investment of the government and large central enterprises in clean energy. Especially considering the huge investment in the early stage of clean power investment and the long recovery period, which requires the intervention of funds from the government and large power enterprises, the government and large power enterprises pay less attention to economic benefits and pay more attention to social responsibility and environmental benefits, so we cannot ignore the role of the government and large power enterprises in clean power investment. Therefore, based on previous studies, this paper measures the amount of clean power investment in each province with the cash paid by listed clean energy companies to build fixed assets, intangible assets, and other long-term assets, plus the amount of investment completed by the government and large power enterprises in clean energy power supply construction. The clean power investment of government and large-scale power enterprises is the sum of the completed investment in the construction of four clean energy sources: nuclear energy, wind energy, solar energy, and hydropower in various regions in *Almanac of China's Water Power*. The total data are shown in Table 3.

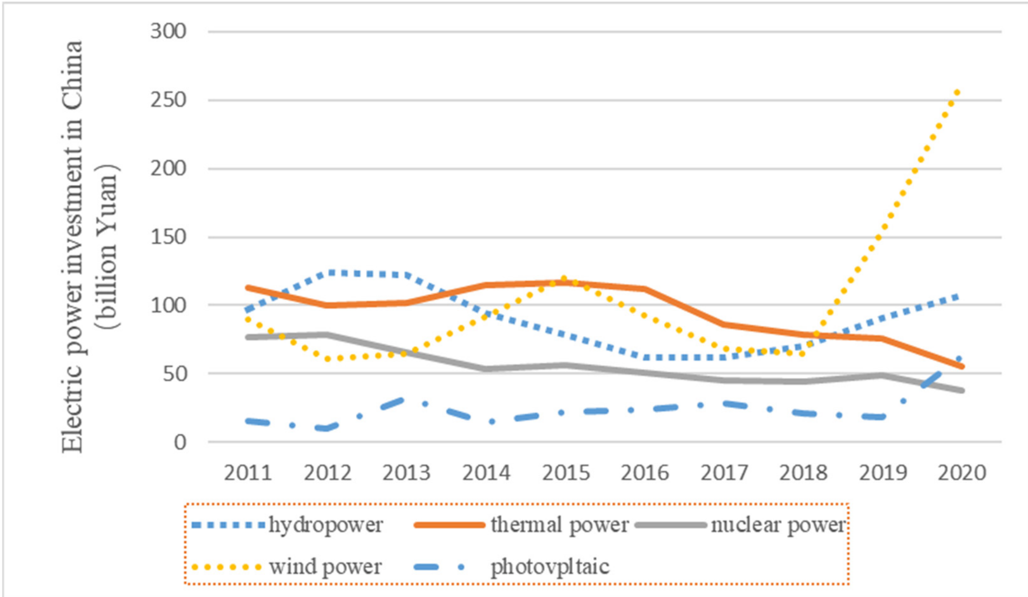


Figure 3. Electric power investment in China from 2011 to 2020.

In this paper, the total investment amount of clean power in each province is the sum of the investment amount of listed companies of clean power and the investment amount of clean power plant construction. Among them, clean power plant construction investment includes investment in hydropower, wind power, nuclear power, and solar power. Due to the vast territory, diverse geological conditions and uneven distribution of natural resources in China, different provinces develop clean power according to their own characteristics. Specifically, Xinjiang, Inner Mongolia, and other western regions, are rich in wind energy and solar energy, and a large amount of water resources in the southwest region are suitable for development and utilization to build large hydropower stations. China's nuclear power stations are all built in the eastern coastal areas because they require a large amount of water for cooling and safety considerations. Similarly, offshore wind energy can only be developed and utilized in provinces near the sea. Due to the uneven distribution of natural resources in different provinces, the investment in various types of clean power is extremely discrepant, resulting in extremely unstable data. Moreover, from the mechanism of clean power investments on high-quality economic development, different types of clean power investment do not significantly affect the development results, but rather, the investment scale is the important factor that affects this effect. Therefore, this paper sums up the investment of various clean power types and then carries out the follow-up measurement analysis.

Table 3. Total clean power investment by region (billion CNY).

Region	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Average
Beijing	26.06	29.41	30.79	39.00	50.77	51.27	51.62	45.50	50.05	48.36	42.28
Tianjin	2.25	2.90	2.15	2.41	2.64	2.48	2.77	5.36	7.92	7.15	3.80
Hebei	11.70	10.04	4.45	4.61	7.15	9.85	11.99	14.07	12.40	15.25	10.15
Shanxi	4.83	8.14	5.46	7.53	11.06	12.42	16.00	12.94	6.87	11.29	9.65
Inner Mongolia	30.56	18.34	11.07	14.68	16.87	15.53	6.51	5.84	5.30	12.27	13.70
Liaoning	18.74	16.71	14.44	10.41	4.30	6.40	5.05	7.88	9.17	10.08	10.32
Jilin	10.34	4.29	3.03	3.61	4.59	7.94	6.70	5.56	8.11	7.43	6.16
Heilongjiang	5.31	4.38	3.40	3.06	2.92	1.80	2.30	2.12	1.75	2.18	2.92
Shanghai	11.04	8.87	8.43	8.65	11.43	10.52	10.72	16.51	21.24	20.56	12.80
Jiangsu	6.26	8.62	8.03	12.25	16.88	25.59	33.06	34.12	36.57	39.87	22.13
Zhejiang	15.46	15.52	11.55	9.11	10.45	11.23	8.55	13.84	13.42	10.70	11.98
Anhui	4.01	4.01	3.75	3.77	3.81	5.08	7.58	7.30	6.91	6.90	5.31
Fujian	16.37	17.99	19.81	16.75	11.87	12.80	13.18	14.65	15.40	19.94	15.88
Jiangxi	0.56	0.66	1.99	2.11	2.33	2.84	3.65	3.37	4.64	7.42	2.96
Shandong	27.65	27.87	29.26	8.47	26.12	24.11	30.05	27.69	26.87	25.44	25.35
Henan	1.19	1.42	0.63	0.40	1.90	2.23	3.06	6.29	5.42	10.69	3.32
Hubei	10.24	4.43	3.63	4.40	4.41	7.30	10.97	9.04	8.58	7.72	7.07
Hunan	5.09	6.01	6.19	5.14	4.37	3.68	4.26	5.45	4.40	6.25	5.08
Guangdong	29.51	43.65	38.62	15.03	34.48	32.04	37.05	38.24	30.76	44.27	34.37
Guangxi	3.84	6.50	7.83	22.39	5.84	6.58	7.77	5.68	8.40	11.15	8.60
Hainan	2.18	3.58	4.70	6.09	4.75	3.73	2.72	4.47	4.51	3.58	3.02
Chongqing	2.72	1.88	1.06	1.97	4.56	5.27	5.44	5.16	2.86	3.57	3.45
Sichuan	38.31	50.13	61.36	57.13	45.17	38.73	35.73	40.96	47.53	43.15	45.82
Guizhou	6.10	7.69	6.07	7.75	6.19	5.95	3.52	3.37	2.31	3.58	5.25
Yunnan	13.64	28.27	45.37	46.28	40.83	36.99	26.74	12.02	8.91	25.43	28.45
Shaanxi	1.74	1.58	2.54	3.64	2.66	7.51	9.93	8.93	7.82	10.82	5.72
Gansu	17.07	7.10	9.11	11.14	17.15	10.04	1.76	1.42	1.38	1.32	7.25
Qinghai	2.70	8.65	2.98	6.13	2.15	4.68	3.19	2.55	3.90	5.53	4.25
Ningxia	3.96	12.98	3.88	5.49	7.30	11.16	4.95	3.49	1.42	5.32	5.66
Xinjiang	10.05	13.58	15.94	31.99	15.83	31.60	21.97	9.89	14.61	24.11	18.96

It can be seen from Table 3 that clean power investment has a high degree of dispersion among provinces. For example, in 2019, the total amount of clean power investment in Sichuan Province reached CNY 43.15 billion, which was 32.6 times that of Gansu Province, which had the least amount of investment. This is because there is an objective gap between the innate resource endowment and the technical level of each province. Northwest China is sparsely populated and suitable for developing clean power, and most of the government's investment is concentrated in this area. Jiangsu, Zhejiang, and Shanghai regions have advanced clean energy technologies in China and can invest in large-scale power projects all over the country. These economically developed regions have a large number of clean energy superior companies, so they invest more in clean energy. Within each province, the investment amount in different years can also be nearly ten times different. For example, Gansu's investment reached its peak in 2010 and 2014, with an investment amount of more than CNY 17 billion, while after 2016, the annual investment amount was just over CNY one billion. This phenomenon is due to the huge investment in the early stage of the construction of large-scale power generation bases. Once the power generation bases are built and put into operation, the construction costs are greatly reduced, and only a small amount of operating costs are needed. Therefore, the investment in clean power in some provinces fluctuates greatly in different years.

It should be noted that the "investment" in this paper not only represents the investment of building clean energy power projects in a certain place, but also includes the clean energy investment of a certain place in other areas. It is particularly noteworthy that there is only a thimbleful of clean energy resources in Beijing. It can be seen that the investment in clean energy power construction in Beijing in the past ten years is only CNY 180 million, while the total investment in clean energy is as high as CNY 42.3 billion, most of which are the investments of large energy enterprises located in Beijing. Although Beijing has very few natural resources of clean energy, a number of large energy groups and listed companies are gathered there by virtue of its political, geographical, and educational advantages. These have sufficient capital, technology, talents, and management experience, which enables Beijing to make efficient investments in areas rich in clean energy resources across the country and make up for the disadvantages of resource-rich areas, such as lack of clean energy-related talents, insufficient investment funds in the early stage, outdated project construction management mode, and backward technology of clean energy development and utilization. R&D and updating of clean energy technology require a large amount of capital investment and scientific and technological talents, which is the most dominant aspect of Beijing. After long-term scientific research investment, a large number of cutting-edge technological updates will be generated, which will further reduce the project construction cost and improve the competitiveness of large energy companies. After completing the expensive construction in the early stage, the benefits of clean energy projects will last for decades, and a large part of the profits will belong to Beijing, where the company's headquarters are located. Because innovation and the competitive advantage will bring the leading position in the industry to the enterprise, the investment income of the enterprise will continue to invest in clean energy technology, which will play a positive feedback role.

In other words, clean energy investment projects also have a positive impact on resource-rich areas such as Xinjiang, Inner Mongolia, and Southwest China. The investment period of large hydropower stations, nuclear power plants, wind farms, and photovoltaic bases is about ten years, with an investment of tens of billions. A large number of construction workers and engineers are needed in the early stage of the project construction, and operators and maintenance workers are needed in the later stage. This has a great positive impact on attracting local employment workers, improving the living quality of local workers, and promoting consumption upgrading. The electricity produced by constructed clean energy fields can be used locally or exported to areas with power shortage such as the east, so as to raise local tax revenue and promote high-quality economic development. Governments in resource-rich areas can vigorously promote the development of large-scale local energy enterprises, absorb the successful experience of Beijing and Shanghai, which are relatively mature in finance and investment, formulate preferential policies to encourage local enterprises to raise funds from the whole country and even the whole world, intensify innovation, increase the attraction of relevant talents, and promote the coordinated development of upstream and downstream enterprises in clean energy industry. Resource-rich areas can rely on their own abundant energy to form their own advantageous industries, and leave the development fruits in the local area as much as possible, so as to promote the high-quality economic development with comprehensive development of clean energy industry.

5. Empirical Findings

In the third chapter, this paper systematically analyzes the mechanism of clean power investment on the high-quality development of the regional economy. In addition, in the fourth chapter, the high-quality economic development level and total clean power investment of 30 provinces from 2010 to 2019 are calculated, and the dynamic changes of high-quality economic development in the whole country and regions are analyzed. Based on the above mechanism analysis and calculation results, this chapter will empirically test and analyze the spatial effect of clean power investment on regional high-quality economic development.

5.1. Methodology and Data

Many factors affect the high-quality development of an economy. Published papers have analyzed the influencing factors from many angles. Referring to previous studies, this paper selects human capital, government intervention, and urbanization rate as control variables. Human capital (HC) is expressed by the number of years of education. Human capital will stimulate local economic growth, and a high-quality labor force can produce a higher level of production. Therefore, it is expected that the promotion of human capital can effectively promote high-quality economic development. Government intervention (GI) is measured by the ratio of fiscal expenditure to GDP. On the one hand, the government's various intervention measures in the market economy can effectively alleviate market failure and promote high-quality economic development. On the other hand, the government's excessive intervention in the market economy may lead to the mismatch of market resources and hinder high-quality economic development. Therefore, the impact of government intervention on high-quality economic development cannot be directly determined. Urbanization rate (UR) is the ratio of the urban population to the total population. From the perspective of economic theory, cities have comparative advantages in improving regional productivity, employment rate, and space utilization efficiency, and urbanization is conducive to enhancing the regional carrying capacity of economic development advantages. The urbanization rate will promote high-quality economic development. On the other hand, urbanization development may lead to a widening income gap between urban and rural areas and increasing energy consumption, which will hurt high-quality economic development.

Based on the analysis of the mechanism of clean power investment on regional economic growth in the previous article, the following panel model is constructed as:

$$HQD_{it} = \alpha_0 + \alpha_1 \ln CEI_{it} + \alpha_2 HC_{it} + \alpha_3 GI_{it} + \alpha_4 UR_{it} + \epsilon_{it} \tag{11}$$

Among them, the explained variable HQD is the score of high-quality economic development level calculated by the entropy TOPSIS method. The explanatory variable CEI is shown in the above section. According to the observation data, the new energy investment in each province fluctuates greatly. To solve the heteroscedasticity problem, the CEI of clean power investment is logarithmic. The control variables are HC, GI, and UR, which respectively represent human capital, government intervention, and urbanization rate. In this equation, i represents region, t represents year, α_0 denotes intercept term, α_1 denotes regression coefficients of core explanatory variables, α_2, α_3 and α_4 represent regression coefficients of human capital, government intervention, and urbanization rate of control variables, respectively. ϵ_{it} represents random error.

In this paper, the panel data of 30 provincial administrative regions in China from 2010 to 2019 are used for empirical analysis. The main sources of data in this paper are China Statistical Yearbook, China Hydropower Yearbook, China Energy Statistical Yearbook, China Industrial Statistical Yearbook, provincial statistical yearbooks, etc. The relevant data are also compiled from official data. The missing data in the yearbook shall be filled by interpolation or median method. Descriptive statistics of related variables are shown in Table 4:

Table 4. Descriptive statistics of variables.

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
HQD	300	0.288	0.061	0.177	0.552
CEI	300	127.62	127.80	3.988	613.64
HC	300	9.088	0.929	6.764	12.782
GI	300	24.55	10.23	10.582	62.836
UR	300	57.73	12.607	33.81	89.6

5.2. Relevant Test

In this paper, the data of 30 provincial administrative regions in the past ten years are selected, where n is 30 and t is 10. They are short panel data, so there is no need for a stationarity test. The results of the fixed effect model and random effect model were obtained by the Hausman test. The test results show that the p value is 0, so the fixed effect model is selected for empirical analysis.

Table 5 shows the fixed effect regression results based on the panel model, which shows the impact of China's overall clean power investment on the high-quality development of the regional economy. It can be seen that all variables are significant, but the regression coefficients are small. First, there is a huge difference in clean power investment in different provincial regions and the level of high-quality development is quite different, so the overall correlation degree is not high. Second, China's energy pattern is unbalanced in distribution and development. The east is a large energy consumer, and the west has a large production capacity. This leads to the fact that clean power investment is mostly concentrated in areas with abundant wind energy and solar energy resources in the west, and the produced electric energy is transported to the east through "West-to-East Power Transmission", which further promotes the high-quality development of the more developed areas in the east and widens the high-quality development gap between the east and the west.

Table 5. Regression results of non-spatial fixed effect model.

Explaining Variables	**Explained Variable HQD**	
	Coefficient	***t*-Value**
lnCEI	0.007 **	2.64
HC	0.014 *	2.03
GI	0.001 **	2.18
UR	−0.0009 *	−1.71
_cons	0.156 ***	2.90
N	300	

Note: ***, ** and * represent passing the significance test at 1%, 5%, and 10% levels, respectively.

5.3. Spatial Model Setting

The spatial weight matrix represents the spatial distance of each region and indirectly reflects the degree of interdependence among regions, which is the premise of spatial econometric analysis. According to the characteristics of the research content, this paper constructs the economic geographical distance matrix and then makes a comparative analysis of the spatial effect between clean power investment and the high-quality development of a regional economy. A spatial weight matrix is a matrix that reflects the dependence of individuals in space. The general form of the matrix is:

$$W = \begin{pmatrix} w_{11} & w_{12} & \cdots & w_{1n} \\ \vdots & & \ddots & \vdots \\ w_{n1} & w_{n2} & \cdots & w_{nn} \end{pmatrix}$$

The spatial matrix depicts the spatial dependence among N individuals, in which w_{ij} indicates the degree of influence of individual i on j. Considering that a large part of the high-quality development of the regional economy is related to economic development, this paper takes the economic geographical distance matrix, a spatial matrix that considers both geographical factors and economic factors, to analyze the research object of this paper at the spatial level. As the degree of convenience of communication is more and more inconvenient, this paper takes the reciprocal of the square of the economic distance between two places as the weight of geographical distance, and then combines it with economic distance, in which the economic distance parameter is set as the reciprocal of the difference of GDP per capita in ten years from 2010 to 2019; d_{ij} is the distance between the two provinces, calculated by the longitude and latitude of the two provinces. The matrix has been standardized, and the form of the economic and geographical distance matrix is as follows:

$$w_{ij} = \begin{cases} \frac{1}{|Y_i - Y_j|} \times \frac{1}{d_{ij}^2} & i \neq j \\ 0 & i = j \end{cases} \tag{12}$$

To explore the possible spatial spillover effect of clean power investment on high-quality economic development, this paper uses the spatial Durbin model to test, and the specific formula is as follows:

$$HQD_{it} = \rho WHQD_{it} + \alpha_0 + \alpha_1 lnCEI_{it} + \alpha_2 HC_{it} + \alpha_3 GI_{it} + \alpha_4 UR_{it} + \lambda_1 WlnCEI_{it} + \lambda_2 WHC_{it} + \lambda_3 WGI_{it} + \lambda_4 WUR_{it} + \mu_i + \varphi_i + \varepsilon_{it} \quad (13)$$

Among them, W is the economic geographical distance matrix, ρ is the spatial autoregressive coefficient, α_0 represents the intercept term that does not change with the individual,α_i denotes the estimated coefficient of each explanatory variable, λ_i is the spatial interaction coefficient of the explained variable, μ_i denotes the individual effect, φ_i denotes the time effect, ε_{it} denotes the random error term.

5.4. Empirical Test

5.4.1. Analysis of Spatial Correlation

Use the global Moran index to judge whether there is a spatial correlation between the high-quality economic development level of 30 provinces in China. Moran index is calculated as follows:

$$I = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(x_i - \overline{x})(x_j - \overline{x})}{S^2 \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}} \quad (14)$$

A negative value of the Moran index indicates negative spatial autocorrelation, a positive value indicates positive spatial autocorrelation, and a value equal to 0 indicates no spatial autocorrelation. The specific calculation results are shown in Table 6:

Table 6. Results of global spatial correlation of high-quality economic development.

Year	Moran's Index	Year	Moran's Index
2010	0.374 ***	2015	0.486 ***
2011	0.388 ***	2016	0.305 ***
2012	0.395 ***	2017	0.232 ***
2013	0.420 ***	2018	0.232 ***
2014	0.469 ***	2019	0.246 ***

Note: *** represents passing the significance test at 1% level.

It can be seen that the Moran's index in the past ten years is greater than 0.2 and is significantly positive at a 1% significance level, indicating that high-quality economic development has a positive spatial correlation and presents the characteristics of spatial concentration distribution. Further observation shows that the Moran index is at a high level from 2010 to 2015, which indicates that the high-quality spatial dependence of regional economy in this period is strong. After 2016, the Moran index shows a downward trend, and the spatial dependence weakened. At the end of 2013, the Third Plenary Session of the 18th CPC Central Committee determined the general policy of comprehensively deepening reform. After two or three years of difficult reform, the results began to appear. The coordinated development of urban and rural areas has taken on a new look. New strategic measures for developing the western region, revitalizing the northeast, raising the middle region, and taking the lead in the eastern region have been continuously launched. The three strategies of "the Belt and Road Initiative" construction, coordinated development of the Beijing-Tianjin-Hebei and Yangtze River Economic Belt have been solidly promoted, and Xiong'an new area has been planned and established. Several national and regional central cities have developed rapidly, and new growth poles and belts are gradually being formed. This reduces the old problem of uncoordinated development among regions, and thus weakens the degree of spatial dependence.

5.4.2. Spatial Model Econometric Analysis

Furthermore, the LM test, Wald test, and LR test are selected to verify whether the spatial Durbin model can degenerate into a spatial lag model or spatial error model, and the Hausman test is used to select the fixed effect or random effect (the results are shown in Table 7). Therefore, it is judged that the spatial Durbin model cannot degenerate into a spatial error model or spatial lag model, and it is necessary to select a fixed effect for subsequent analysis.

Table 7. Test results.

Test	Statistics	*p*-Value
LM lag	0.100	0.752
Robust LM lag	3.198 *	0.074
LM error	2.013	0.156
Robust LM error	5.111 **	0.024
LR (H0: SAR nested in SDM)	21.59 ***	0.0002
LR (H0: SEM nested in SDM)	20.77 ***	0.0004
Wald	14.91 ***	0.0049
Hausman	20.65 **	0.014

Note: ***, ** and * represent passing the significance test at 1%, 5% and 10% levels respectively.

For the fixed effect, it is necessary to further examine the use of the individual fixed effect, time fixed effect, or double fixed effect. LR test results are shown in Table 8:

Table 8. LR test results.

	Statistics	*p*-Value
LR (H0:ind nested in both)	47.09 ***	0.0000
LR (H0: time nested in both)	597.84 ***	0.0000

Note: *** represent passing the significance test at 1% level.

In the tests of individual fixed effect, time fixed effect, and double fixed effect, the results showed that the original hypothesis was rejected at a 1% significance level, so the time-space double fixed model was chosen.

Based on the above comprehensive test, this paper selects the fixed effect of the spatial Durbin model (SDM) and the double fixed model of time and space to make a spatial econometric analysis of the clean power investment and the high-quality development of the regional economy and compares it with the mixed OLS regression without considering the spatial effect. The regression results of the model are shown in Table 9.

By observing AIC and BIC, it can be seen that the fitting degree of the model considering spatial effect is higher, so it can be concluded that the effect of spatial effect on high-quality economic development should be considered.

According to the results in Table 9, the spatial autoregressive coefficient of high-quality economic development is −0.1698, which is significant at the level of 5%, indicating that there is a negative spatial spillover effect in high-quality economic development. The possible reason is that the "siphon effect" exceeds the "spillover effect", and the high-quality development of central cities in developed provinces gathers more resources from neighboring areas, such as high-tech and innovative talents, and investment funds, resulting in provinces with higher economic development levels. Clean power investment, human resource level, government intervention, and urbanization rate all have significant positive effects on the high-quality development of the local economy, while they all inhibit the neighboring provinces.

Table 9. Spatial Durbin model regression results.

Variables	OLS	SDM
ln CEI	0.0072 ** (0.0027)	0.0069 *** (0.0017)
HC	0.0139 * (0.0068)	0.0100 * (0.0056)
GI	0.0012 ** (0.0005)	0.0015 *** (0.0005)
UR	−0.0009 * (0.0006)	0.0016 ** (0.0008)
W×ln CEI		0.0190 *** (0.0035)
W×HC		−0.0643 *** (0.0105)
W×GI		−0.0028 *** (0.0008)
W×UR		−0.0041 *** (0.0012)
rho		−0.1698 **
AIC	−1679.465	−1736.668
BIC	−1664.649	−1699.631

Note: ***, ** and * represent passing the significance test at 1%, 5%, and 10% levels, respectively. The standard errors are in brackets.

5.4.3. Decomposition of Spatial Effect

As the autoregressive coefficient in the spatial Durbin model cannot fully reflect the influence of independent variables on dependent variables, this paper, referring to LeSage and Pace's method, decomposes the influence of independent variables on dependent variables into direct effects, indirect effects, and total effects by the partial differential method. The effect decomposition results are shown in Table 10.

Table 10. Spatial effect decomposition of spatial Durbin model.

Variables	Direct Effects	Indirect Effects	Total Effects
ln CEI	0.006158 *** (3.55)	0.016171 *** (5.09)	0.016171 *** (7.14)
HC	0.011907 ** (2.16)	−0.04292 *** (−4.41)	−0.04292 *** (−3.17)
GI	0.001649 *** (3.68)	−0.00282 *** (−3.68)	−0.00282 (−1.56)
UR	0.001779 ** (2.12)	−0.00394 *** (−3.28)	−0.00394 *** (−2.96)

Note: *** and ** represent passing the significance test at 1% and 5% levels, respectively.

The effect directly reflects the impact of clean power investment and other variables on the high-quality development level of the province's economy. It can be seen that all variables are positive at least at a 5% significance level. Clean power investment is significantly positive at the level of 1%; that is, for each additional unit of clean power investment, the high-quality development level of the local economy will increase by 0.6 percentage points. This is because clean power investment has a positive impact on high-quality economic development in five directions: innovation, coordination, green, openness, and sharing. For each additional unit of human resources, the high-quality development level of the local economy will increase by 1.1 percentage points, and the improvement of the education level will significantly increase the quality of workers. When the number of college students changes to a certain extent, it will change qualitatively, resulting in a large number of innovative achievements. Citizens with higher education generally have a greener and more inclusive attitude toward life, which can promote the economy to turn to a higher-quality development direction. Government intervention and urbanization rate are also significant positive effects on the high-quality development of the local economy, but they are not as big as clean power investment and human capital. Adding one unit can promote the high-quality development of the local economy by about 0.1 units.

The indirect effect after decomposition is the spatial spillover effect, which shows the influence of local related variables on the neighboring areas. The indirect effect regression coefficient of clean power investment is significantly positive at the level of 1%; that is, for every unit of local clean power investment, the high-quality economic development level of neighboring provinces will increase by 1.6 percentage points. This is because clean power investment is mostly concentrated in economically developed provinces or areas with abundant wind energy, light energy, and water energy resources. The increase of a province's own clean power investment will drive the coordinated development of related upstream industries and downstream industries in neighboring areas, promote economic exchanges between regions, and exert the agglomeration effect of clean energy industries, thus promoting the high-quality economic development of neighboring provinces. However, human resources, government intervention, and urbanization rates are all significantly negative at the level of 1%. Taking human resources as an example, every unit of education year in this area will inhibit the high-quality economic development level of neighboring areas by 4.3 percentage points. The possible reason is that the improvement of education years reflects not only the local education level but also the local comprehensive level. The improvement of the comprehensive level will attract more high-quality talents to develop their careers in this area, thus promoting the economy, science and technology, and environment.

5.5. Robust Test

The robustness of the spatial econometric model can be tested by changing the explained variables. In this paper, the per capita GDP (PGDP) is used to replace the score of the high-quality economic development index to indicate the high-quality economic development level. Re-perform the bi-directional fixing effect based on the spatial Durbin model and decompose the spatial effect to get the results in Table 11.

Table 11. Decomposition results of spatial effects based on different explained variables.

Variables	HQD			PGDP		
	Direct Effects	Indirect Effects	Total Effects	Direct Effects	Indirect Effects	Total Effects
ln CEI	0.0061 *** (3.55)	0.0161 *** (5.09)	0.0161 *** (7.14)	0.0911 * (1.48)	0.3350 *** (2.79)	0.4261 *** (3.43)
HC	0.0119 ** (2.16)	−0.0429 *** (−4.41)	−0.0429 *** (−3.17)	0.3072 (1.58)	−0.8616 ** (−2.32)	−0.5544 (−1.42)
GI	0.0016 *** (3.68)	−0.0028 *** (−3.68)	−0.0028 (−1.56)	−0.1976 *** (−12.6)	−0.1017 *** (−3.68)	−0.2993 *** (−10.6)
UR	0.0017 ** (2.12)	−0.0039 *** (−3.28)	−0.0039 *** (−2.96)	−0.1480 *** (−5.08)	−0.2126 *** (−4.86)	−0.3606 *** (−12.3)

Note: ***, ** and * represent passing the significance test at 1%, 5%, and 10% levels, respectively.

From Table 11, it can be seen that most variables are significant and their positive and negative are unchanged, so the previous spatial econometric test results are relatively stable.

6. Conclusions and Policy Suggestions

In this paper, the entropy TOPSIS method is used to measure the high-quality economic development level of 30 provincial administrative regions (excluding Tibet, Hong Kong, Macao, and Taiwan), and the current situation of high-quality economic development and clean power investment in each province is analyzed. Then, the high-quality economic development level is studied by the spatial autocorrelation model. The global spatial autocorrelation model shows that the spatial correlation first rises and then falls, while the local spatial autocorrelation model shows that the Yangtze River Delta, Pearl River Delta, and Beijing-Tianjin regions are in a "high-gathering" state, and the overall high-quality economic development level gradually weakens from east to west. Then, the spatial Durbin model is used to analyze the factors that affect high-quality economic development. The results show that clean power investment not only promotes the high-quality economic development of the local area but also has a significant and more positive impact on the high-quality economic development of neighboring areas. However, the improvement of human resources, government intervention, and urbanization rate has a significant positive effect on the increase of high-quality development level of the local economy but has an opposite inhibitory effect on neighboring provinces.

According to the above conclusions, we can get the following policy suggestions: (1) We should pay more attention to clean power investment and increase support for clean power investment. By increasing investment in clean power, the clean power industry will be organically combined with new infrastructure, 5G, artificial intelligence, and UAV technology, giving full play to digital advantages, and promoting the further development of upstream and downstream related industries of the clean power industry with low energy consumption and high-efficiency development mode, resulting in a more prominent spillover effect to promote the high-quality development of the regional economy. (2) Governments can strengthen the flow of technology, talents, and management experience among regions, take full advantage of the leading role and radiation effect of the Yangtze River Delta, Pearl River Delta, and Beijing-Tianjin advantageous developed regions, and try to get rid of the negative influence of local protectionism and other undesirable forces. Exporting high-quality talents, an experienced labor force, and high tech to neighboring areas will drive the rapid development of underdeveloped areas in the middle and western regions and improve their high-quality economic development level. (3) According to the different resource endowments of different places, invest in clean energy of appropriate scale according to local conditions. Do not over-invest to cause a large number of undesirable phenomena, such as abandoning wind and light. Enhance the synergy of high-quality economic development among regions, jointly research and develop clean energy technologies within regions, improve productivity, enhance the mobility of spatial elements, and promote clean power investment to further exert the spatial spillover effect. (4) Make the most of advantages of the central government to make overall plans. In education, medical care, culture, sports, infrastructure, etc., the central government should increase its support to further strengthen and improve the financial transfer system, continue to support backward areas, reduce regional disparities, and enable the overwhelming majority of people to enjoy the fruits of economic development. (5) Governments at all levels will incorporate rural energy construction into economic and social development planning, and strengthen support for rural energy in poverty-stricken areas. Encourage financial institutions to innovate financing methods and service models, focus on supporting county rural energy industry development and energy infrastructure construction as green financial services, and give differentiated support to high-quality rural energy projects in terms of loan access, term, and interest rate, to narrow the development gap between urban and rural areas.

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