


## Article

# Influence Mechanism of High-Tech Industrial Agglomeration on Green Innovation Performance: Evidence from China

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**Abstract:** This paper uses panel data from 30 provinces and cities in China between 2008 and 2017. It calculates the green innovation performance of each province and city based on the super-efficiency SBM model of unexpected output and measures the high-tech industrial agglomeration degree of each province and city by using the location entropy method. The influence of high-tech industrial agglomeration on green innovation is also empirically tested. It is found that the agglomeration level of high-tech industry and green innovation performance in Eastern China are much higher than those in Central and Western regions. There is a significant positive relationship between high-tech industrial agglomeration and green innovation performance. Human capital has a mediating effect in the positive impact of high-tech industry agglomeration on green innovation performance. The moderating effect of environmental regulation is markedly established. The higher the level of environmental regulation, the stronger the mediating effect of human capital. Based on the above conclusions, this paper puts forward relevant policy suggestions for promoting the organic combination of green and innovation-driven development and for promoting green transformation in China.

**Keywords:** high-tech industry agglomeration; green innovation performance; human capital; environmental regulation



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## 1. Introduction

With the rapid development of science and technology, China's economy has achieved a qualitative leap and become the world's second largest economy. However, it also brings social problems such as excessive resource consumption, ecological imbalance and serious environmental pollution. To achieve the sustainable development, green innovation has become the inevitable choice to break through the bottleneck constraints of resources and environment [1]. Different from traditional innovation, green innovation reflects the integration of green development and innovation-driven development [2], which reduces resource consumption and environmental pollution with the assistance of new technologies and concepts, and realizes the coordinated development of economy, resources and environment [3]. It can not only provide value for enterprises and consumers, but also reduce the impact on the environment and play an important role in economic development and environmental protection [4]. Therefore, many countries are developing the green economy and taking it as a new engine to activate the economy [5,6]. Increasing green innovation will also help enterprises to improve their image and develop new markets [7]. Practice has proved that the development of high-tech industries is an important choice to achieve green economic growth. High-tech industries have the characteristics of high technology content, low energy consumption, low pollution and strong innovation, which also determine that they can break through the pollution dilemma of traditional industries [8]. It is the supporting industry for countries to achieve green innovation [9]. From the perspective of industrial development, moderate agglomeration is conducive to large-scale, intensive

and efficient production [10]. With the gradual agglomeration of high-tech industries in geographical location, its mechanism on green innovation performance needs further study.

In the new economic geography, the mechanism of industrial agglomeration improving green innovation performance mainly focuses on the knowledge spillover effect, scale effect and competition effect [11]. Relevant studies have found that high-tech industrial agglomeration can not only strengthen the information exchange between enterprises and realize the efficient utilization of resources in the agglomeration area, so as to achieve the effect of economies of scale [12], but also effectively encourage enterprises to achieve environmental protection in the production process and promote the green development of the whole region [13]. On the other hand, high-tech industrial agglomeration may also bring some environmental problems. It will lead to the expansion of industry and the increase of energy consumption, accompanied by the increase of pollutant emissions, thus aggravating the agglomeration of environmental pollution [12,14]. However, some scholars believe that the positive externalities of high-tech industrial agglomeration are greater than the negative externalities [12,15]. Under these positive externalities, unnecessary waste of resources is reduced, and green innovation performance is improved. High-tech industry agglomeration has an important impact on green innovation performance, but its influence mechanism is still uncertain [9,16]. As for the ways that high-tech industrial agglomeration can promote local green innovation, this paper argues that, in addition to the above reasons, a very important reason comes from the human capital promotion effect of high-tech industrial clusters. When the agglomeration of high-tech industry is gradually strengthened, it will provide many jobs suitable for high-level talents [17] and form a platform for high-level talent exchange and development space [18]. Talents are also inclined to stay in an environment with high technical level to enjoy positive knowledge spillover [19]. Therefore, high-tech industrial agglomeration is conducive to improving the level of human capital. The promotion and concentration of human capital is an important factor in stimulating innovation [20,21]. High-level talents have stronger requirements for the environment, and they also master the knowledge of green innovation [22]. Thus, the improvement of human capital level has a positive role in improving the level of green innovation performance.

Moreover, green innovation performance is usually subject to moderation by the environmental regulation. For example, the introduction of policies such as the “2016–2020 Industrial Green Development Plan” guides the direction of green innovation for enterprises and provides support and guarantee for the development of green economy in the region. The Porter hypothesis believes that environmental regulation will increase the cost of pollution control and squeeze the investment of green innovation funds in the short term [23], which is not conducive to green development. However, in the long run, environmental regulation has the effect of innovation compensation. Moderate environmental regulation will improve resource utilization efficiency, force enterprises to carry out technological innovation and achieve a win-win situation between the environment and economy [24]. This conclusion has also been supported by many scholars [25,26]. From the perspective of institutional theory, corporate behavior is highly restricted by the institutional environment [27]. Enterprises under the pressure of environmental regulation are easy to establish green innovation consciousness and increase human capital investment to improve green innovation performance [28]. On the contrary, local governments are more likely to support the development of enterprises and relax pollution emission standards for economic development in areas with weak environmental regulation. At the same time, enterprises will not invest too much professional innovative talent on green innovation [29]. However, the existing research has mainly analyzed the direct driving effect of external environmental regulation on enterprise green innovation [30,31] but ignored its moderating role. It will be a very meaningful research work to further investigate the moderating effect of environmental regulation on the relationship between human capital and green innovation performance. Based on the above analysis, our study analyses the impact of high-tech industry agglomeration on the green innovation performance of local industries

with human capital level as the mediating variable and environmental regulation as the moderating variable.

This study seeks to make three significant contributions: Firstly, it expands the theoretical model of high-tech industrial agglomeration on green innovation performance and enriches the related theories of high-tech industrial agglomeration and green innovation performance. Secondly, based on micro data, this paper measures the high-tech industry and green innovation performance in various regions of China and expands the measurement method of green innovation performance. Finally, we improve the research on the influencing factors of green innovation performance and introduce human capital as a mediating variable and environmental regulation as a moderator variable for analysis.

The rest of this paper is as follows: Section 2 introduces the literature review and hypotheses development. Section 3 shows the analysis of high-tech industrial agglomeration and green innovation performance. Section 4 introduces the data and illustrates the methodology used. Section 5 introduces the empirical analysis. Section 6 provides our conclusions and recommendations.

## 2. Literature Review and Hypotheses Development

### 2.1. Literature Review

With the global resource and environment problems, green innovation performance has gradually become the focus of social attention. Different from the traditional innovation performance emphasizing the maximization of economic benefits, green innovation performance includes not only economic performance, but also environmental performance and social performance [32]. Scholars have conducted research on green innovation performance from multiple perspectives and achieved fruitful results. Their research mainly focused on the evaluation and influencing factors of green innovation performance.

The existing evaluation of green innovation performance mainly studies it from two aspects. One is to evaluate by establishing a comprehensive index system. Huang et al. (2018) [33] used green product and process innovation performance to measure green innovation performance. They confirmed that environmental innovation strategy and partner resource coordination were positively correlated with green innovation performance. García-Granero et al. (2018) [34] divided 30 performance indicators into four different types of green innovation: products, processes, organizations and marketing. They measured green innovation performance from product performance, manufacturing performance, organizational performance and marketing performance. Guo et al. (2018) [35] divided green innovation performance into green product and process innovation and measured green innovation from the perspective of energy conservation and emission reduction. Other scholars have established indicators to evaluate efficiency from the perspective of input and output. Jie (2020) [36] used the SBM model of undesirable output and the Malmquist index model to measure the efficiency of green innovation, analyzed the current situation of green innovation efficiency in China and put forward corresponding improvement measures. Zeng et al. (2021) [37] used the global Malmquist–Luenberger index to measure the efficiency of green innovation, and analyzed the various factors affecting the performance of green innovation. By reviewing the previous literature, it can be found that the evaluation of green innovation performance is mainly based on the economic and environmental dimensions. There are many departments and links involved in green technology innovation. Scholars have not formed a consistent view on the selection of indicators, which makes the evaluation system incomplete and the boundaries unclear.

The existing research on the influencing factors of green innovation performance mainly analyzes them from the perspectives of the economic development level [38], corporate ethics environment [39,40], environmental regulation [41,42], R&D investment [43], FDI [44,45] and so on. Although there is some research on the relationship between high-tech industry agglomeration and green innovation performance, there are great differences. These studies are mainly based on static innovation efficiency perspective without considering environmental constraints. Overall, the most representative three ways are positive,

negative and nonlinear. The first view holds that high-tech industrial agglomeration has a positive impact on green innovation performance. It is believed that the agglomeration of high-tech industries can generate regional innovation effect by strengthening the technology and knowledge spillover among high-tech enterprises [9], which can generate the competition effect among enterprises and help to improve the technology absorptive capacity [46], accelerating the green technology flow among agglomeration regions and generating the technology spillover effect. The second view holds that the agglomeration of high-tech industries hinders green innovation and increases the degree of environmental pollution. Cheng et al. (2016) [47] believe that after the development of high-tech industry agglomeration to a certain extent, its negative externalities will gradually emerge, and environmental pollution will be further aggravated. Dong et al. (2020) [15] believe that industrial agglomeration leads to the increase of energy consumption and pollution emissions, and the expansion of output also brings pollution agglomeration. However, there is also a view that the relationship between industrial agglomeration and green innovation is uncertain. Shen et al. [48] used a spatial panel model to analyze the impact of high-tech industry agglomeration externalities on environmental efficiency and concluded that there was a “U” type relationship between them. Some scholars believe that the relationship between the two is different at different stages of agglomeration [49].

In summary, the existing research has made some achievements, which provides a solid foundation for this study. However, there is still room for further deepening. Firstly, the existing research on the impact of high-tech industry agglomeration on green innovation performance has not yet formed a consistent point of view. Secondly, the existing literature mainly focuses on empirical research in methods and lacks theoretical research on specific mechanisms and transmission mechanisms. Finally, there is little research on high-tech industrial agglomeration, green innovation performance, human capital and environmental regulation under the same framework. Based on the above, this paper mainly discusses the impact of high-tech industrial agglomeration on green innovation performance and introduces human capital and environmental regulation as mediating and moderating variables. Based on the existing literature and basic theory, this paper constructs the mechanism model of high-tech industrial agglomeration on green innovation performance.

## 2.2. High Technology Industry Agglomeration and Green Innovation Performance

Based on externality theory and new economic geography theory, the positive impact of high-tech industry agglomeration on green innovation performance depends on the multiple effects of agglomeration, such as knowledge spillover effect, scale effect, labor resources and infrastructure sharing [10]. The strength of externality depends on the geographical distance. The geographical distance proximity between enterprises will produce externality effect when high-tech industries are clustered [50]. It is conducive to promoting the knowledge spillover, increasing returns to scale and incomplete competition of enterprises in the cluster. These positive external effects enhance green innovation performance. Existing studies believe that high-tech industrial agglomeration mainly affects green innovation performance through knowledge spillover effect, scale economy effect and competition effect.

From the perspective of knowledge spillover effect, the agglomeration of high-tech industries has promoted the rapid dissemination of green production technologies and knowledge such as environmental protection, high efficiency and cleanness in the region, thus shortening the time and distance for enterprises to collect relevant technologies and knowledge [9]. Secondly, enterprises in high-tech industrial agglomeration areas have frequent exchanges and relatively high mutual trust. Therefore, enterprises will share resources and information with each other to promote technology absorption and improve green innovation performance [51]. Thirdly, industrial agglomeration strengthens relationships between firms in the region and allows knowledge and technology to flow within clusters at low cost [52]. Smooth information communication will make it easy for

enterprises to reach consensus on environmental protection technology and promote the green innovation performance of the overall agglomeration area.

From the perspective of scale effect and synergy effect, with the agglomeration of high-tech industries, the production scale is expanding and the spatial distance between enterprises is shortened. The economy effect and synergistic effect gradually appear. Firstly, enterprises in the industrial agglomeration area can share high-quality innovation personnel, R&D infrastructure, R&D knowledge and improve the green innovation performance of enterprises. Secondly, the production factors among enterprises can easily flow within the cluster to further deepen the specialization of division of labor and cooperation, reduce the cost and make the saved cost effectively become innovative capital investment [53]. Finally, the scale effect ensures centralized pollution control, reduces pollutant emissions, increases expected output in innovation activities and reduces undesirable output.

In terms of competition effect, high-tech industry agglomeration will intensify competition among enterprises to some extent. First, the positive competition induced by high-tech industry agglomeration helps to promote the integration and allocation of innovative resources, thereby promoting technological progress to improve energy efficiency [54]. Secondly, to maintain their advantages, enterprises will promise innovation and product improvement to meet consumer preferences under competitive pressure and produce products that meet green standards [55]. When an enterprise takes the lead in introducing new green products, it breaks the competition pattern under the original mode, and even weakens and eliminates the previous innovation results, which will stimulate many enterprises to open a new round of innovation and improve innovation output.

Based on the above analysis, the positive externality of high-tech industrial agglomeration on green innovation performance is greater than the negative externality. The following assumptions are made:

**Hypothesis 1.** *High-tech industry agglomeration has a significant positive impact on green innovation performance.*

### 2.3. The Intermediary Role of Human Capital

In addition to the knowledge spillover, competition effect and scale effect mentioned above, this paper argues that an important reason is that high-tech industry agglomeration provides more employment opportunities. According to the push-pull theory, industrial agglomeration provides a platform for the labor force to provide jobs, exchange and exert capabilities [56], which meets the requirement that talents have room for improvement in work, thereby enhancing the “pull” of industrial agglomeration areas on talents, and is conducive to attracting and retaining talents. The promotion effect of high-tech industrial agglomeration on human capital is mainly reflected in the following three aspects: First, the high-tech industry is innovative. It involves information technology, aerospace technology, biological engineering technology and other industries. Compared with the traditional industry, it has a stronger sense of innovation and a stronger attraction for talents [57]. Therefore, with the development of the high-tech industry, more and more talents will be attracted to enter the industrial agglomeration area. Secondly, there are a lot of resources in high-tech industrial agglomeration areas, which can provide more opportunities for talents to share and exchange information and provide more convenient conditions for them [18]. More talents will flow into high-tech industrial agglomeration areas. Finally, human resources are a kind of scarce resources. In order to obtain such resources, high-tech enterprises will provide favorable welfare and treatment, and then attract a large number of talents to flow in, resulting in the “herding effect” of talent agglomeration, and improving the level of human resources in the local region.

On the role of human capital in promoting green technology innovation, existing research suggests that human capital has a positive spillover effect on green innovation [58]. Absorptive capacity theory holds that human beings are the main body of enterprises’ technological activities, and their capabilities, technologies and knowledge are the key



to improving enterprises' innovation level [59]. The improvement of the level of green innovation in a region needs to give full play to the great advantages of talent strategy. This is because the stock of high-level human capital in a region can ensure the consistency of the current enterprise production process, which is enough to promote the output of applied innovation and enhance the technological innovation ability of the current industry. At the same time, high level of human resources is conducive to improving the level of green innovation of enterprises [60,61], promoting the transformation of green innovation achievements and realizing industrial greening [62]. Overall, human capital affects green innovation performance mainly through the following paths: First, the introduction of many high-level talents, especially those who master green technology innovation, can improve the activity of enterprise R&D investment. Secondly, the improvement of human capital level helps to improve the labor efficiency of green innovation and the use efficiency of green equipment. Finally, talent agglomeration brings high green awareness and green demands, and has low tolerance for non-green behaviors in the working process. This accelerates the progress of green innovation of enterprises, thereby improving the performance of green innovation of enterprises.

High-tech industrial agglomeration provides jobs and high rewards to attract talents, improves the level of human capital in the region and thus promotes the improvement of innovation performance. Human capital enlarges the spillover effect of high-tech industrial agglomeration, improves the performance of green innovation and realizes the common development of economy and environment. We thus formulated the following hypothesis:

**Hypothesis 2.** *High-tech industrial agglomeration affects green innovation performance through the intermediary role of human capital.*

#### 2.4. Moderating Effect of Environmental Regulation

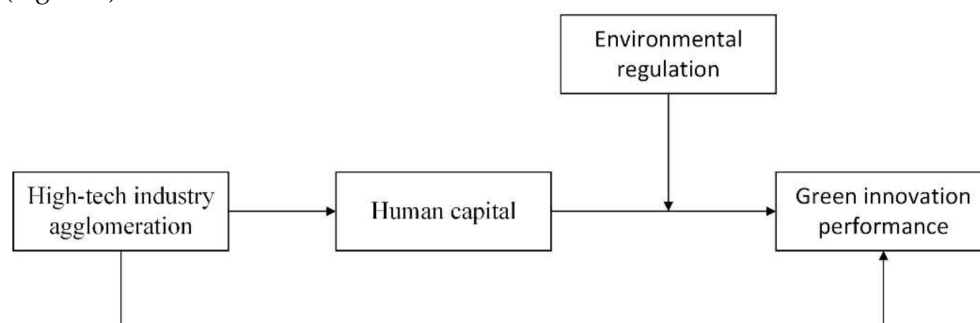
Environmental regulation represents the intensity of local environmental governance in a region. According to the regulation theory, the behavior of social organizations will be constrained by the economic or social system [63]. Enterprises as the main body of green innovation. If there are no environmental regulation policy constraints, then most enterprises will make only the pursuit of efficiency does not care about the environment. China implements the concept of green development and has introduced a series of environmental policies to promote green innovation, which also affect the company's strategic decisions. Scholars have conducted many analyses and demonstrations on the relationship between environmental regulation and innovation according to the Porter hypothesis, and gradually developed three viewpoints: (1) Environmental regulation is the initial driving force to stimulate green innovation and promote green innovation behavior of enterprises. Strengthening environmental regulation can ensure green technology spillovers from FDI [31]. Under the influence of environmental regulation, enterprises will invest more R&D funds into green innovation. (2) Environmental regulation will inhibit the performance of green innovation, and environmental regulation enforced by the government will inhibit the investment of enterprises in innovation [64]. Therefore, the government should choose appropriate regulatory tools and moderately participate in the environmental governance of enterprises. (3) There is a nonlinear relationship between environmental regulation and innovation performance. Shen et al. [48] found a U-shaped relationship between their effects through empirical studies, while China is in a pre-inflexion phase of repression.

Environmental regulation is an important way for government to promote green innovation [65]. Relevant research points out that environmental regulation policy will have a certain impact on green innovation behavior of enterprises by influencing human capital [66]. First, the local government will pay more attention to green innovation when the pressure of environmental regulation is heavier. At the same time, enterprises will establish the sense of green innovation and invest more human capital in strengthening environmental protection to maintain competitive advantage under this pressure [67]. The

role of human capital in promoting green innovation performance will be enhanced. On the contrary, local governments relax pollution emission standards from the perspective of economic development in regions with less pressure on environmental regulation. Since green technology innovation cannot bring direct economic benefits to enterprises and it will occupy the investment in production activities, enterprises will not invest too much attention in green innovation and they will be more inclined to invest human capital in other production activities that can bring economic benefits [29], thereby reducing the impact of human capital on green innovation performance. Therefore, environmental regulation affects enterprises' investment in green human capital to a certain extent. Secondly, it will inevitably cause pressure on enterprises in a short time when the government implements strict environmental system. This will increase the production cost of enterprises, force enterprises to suspend the current development plan and focus on pollution control to protect their status [68]. However, enterprises subject to environmental regulation also have increased demand for "green talents". It can also attract talents because its production environment meets the green standard [28]. Increasing human capital investment will have a positive impact on green innovation performance, eventually offsetting regulatory costs and even generating additional profits. Based on these arguments, we hypothesized the following:

**Hypothesis 3.** *Environmental regulation has a moderating effect on the mediating effect of human capital between high-tech industrial agglomeration and green innovation performance.*

According to the research results and hypotheses, the conceptual model of the impact of high-tech industrial agglomeration on green innovation performance is constructed (Figure 1).



**Figure 1.** Research theoretical model.

### 3. Analysis of High-Tech Industrial Agglomeration and Green Innovation Performance

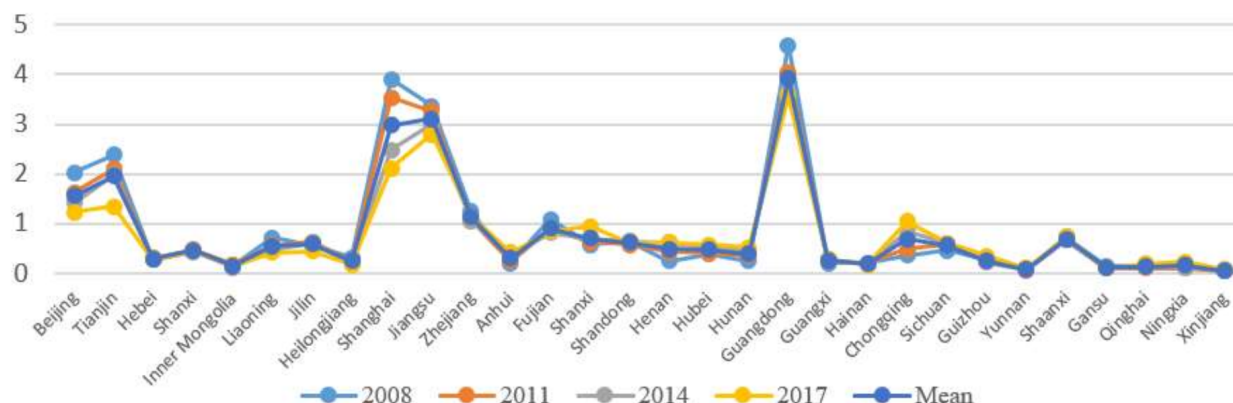
#### 3.1. Analysis on Agglomeration Characteristics of High-Tech Industries in Provinces

With reference to the existing research [69], the location entropy index method can be measured by the data, which are easy to obtain. It can also reflect the differences between regions and reflect the spatial distribution of industries. Therefore, the location entropy method was used to measure the agglomeration level of high-tech industries in 30 provinces and cities in China from 2008 to 2017. The formula is as follows:

$$LQ_{ij} = \frac{q_{ij}/q_j}{q_i/q} \quad (1)$$

where  $q_{ij}$  represents the number of employees in the  $i$  industry in  $j$  area and can also be expressed by indicators such as output value and business income,  $q_i$  represents the number of employees in the whole country or industry  $i$ ,  $q_j$  is the total number of employees in  $j$  area and  $q$  represents the total number of employees in the whole country. When the value of location entropy index is greater than 1, the level of regional industrial agglomeration is higher than the national average, and when the value is less than 1, it is lower than the national average. The average level of 10 years and the specific indicators of 4 years are

shown in Figure 2. The comparison of the Eastern, Central and Western regions is shown in Table 1.



**Figure 2.** Location entropy index of high-tech industry in different provinces of China.

**Table 1.** Location entropy index of high-tech industries in different regions of China.

Region	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Mean
Eastern	2.04	1.96	1.93	1.88	1.80	1.75	1.70	1.66	1.63	1.62	1.80
Central	0.33	0.36	0.36	0.36	0.39	0.42	0.44	0.47	0.49	0.50	0.41
Western	0.27	0.27	0.26	0.29	0.35	0.35	0.36	0.38	0.39	0.40	0.33

It can be seen from Table 1 that, from 2008 to 2017, the agglomeration level of high-tech industries in the Eastern region was far higher than the average level of other regions in the country. It is mainly because the Eastern region has various resources advantages, many ports, early opening to the outside world and intensive flow of talents. However, with the economic driving effect of the Belt and Road Initiative on the Central and Western cities, they will also form a good high-tech industrial agglomeration in the future, which requires the governments to improve infrastructure and investment policies full preparations for undertaking industrial transfer. The agglomeration value of high-tech industries in the Eastern region declined during the study period, which may be due to higher operating costs due to higher rents and labor prices in the Eastern region. Due to their own production and operation costs, national policy requirements and other factors, some high-tech industries gradually shift to the Central and Western regions, the Western industrial agglomeration value has risen steadily.

### 3.2. Analysis on Performance Characteristics of Green Innovation in Provinces

Appropriate indicators are selected based on the two dimensions of input and output. Five secondary indicators are selected from three aspects of human, capital and energy for green innovation input indicators. The green innovation output index selects six secondary indexes from three aspects of innovation benefit, economic benefit and environmental benefit. Since a single indicator cannot fully measure the actual situation of pollution, we refer to the practice of Feng et al. [65], select industrial wastewater emissions, industrial waste gas emissions and industrial solid waste production as alternative indicators to measure the unexpected output of green innovation and construct a green innovation performance index system based on unexpected output. The improved Super-SBM model considering unexpected output is used to measure the green innovation performance. The following is a brief description of the selection of relevant input and output indicators in the measurement of green innovation performance.

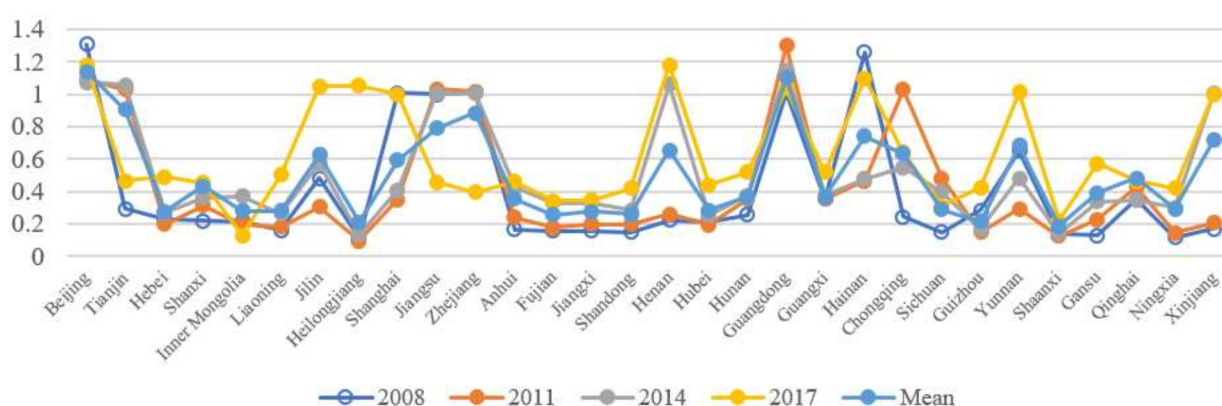
The input indicators are as follows. (1) Manpower input: select R&D personnel at the time to measure. (2) Capital input: R&D expenditure, new product development expendi-



ture, technology introduction and transformation expenditure are selected to measure it. (3) Measuring energy input by total industrial energy consumption.

Output indicators are as follows, (1) Innovation benefits: measured by the number of valid invention patents. (2) Using new product sales revenue and GDP to measure economic benefits. (3) Environmental benefits: this paper mainly studies the environmental problems of green innovation performance. Therefore, industrial wastewater emissions, industrial solid waste emissions and industrial sulfur dioxide emissions are selected as undesirable outputs to measure environmental pollution caused by green innovation activities in high-tech industries.

Using the super-efficiency SBM model based on undesirable outputs and DEA-SOLVER PRO 5.0 software, the green innovation performance is measured. Figure 3 shows the average for 10 years and the specific indicators for 4 years. The development status of regional green performance in China is as follows (Figure 3).



**Figure 3.** Results of green innovation performance evaluation in China.

The regional green innovation performance of China's high-tech industry shows a fluctuating growth trend. This shows that the supply-side reform and green measures make the development of China's high-tech industry gradually transition to green and ecological. Green innovation capability has been greatly improved. However, the regional differences of China's green innovation performance value are obvious. During the study period, the annual green innovation performance in the Eastern region was much higher than that in the Central and Western regions. During the study period, the overall performance of green innovation in the Eastern region was 0.789, which was higher than the national average. The performance values of the Central and Western regions were 0.348 and 0.38, respectively, which were lower than the national average. Therefore, it is necessary to base on regional characteristics and make use of their own advantages to develop economy. It is necessary for the government to formulate reasonable investment to promote industrial transformation and upgrading and establish a two-way cooperation relationship between the improvement of output value of high-tech industries and the improvement of green innovation performance.

#### 4. Model Construction and Variable Selection

##### 4.1. Model Construction

##### 4.1.1. Benchmark Model

We introduce the factors that affect green innovation performance such as economic development level, government regulation, scientific research personnel and R&D costs into the model as control variables. Considering that green innovation performance in the current period may be affected by the previous period due to inertia, we introduced the lag period of explained variables into the model. The dynamic panel model is established as follows:

$$GIE_{it} = \theta + \beta_1 GIE_{it-1} + \beta_2 Agglo_{it} + \beta_3 PKS_{it} + \beta_4 ER_{it} + \beta_5 Pgdp_{it} + \beta_6 GIA_{it} + \beta_7 RDP_{it} + \beta_8 RDI_{it} + \beta_9 X_i + \varepsilon_{it} \quad (2)$$

where  $GIE_{it}$  represents the green innovation performance,  $GIE_{it-1}$  represents the green innovation performance with one year lag,  $Agglo_{it}$  represents high-tech industry agglomeration,  $PKS_{it}$  represents human capital,  $ER_{it}$  represents environmental regulation,  $RDP_{it}$  represents scientific researchers input and  $RDI_{it}$ ,  $Pgdp_{it}$  and  $GIA_{it}$  represent R&D investment, economic development level and government regulation, respectively. Further,  $i$  represents the region,  $t$  represents the year (2008–2017),  $X$  represents the individual effects of provincial sections that do not change over time and  $\varepsilon_{it}$  represents the random interference term.

#### 4.1.2. Mediating Effect Model

In addition to analyzing the direct effect of high-tech industrial agglomeration and human capital on green innovation performance, the existence of intermediary effect should also be considered. We get the following models:

$$GIE_{it} = \theta_1 + a_1 Agglo_{it} + \beta_1 X_i + \varepsilon_{it} \quad (3)$$

$$PKS_{it} = \theta_2 + a_2 Agglo_{it} + \beta_1 X_i + \varepsilon_{it} \quad (4)$$

$$GIE_{it} = \theta_3 + a_3 Agglo_{it} + b PKS_{it} + \beta_1 X_i + \varepsilon_{it} \quad (5)$$

The meanings of  $GIE$ ,  $Agglo$ ,  $PKS$ ,  $\theta$ ,  $\varepsilon$  and  $X$  are the same as those in the benchmark model. Additionally,  $a_1$  is the total effect of  $Agglo$  on  $GIE$ ,  $a_2$  is the mediating effect of  $Agglo$  on  $PKS$ ,  $b$  is the effect of  $PKS$  on  $GIE$  after considering the influence of  $Agglo$  on  $GIE$  and  $a_3$  indicates the effect of  $Agglo$  on  $GIE$  after considering the influence of  $PKS$  on  $GIE$ .

Test Equation (3), whether  $a_1$  is significant, and if it is, the mediating effect hypothesis holds. Then test whether  $a_2$  and  $b$  in Equations (4) and (5) are obvious or not, and if both hold, the indirect effect is obvious. If at least one of them is not obvious, the bootstrap test is carried out. Finally, we test whether  $a_3$  and  $a_2$ ,  $b$  have the same sign. The same sign is regarded as a partial mediating effect.

#### 4.1.3. Moderated Mediation Model

To test whether environmental regulation moderates the mediating effect of human capital between high-tech industrial agglomeration and green innovation performance, the following tests are conducted: First, take green innovation performance as the dependent variable to analyze the regression of high-tech industry agglomeration and environmental regulation. Secondly, use human capital as dependent variable to analyze high-tech industrial agglomeration. Finally, with green innovation performance as the dependent variable, regression analysis is conducted on the interaction terms of high-tech industrial agglomeration, human capital, environmental regulation and human capital and environmental regulation. Construct the model as follows:

$$GIE_{it} = \theta_1 + c_1 Agglo_{it} + d_1 ER_{it} + \beta_1 X_i + \varepsilon_{it} \quad (6)$$

$$PKS_{it} = \theta_2 + e_1 Agglo_{it} + \beta_1 X_i + \varepsilon_{it} \quad (7)$$

$$GIE_{it} = \theta_3 + c'_1 Agglo_{it} + d'_1 PKS_{it} + d'_2 ER_{it} + d_3 PKS_{it} \times ER_{it} + \beta_1 X_i + \varepsilon_{it} \quad (8)$$

The coefficient  $c_1$  of Equation (6), the coefficient  $e_1$  of Equation (7) and the interaction coefficient  $d_3$  of Equation (8) are tested in turn. If  $e_1 \neq 0$  and  $d_3 \neq 0$ , it means that environmental regulation has a moderating effect. Conversely, the bootstrap method is used to test again.

#### 4.2. Control Variables and Data Sources

In addition to the explanatory variables (green innovation performance:  $GIE$ ) and core explanatory variables (high-tech industry agglomeration:  $Agglo$ ), the measurement of the variables is as follows.

Human Capital ( $PKS$ )

Based on the measurement indicators of Yao et al., (2019) [70], we selected the average years of education to measure the level of human capital. The higher the degree of education, the stronger the ability to work and the higher the professional quality, so it can reflect the level of regional human capital.

#### Environmental Regulation (ER)

We used the total investment in industrial pollution control as the proxy variable to measure the intensity of environmental regulation and take the natural logarithm [71]. Only when environmental regulation is formulated properly can it play an important role and it can achieve a win-win situation of economy and environmental protection. Additionally, environmental regulation can produce a compensation effect on green innovation and improve innovation ability.

#### Economic Development Level (Pgdp)

We selected natural logarithm of annual GDP (LnPgdp) to measure the level of economic development. Social and economic development can continuously promote innovation and development. The improvement of innovation ability and performance cannot be separated from the good social environment brought by economic development. Therefore, this paper believes that the level of economic development can promote green innovation performance.

#### Government Regulation (GIA)

We use the natural logarithm of government expenditure on science and technology (LnGIA) to measure government regulation and support. The government supports innovation activities through tax policies, capital investment and other activities to stimulate social innovation vitality. Therefore, this paper argues that government regulation has a positive effect on green innovation performance.

#### R&D Personnel Input (RDP)

The full-time equivalent natural logarithm of R&D personnel (LnRDP) is selected to measure the input level of scientific researchers. The more scientific research personnel input, the higher the green innovation performance. Therefore, we believe that scientific research personnel investment has a positive effect on green innovation performance.

#### R&D Investment (RDI)

The natural logarithm of R&D expenditure (LnRDI) is selected to measure R&D expenditure level. R&D investment can not only provide green technology and equipment for enterprises, but also strengthen the green innovation consciousness of personnel, so that enterprises can comprehensively enhance green innovation ability and improve green innovation efficiency.

This paper selected 2008–2017 data for empirical research. The data were obtained from the China Statistical Yearbook, China Statistical Yearbook on Industrial Economy, China Energy Statistics Yearbook, China Statistical Yearbook of Science and Technology, China Environmental Statistics Yearbook, Statistical Yearbook of Scientific and Technological Activities of Industrial Enterprises and Local Statistical Yearbooks of provinces, cities and autonomous regions.

## 5. Empirical Analysis

### 5.1. Descriptive Statistic

Using the panel data of 30 provinces, municipalities and autonomous regions in China from 2008 to 2017 for the descriptive statistics, Table 2 shows the descriptive statistics for variables.

**Table 2.** Descriptive statistics of variables.

Variables	Observed Values	Mean Values	Standard Deviations	Minimum Values	Maximum Values
GIE	300	0.508	0.358	0.025	1.307
Agglo	300	0.799	0.968	0.023	4.581
PKS	300	8.975	0.996	6.764	13.227
LnER	300	11.897	0.946	8.178	14.164
LnPgdp	300	10.561	0.544	7.650	11.768
LnGIA	300	13.096	1.052	10.535	15.924
LnRDP	300	11.005	1.169	7.454	13.245
LnRDI	300	14.371	1.352	10.419	16.970

### 5.2. Regression Analysis of Benchmark Model

The measurement model contains the lag term of the explained variable. Considering the endogeneity problem, this paper uses the system GMM to analyze. This method can solve the endogeneity problem and improve the estimation efficiency. The regression results of fixed effect estimation (FE) are also reported. The results are shown in Table 3.

**Table 3.** Regression results of influencing factors of green innovation performance in China.

Variables	FE	System GMM
L.GIE		0.202 *** (0.018)
Agglo	0.002 ** (0.081)	0.033 ** (0.021)
PKS	−0.009 (0.061)	0.042 *** (0.011)
LnER	−0.006 * (0.029)	−0.050 *** (0.009)
LnPgdp	0.101 (0.075)	0.136 *** (0.012)
LnGIA	−0.146 * (0.075)	−0.037 (0.027)
LnRDP	−0.669 *** (0.155)	−0.214 *** (0.050)
LnRDI	0.623 *** (0.147)	0.228 *** (0.049)
Constant Terms	−0.084 ** (0.710)	−1.323 *** (0.171)
Observed Values	300	300
F	8.410 *** (0.0000)	14,583 *** (0.0000)
Hausman	33.764 ** (0.026)	
AR(1)		−3.053 *** (0.002))
AR(2)		0.872 (0.383)
Sargan		21.921 (0.997)

Note: Robust standard deviation in small parentheses; \*\*\*, \*\* and \* indicate significant levels at 1%, 5% and 10%, respectively.

The regression results show that the coefficient of the first-order lag term  $GIE_{it-1}$  of green innovation performance is significantly positive at the level of 1%. It shows that the impact of green innovation performance in the previous period on the latter period has a positive lag. In the model, AR (1) rejects the original hypothesis and AR (2) accepts the original hypothesis, indicating that there is no second-order autocorrelation in the disturbance term. The Sargan test accepts the null hypothesis that all instrumental variables are valid, indicating that the model setting is reasonable and the estimation using system GMM is effective.

In the Table 3, the first-order coefficient of high-tech industrial agglomeration is significantly positive at the 5% level, indicating that the impact of high-tech industrial agglomeration on green innovation performance is positively correlated. Hypothesis 1 is supported. With the gradual expansion of the scale of agglomeration, the relationship between enterprises is not only a competitive relationship, but more important is the cooperative relationship. Enterprises will cooperate with each other and share resources to form specialization. It will improve the utilization rate of energy resources and carry out green innovation activities. Enterprises often try green technology innovation in the cluster, and each innovation activity will further cluster personnel and capital, thus driving the green innovation level of the entire agglomeration area and improving the green innovation performance.

It also can be seen that human capital has a positive effect on green innovation performance at 1% level, which indicates that human capital has positive effect on green innovation performance. It is very important to exert the subjective function of human capital to promote innovation ability. Human capital contains individuals who can transform knowledge into productivity. Therefore, the higher the level of human capital in the region, the higher the level of education and personal ability, the more innovative enterprises can bring vitality.

Environmental regulation has a significantly negative correlation with green innovation performance at the 1% level. Indicating that the current intensity of environmental regulation in China will inhibit green innovation of enterprises. In addition, the government will adopt strict environmental supervision policies to manage pollution emissions in agglomeration areas to promote high-quality development. The implementation of environmental regulation policy will increase the burden of enterprises, which makes enterprises unable to bear the investment in green innovation and affects the improvement of green innovation performance. Inappropriate environmental regulation will make enterprises unable to take high costs to exit the agglomeration area, reduce the scale of agglomeration and affect the improvement of green innovation level. These industries withdrawing from the agglomeration may shift to areas with low environmental regulation, so that enterprises will not carry out green innovation activities with large early investment and high return risk and tend to choose to buy pollution control facilities, which inhibits the level of innovation in the region.

In terms of control variables, regional economic development has a positive impact on green innovation efficiency. The higher the level of regional economic development, the government's investment in green innovation will increase. Furthermore, talents tend to flow to areas with good economic development. The regression coefficient of government regulation is  $-0.037$ , which indicates that the effect of government regulation on green innovation performance is not obvious. The regression coefficient of R&D input is  $-0.214$ , which is significant at 1% level, indicating that R&D input is high and green performance is low. It may be due to the high cost of personnel training and introduction, which reduces the investment in green innovation and cannot be quickly translated into green performance. The regression coefficient of R&D investment is obvious at the level of 1%, indicating that innovation investment can effectively promote green innovation performance. When the investment of innovation funds is high, the greater the cost of innovation payment on behalf of enterprises, the more emphasis on the status of innovation and then the performance of green innovation has improved.

### 5.3. The Mediating Effect Test of Human Capital

To further understand the relationship among high-tech industrial agglomeration, human capital and green innovation performance, the mediating effect of the three is analyzed. Since the FE estimation of the benchmark model passed the F test and Hausman test, the fitting of each formula in the mediating effect is still analyzed by the fixed effect model. The fitting results are detailed in Table 4. (1) In model 2, the total effect of high-tech industry agglomeration on green innovation performance is 0.178, and it shows at 1% level significant. (2) In model 3, the value of  $a_2$  is 0.676, and it is significant at the level of 1% dominance. It indicates that high-tech industrial agglomeration has a significant promoting effect on human capital, with the mediating effect is of 0.099, accounting for 55.45% of the total effect. It also can be seen that the effect of high-tech industrial agglomeration on green innovation performance is 55.45% through human capital, so Hypothesis 2 is established. In summary, high-tech industrial agglomeration has a significantly positive impact on green innovation performance and the mediating effect of human capital is significant. Human capital plays a strong transmission role between high-tech industrial agglomeration and green innovation performance (Table 4).



**Table 4.** The mediating effect test of human capital.

Variables	Model 2	Model 3	Model 4
	GIE	PKS	GIE
Agglo	0.178 *** (0.039)	0.676 *** (0.159)	0.079 ** (0.038)
PKS			0.146 *** (0.025)
Constant Terms	0.415 *** (0.052)	9.515 *** (0.130)	−0.866 *** (0.229)
F	4.55 *** (0.0000)	18.118 *** (0.0000)	14.541 *** (0.0000)
Huasman	5.387 ** (0.020)	31.647 *** (0.002)	2.715 ** (0.037)

Note: Robust standard deviation in small parentheses and  $p$  value in middle parentheses; \*\*\* and \*\* indicate significant levels at 1% and 5%, respectively; Since the coefficients  $a_2$  and  $b$  are distinct, the bootstrap test is not necessary.

#### 5.4. Post-Adjustment Test of Environmental Regulation

According to the above moderated mediation model test method, we tested the post-adjustment of environmental regulation in human capital mediation model in three steps. The test results are shown in Table 5. The details are as follows: (1) Model 5 shows that high-tech industry agglomeration is positively correlated with green innovation performance ( $c_1 = 0.119$ ). (2) Model 6 shows a significant positive correlation between high-tech industrial agglomeration and human capital ( $e_1 = 0.488$ ). (3) Model 7 shows that the interaction between environmental regulation and human capital is positively correlated with green innovation performance ( $d_3 = 0.015$ ). The test results show that when human capital is used as an intermediary variable,  $e_1 \neq 0$  and  $d_3 \neq 0$ , so that Hypothesis 3 is established. Environmental regulation has a moderating effect on the mediating effect of human capital between high-tech industry agglomeration and green innovation performance. The above test results show that when the level of environmental regulation is high, the intermediary role of human capital is stronger. Talents not only have a certain amount of knowledge reserves, but also have a strong sense of environmental protection and a high demand for the working environment. There will be demands for green health in the working process. The agglomeration of talents will bring more knowledge and technology to enhance the green innovation ability of enterprises when the degree of environmental regulation is high.

**Table 5.** The moderating effect test of environmental regulation.

Variables	Model 5	Model 6	Model 7
	GIE	PKS	GIE
Agglo	0.119 *** (0.037)	0.488 *** (0.150)	0.080 ** (0.037)
PKS			0.152 *** (0.026)
ER	−0.016 * (0.025)		−0.025 * (0.025)
PKS × ER			0.015 * (0.018)
Constant terms	0.216 * (0.296)	5.385 *** (0.625)	−0.648 *** (0.471)
F	1.289 *** (0.0000)	33.208 *** (0.0000)	7.497 *** (0.0000)
Huasman	13.088 ** (0.027)	28.483 ** (0.013)	9.459 * (0.051)

Note: Robust standard deviation in small parentheses and  $p$  value in middle parentheses; \*\*\*, \*\*, and \* indicate significant levels at 1%, 5% and 10%, respectively.

#### 5.5. Robustness Test

##### (1) Robustness test of benchmark model

To make the conclusion more reliable, this paper chooses to use POLS to re-estimate. The results show that the coefficient of high-tech industrial agglomeration is still significantly positive, which is consistent with the above results. It further verifies that there is a positive relationship between high-tech industrial agglomeration and green innovation performance.

## (2) Robustness test of mediating and moderating effects

To verify the robustness of the empirical results of mediating effect and moderating effect we use POLS to re-estimate. The results of robust test are like the previous results, and the mediating effect accounts for 28.6% of the total effect. Human capital, environmental regulation and the interaction coefficient of the two do not change significantly in the explicitness and direction of action and the estimated results are robust.

## 6. Conclusions and Recommendations

### 6.1. Conclusions

Based on the internal mechanism of the impact of high-tech industrial agglomeration on green innovation performance, this paper introduces human capital as an intermediary variable and environmental regulation as a moderator variable to construct the impact model of high-tech industrial agglomeration on green innovation performance. Based on the panel data of 30 provinces and cities in China from 2008 to 2017, we measured green innovation performance based on the Super-SBM model of unexpected output and high-tech industry agglomeration by location entropy method. We test the impact of high-tech industrial agglomeration on green innovation performance, the moderating effect of environmental regulation and the mediating effect of human capital. Finally, we draw the following conclusions.

- (1) High-tech industry agglomeration promotes green innovation performance. The development of high-tech industries is conducive to improving the intensity of resource investment. With the agglomeration of high-tech industries, the advantage of scale effect gradually emerges. Companies in the region can save production and operating costs by sharing infrastructure, thereby putting more resources into green innovation activities. In addition, the further agglomeration of enterprise researchers and capital enhances the spillover effect of knowledge and technology, strengthens the sharing of resources and information between enterprises, and promotes the flow of knowledge and technology, which can promote green innovation in the whole field. With the gradual expansion of the scale of agglomeration, the relationship between enterprises is not only a competitive relationship, more important is the cooperative relationship. Enterprises cooperate with each other and share resources to form a professional division of labor, which can not only improve the utilization rate of energy resources and improve environmental pollution, but also save funds and carry out green innovation activities.
- (2) Human capital plays a mediating role between high-tech industry agglomeration and green innovation performance. High-tech industrial agglomeration provides enough development space, platform and welfare for talents through knowledge spillover effect, which is beneficial to attract and retain talents, and accelerates the improvement of human capital level. The subjective role of human capital is very important to improve the performance of green innovation. Individuals transform knowledge into productivity and improve the activity of enterprise R&D investment and the labor efficiency of green innovation. The improvement of human capital not only updates knowledge and technology, but also puts forward higher requirements for the environment and indirectly promotes green innovation performance.
- (3) The higher the level of environmental regulation, the stronger the impact of high-tech industrial agglomeration on green innovation performance through human capital. Firstly, in regions with high environmental regulation, enterprises pay more attention to the main role of talents in green innovation under the competitive effect of high-tech industry agglomeration. They will increase investment in attracting and retaining talent. Increasing human capital investment has a positive impact on green innovation performance, eventually offsetting regulatory costs and even generating additional profits. Therefore, the effect of high-tech industrial agglomeration on green innovation performance indirectly through human capital is better. In addition, the pressure of green technology innovation and the cost of green governance are high in these areas.

Enterprises will continue to improve existing processes and use cleaner production to minimize costs. Green innovation performance will be further enhanced.

## 6.2. Theoretical Contribution

- (1) Taking 30 provinces and cities in China as the research objects, this paper measures the level of high-tech industry agglomeration and green innovation performance and analyzes the mechanism of high-tech industry agglomeration on green innovation performance. It not only enriches the research on green innovation performance, but also deepens the understanding of the positive impact of high-tech industrial agglomeration.

Firstly, previous studies mainly focus on two aspects to evaluate green innovation performance. One is by establishing a comprehensive index system [33–35]. The other is to measure it from the perspective of efficiency [36,37]. There are no uniform indicators for both studies. Therefore, the evaluation system is incomplete, and the boundaries are not clear. This paper measures the green innovation performance of 30 provinces and cities in China by the method of location entropy index and analyzes the development trend, which provides a new perspective for the measurement of green innovation performance. Second, there are some studies on the impact of high-tech industrial agglomeration on green innovation, but there are great differences in the relationship between them. Previous scholars believe that there are three main relationships between them: positive, negative and nonlinear [46,47,49]. This paper analyzes the scale effect, knowledge spillover effect, competition effect and talent agglomeration effect of high-tech industry agglomeration. We believe that the positive externality brought about by high-tech industrial agglomeration is greater than the negative externality. This paper specifically explains the impact mechanism of high-tech industry agglomeration on green innovation performance, which is an effective supplement to previous studies.

- (2) This paper verifies the mediating role of human capital between high-tech industrial agglomeration and green innovation performance. From the perspective of the push-pull theory and absorptive capacity theory, this paper answers how high-tech industrial agglomeration attracts talents and how the improvement of human capital promotes green innovation performance. It provides a new perspective to explain the impact of high-tech industry agglomeration on green innovation performance.

Although there are some studies about the influence mechanism of high-tech industrial agglomeration on green innovation, they mainly analyzed its internal mechanism from the perspective of various external effects brought by agglomeration based on the agglomeration economy theory [10,52,54]. A few studies have noticed the role of human capital, but lack of in-depth and detailed discussion [46]. First, we believe that the high-tech industry provides more employment opportunities, favorable treatment and better development platform for the labor force. It plays the role of attracting and retaining talents, thereby enhancing the promotion effect of human capital. Secondly, the technology and knowledge contained in human capital are the key to improve the innovation ability of enterprises. Enterprises improve the activity of R&D investment by introducing professionals with green innovation technology, which has a positive impact on green innovation performance.

- (3) The moderating effect of environmental regulation on the relationship between human capital and green innovation performance is verified. According to institutional theory, when enterprises are under greater pressure of environmental regulation, they are more likely to establish green innovation awareness, thereby increasing human capital investment to improve green innovation performance. This study enriches the content of environmental regulation research.

As for the study of environmental regulation, scholars mainly analyzed its direct effect on enterprise green innovation. However, there is no unified view about the relationship between them [31,48,64], and research has mainly ignored its moderating effect. Institutional Theory holds that the behavior of enterprises is highly restricted by relevant national systems [27]. Based on this theory, we suggest that the greater the intensity of

environmental regulation, the easier to put pressure on enterprises to establish a sense of green innovation. To maintain their competitive advantage, enterprises will invest more capital for green innovation talents [67]. Thus, green innovation performance will be improved. On the contrary, enterprises will pay more attention to the development of economy and pay less attention to green innovation in areas with low environmental regulation. This study reveals the mechanism of the impact of high-tech industrial agglomeration on green innovation performance, and it is an effective supplement to the research on environmental regulation.

### 6.3. Recommendations

Based on this, to promote economic green transformation and green innovation in China, we propose the following policy recommendations:

(1) Increase government investment and implement talent strategy.

While increasing R&D investment in green innovation, it is necessary to increase investment in human capital. Promoting the improvement of national green consciousness and education level, providing continuous impetus for green innovation of enterprises. Governments should adhere to the two-way mutually beneficial view of talent promoting industrial development and attracting talent agglomeration and promote the virtuous cycle interaction between human capital promotion and high-tech industrial agglomeration. This would fundamentally solve the problem of insufficient technological innovation ability in China. In addition, they should introduce policies to encourage the introduction of talents based on local industrial development. After the completion of talent introduction, it is necessary to do talent protection work to solve the worries of talents. Only reasonable matching of human resources and other resources can ensure the active technology market and enhance the transformation ability of green innovation achievements.

(2) Building multiple sharing platform to guide industrial agglomeration optimization.

Governments should guide the rational agglomeration of high-tech industries and achieve a win-win situation of regional economic performance and environmental performance based on the local actual situation. The level of high-tech industrial agglomeration in the Eastern region is high, so the governments should coordinate the industrial layout scientifically. To maximize the knowledge technology spillover effect and scale economy effect generated by high-tech industrial agglomeration, they should focus on technology hotspots and actively use new technologies such as artificial intelligence and blockchain to promote innovation resource sharing. Secondly, it is necessary to establish a strict dynamic evaluation mechanism and environmental supervision platform in the agglomeration area, improve the access threshold, eliminate unqualified non-green enterprises, and moderately guide some strong high-tech enterprises to Midwestern region (the Midwest).

The agglomeration degree of high-tech industry in the Central and Western regions is low, so it is necessary to refer to some mature industrial systems in the Eastern region to develop high-tech industry based on the reality. The governments should establish high-quality industrial parks to provide good policies and environment for the development of enterprises. Secondly, they should improve the infrastructure for centralized pollution treatment and strengthen the communication and interaction among enterprises, scientific research institutions and universities within the cluster. To give full play to the advantages of industrial agglomeration, they should keep up with the process of clean energy development and explore the innovation of environmental protection technology.

(3) Perfecting environmental regulation and implementing policies according to local conditions.

Local governments need to improve laws and regulations related to environmental protection, improve environmental protection law, strengthen supervision and law enforcement and increase the cost of corporate governance of environmental pollution. At the same time, the formulation of environmental regulation policies should be based on the

principle of meeting the interests of consumers. The government encourages consumers to buy green environmental protection products and green low carbon consumption by issuing consumer vouchers to guide enterprises to carry out green innovation in production technology from the demand side.

Environmental regulation plays different roles in different regions, and environmental regulation needs to be implemented in different regions. Governments can adopt incentive and strict constraint coordination regulation policy for the Eastern region with high-tech industry agglomeration degree. They should vigorously support the development of green innovative enterprises, reduce the tax revenue of enterprises and provide preferential subsidies to them and provide financial allocation for innovative production technology of enterprises. The agglomeration of high-tech industries in the Central and Western regions is low, and most of them are small- and medium-sized enterprises with weak innovation ability. Therefore, governments can adopt the rule policy of relative incentive and moderate constraint coordination.

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