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Does the Belt and Road Initiative Promote Green Innovation Quality? Evidence from Chinese Cities

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Abstract: When formulating international economic cooperation agreements, policymakers should consider not only their economic promotion effects but also their impact on green development. This paper is an examination of whether the Belt and Road Initiative contributes to green innovation quality. Objectively assessing the green innovation promotion effects of its implementation is not only important for its completion and improvement in the future, but also to verify whether the Belt and Road Initiative promotes sustainable development in participating regions. A difference-in-difference model was constructed using the data of 291 cities in China from 2008 to 2019. The results show the following: (1) the Initiative has significantly improved the quality of green innovation in cities along the Belt and Road; (2) a series of robustness tests showed that the main results are highly robust; (3) the Belt and Road Initiative has a significant policy spillover effect—while improving the quality of local green innovation, it can also significantly promote the quality of green innovation in surrounding areas. This paper has reference significance for further understanding the policy effect of China's Belt and Road Initiative and the promotion and strengthening of subsequent policies.

Keywords: Belt and Road Initiative; green innovation quality; policy spillover effect; difference-in-difference model

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1. Introduction

In recent years, the international situation has become increasingly tense. Resource shortages, environmental pollution, continuing financial crises and economic uncertainties created by the global pandemic have all posed serious obstacles to the sustainable development of all countries [1]. In the context of the negative attitude of the United States toward these issues and the European Union struggling with its own debt crisis, China, as an emerging economy, has attracted increasing attention from the international community [2]. As the most populous country in the world, China faces severe pressures on resources, the environment and poverty alleviation. Therefore, China has always adhered to innovation-driven green technology and an open and shared development strategy and has actively cooperated with other countries. It has gradually changed from a passive participant in maintaining the global economic order and environmental governance to a contributor and leader. Policies and initiatives that reflect China's wisdom have become key tools to address global economic and environmental problems.

Among the many initiatives implemented, the Belt and Road Initiative, proposed in 2013, has had the greatest impact on the global economy and environment [3]. This initiative hopes to build an open, efficient and win–win platform for regional cooperation through multilateral mechanisms and to jointly promote the sustainable development of participating countries. As of November 2021, the Initiative included 141 countries and 32 international organizations. The Belt and Road Initiative spans the continents of Asia, Europe and Africa with complex geological conditions. However, countries in the "Silk Road Economic Belt" region are mostly located in the inland hinterland where energy resources

are abundant, but the ecological environment is quite fragile; here, water resources are limited and are often in a semiarid state, forest cover is lower than the world average, and the "21st Century Maritime Silk Road" region mostly passes through developing countries, which have ecological problems, especially marine ecological problems, caused by low productivity development [4]. The implementation of the Belt and Road Initiative faces the risk of ecological and environmental damage. Therefore, China has incorporated the concept of green development into the implementation of the Belt and Road Initiative in the hope of delivering high-quality green technologies through a green innovation-driven strategy so that the regions along the routes can share the fruits of China's development and learn from China's past experience of pollution first and treatment later.

As a regional means of environmental governance, the Belt and Road Initiative can theoretically enhance the level of green technology innovation through policy effects, thus promoting local sustainable development. However, the development of reality is not as optimistic. According to the "Global Environmental Performance Index Report" released by Yale University and other institutions, although the average economic growth rate of regions along the Belt and Road is higher than the world average economic growth rate, their energy use is far beyond the world average for the same period. There are also numerous problems in local development, such as a low efficiency of resource utilization and a low technical level. Additionally, according to the Pollution Haven Hypothesis (PHH), in order to achieve their own sustainable development, developed regions often tend to transfer labor-intensive and heavily polluted industries to developing areas, which affects the latter's technological progress and green development. Thus, the following questions are raised: has the implementation of the Belt and Road Initiative caused pollution transfer in the regions along the routes? Has the initiative truly helped elevate the level of green innovation in the Belt and Road regions? Is China fulfilling its commitment to building a green and sustainable Belt and Road strategy? This paper tries to answer these questions by exploring the promotion effects of the Belt and Road Initiative on the green innovation quality.

Most of the existing research on the Belt and Road Initiative focuses on outbound investment and trade relations. Han et al. [5] found that the Belt and Road Initiative significantly promoted China's outward foreign direct investment (OFDI), and the positive impact of investment on private enterprises was more significant. Chen and Qi [6] measured the investment efficiency of 98 Belt and Road countries through the stochastic frontier gravity model, and the results show that China's FDI potential was higher in noncarbon-intensive industries than in carbon-intensive industries, which indicates that the FDI investment strategy of the Belt and Road Initiative was more inclined to be green and low-carbon. Li et al. [7] found that trade flows between China and 64 countries along the Belt and Road became more frequent after the Belt and Road Initiative was put forward. Baniya et al. [8] analyzed the trade-related impact of the Belt and Road Initiative through a gravity model, and the results show that the initiative increased trade flows between participating countries by 4.1%.

In addition to its specific impact on foreign trade, the Belt and Road Initiative is essentially a new way of undertaking regional economic cooperation, and many scholars have also focused on its economic impact. Sun et al. [9] evaluated the promotion effect of the Belt and Road Initiative on economic growth by combining propensity score matching and a difference-in-difference (PSM-DID) model. The results show that the initiative effectively promoted the rapid growth of GDP in the Belt and Road regions, but the improvement of per capita GDP was not obvious. Bird et al. [10] explored the impact of the Belt and Road Initiative on economic growth in Central Asia by building a spatial gravity model, and the results show that the actual economic income brought about by the initiative accounted for approximately 2–3% of the total regional income. When the initiative creates clusters of economic activity in some regions, incomes can rise by as much as 12%.

As global environmental issues have become increasingly intense, scholars have begun to pay more attention to the resource and environmental impacts of the Belt and Road Initiative. Abbas et al. [11] believed that using renewable and clean energy can help

countries along the Belt and Road maintain environmental conditions without affecting technological progress and economic growth. Jiang et al. [2] used the PSM-DID method to find that the Belt and Road Initiative can significantly improve the energy saving and emission reduction benefits of participating countries and revealed the influencing mechanism of the policy through an analysis of the mediation effect; that is, the Belt and Road Initiative improves the sustainable development level of participating countries through technology spillover and industrial structure optimization. He et al. [12] analyzed the economic and environmental performance of 61 countries along the Belt and Road and found that the average annual growth rate of the green total factor productivity in the countries along the Belt and Road Initiative was 3.1%. Some countries show robust economic growth, while environmental performance slows green growth. In addition, technological innovation is not only the main driving force for economic development but also a key element in solving environmental problems [13]; therefore, some scholars have also discussed the impact of the Belt and Road Initiative from an innovative perspective. Xu et al. [14] believed that foreign trade and technological innovation are the main driving forces for the development of the participating countries of the Belt and Road Initiative, but technological innovation has an obvious threshold effect on the improvement of the green development level of the participating countries. Li et al. [15] studied the impact of direct investment on enterprise innovation in countries along the Belt and Road from the perspective of host country characteristics. The results show that OFDI can promote Chinese enterprises' innovation through multiple reverse innovation spillover channels, and the promotion effect is more significant after the Belt and Road Initiative was proposed. Li et al. [16] used the differential difference model to test the impact of the Belt and Road Initiative on enterprise innovation efficiency and its dynamic evolution process. The results show that the implementation of the Belt and Road Initiative significantly improves the innovation investment of enterprises in the short term. In the long run, the innovation output and efficiency of enterprises are also significantly improved. Yang et al. [17] constructed a PSM-DID model to empirically test the impact of the Belt and Road Initiative on enterprise innovation and upgrading and its mechanism. The results show that the Belt and Road Initiative significantly improves the quantity and quality of enterprise patent innovation, which promotes enterprise innovation and upgrading.

In summary, with the implementation of the Belt and Road Initiative and its increasing global influence, there are abundant studies on the Belt and Road Initiative, especially in terms of outbound investment, trade and economic impact. Regarding the environmental impact of the Belt and Road Initiative, most studies focus on the assessment of emission reduction benefits and the level of the green economy in the regions along the Belt and Road. As a key tool to solve environmental problems, green innovation refers to a series of technologies, processes or products that have been developed to avoid, eliminate or mitigate eco-environmental pollution and destruction, reduce energy consumption, and improve environmental quality. Currently, a few scholars have discussed the impact of the Belt and Road Initiative on innovation, but most of these discussions are based on the perspective of microenterprises. Few scholars have paid attention to whether the Belt and Road Initiative has truly promoted the level of green innovation and, as an open policy, few studies have explored whether the Belt and Road Initiative has policy spillover effects. To fill the above research gaps, this paper takes the Belt and Road Initiative as a quasi-natural experiment with 291 prefecture-level cities in China as samples and uses the DID method to explore the impact of the initiative on green innovation quality and its policy spillover effect at the city level. In addition, the differences between technologies are reflected not only in the environmental protection degree and production links, but also in the differences in innovation quality due to different technological levels [18]. In reality, some enterprises prefer low-quality innovation and apply for a large number of invalid patents for strategic competition [19]. Especially in the context of the Belt and Road Initiative, strongly encouraging innovation and the government's enhancement of innovation subsidies, enterprises are more willing to pursue the quantity of innovation rather than the quality of innovation

to obtain a policy tilt. To better reflect the original intention of this paper, adopting green innovation quality instead of quantity to represent the regional green innovation level can better reflect the policy effect of the Belt and Road Initiative.

The marginal contribution of this paper is as follows. (1) This paper establishes a theoretical analysis framework, discusses the internal mechanism of the Belt and Road Initiative's effect on regional green innovation quality based on the five aspects of "policy communication", "infrastructure connectivity", "unimpeded trade", "financial integration" and the "people-to-people bond", and empirically tests the research hypothesis to thus enrich the research horizon. (2) This paper uses the DID method to test the exogenous impact brought about by the Belt and Road Initiative, accurately verifies the impact of the Belt and Road Initiative on the quality of green innovation in cities along the Belt and Road and performs a series of robustness tests to prove the robustness of the results. (3) Considering that the Belt and Road Initiative is a regional open policy, we identify and test the policy spillover effects of the initiative and provide a reference for the promotion and strengthening of further policies.

2. Background

With the persistence of the global financial crisis, the lack of a driving force for economic growth and increasingly prominent environmental problems, all countries are facing serious development problems. In this context, at the end of 2013, China put forward a major initiative that sought to jointly build the "Silk Road Economic Belt" and the "21st Century Maritime Silk Road", also known as the Belt and Road Initiative. This initiative is dedicated to promoting coordinated policy communication, efficient resource reorganization, deep market integration, and trade-free circulation by strengthening the interconnectivity of regional countries in areas such as transportation, energy, and networks. It also establishes an open, equal, inclusive, and reciprocal regional cooperation platform for the economic cooperation of participating countries based on multilateral cooperation mechanisms, which will collectively improve the level of economic development of the participating countries. Currently, the Belt and Road Initiative's radiating scope covers 39% of the global land area, including 62% of the global population [3].

2.1. Green Innovation Actions of the Belt and Road Initiative

In addition to promoting economic development, the Belt and Road Initiative calls for participating countries to actively pursue policy reforms on environmental aspects to drive the transformation of the traditional economic growth model to green development through innovation [4]. In May 2017, the Ministry of Environmental Protection, the Ministry of Foreign Affairs, and the Development and Reform Commission of China jointly issued the "Guidance on Advancing the Construction of the Green Belt and Road", which calls for adherence to the development concept of innovation, coordination, greenness, openness and sharing and uses a period of 3–5 years to establish a pragmatic and efficient eco-environmental cooperation and communication system to develop a series of eco-environmental risk prevention policies and measures. In the same year, at the Belt and Road International Cooperation Forum, China reemphasized the importance of green innovation and sustainable development and proposed establishing the "Belt and Road Initiative International Green Development Coalition" to promote the exchange and transfer of advanced green and low-carbon technologies through green innovation cooperation between participating countries and to enhance the capacity of Belt and Road countries for environmental protection and pollution prevention. This shows that the Belt and Road Initiative not only focuses on economic cooperation but also emphasizes the need for aid to participating countries to achieve a green innovation-driven economic growth model. To date, there have been some achievements in green innovation and cooperation among the various Belt and Road participating countries, and some examples are shown in Table 1.

Table 1. Examples of green innovation cooperation projects.

Country or Region	Cooperation Projects and Specific Content
Russia	Established a green development platform: actively conducting green innovation and environmental protection activities, improving public welfare, and encouraging residents to develop green and reasonable resource use habits.
Bangladesh	Implemented a range of green innovation policies: providing exempt advantages to commercial production of renewable energy through the Sustainable Energy and Renewable Energy Act.
Kazakhstan	Agricultural Innovation Park: mutual citation experiment crop of 45 varieties from six major groups of wheat, maize, soybean, etc.
Turkmenistan	A series of green and innovative cooperative projects include desert integrated use, wind control and sand control, soil improvement, plant pest control and water conservation technologies.
Southeast Asia	China-ASEAN energy investment policy: vigorously supports clean energy projects and increases investment in clean energy sectors such as solar, wind, nuclear, and bioenergetics.
	Modern fishery technology training seminar class: exporting advanced fishery technology, management experience and high-quality aquatic product germplasm resources in China.

2.2. Core Cities of the Belt and Road Initiative in China

Limited by the data collection capacity, we tentatively use the data of prefecture-level cities within China as a sample to construct the treatment and control groups and explore the impacts of the Belt and Road Initiative on the quality of green innovation. The selection criteria for cities in the treatment group are as follows. According to the "Vision and Actions for Jointly Building the Silk Road Economic Belt and the 21st Century Maritime Silk Road" and relevant documents released by the National Development and Reform Commission of China, the Ministry of Foreign Affairs and the Ministry of Commerce in March 2015, core cities along the Belt and Road can be identified from the following four regions: (1) Northwest and Northeast China, which covers nine provincial-level regions, including Xinjiang, Shanxi, Gansu, Ningxia, Qinghai, Inner Mongolia, Heilongjiang, Jilin and Liaoning, and three key cities, including Xi'an, Lanzhou and Xining; (2) Southwest China, three provinces of which are Guangxi, Yunnan, and Xizang; (3) coastal areas, which cover eight provincial-level regions, including Guangdong, Shandong, Fujian, Hainan, Shanghai, Zhejiang, Tianjin and Taiwan, and 16 key cities, including Shanghai, Tianjin, Ningbo, Zhoushan, Guangzhou, Shenzhen, Zhanjiang, Shantou, Qingdao, Yantai, Dalian, Fuzhou, Xiamen, Quanzhou, Haikou and Sanya; and (4) inland areas which cover seven provincial-level regions, including Chongqing, Sichuan, Henan, Hubei, Hunan, Jiangxi and Anhui, and six key cities, including Chengdu, Zhengzhou, Wuhan, Changsha, Nanchang and Hefei. In addition, considering the importance of key port cities along the route in building the 21st Century Maritime Silk Road, Lianyungang, Nanjing, Suzhou and other important port cities are included as core cities along the Belt and Road. Accordingly, it can be determined that there are 37 core cities along the Belt and Road, including 18 cities along the Silk Road Economic Belt and 19 cities along the 21st Century Maritime Silk Road, as shown in Table 2.

Table 2. Core cities of the Belt and Road Initiative in China.

Core cities along the Silk Road Economic Belt	Urumqi, Xining, Hohhot, Lanzhou, Yinchuan, Xi'an, Harbin, Changchun, Zhengzhou, Hefei, Wuhan, Nanchang, Changsha, Chongqing, Chengdu, Kunming, Nanning, and Lhasa
Core cities along the 21st Century Maritime Silk Road	Dalian, Tianjin, Yantai, Qingdao, Lianyungang, Nanjing, Suzhou, Shanghai, Ningbo, Zhoushan, Fuzhou, Quanzhou, Xiamen, Shantou, Guangzhou, Shenzhen, Zhanjiang, Haikou, and Sanya

3. Theories and Hypotheses

Since the Belt and Road Initiative was proposed, its cooperation has focused on many areas, such as the economy, politics, transportation and culture. All participants build

a new platform for international innovation cooperation around policy communication, infrastructure connectivity, unimpeded trade, financial integration and people-to-people bonds (hereinafter referred to as the "Five Links") to improve regional innovation efficiency through high-quality resource complementarity and information and knowledge sharing, achieving high-quality economic growth and jointly addressing global issues such as economic downturns and environmental degradation. The Belt and Road Initiative will not only help to eliminate the uncertainty of overseas investment and encourage the exchange of innovative and environmentally friendly enterprises, but also stimulate their environmental protection and innovation motivation and optimize the green innovation capacity and layout of cities along the Belt and Road. Based on this context, we attempt to combine the contents of the "Five Links" and the top framework design of the Belt and Road Initiative to elaborate on how the initiative affects and promotes urban green innovation quality.

First, in the "Five Links", policy communication is the foundation, and a good political environment can promote innovation cooperation between regional enterprises [20–22]. At present, more than 100 countries and regions and some important international organizations have actively participated in the Belt and Road Initiative. The stable and reliable alliance formed by them has provided a guarantee for the effective implementation of innovation activities, and the consensus on environmental protection within the alliance has promoted the green processes of innovation activities. Second, infrastructure connectivity is the bridge of communication. Infrastructure connectivity should be a priority area for jointly building the Belt and Road Initiative, which specifically includes transportation infrastructure construction, information infrastructure construction, communication construction, etc. At present, China is building the China–Europe Freight Train and China–Laos Railway and has close ties with countries in Northeast Asia and Central Asia. Research shows that the improvement of infrastructure can enhance the level of technological innovation [23]. Good infrastructure can attract a large number of enterprises to invest and set up factories locally to form a scale effect and effectively reduce costs. At the same time, it can also attract the inflow of innovative talent and promote the aggregation of knowledge and technology to improve innovation efficiency and quality [24]. With the continuous development of transportation, electricity, the internet and communication facilities, cities along the Belt and Road have gradually expanded their coverage to neighboring areas, and the continuous aggregation of innovation factors contributes to the improvement of the green innovation ability of cities along the Belt and Road. Third, unimpeded trade and financial integration are also important parts of the Belt and Road Initiative. On the one hand, trade liberalization can effectively expand the market size, reduce trade costs, improve the return on R&D investment, and stimulate the innovation vitality of enterprises [25]. As a national opening-up policy, the Belt and Road Initiative advocates for the liberalization of international trade, encourages innovative enterprises to participate in international competition and carries out transnational or transregional exchanges and cooperation. Learning and absorbing excellent experience is conducive to transferring the excess capacity of innovative enterprises in the regions along the Belt and Road and realizing the upgrading of the urban industrial structure. On the other hand, a good financial environment can promote enterprise innovation [26]. The Asian Infrastructure Investment Bank (AIIB), established in December 2015 under the leadership of China, is an important platform for financing the Belt and Road Initiative. By 2020, the AIIB had more than 100 members and had approved 87 projects involving 24 economies with a total investment of more than USD 19.6 billion. The establishment of the AIIB has solved the financing difficulties of high-tech and environmental protection enterprises and stimulated enterprises to carry out high-quality innovation. Finally, people-to-people bonds are a nonnegligible part of the Belt and Road Initiative. Some studies believe that having similar cultures is conducive to exchange and cooperation between countries [27]. When the exchanges and cultures between countries along the Belt and Road become smoother, the cooperation between enterprises on green innovation will also be further enhanced.

Accordingly, the Belt and Road Initiative has promoted green innovation in the cities along the routes through the "Five Links". However, we hold that the top-level framework design of the Belt and Road initiative plays a decisive role in the construction process of the Belt and Road Initiative and the Five Links. When designing the top-level framework of the Belt and Road Initiative, China has set as its goal the building of a new platform for international cooperation and new drivers for common development. Apart from making the initiative a road of openness, green development and innovation, China has also adopted the strategic principle of "High-Quality Development". The "High-Quality Development" strategy, proposed at the 19th National Congress of the Communist Party of China (CPC), places more emphasis on the quality of economic growth than its speed. Innovation is the primary driving force for development [28]. The High-Quality Development strategy requires a focus on improving the transformational ability of scientific and technological achievements and on breaking through core technological difficulties by promoting a deep integration of industry, universities and research, by increasing the support of fiscal and tax policies, by creating a fair market environment, and by improving the intellectual property protection system. At the same time, the strategy indicates that green and sustainable innovation is an important part of high-quality innovation, which emphasizes the environmental quality of the innovation results. As the Belt and Road Initiative deepens, along with the concept of high-quality development, the notion of a high-quality innovation drive continues throughout the implementation of the initiative, which will necessarily lead to an improvement in the quality of green innovation in the cities along the routes. As an important external development strategy of China, the Belt and Road Initiative has always been committed to high-quality and sustainable development with high standards and has always striven to complement each city's advantages through regional exchange and innovation cooperation to promote the common improvement of all parties. Based on the above theoretical review, we propose the following hypothesis:

Hypothesis 1 (H1). *The Belt and Road Initiative will affect the quality of urban green innovation. Specifically, the quality of green innovation in the cities along the Belt and Road will be significantly improved after the initiative is proposed.*

Some research has shown that policy implementation has uncertain policy space spillover effects on neighboring areas [29]. As an open policy in China, the Belt and Road Initiative aims to maximize its reach through active exchanges and cooperation. Moreover, improving the quality of green innovation in the Belt and Road regions through initiatives is essentially an incentive environmental regulation, which has a strong spatial correlation that is similar to technological innovation [30]. Therefore, ignoring the policy spillover effect of the Belt and Road Initiative may affect the effectiveness of the policy evaluation results; because of this, we also attempt to explain the policy spillover effect of the Belt and Road Initiative to improve the quality of green innovation from the aspects of policy communication, infrastructure connectivity, etc.

First, from the perspective of policy communication, the Belt and Road Initiative actively promotes innovation cooperation between the Belt and Road and surrounding regions, strengthens information interaction and knowledge sharing, and guides local governments to adopt similar policies [30], which is conducive to promoting the implementation of green innovation strategies in surrounding areas. Second, in terms of infrastructure connectivity, the improvement of infrastructure along the Belt and Road benefits the surrounding areas, facilitates the interregional flow of information and talent, promotes the orderly flow of innovation elements and the effective diffusion of knowledge, and provides an impetus for high-quality innovation in the surrounding areas [31]. Finally, in terms of unimpeded trade, there are obvious cost effects and technology spillover effects in the trade process among the cities in the Belt and Road region and surrounding area [32]. On the one hand, the convenient transportation conditions in the Belt and Road area will effectively reduce the trade cost of enterprises in surrounding areas so that enterprises

have sufficient funds for R&D investment and talent introduction, indirectly improving the innovation quality of enterprises. On the other hand, enterprises in the surrounding areas can absorb advanced technologies from the green and high-tech products that they purchase and implement imitation innovation. Through the interaction of the learning effect and complementary effect, the green innovation ability of enterprises can be improved, which is conducive to the overall improvement of the green innovation level in surrounding areas. Accordingly, regions along the Belt and Road have improved local economic and environmental conditions through high-quality green innovation, which has a good demonstration effect on the surrounding areas and has effectively promoted the coordinated development of green innovation quality in the surrounding areas through policy communication, infrastructure connectivity and unimpeded trade. Based on the above theoretical review, we propose the following hypothesis:

Hypothesis 2 (H2). *The Belt and Road Initiative has a policy spillover effect. Specifically, the quality of green innovation in the vicinity of the cities along the Belt and Road will also be significantly improved after the initiative is proposed.*

4. Empirical Strategy

4.1. Method Selection

The implementation of the Belt and Road Initiative can be considered a quasi-natural experiment, and the DID method can be used to compare the changes before and after its implementation. According to Section 2, the core cities along the Belt and Road mainly include 37 cities, and these cities were taken as the treatment group, while some non-Belt and Road cities were taken as the control group to construct the following DID model:

$$Y_{it} = \beta_0 + \beta_1 treated_{it} + \beta_2 post_{it} + \beta_3 treated_{it} * post_{it} + \beta_2 X_{it} + \gamma_t + u_i + \varepsilon_{it} \quad (1)$$

where subscripts i and t represent city i and year t, respectively. *Treated* is the dummy variable of the treatment group. It takes the value of 1 when a city is the core city of the Belt and Road Initiative and is 0 otherwise. *Post* is the dummy variable of the experimental period. It takes the value of 1 after the implementation of the Belt and Road Initiative and is 0 otherwise (since the Belt and Road Initiative was put forward at the end of 2013, we consider 2014 as the year when the policy began to have an impact). X_{it} is the control variable, while γ and u represent time fixed effects and individual fixed effects, respectively. ε is the random error term and the dependent variable Y means the green innovation quality of every city.

The meaning of each parameter in the DID model is shown in Table 3. It can be found from regression equation (1) that, for core cities (treated = 1), changes before and after the Belt and Road Initiative on the policy effect green innovation quality are $\beta_0 + \beta_1$ and $\beta_0 + \beta_1 + \beta_2 + \beta_3$, respectively. The green innovation quality of core cities along the Belt and Road before and after the initiative changes to $\Delta y_1 = \beta_2 + \beta_3$. For the non-Belt and Road cities, the green innovation quality changes before and after the initiative are β_0 and $\beta_0 + \beta_2$, respectively. Green innovation quality change in the non-Belt and Road cities is $\Delta y_2 = \beta_2$. Therefore, the policy effect of the Belt and Road Initiative should be reflected in the difference in green innovation quality between the core cities and non-Belt and Road cities after the implementation of the initiative. The difference in this value is $\Delta\Delta y = \beta_3$. If the coefficient of β_3 is significantly positive, this indicates that the initiative will promote the quality of green innovation in the cities along the Belt and Road; otherwise, the initiative does not affect the green innovation quality of the Belt and Road cities.

Table 3. The meaning of each parameter.

Green Innovation Quality	Before the Belt and Road Initiative (Post = 0)	After the Belt and Road Initiative (Post = 1)	Difference
Core cities (treated = 1)	$\beta_0 + \beta_1$	$\beta_0 + \beta_1 + \beta_2 + \beta_3$	$\Delta y_1 = \beta_2 + \beta_3$
Non-Belt and Road cities (treated = 0)	β_0	$\beta_0 + \beta_2$	$\Delta y_2 = \beta_2$
DID estimator			$\Delta\Delta y = \beta_3$

Since both regional policies and innovation behaviors have strong spatial association characteristics [29,30], ignoring the policy spillover effect of the Belt and Road Initiative may lead to biased policy evaluation results; therefore, we use the spatial panel Dubin model to further explore the policy spillover effect of the Belt and Road Initiatives on the quality of green innovation in surrounding regions, and the model is constructed as follows:

$$Y_{it} = \beta_0 + \beta_1 w_{ij} * Y_{it} + \beta_2 treated_{it} * post_{it} + \beta_3 w_{ij} * treated_{it} * post_{it} + \beta_4 X_{it} + \beta_5 w_{ij} * X_{it} + \varepsilon_{it} \quad (2)$$

where w_{ij} is the spatial weight matrix that describes the spatial adjacency relationship between regions and selects a 0,1 spatial weight matrix. This takes the value of 1 when a city is adjacent to cities along the Belt and Road and is 0 otherwise.

4.2. Variables and Data

4.2.1. Measurement of Variables

Dependent variables: To measure innovation quality, most studies use patent information as dependent variables; for example, Rubashkina et al. [33] and Johnstone et al. [34] used the number of patent citations to measure the innovation quality of China, and Fisch et al. [35] used the time span of the first citation of the patent since the application to evaluate the patent quality. To ensure that innovation quality covers more patent information, Lanjou et al. [36] and Schettino et al. [37] used principal component analysis to weight the four characteristics of the correlation patent scale, patent application width, and patent forward and backward citations as indicators. The above research provides a reference for the measurement of green innovation quality in this paper. However, considering the difficulty and workload of collecting the patent citation information of each city and the low disclosure of green innovation patent citation information, according to Boeing [38], we consider applications for green patents as signifiers of green innovation quality. In the context of this study, applications are preferable to patent grants because applications are close to the time of invention, which as an indicator can more accurately reflect the green innovation level of research objects in the current period. Furthermore, referring to the classification of patents by Hu et al. [39], we consider applications for green invention patents so as to identify high-quality green innovation (Patent_I) and applications for green utility patents so as to identify low-quality green innovation (Patent_U). The practical basis of this innovation quality classification comes from the patent classification of the China Patent Office. The Chinese Patent Office divides patents into invention patents, utility patents and design patents. The application of invention patents must meet the requirements of "novelty, creativity and practicality" so that they have the highest novelty and technical creativity, which can be regarded as having a higher quality of innovation. In contrast, the application of utility and design patents only requires similar patent applications that have not been previously granted, as compared with invention patents, they have lower requirements for the innovativeness of the patent. In addition, as the most basic innovation, design patents are relatively low in technical content and mostly have no environmental protection attributes; thus, they are excluded from the classification of green innovation quality in this paper.

Dependent variables: To identify the policy effects of the initiative, we set the independent variable as a multiplicative term of treated versus post. Treated is the dummy variable

of the experimental group. It takes the value of 1 when a city is a core city of the Belt and Road Initiative (one of the 37 Belt and Road Initiative core cities identified in Section 2) and is 0 otherwise. Post is the dummy variable of the experimental period. It takes the value of 1 after the implementation of the Belt and Road Initiative and is 0 otherwise (since the Belt and Road Initiative was put forward at the end of 2013, we consider 2014 as the year when the policy began to have an impact).

Control variables: In fact, the level of green innovation quality of a city is affected by complex, varied factors stemming from cities' unique characteristics. Diverse influencing factors have been studied by scholars, including a cities' level of economic development, industrial structure, opening-up level, reserve of talents, as well as other social factors [40–47]. Therefore, according to the previous literature, five variables were selected as control variables: (1) urbanization (Urban), Chen et al. [40] confirmed the technology promotion effect of urbanization, which stemmed from the tendency of urbanization to promote productivity; (2) industrial structure (IND), Greunz [41] found that the effect of industrial structure is positive and indicated that the upgrading of industries could promote resource utilization efficiency, and further improve the local green innovation level; (3) foreign direct investment (FDI), studies on the relationship between FDI and green innovation have been fruitful, with Lin [42] finding that FDI drove increases in innovation while Feng et al. [43] revealed the positive effects of FDI on urban green innovation quality; (4) economic development level (PerGDP), most scholars have argued that economic growth can raise innovation capability, and Galindo and Mendez [44] found that a feedback effect is at work in which economic activity promotes entrepreneurship and innovation activities, and the latter enhances economic activity; (5) education (EDU), there is no doubt that the improvement in education level will improve the quality of production factors [45], and thus promote the level of green innovation. The implications and computing method of the above variables are specified in Table 4.

Table 4. Main variables and their data sources.

Variable Name	Variable Meaning	Proxy Variable	Data Sources
Patent	Green innovation quantity	Number of total green patent applications	CNRDS
Patent_I	High-quality green innovation	Number of invention green patent applications	CNRDS
Patent_U	Low-quality green innovation	Number of utility green patent applications	CNRDS
treated	Belong or not belong Belt and Road core cities	Dummy variable (0,1)	—
post	Policy implementation time	Dummy variable (0,1)	—
Urban	Urbanization	Ratio of urban population to total population	CCSY
IND	Industrial structure	Ratio of the secondary industry to the tertiary industry	CCSY
LnFDI	Foreign direct investment	Net inflows of foreign direct investment	CCSY
LnPerGDP	Economic development level	Numerical value of per capital GDP	CCSY
LnEDU	Education	Number of college students per ten thousand people	CCSY

4.2.2. Samples and Data Sources

The Belt and Road Initiative was proposed at the end of 2013, so the policy implementation time was determined to be 2014. Our data sample covered 291 cities (37 core cities along the Belt and Road and 254 Non-Belt and Road cities), and since there are a large number of missing values of patent data in 2020 and 2021, and the data of most proxy variables in 2022 have not been counted, we determined the data period spanned from 2008 to 2019 (inclusive of the 6 years before and 5 years after the policy implementation) in order to compare the differences of the green innovation quality before and after the implementation of the policy. The data of the urban patent applications in this paper were from the Chinese Research Data Services Platform (CNRDS), and other macro data were from the China City Statistical Yearbook (CCSY). After removing missing values and abnormal data, 3492 observations were obtained over a 12-year period. In addition, to avoid the influence of extreme values, a 1% tail reduction was applied to the left and right ends of each control variable after logarithmic transformation. The data sources of each main variable are specified in Table 4.

5. Results and Discussion

5.1. Main Results

Table 5 reports the regression results of the DID model of Equation (1). In general, the coefficients of the multiplicative term treated×post are significantly positive at the 1% level, which indicates that the Belt and Road Initiative has a positive impact on the quantity of green innovation (Patent), high-quality green innovation (Patent_I) and low-quality green innovation (Patent_U). Specifically, compared with Model (3), the coefficient level of the policy effect in Model (2) is higher, which suggests that, compared with increasing the number of green innovations, the implementation of the Belt and Road Initiative is more able to induce cities to pursue improvements in the quality of green innovation. According to the coefficient (0.620) of the multiplicative term treated×post in Model (2), compared with the control group, the Belt and Road Initiative leads to an increase of approximately 0.62 in the number of high-quality green innovation patent applications in the cities of the treatment group, which is a significant improvement in the quality of urban green innovation. Therefore, the driving effect of the Belt and Road Initiative on the quality of green innovation in cities along the route revealed in H1 has strong statistical and economic significance.

Table 5. DID model estimates.

Model	**(1)**	**(2)**	**(3)**
Variable	**Patent**	**Patent_I**	**Patent_U**
Treated×post	0.565 ***	0.620 ***	0.444 ***
	(14.18)	(15.69)	(9.10)
Urban	−0.195 *	−0.046	−0.373 ***
	(−1.87)	(−0.42)	(−3.55)
IND	0.028	0.081 ***	−0.035 *
	(1.61)	(4.94)	(−1.64)
LnFDI	−0.067 ***	−0.083 ***	−0.050 ***
	(−5.78)	(−6.99)	(−3.89)
LnPerGDP	0.980 ***	1.139 ***	0.754 ***
	(36.78)	(40.41)	(25.33)
LnEDU	0.145 ***	0.152 ***	0.120 ***
	(5.81)	(5.55)	(4.57)
Constant	−10.194 ***	−11.999 ***	−7.777 ***
	(−32.24)	(−35.57)	(−23.34)
Year dummy	Yes	Yes	Yes
City dummy	Yes	Yes	Yes
N	2916	2916	2916

Note: (1) *** and * represent significance levels of 1% and 10%, respectively; (2) the t statistics are shown in parentheses; and (3) the results are estimated by STATA 15.

Furthermore, the regression results of control variables are explained as follows: (1) The coefficients of LnPerGDP and LnEDU were significantly positive in all models, which indicates that higher economic and educational levels do have a significant promotion effect on green innovation. (2) Compared with Model (3), the coefficient level of the LnFDI in Model (2) is higher and significantly positive, which suggests that optimizing industrial structure is an effective way to improve the quality of green innovation. (3) The coefficient values of Urban and LnFDI were negative, which looks counterintuitive. We argued that the abnormality in the value of the *Urban* coefficient may be attributed to the sample selection in this paper. The sample included 291 prefecture-level cities in China, which did not contain rural areas. Therefore, the sample individuals all had a high urbanization rates with little variation between each other, which leads to the counterintuitive regression results. Furthermore, the reason that the LnFDI coefficient value is negative may be that the entry of FDI extrudes innovation input from local firms and has a negative spillover effect on green innovation [48].

5.2. Robustness Check

To examine the robustness of our main results that show that the Belt and Road Initiative promotes urban green innovation quality, robustness tests were conducted by performing a parallel trend test and placebo test and using the PSM-DID estimation approach.

5.2.1. Parallel Trend Test

In the main result, we identify the causal effect of the Belt and Road Initiative on the quality of green innovation in the cities along the routes. But an important precondition for the use of the DID model is that there is no significant difference in the level of green innovation quality between core cities along the Belt and Road (treatment group) and non-Belt and Road cities (control group) before the policy implementation. Therefore, to further prove the validity of the analysis results, the parallel trend test of the DID model is needed, and the result is shown in Figure 1. The test results show that the regression coefficients of the multiplicative term treated×post are all distributed around 0 and statistically insignificant before the implementation of the Belt and Road Initiative, which indicates that the green innovation quality of the treatment group and the control group have the same growth trend before the implementation of the Belt and Road Initiative. In addition, we can find that the quality of green innovation in cities along the Belt and Road has significantly increased since the initiative was proposed. Specifically, with the implementation of the Belt and Road Initiative, the driving effect on the quality of green innovation in the cities along the routes generally experienced a process of first increasing and then decreasing and reached a maximum of four years after the initiative was put forward. We believe that the reasons for the weakening of the policy effect in the later period are as follows: in the process of China's structural reform, with the deepening of the concept of "High-Quality Development", the regions along the Belt and Road have a declining policy advantage over other regions in terms of time, and the "institutional rent" formed will continue to dissipate. As a result, the driving effect of the Belt and Road Initiative on the quality of green innovation will show strong heterogeneity with an increase in the policy implementation time.

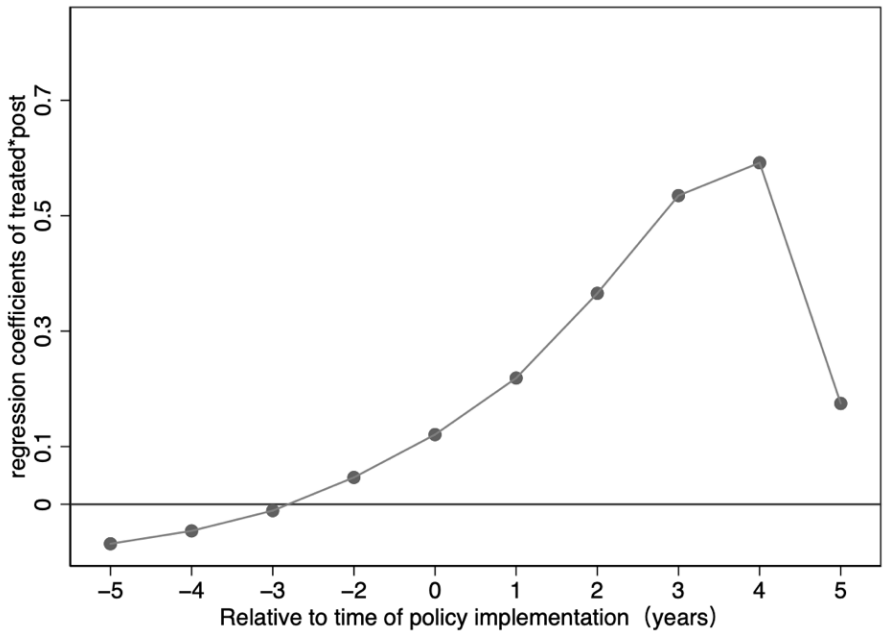

Figure 1. The parallel trend test of the DID model.

5.2.2. Placebo Test

We carried out a placebo test based on two aspects. The timing of treatment and changes in the control and treatment groups. The Belt and Road Initiative was formally

initiated at the end of 2013; therefore, we take 2014 as the starting year when the control group was impacted by the policy, and our main results prove the existence of green innovation quality-promoting effects. However, the treatment group was sensitive to the selection of time; thus, we changed the timing of the treatment to further demonstrate the robustness of the main estimated results. Table 6 shows the regression results of changing the timing of the treatment. Models (4) to (6) assume that the implementation year of the initiative is 2011, and Models (7) to (9) assume that the implementation year of the initiative is 2012. Compared with the main regression results, the coefficients of the multiplicative term treated×post decreased significantly and were all not significant, which indicates that changing the timing of the implementation year of the initiative significantly reduces the green innovation quality-promoting effects of the initiative. This also proves from a counterfactual perspective that the implementation of the Belt and Road Initiative did improve the urban green innovation quality of the treatment group. Another placebo test was conducted by changing the samples in the control and treatment groups, and the process was designed as follows: the core Belt and Road cities in the original treatment group were regarded as the new control group, and then some cities were randomly selected from the non-core cities as the new treatment group to form a new sample by which to rerun the main regression estimates. By repeating the above process 500 times, 500 treated×post multiplicative term coefficients could be obtained. Figure 2 is the probability distribution diagram of the multiplicative term coefficient. As shown in the figure, the false coefficient is basically distributed around 0, which suggests that the policy effect of the Belt and Road Initiative is obviously location-oriented and has the most significant driving effect on the quality of green innovation in the cities along the Belt and Road.

Table 6. Robustness check by changing the time of treatment.

Time	**2011**			**2012**		
Model	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Variable	**Patent**	**Patent_I**	**Patent_U**	**Patent**	**Patent_I**	**Patent_U**
treated×post	0.051	0.018	0.047	0.029	0.005	0.026
	(1.31)	(0.38)	(1.20)	(0.86)	(0.13)	(0.79)
Urban	0.265 **	0.601 ***	0.069	0.277 **	0.606 ***	0.078
	(2.32)	(5.09)	(0.59)	(2.44)	(5.17)	(0.66)
IND	−0.037 **	−0.059 ***	−0.026	−0.037 **	−0.059 ***	−0.026
	(−2.39)	(−3.13)	(−1.55)	(−2.38)	(−3.11)	(−1.54)
LnFDI	0.022 ***	0.026 ***	0.010	0.022 ***	0.026 ***	0.010
	(2.77)	(2.70)	(1.16)	(2.77)	(2.70)	(1.17)
LnPerGDP	0.340 ***	0.338 ***	0.288 ***	0.339 ***	0.338 ***	0.287 ***
	(9.90)	(8.27)	(7.68)	(9.88)	(8.26)	(7.66)
LnEDU	0.182 ***	0.138 ***	0.265 ***	0.183 ***	0.139 ***	0.266 ***
	(7.28)	(4.84)	(9.52)	(7.31)	(4.87)	(9.55)
Constant	−4.361 ***	−4.457 ***	−4.520 ***	−4.369 ***	−4.467 ***	−4.529 ***
	(−11.03)	(−9.88)	(−10.17)	(−11.03)	(−9.89)	(−10.17)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
City dummy	Yes	Yes	Yes	Yes	Yes	Yes
N	2916	2916	2916	2916	2916	2916

Note: (1) *** and ** represent significance levels of 1% and 5%, respectively; (2) the t statistics are shown in parentheses; and (3) the results are estimated by STATA 15.

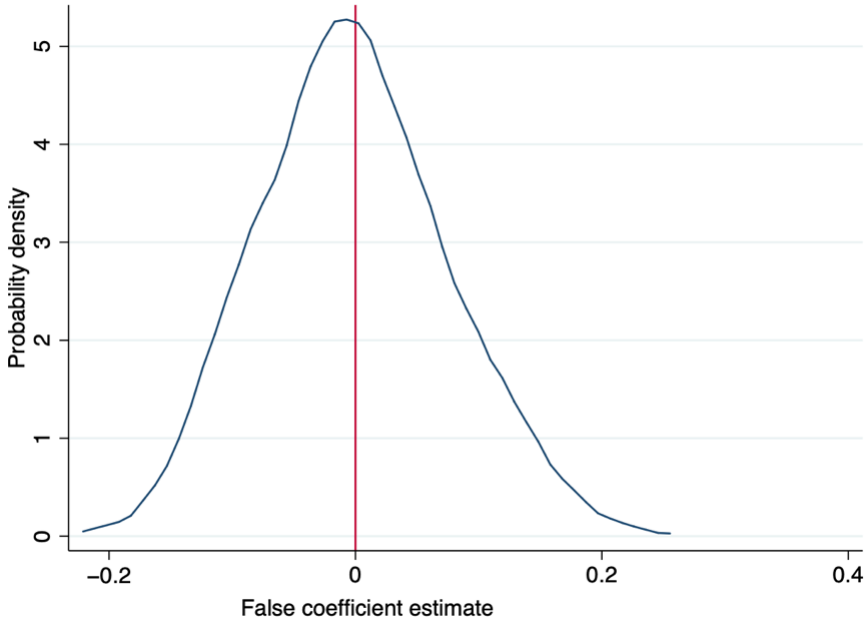

Figure 2. Robustness check according to changes in the control and treatment groups.

5.2.3. PSM-DID Test

The treatment and control groups were not divided randomly, and they had different economic, social, and environmental attributes, which could lead to selection bias when using the DID estimator. Such biases can cause an endogeneity problem, since the explanatory variables can become correlated with the residual term. To mitigate the potential bias, we use the PSM method to pair the treatment cities with others that had similar observed attributes to those in the control group and then proceed with the DID estimator.

We constructed a logit probabilistic model of whether a city is a core city of the Belt and Road Initiative by using nearest neighbor matching, radius matching, and kernel matching to match the cities from the treatment group and control group according to the variables of Urban, IND, LnFDI, LnPerGDP and LnEDU. Then, the matched samples were used for the main regression examination. The regression results shown in Table 7 indicate that the coefficients of the multiplicative term treated×post are all significant at the 1% level, which implies that the core conclusion is still robust.

Table 7. Robustness check with the PSM-DID method.

Method	**Nearest Neighbor Matching**	**Radius Matching**	**Kernel Matching**
Model	**(10)**	**(11)**	**(12)**
Variable	**Patent_I**	**Patent_I**	**Patent_I**
treated×post	0.527 ***	0.539 ***	0.565 ***
	(8.98)	(9.14)	(14.18)
Urban	0.154	0.182	−0.195 *
	(0.92)	(1.08)	(−1.87)
IND	0.020	0.033	0.028
	(0.64)	(1.09)	(1.61)
LnFDI	−0.025	−0.019	−0.067 ***
	(−1.01)	(−0.74)	(−5.76)
LnPerGDP	0.886 ***	0.892 ***	0.980 ***
	(14.06)	(14.22)	(36.76)
LnEDU	0.245 ***	0.239 ***	0.145 ***
	(3.66)	(3.57)	(5.81)
Constant	−11.049 ***	−11.131 ***	−10.194 ***
	(−12.87)	(−12.99)	(−32.22)

Table 7. *Cont.*

Method	Nearest Neighbor Matching	Radius Matching	Kernel Matching
Model	**(10)**	**(11)**	**(12)**
Variable	**Patent_I**	**Patent_I**	**Patent_I**
Year dummy	Yes	Yes	Yes
City dummy	Yes	Yes	Yes
N	610	608	2914

Note: (1) *** and * represent significance levels of 1% and 10%, respectively; (2) the t statistics are shown in parentheses; and (3) the results are estimated by STATA 15.

5.3. Policy Spillover Effect Test

Before performing the spatial panel model parameter regression, we used the Moran index to test the spatial correlation of the main dependent variable (urban green innovation quality). The results show that there is a significant spatial correlation of urban green innovation quality (Moran's I = 0.378, p = 0.000), which proves the rationality of discussing the policy spillover effects of the Belt and Road Initiative through a spatial panel model. The regression results of Model (13) in Table 8 show that the regression coefficients of the spatial lag terms of the DID dummy variables are all significantly positive at the 1% level, which suggests that the implementation of the Belt and Road Initiative also has a promoting effect on green innovation in neighboring regions. Similarly, compared with Model (15), the coefficient level of the spatial lag term in Model (14) is higher, which signals that in the process of policy spillover, the Belt and Road Initiative has a greater impact on high-quality green innovation in neighboring areas than on low-quality innovation. On the one hand, under the condition of strategic energy saving competition and environmental protection pattern imitation between regions, the incentive effect of the initiative on green innovation in the regions along the Belt and Road can form an effective demonstration effect on the neighboring regions so that the innovation incentive effect of the Belt and Road Initiative can be strengthened in the spatial dimension. Furthermore, under the pressure of a national emphasis on energy conservation and emission reduction, the implementation of the initiative will help to promote the quality of green innovation and help make industrial transformation and upgrading in the regions along the Belt and Road a priority, which will have a positive impact on the green innovation in the neighboring regions through various channels such as economic cooperation and technology spillover.

Table 8. Regression results of the policy spatial spillover effects of the Belt and Road Initiative.

Model	(13)	(14)	(15)
Variable	**Patent**	**Patent_I**	**Patent_U**
treated×post	0.782 ***	0.883 ***	0.664 ***
	(10.14)	(11.43)	(8.71)
w×treated×post	0.827 ***	0.947 ***	0.680 ***
	(16.56)	(16.86)	(14.03)
Control variables	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes
City dummy	Yes	Yes	Yes
Adjusted R^2	0.218	0.225	0.191
N	3492	3492	3492

Note: (1) *** represent significance levels of 1%; (2) the t statistics are shown in parentheses; and (3) the results are estimated by STATA 15.

In addition, to more specifically explain the regression coefficient of the spatial lag term of the DID virtual variable, the average policy effect of the Belt and Road Initiative was decomposed into direct and indirect effects, as shown in Table 9. Either from the perspective of the short or long term, both the direct and indirect effects of the Belt and Road Initiative on the quality of green innovation are significantly positive at the 1% level,

but the absolute value of the coefficient of the long-term effect is larger, which indicates that the establishment and improvement of the economic cooperation platform of the Belt and Road requires a certain period of time, and the improvement of the green technology innovation level also has time accumulation. Overall, the indirect effects of the Belt and Road Initiative account for approximately 75% of the direct effects, which also demonstrates that the Belt and Road Initiative has a significant promotion effect on the quality of green innovation in both the pilot regions and their neighboring regions; that is, the initiative has a significant policy spillover effect.

Table 9. Policy effect decomposition.

Variable	Short-Term			Long-Term		
	Direct Effect	**Indirect Effect**	**Total Effect**	**Direct Effect**	**Indirect Effect**	**Total Effect**
treated×post	0.761 ***	0.618 ***	1.379 ***	0.981 ***	0.733 ***	1.714 ***
	(9.65)	(16.26)	(13.57)	(12.50)	(18.33)	(17.27)

Note: (1) *** represent significance levels of 1%; (2) the t statistics are shown in parentheses; and (3) the results are estimated by STATA 15.

The results have the following implications: normally, due to lax environmental regulations, developing regions are usually the first choice of developed ones for transferring their polluting industries elsewhere, thus the former tend to become 'pollution havens'. Therefore, the developing regions tend to be faced with grave sustainable development problems. However, our research results show that the Belt and Road Initiative can not only improve the quality of local green innovation, but it can also promote green technology progress in surrounding areas through policy spillover effects. These results agree closely with Xu et al.'s [49]. Regions along the Belt and Road can improve their green technologies and optimize their energy utilization efficiency to reduce the consumption of fossil fuels [50], thus promoting their sustainable development. One of the main goals of the Belt and Road Initiative is to establish an ecologically sustainable civilization and promote green, low-carbon development strategies by prioritizing the development of green innovation and technologies [51], and our results confirm that. Therefore, the Belt and Road Initiative is consistent with the global consensus and has positive, far-reaching effects on green innovation and development in the regions along the Belt and Road.

The results highlight the significance of the Belt and Road Initiative and how it promotes green innovation quality in the regions along the Belt and Road, which has positive impacts on global environmental governance and plays a key role in accelerating the progress of global sustainable development.

6. Conclusions and Policy Implications

The Belt and Road Initiative, as an open national policy dedicated to building an open, efficient and win–win regional cooperation platform through multilateral mechanisms, has attracted widespread attention worldwide, and there is no doubt that it can promote foreign trade and the economic growth of all parties involved; however, whether it can improve the technological level of the regions along the route and guide local green and sustainable development is still controversial. To solve this problem, this paper examines the impact of the Belt and Road Initiative on the quality of green innovation. Based on the sample data of 291 prefecture-level cities in China from 2018 to 2019, we group green innovation into green innovation quantity, low-quality green innovation, and high-quality green innovation according to the total amount and category of local patent applications and use the DID method to construct a quasi-natural experimental framework for the Belt and Road Initiative and regional green innovation quality. The conclusions are as follows. (1) Based on the results of the benchmark model analysis, the Belt and Road Initiative has a positive effect on both the quantity and quality of urban green innovation in the treatment group. Based on the impact degree, the impact coefficient of the initiative on the "invention model" green patent application is greater than that on the "utility model"

green patent application, which signifies that the Belt and Road Initiative does contribute to the high-quality development of green innovation levels in the regions along the routes. (2) According to the robustness test results, the main conclusions of this paper are still valid in a series of robustness tests, such as a parallel trend test, a placebo test by the advance policy impact time on the treatment group and changing the samples in the control and treatment groups, and re-estimation that uses the PSM-DID method, which show that the main effect is highly robust. (3) Based on the results of the policy spillover test, the Belt and Road Initiative has not only a direct promotion effect on the quality of green innovation in the regions along the routes but also a policy spillover effect on neighboring regions to enhance their quality of green innovation, thereby further verifying the robustness of the conclusion that the implementation of the Belt and Road Initiative contributes to the improvement of green innovation quality in the spatial dimension. The regression coefficient of the long-term effect is larger than that of the short-term effect, which reveals that the incentive effect of green innovation under the Belt and Road Initiative exerts a certain periodicity, and its incentive effect gradually becomes significant in the long term.

Based on the results in this paper, the Belt and Road Initiative represents a successful step in improving the level of green technology and innovation quality, and the results have the following policy implications. First, the Belt and Road Initiative has enhanced connectivity among the regions along the routes and has promoted the optimization of the mode of free allocation among regions and the division of cooperation among different markets. The initiative has not only boosted the quantity of innovation in the Belt and Road regions but also further enhanced the depth and quality of green innovation. Therefore, decision-makers should continue to accelerate the development of the Belt and Road Initiative into a high-quality platform for regional cooperation, further improve the top-level design of the Belt and Road Initiative and the construction of the "Five Links", give full play to China's advantages in infrastructure and production capacity cooperation, and promote sustainable development shared by all parties. Second, although the technology levels in the regions along the Belt and Road have improved significantly after policy implementation, the overall situation is still behind the world average level. In the future, the policy environment of the Belt and Road Initiative should continue to be improved, this should involve formulating unified industry standards and regulations to reduce the cost of technological exchange and innovation between enterprises; persuading countries and regions along the Belt and Road to pay more attention to the relationship between economic development and environmental protection; and strengthening the business environment and optimizing legal, institutional, social and media safeguards. Additionally, according to the findings of this paper, the policy effects of the Belt and Road Initiative will diminish dramatically in the fifth year after the policy's implementation; therefore, the sustainability of the policy effect should be ensured through continuous adjustment and improvement of policy programs. Finally, considering the spatial spillover of the green innovation incentive effect of the Belt and Road Initiative, the promotion of the initiative and the construction of the platforms should focus on balanced development and avoid vicious competition and the inefficiency of innovation resource utilization caused by the unbalanced development of inter-regional trading markets.

Although this paper empirically examines the promotion effect of the Belt and Road Initiative on the quality of green innovation and passes a series of robustness tests, the following content still needs further research. Limited by data acquisition ability, we only selected 291 cities in China as samples to construct the treatment group and the control group, and future research can further expand the sample size to examine the reliability of the results in this paper. In addition, we propose that the Belt and Road Initiative promotes the quality of green innovation through the five approaches of "policy communication", "infrastructure connectivity", "unimpeded trade", "financial integration" and "people-to-people bonds", but we do not examine its functional mechanism. Therefore, it will be interesting to develop more data and indicators to evaluate the action path of the Belt and Road Initiative on affecting green innovation.

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