The Influence of the Belt and Road Initiative on the Technological Upgrade of Enterprises in Countries and Regions along the Belt and Road: Study based on Difference-in-difference Model

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Abstract. Remarkably, the Belt and Road Initiative has increasingly injected important impetus into the economic growth of countries and regions along the Belt and Road. However, how such a growth model affects local businesses? In this regard, this paper constructs a Difference-in-difference (DID) model based on whether the Belt and Road Initiative can promote the technological upgrading of countries and regions along the Belt and Road. The data of listed companies in countries and regions along the Belt and Road Initiative from 2013 to 2020 are used for verification. It is found that the Belt and Road Initiative can significantly promote the technological upgrading of listed companies in countries and regions along the Belt and Road, represented by the number of patents granted. This conclusion implies that the implementation of the Belt and Road Initiative will promote the common development of countries and regions along the Belt and Road, and provides theoretical support for promoting the high-quality development of the Belt and Road. In the meantime, amid the implementation of the Belt and Road Initiative, relevant countries ought to strengthen communication and negotiation, consolidate and deepen cooperation, expand the sphere of influence and adhere to the innovation-driven development strategy, so as to build the Belt and Road Initiative into a platform for the implementation of a community with a shared future for mankind.

Keywords: the Belt and Road Initiative; technological upgrade; patents granting; high-quality development.

1. Introduction

Against the backdrop of anti-globalization and rising trade protectionism, China has always been committed to opening up and promoting economic exchanges with countries and regions along the Belt and Road, so as to build the Belt and Road into a major platform for practicing a community with a shared future for mankind. Following the great success of the Belt and Road Initiative, General Secretary Xi Jinping made it clear at the second Belt and Road Forum for International Cooperation that high-quality Belt and Road cooperation should be promoted. In recent years, China has boosted local economic growth by exchanging resources, technology and human resources with countries and regions along the Belt and Road. According to statistics, China's cumulative direct investment in countries along the Belt and Road has reached nearly US $140 billion, and cumulative trade with each other has exceeded US $10 trillion. Over the past eight years, China has signed a total of US $940.9 billion in new contracts and US $638.9 billion in sales in the Belt and Road countries and regions. Despite the COVID-19 pandemic and a 3.3 percent contraction in the global economy, China's total import and export volume to countries along the Belt and Road in 2020 was 9,369.6 trillion yuan, with exports reaching 5,426.3 trillion yuan, up 3.2 percent from the previous year. Under the Belt and Road Initiative, will the economic growth model of countries and regions along the Belt and Road only focus on "quantity growth" model, or will China's investment and trade export cause the demise of local innovative enterprises? The study on this issue will provide sufficient theoretical support for the sustainable development of the Belt and Road Initiative.

After the initiative of Jointly Promoting High-quality Development along the Belt and Road was put forward, more and more scholars began to pay attention to the impact of the Belt and Road Initiative on the economic growth patterns of countries and regions along the Belt and Road. Some

scholars point out that innovation is needed to transform the economic growth mode based on scale expansion into high-quality and sustainable economic growth mode based on quality and efficiency (Hall and Jones,1999; Zhang Jie, 2015). In the opinion of some scholars, technological upgrading is the fundamental driving force for the high-quality development of the Belt and Road (Zhang Xiaojing et al., 2020). According to the research object and research area, the existing literature can be divided into two parts.

From the perspective of the regions involved in the research, the existing literature often explores the impact of the Belt and Road Initiative on relevant provinces and cities in China, while there is a lack of research on the impact of the Belt and Road Initiative on countries or regions along the Belt and Road. Based on the DID method, Wang Guijun and Lu Xiaoxiao (2019) explored and found that the Belt and Road Initiative could significantly improve the technological upgrading of Chinese enterprises represented by total factor productivity. Via the same measurement method, Lu Shengfeng, Dong Ruyu and Ye Chusheng (2020) also explored and found that the "Belt and Road" initiative could significantly improve the average export quality of Chinese enterprises. Given that the Belt and Road Initiative is an important platform for the implementation of a community with a shared future for mankind, it is not enough for scholars to focus only on the impact of the Belt and Road Initiative on China. Therefore, this paper draws on and improves the practice of Li Bing, Yue Yunsong and Chen Ting (2016) to measure the technological upgrading of enterprises by the number of patent licenses. After that, this paper attempts to test whether the Belt and Road Initiative can promote the technological upgrading represented by the number of patent licenses in countries and regions along the Belt and Road, and whether the Belt and Road Initiative can promote the international and regional common development of the Belt and Road.

From the perspective of research objects, the vast majority of existing literatures (He Li, 2020; Wang Guijun and Zhang Hui, 2020) explore whether the Belt and Road Initiative can promote the technological upgrading of enterprises based on OFDI (outward foreign direct investment) as a single entry point, while ignoring other forms of economic activities. Based on analysis of trade data from other regions, some scholars have found that international trade can also promote technological upgrading. Scholars in this part believe that "Spillover Effect" will lead to innovation in countries and regions participating in international trade. (Fritsch and Görg, 2015;Goldberg et al.,2009). As international trade boomed around the world, the cost of input for technologically backward enterprises was reduced. In other words, the advanced technology in traded goods was easy for them to obtain and translate into their own strength. However, the reason why few scholars study the relationship between the "Belt and Road" Initiative and enterprise technological upgrading by taking trade export as the relevant point may be that there is no unified conclusion about whether trade export can really promote technological upgrading in the academic circle. Dixit and Stiglitz (1997) believed that trade export would exert a "restraining effect" on the technological upgrading of enterprises in participating countries.

The main contributions of this paper are as follows: First of all, taking the Belt and Road Initiative as an opportunity and countries and regions participating in the Belt and Road Initiative as research objects, this paper focuses on the influence of the Belt and Road Initiative on the technological upgrading of enterprises in participating countries and regions represented by the number of patents. It provides new empirical evidence for a deeper understanding of the connotation of the Belt and Road initiative and the realization of the goal of win-win cooperation between China and the Belt and Road Initiative countries and regions. Secondly, the sample selected in this paper covers the period from 2013 to 2020, including listed companies in Asia, Europe, Africa, Oceania, Central and South America and other continents. This paper has an insight into the Belt and Road Initiative from a global perspective, and further examines whether the Belt and Road Initiative contributes to the economic growth of countries and regions along the Belt and Road, and expands a new path for the sustainable development and even economic globalization of the participating countries. Finally, on the basis of previous studies, this paper optimizes the measurement model and comprehensively discusses the mechanism of the implementation of the Belt and Road Initiative on the technological upgrading of

enterprises in participating countries and regions through the formation of DID method, and demonstrates whether the implementation of the Belt and Road Initiative can promote the technological upgrading of participating countries. In addition, the direct index of the number of patents granted by enterprises is tested, which provides a clear practical basis for the high-quality development of participating countries and regions in the Belt and Road Initiative.

2. Institutional Background and Characteristic Facts

2.1 Institutional Background

(1) Background

Since the Belt and Road Initiative was put forward, China has witnessed many achievements. The Belt and Road initiative has not only raised the level of openness of various regions in China, but also explored a new way to promote common development and achieved mutual benefit and win-win results with the countries that jointly build the Belt and Road. Taking trade exports as an example, in 2018, trade between China and countries and regions involved in the Belt and Road initiative reached $1.3 trillion, up 16.3 percent year on year. The Belt and Road Initiative has been an important factor in promoting economic growth in these countries. A new round of scientific and technological revolution and industrial transformation is in full swing. If the Belt and Road Initiative only promotes the economic growth of countries along the Belt and Road with quantitative expansion, labor-intensive mode and low prices, it will be difficult to achieve sustainable development for mutual benefit. Therefore, based on the overall layout of the Belt and Road Initiative, General Secretary Xi Jinping has proposed that "looking ahead to the future, we should focus on key areas and make intensive efforts to push forward the Belt and Road initiative along the direction of high-quality development", so as to transform the high-speed economic growth of countries and regions along the Belt and Road led by China into high-quality growth. Innovation is the fundamental driving force behind the high-quality development of the Belt and Road Initiative. We should seize the opportunity of innovation-oriented development, vigorously promote enterprise innovation, especially increase the number of patents held by enterprises, and strive to build the Belt and Road into a mutually beneficial Silk Road of Innovation.

(2) Countries along the Belt and Road

The Belt and Road initiative includes six major international economic cooperation corridors, namely, the New Eurasian Land Bridge, China-Mongolia-Russia, China-Central Asia-West Asia, China-Indochina Peninsula, China-Pakistan and Bangladesh-China-India-Myanmar Economic Corridor. By February 2022, China had signed more than 200 cooperation documents on Belt and Road Cooperation with 148 countries and regions and 32 international organizations, covering five continents: Asia, Europe, Africa, the Americas and Oceania. The countries and regions along the Belt and Road are expanding from those originally concentrated along the ancient Silk Road to the whole world.

On the whole, the countries participating in the Belt and Road Initiative have uneven economic development, low level of development and lack of innovation. According to the Report on Regional Environmental Cooperation and National Ecological Environment status along the Belt and Road, countries and regions along the Belt and Road initiative generally have low productivity but high energy and resource consumption. Among the countries and regions along the Belt and Road, except for the South Korea and Israel, the vast majority are developing countries. In general, central and Eastern European countries have a high level of development, while South Asia and Africa have a low level of economic development. The countries and regions along the Belt and Road are rich in natural resources, accounting for 57.9% of the global oil supply, 54.2% of the global natural gas supply and 70.5% of the global coal supply. Abundant natural resources can provide strong support for economic development and technological innovation, which however are not well utilized by local enterprises.

2.2 Characteristic Facts about Trade

A patent is a set of exclusive rights granted by law to an applicant for a new, non-obvious, and commercially applicable invention. A patent is an intangible asset that is characterized by novelty, utility, and exclusivity. First of all, the characteristic of patent novelty means that it is obviously different from the previous technology, so the product transformed by patent also has the characteristic of scarcity. This feature can make it easier for companies to create more wealth. Secondly, the practicality of patents means that patents have practical value that can be used. Enterprises can create positive social value by transforming intangible patents into stylish products. At the same time, value can also bring economic benefits to enterprises in the process of transformation. Finally, the exclusivity of patents makes it difficult or impossible for other enterprises to imitate and steal the technical knowledge in patents privately. Even if this happens, the patent holder can defend his interests through legal means and seek compensation. The above three characteristics increase the competitiveness and operation ability of enterprises holding patents in the market.

The number of patent granted is a dynamic reflection of technological innovation and patent advantage of a country and an enterprise. The number of patents granted refers to the number of patents granted to qualified patents, issued patent certificates, and registered and announced after the specific department has no objection to the patent application or the objection is not established after examination. According to the number of patents in 107 Countries along the Belt and Road in WIPO database in 2020, it is found that the total amount of licenses in countries along the Belt and Road is uneven.

First of all, from the distribution of patent licenses in different continents (as shown in Figure 1), the vast majority of patent licenses come from Asia, accounting for 74.49% of the total number of patent licenses in 107 countries, and nearly three-quarters of the total number of patent licenses in 107 countries. The least number of patents were granted from Oceania, accounting for 0.79% of the total applications from 107 countries.

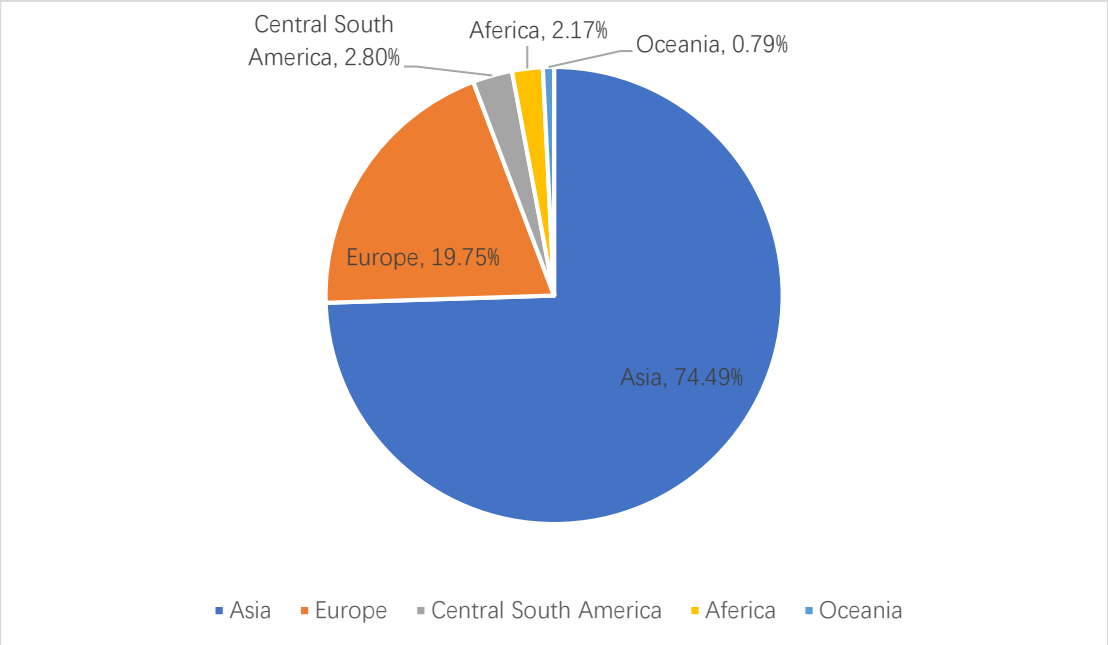

Figure 1. Proportion of Patent Licenses by Continent

By country, the vast majority of patents are granted in a few relatively rich countries. In 2020, there are six countries with more than 5000 patents authorized, of which South Korea has the largest number of applications, 134766, 4.68 times that of Russia, which ranks second. The number of patents granted in Italy is 9,152, while the number of patents granted in Malaysia, Indonesia and Singapore is 8,206, 7,981 and 5,386 respectively (see Figure 2).

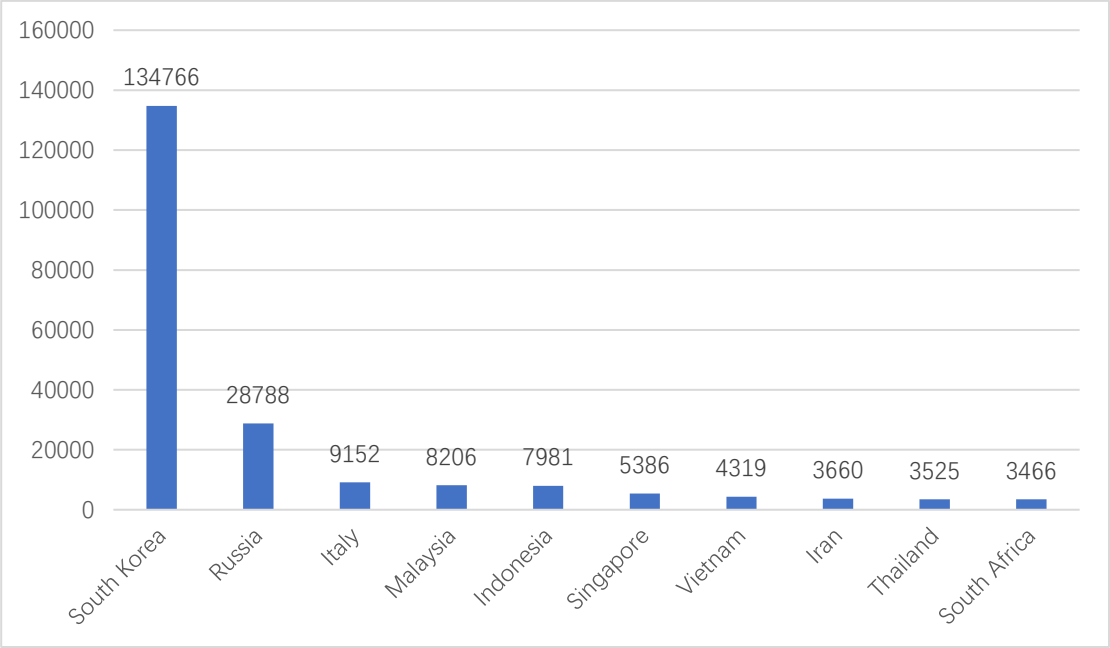

Figure 2. The Top 10 Countries along the Belt and Road in Terms of Total Patent Granting

However, from the perspective of the number of patents granted during 2016-2020, among the top 10 countries, Russia, Singapore and South Africa showed a downward trend in the number of patents granted, with an average growth rate of -3.01%, -6.01% and -4.02% respectively, while the other 7 countries showed positive growth (as shown in Table 2).

Table 1. Average growth rates of the top 10 countries in terms of patent grants 2016-2020

Countries	Average growth rate from 2016 to 2020
South Korea	4.36%
Russia	-3.01%
Italy	7.32%
Malaysia	19.81%
Indonesia	21.57%
Singapore	-6.01%
Vietnam	24.86%
Iran	2.29%
Thailand	13.91%
South Africa	-4.02%

3. Theoretical mechanism and research hypothesis

In order to achieve long-term and stable development, the Belt and Road Initiative should not only promote rapid economic growth in countries and regions along the Belt and Road, which however ignores the way of growth. Most of the countries along the Belt and Road are developing countries that lack innovation capacity. Although China is also a developing country, its comprehensive innovation capacity ranked 12th in the world by 2021. Compared with countries and regions along the Belt and Road, China's economy is more developed and its enterprises are more innovative. There are two main theoretical mechanisms for these countries and regions along the "Belt and Road" to realize technological upgrading in the process of economic exchanges with China.

(1) Learning Effect(learning by doing effect). In the course of engaging in economic activities with China, enterprises in countries and regions along the Belt and Road accumulate experience through "learning by doing", thus promoting enterprise innovation. This process is called learning effect. First of all, in order to gain competitive initiative in the highly competitive market, Chinese enterprises

pay more and more attention to technological upgrading at present, which also increases the opportunities for countries and regions along the Belt and Road to learn advanced technologies from cooperation with China. Taking trade export as an example, according to existing studies, the Belt and Road Initiative has effectively promoted the improvement of export quality of Chinese enterprises, and boosted the innovation and technology of trade export products (Lu Shengfeng). Under the circumstances of not investing a large amount of research and development expenses, enterprises in countries and regions along the Belt and Road can learn and absorb the techniques, technical knowledge and innovative ideas contained in China's export commodities through economic exchanges, which plays a role in promoting their technological upgrading. Second, after these countries signed the Belt and Road Cooperation agreement with China, a series of trade and investment barriers will be gradually lowered or even eliminated, which will promote the diversity of economic activities in countries and regions along the Belt and Road and China, increase the possibility of technology spillover among commodities, and provide more learning channels for local enterprises. Finally, through different modes of international entry, countries and regions along the Belt and Road can apply advanced production equipment from China, and local enterprises can rely on advanced production equipment to creatively produce more technical goods. Meanwhile, local enterprises can also learn from the operation mechanism of advanced equipment in daily production, imitate and creatively produce their own production equipment.

(2) Competition effect. The entry of Chinese enterprises with advanced technologies into the countries and regions along the Belt and Road will intensify the fierce competition in the local market, change the monopoly situation of some enterprises in the countries and regions along the Belt and Road in certain fields, and force them to upgrade their technologies. In this process, it is inevitable that some enterprises will be replaced, but the flow of production factors to enterprises with high innovation will lead to the withdrawal of these enterprises lacking innovation (Jiang Feng, Lan Qingxin and Zhang Hui, 2021). After that, these remaining enterprises must continue to upgrade technology, so as to enhance their competitiveness in the market and relieve the impact of fierce competition.

Based on the above theoretical analysis, the following hypotheses are proposed and tested:

H1: The Belt and Road Initiative will promote the technological upgrading of enterprises in countries and regions along the Belt and Road, and the number of patents granted by enterprises will significantly increase after the countries join the Belt and Road Initiative.

4. Empirical methods and analysis of empirical results

4.1 Building of econometric model

In recent years, the DID method of quasi-natural experiment has been widely used in the research involving the effect of policy implementation. The DID model can well mitigate the interference of other factors other than policy to the estimated results by applying DID model. The key step to estimate the actual effect of policy by using the differential method is to determine the time node when the policy takes effect.

For the determination of the time of policy impact, previous studies on the Belt and Road Initiative and technological upgrading mostly focused on China, and the policy implementation time was fixed. Therefore, scholars mostly chose 2014, the second year after the Belt and Road Initiative was put forward, as the time node when the policy came into effect. However, this paper focuses on the impact of the Belt and Road Initiative on the technological upgrading of countries and regions along the Belt and Road. These countries have joined the Belt and Road initiative at different times, and there is no unified policy impact node. Therefore, on the basis of previous research, this paper improved the measurement method and studied enterprises in different countries by constructing a multi-period DID model. According to the information of each country recorded by "China's Belt and Road Network", the second year of each country joining the "Belt and Road" is determined as the time node of policy impact.

In terms of model setting, this paper refers to the multi-phase differential model constructed by Si Chunxiao, Sun Shiyi and Luo Changyuan (2021), and identifies the promotion effect of the implementation of the Belt and Road Initiative on enterprise technology upgrading in countries and regions along the Belt and Road as follows.

$$\ln granted_{itj} = \alpha + \beta post_{itj} + \theta X_{itj} + \lambda_i + \mu_i + \varepsilon_{itj} \quad (1)$$

In the formula, i, t, j represents the company, year, and country; lngranted is the explained variable - The number of patents refers to the technological upgrading represented by the enterprise, and is specifically expressed as the number of patents authorized by the enterprise. The core explanatory variable is post. If company i's country j joins the Belt and Road Initiative in the i year, the value is 1 after the i +1 years (including the i +1 year); otherwise, it is 0. In the formula, X represents the group of control variables. Referring to the practice of Wang Guijun and Lu Xiaoxiao (2019), this paper controls the age, size, growth capacity and capital structure of enterprises. Enterprise age is represented by the natural logarithm of the difference between the data year and the establishment time of the enterprise; enterprise size is represented by the natural logarithm of the number of employees; growth is represented by the growth rate of turnover; and capital structure is represented by the asset-liability ratio of the enterprise. On this basis, this paper also controls the enterprise's R&D cost (research), which is expressed as the natural logarithm of enterprise's R&D investment. λ_i represents time fixed effect, μ_i represents the fixed effect of enterprises, ε is the random perturbation term. β is the coefficient of the core explanatory variable post, which represents the impact of the Belt and Road Initiative on the technological upgrading of enterprises after removing the interference.

4.2 Data description and descriptive statistics

Based on the availability of data, this paper selects a total of 8,000 enterprise samples from 52 countries that have signed cooperation documents with China to jointly build the Belt and Road. The sample was selected from 2013 to 2020, starting from the year when the Belt and Road Initiative was proposed, and ending from the latest data available in the database. The number of patents granted in the metering model is from BVD's Orbis Intellectual Property database. The control variables of enterprise age, number of employees, R&D expenditure, used to calculate balance sheet, and operating growth rate were obtained from Osiris database of BVD. The two pieces of data are matched by an ID unique to each enterprise in the BVD database. According to the practice of existing research, this paper proposes and deals with the samples with serious missing in financial and core variables. At the same time, relatively few countries and regions in the north of America have signed cooperation documents on the Belt and Road with China, and most of them are in Central and South America. In addition, due to many reasons, countries in the north of America are less likely to join the Belt and Road Initiative in a short time. Therefore, for the sample of America, this paper only considers countries in Central and South America. In addition, it should be noted that since the data of enterprise age, number of employees and R&D expenditure differ greatly and are scattered, this paper takes natural logarithm of enterprise age, number of employees and R&D expenditure during regression, in order to alleviate the possible problem of non-normal distribution. Table 2 presents descriptive statistics of the above variables.

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
lngranted	35128	2.215	1.526	0.693	7.152
lnage	35002	4.336	0.77	0	4.836
lnemployee	13019	6.384	2.12	0.693	13.404
lnresearch	14092	0.634	1.783	0	6.908
increaserate	28472	0.111	0.531	-0.77	3.9
debttoasset	20619	0.496	0.326	0.02	2.28

4.3 Empirical results

Referring to the multi-period DID model and data mentioned above, this paper adopts statistical software Stata to test the impact of the Belt and Road initiative on the technological upgrading of listed companies in participating countries and regions represented by the number of patent licenses. In the test process, the dependent variable patent authorization is reduced by 1% before and after. The empirical results are shown in Table 3. It can be seen from Table 3 that the regression coefficient of the core explanatory variable post is significantly positive, which indicates that the Belt and Road Initiative can significantly promote the technological upgrading of listed companies in participating countries and regions represented by the number of patent licenses, thus verifying theoretical hypothesis 1.

Table 3. Baseline regression result

VARIABLES	(1) lngranted
post	0.287***
	(3.59)
lnage	0.366
	(1.32)
lnemployee	-0.023***
	(-3.24)
lnresearch	0.012
	(1.52)
increaserate	0.026
	(0.86)
debttoasset	-0.023
	(-0.55)
Constant	0.987
	(0.81)
Observations	4,915
R-squared	0.875
Company FE	YES
Year FE	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.4 Robustness test

(1) Propensity score matching analysis was used to deal with the selection bias. Due to the different economic conditions of countries and regions along the Belt and Road, and the regional aggregation of listed companies in spatial distribution, there is a possibility of bias in the research samples selected in this paper. In order to alleviate this problem, this paper refers to the treatment method of Wang Xiongyuan and Bu Luofan (2019) and adjusts it. The enterprise age, number of employees, and R&D cost were used as first-order covariables, and the square term of enterprise age was used as second-order covariable to conduct propensity score matching. Then the regression in Table 3 was repeated with matched samples, and it was found that the coefficients of the core explanatory variables were still significant and positive, while the coefficients increased (the results are shown in Table 4).

Table 4. PSM-DiD Results

VARIABLES	(1) lngranted
post	0.287***
	(3.59)
lnage	0.376
	(1.35)
lnemployee	-0.023***
	(-3.21)
lnresearch	0.012
	(1.51)
increaserate	0.026
	(0.87)
debttoasset	-0.025
	(-0.59)
Constant	0.941
	(0.77)
Observations	4,904
R-squared	0.875
Company FE	YES
Year FE	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(2) The continents of participating countries were used for heterogeneity analysis. The geographical distribution of countries and regions participating in the Belt and Road Initiative is very uneven. Most of these countries are concentrated in Asia, central and Eastern Europe and Africa, and relatively few countries are located in North America. In order to eliminate the impact of uneven geographical distribution and further test the impact of the Belt and Road Initiative on the technological upgrading of enterprises in countries on different continents, this paper conducts heterogeneity analysis according to the geographical distribution of countries.

Table 4. Results of heterogeneity analysis

VARIABLES	(1) Asia	(2) Europe	(3) CS_America
post	0.417***	0.472***	0.765***
	(3.97)	(3.45)	(7.50)
lnage	0.538*	-0.930	4.720
	(1.83)	(-0.40)	(1.62)
lnemployee	-0.009	-0.024	-0.068***
	(-1.13)	(-1.51)	(-3.42)
lnresearch	0.022**	0.012	-0.023
	(2.41)	(0.85)	(-0.79)
increaserate	0.027	0.020	-0.072
	(0.76)	(0.39)	(-0.67)
debttoasset	-0.003	-0.114	0.182*
	(-0.05)	(-1.25)	(1.81)
Constant	0.030	7.286	-19.064
	(0.02)	(0.67)	(-1.40)
Observations	2,841	1,340	664
R-squared	0.892	0.897	0.837
Company FE	YES	YES	YES
Year FE	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As shown in Table 4, the Belt and Road Initiative can significantly promote the technological upgrading of listed companies in Asia, Europe, Central and South America, as represented by the number of patents granted. The sample of listed companies from countries and regions participating in the Belt and Road Initiative in Africa and Oceania is too small, so they are excluded from this part.

(3) OLS regression was used to test the coefficients of control variables. Through model replacement, the dependent variable was regressed with the 5 control variables selected, and the results were shown in Table 5. As can be seen from Table 5, the coefficient display is consistent with the hypothesis, and the verified results are still robust.

Table 5. OLS regression results

VARIABLES	(1) Asia
lnage	0.231***
	(9.40)
lnemployee	0.037***
	(4.26)
lnresearch	0.002
	(0.20)
increaserate	0.033
	(0.90)
debttoasset	0.070
	(1.23)
Constant	0.983***
	(8.02)
Observations	7,023
R-squared	0.016
Company FE	NO
Year FE	NO

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5. Conclusions and policy implications

5.1 Major conclusion

The Belt and Road Initiative is a great endeavor to build a community with a shared future for mankind. It is a great endeavor to promote the economic development of participating countries and regions and revitalize the world economy. Adhering to the principles of "peace, development, cooperation and win-win", China has provided countries and regions along the Belt and Road with unprecedented development opportunities and resources. However, some people with ulterior motives have been trumpeting the China threat theory, and there has been a clamour that the implementation of the Belt and Road Initiative will destroy enterprises along the Belt and Road. Based on the data of listed companies from 98 countries and regions participating in the Belt and Road Initiative from 2013 to 2020, this paper attempts to explore the impact of the Belt and Road Initiative on the technological upgrading of listed companies in participating countries and regions represented by the number of patent licenses by using a multi-period DID model. This paper mainly draws the following conclusions: First, the Belt and Road Initiative can significantly improve the technological upgrading of listed companies in countries and regions along the belt and Road, as represented by the number of patents granted. The results were significant even after the sample selection bias was treated with the score of propensity matching. In addition, this paper adopts the geographical location of enterprises to conduct heterogeneity analysis, and the results show that the

Belt and Road Initiative has significantly promoted the technological upgrading of listed enterprises in Europe, Asia, and Central and South America, as represented by the number of patent licenses.

5.2 Policy implications

The research conclusions of this paper provide theoretical support for the Belt and Road Initiative to promote the economic development of participating countries and regions, and have important policy implications for the high-quality construction of a "community with a shared future for mankind". First of all, China and the participating countries and regions should continue to strengthen dialogue and consultation with the gradual implementation of the Belt and Road Initiative, turn differences and conflicts into mutual trust and cooperation, strengthen trade cooperation relations, and achieve mutual benefit and win-win situation. Second, it is time to further consolidate and deepen economic cooperation between China and the participating countries and regions, so as to liberalize and facilitate trade and investment and expand the influence of the Belt and Road Initiative. Finally, as the Belt and Road Initiative continues to be implemented, countries should always adhere to the innovation-driven development strategy. More importantly, it is necessary for China to focus on and participate in the economic exchanges of low-tech industries between countries and regions, supplemented by effective policy support, so as to promote the technological upgrading of countries and regions along the Belt and Road and strive to build the Belt and Road into a high-quality development platform worldwide.

References

[1] He Li. Research on China’s Reverse Technology Spillover Effect of OFDI in Countries Along the “Belt and Road” [J]. Statistics and Decision, 2020, 36(06): 100-103. DOI: 10.13546/j.cnki.tjyjc. 2020.06.022.

[2] Jiang Feng, Lan Qingxin, Zhang Hui. China's exports promote the technological upgrading of the "Belt and Road": a study based on 88 participating countries [J]. World Economy, 2021, 44(12): 3-27. DOI: 10.19985/j.cnki.cassjwe.2021.12.002.

[3] Li Bing, Yue Yunsong, Chen Ting. Export and independent technological innovation of enterprises: An empirical study from enterprise patent data [J]. World Economy, 2016, 39(12): 72-94.

[4] Lu Shengfeng, Dong Ruyu, Ye Chusheng. Has the "Belt and Road" Initiative Promoted China's High-Quality Exports: Evidence from Micro-Enterprises [J]. China Industrial Economy, 2021(03): 80-98. DOI: 10.19581 /j.cnki.ciejournal.2021.03.012.

[5] Si Chunxiao, Sun Shiyi, Luo Changyuan. The effects of foreign capital creation and foreign capital transfer in free trade zones: A study based on the propensity score matching-double difference method (PSM-DID) [J]. World Economic Research, 2021(05): 9-23+134.DOI: 10.13516/j.cnki.wes.2021.05.002.

[6] Wang Guijun, Lu Xiaoxiao. The “Belt and Road” Initiative and the Upgrading of Chinese Enterprises [J]. China Industrial Economy, 2019(03):43-61. DOI:10.19581/j.cnki.ciejournal.2019.03.013.

[7] Wang Guijun, Zhang Hui. The Belt and Road Initiative and Chinese OFDI Enterprise TFP: The Perspective of Investment in Developed Countries [J]. World Economy, 2020, 43(05): 49-72.

[8] Wang Xiongyuan, Bu Luofan. International Export Trade and Enterprise Innovation: A Quasi-Natural Experiment Study Based on the Opening of "China-Europe Railway Express" [J]. China Industrial Economy, 2019(10): 80-98.

[9] Zhang Jie. Research on the Inhibitory Effect of Imports on Patent Activities of Chinese Manufacturing Enterprises [J]. China Industrial Economy, 2015(07): 68-83. DOI: 10.19581/j.cnki.ciejournal.2015. 07.005.

[10] Zhang Xiaojing, Wang Kangni, Li Jiao, Song Huike. Strategic thinking of Chinese enterprises "going out" under the background of "One Belt, One Road" high-quality development [J]. International Trade, 2020(01): 15-21. DOI: 10.14114/j.cnki.itrade.2020.01.004.Dixit, A. K., Stiglitz J. E. Monopolistic Competition and Optimum Product Diversity [J]. American Economic Review, 1997, (3): 297-308.

[11] Dixit, A. K., Stiglitz J. E. Monopolistic Competition and Optimum Product Diversity[J]. American Economic Review, 1997, (3): 297-308.

[12] Fritsch, U. and Görg, H. Outsourcing, Importing and Innovation: Evidence from Firm-level Data for Emerging Economies[J]. Review of International Economics, 2015,23(4):687–714.Doi:10.1111/roie.12187.

[13] Gereffi, G., Humphrey, J. and Sturgeon, T. The governance of global value chains[J]. Review of International Political Economy, 2005, 12(1):78–104.Doi:10.1080/09692290500049805.

[14] Goldberg, P. K., Khandelwal, A. K Pavcnik, N. and Topalova, P. Imported Intermediate Inputs and Domestic Product Growth: Evidence from India[J]. The Quarterly Journal of Economics, 2010,125(4), 1727–1767.Doi:10.1162/qjec.2010.125.4.1727.

[15] Hall, R. E. and Jones, C. I. Why do Some Countries Produce So Much More Output Per Worker than Others? [J]. The Quarterly Journal of Economics, 1999,114(1):83–116.Doi:10.1162/003355399555954.