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The Belt and Road, Open Innovation and Enterprise Innovation Performance——Moderated Intermediary Effect

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ABSTRACT

Based on the patent data of China's A-share listed companies from 2009 to 2021, this paper takes the quasi-natural experiment proposed by the "the Belt and Road" initiative as the entry point, and uses the double difference model to investigate the impact of the "the Belt and Road" initiative on enterprise innovation and its path of action. The main conclusions are as follows: First of all, the "the Belt and Road" initiative has significantly promoted the technological innovation of participating enterprises, and a series of effectiveness and robustness tests show that this promotion effect exists significantly. Secondly, the "the Belt and Road" initiative improves the innovation performance of enterprises by promoting open innovation of enterprises. Once again, through the moderation effect test, it was found that increasing digital investment by enterprises can promote open innovation and improve the innovation performance and quality of participating enterprises. Finally, from the heterogeneity analysis, it is found that the "the Belt and Road" initiative can promote the innovation and invention patent output of state-owned enterprises and eastern enterprises.

KEYWORDS

"The Belt and Road" initiative; Enterprise innovation; Open innovation; Enterprise digitalization

1. INTRODUCTION

Innovation is the primary driving force for development and the strategic support for building a modern economic system. The existing research mainly examines the impact of the "the Belt and Road" initiative on innovation from the following perspectives: (1) In terms of national innovation, there are existing literature on innovation cooperation networks [1, 2] Innovative cooperation models [3–5] Innovation evaluation indicators [6, 7] And other perspectives to explore the innovative development relationship between China and countries along the "the Belt and Road". (2) In terms of regional innovation, existing literature believes that the "the Belt and Road" has promoted the development of regions along the Belt and Road [8] Province [9, 10] City [11] Improvement of innovation efficiency and capability, but some scholars believe that the "the Belt and Road" initiative policy has not improved the innovation efficiency of provinces and cities along the line [12]. (3) In terms of industrial innovation, on the one hand, the "the Belt and Road" has promoted high-tech industries [13] manufacturing [14] Traditional Chinese Medicine Industry [15] Cultural industry [16] The improvement of innovation capabilities in industries. Only a few studies have studied the relationship between the "the Belt and Road" and enterprise innovation from the micro level, respectively from the perspective of enterprise survival environment, such as market competition [17] From the perspective of enterprise innovation investment, such as research and development funds [18, 19] R&D investment [20] R&D cost sharing [21] From the perspective of corporate investment, such as outward direct investment [21, 22] To explore the mechanism of the impact of the "the Belt and Road" on enterprise innovation, but few scholars have explored the mechanism of the change of

enterprise innovation model in the context of the "the Belt and Road" in the impact of the "the Belt and Road" initiative on enterprise innovation.

Based on this, this paper takes listed companies in Shanghai and Shenzhen stock markets as samples, and explores the impact mechanism of the implementation of the "the Belt and Road" policy on enterprise technological innovation from multiple dimensions, such as the direct and indirect impact of the "the Belt and Road" on enterprise innovation, and the moderating role of enterprise digitalization and absorptive capacity.

2. THEORETICAL FOUNDATIONS AND RESEARCH HYPOTHESES

2.1. "The Belt and Road", Open Innovation and Enterprise Technology Innovation

Open innovation was first proposed in 2003, defined as enterprises breaking through existing organizational boundaries, combining external knowledge and resources with their existing technologies and organizational strategies to promote innovation [23]. The implementation of the "the Belt and Road" initiative has accelerated the transformation of Chinese enterprises to open innovation. On the one hand, government departments have provided a large number of preferential policy support for enterprises participating in the construction of the "the Belt and Road", which has enabled domestic enterprises related to the "the Belt and Road" to participate in the construction of the "the Belt and Road", further promoting the integration of supply chains in related industries. The resulting supply chain integration effect is conducive to strengthening the cooperative innovation relationship between enterprises and promoting open innovation of enterprises [18]. On the other hand, enterprises can generate reverse knowledge spillovers in cross-border direct investment, and its positive role has been widely recognized [24]. Enterprises participating in the "the Belt and Road" will expand R&D investment scale, share R&D costs and risks, and promote the flow of personnel and knowledge through cooperation with governments or enterprises of countries along the line [25]. Therefore, this article proposes research hypotheses H1a and H2b.

H1a: The "the Belt and Road" initiative helps promote technological innovation of enterprises.

H1b: The "the Belt and Road" initiative promotes technological innovation of enterprises by promoting the transformation of enterprises' innovation model to open innovation.

2.2. The Regulatory Role of Enterprise Digitization

Enterprise digitization refers to the development of digital technology by enterprises to improve the quality and efficiency of data collection, transportation, processing, and application, optimize production operations, value chains, and services, and create an enterprise environment centered on digital operations [26]. Digitalization of the industry means more use of technologies such as artificial intelligence, cloud computing, blockchain, and big data to help enterprises acquire and integrate resources, break down organizational barriers, and alleviate the problem of insufficient innovation resources [27]. Secondly, it can effectively improve the existing operational departments, enhance enterprise operational efficiency, reduce operational costs, make departmental communication more concise and efficient, and promote the enhancement of the enterprise's ability to learn, absorb, and output knowledge [28]. In addition, enterprises' open innovation in the construction of the "the Belt and Road" will generate search costs [29]And collaboration costs [30] Enterprises with higher levels of digitalization strengthen cooperation between enterprises, making it easier for them to obtain heterogeneous knowledge elements. At the same time, it can promote the interaction and integration of their own knowledge and external knowledge, reduce learning and identification costs, and benefit from collaborative innovation between enterprises [31], which helps enterprises to innovate in technology. Therefore, this article proposes the following assumptions:

H2a: Enterprise digitalization has a positive moderating effect on open innovation in the front end of the intermediary effect between the "the Belt and Road" and enterprise innovation.

H2b: Enterprise digitalization has a positive moderating effect on the back end of the mediating effect of open innovation between the "the Belt and Road" and enterprise innovation. As shown in Figure 1.

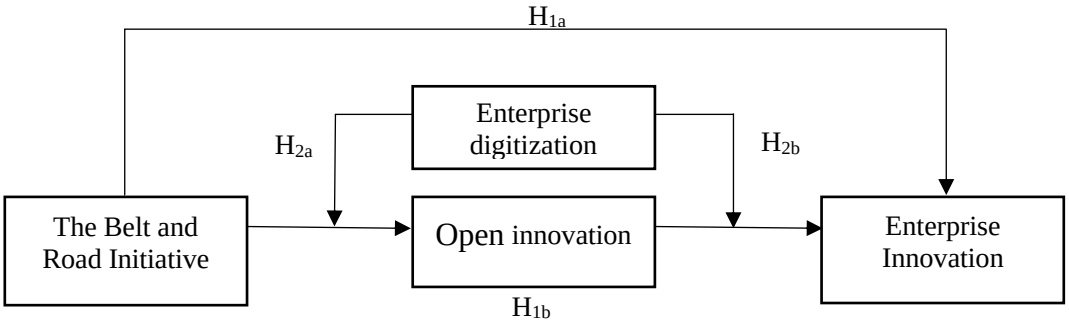

Figure 1. The theoretical model of "the Belt and Road" and enterprise innovation

3. RESEARCH DESIGN

3.1. Measurement Model Setting

3.1.1. Benchmark model

This article uses a double difference model, with reference to Xu Si et al [32] Select the listed enterprises in the "the Belt and Road" concept section of the Tonghua Shun stock trading software as the experimental group, that is, the enterprises affected by the "the Belt and Road" initiative, and all other listed enterprises as the control group. The benchmark regression model is set as follows:

$$lnapp_{it} = \beta_0 + \beta_1 treat_i \times post_t + \beta_2 X_{it} + u_i + u_t + \varepsilon_{it} \quad (1)$$

Where i and t represent each enterprise and year, respectively, $lnapp_{it}$ represents the innovation level of enterprise i at time t, $treat_i$ is a virtual variable for enterprise grouping, $post_t$ is a virtual variable for the treatment effect period, X_{it} is a control variable that affects enterprise innovation, u_i is an individual fixed effect, u_t is a time fixed effect, and ε_{it} is a robust standard error fixed to the enterprise level.

3.1.2. Mediation effect

This article refers to Wen Zhonglin et al[33]The mediation effect test program constructed on the basis of Bootstrap test identifies the transmission mechanism of the impact of the "the Belt and Road" initiative on enterprise innovation.

$$open_{it} = \alpha_0 + \alpha_1 treat_i \times post_t + \alpha_2 X_{it} + u_i + u_t + \varepsilon_{it} \quad (2)$$

$$lnapp_{it} = \gamma_0 + \gamma_1 treat_i \times post_t + \gamma_2 open_{it} + \gamma_3 X_{it} + u_i + u_t + \varepsilon_{it} \quad (3)$$

Among them, $open_{it}$ is the level of open innovation of enterprise i in t, representing the mediating variable.

3.1.3. Mediating effect with regulation

This article refers to Wen Zhonglin et al [34] The proposed method for testing the moderating mediating effect of enterprise digitalization is to construct models (4) to (5) to verify the moderating effect of enterprise digitalization.

$$open_{it} = b_0 + b_1 treat_i \times post_t + b_2 lndig_{it} + b_3 treat_i \times post_t \times lndig_{it} + b_3 X_{it} + u_i + u_t + \varepsilon_{it} \quad (4)$$

$$lnapp_{it} = c_0 + c_1 treat_i \times post_t + c_2 lndig_{it} + c_3 open_{it} + c_4 lndig_{it} \times open_{it} + c_3 X_{it} + u_i + u_t + \varepsilon_{it} (5)$$

Among them, $lndig_{it}$ is the digitalization level of enterprise i at time t, representing the moderating variable. $treat_i \times post_t \times lndig_{it}$ represents as the interaction term between explanatory variables and moderating variables. $lndig_{it} \times open_{it}$ represents the interaction term between moderating variables and mediating variables.

3.2. Variable Measurement and Data Sources

3.2.1. Enterprise innovation

This article uses the number of enterprise patent applications (lnapps) as a proxy variable for enterprise innovation for regression analysis. At the same time, in order to better measure the substantive innovation ability of enterprises, this article excludes enterprise design patents.

3.2.2. "the Belt and Road" Initiative ($treat_i \times post_t$)

When the enterprise is affected by the "the Belt and Road" initiative, $treat_i$ is 1; when the enterprise is not affected by the "the Belt and Road" initiative, $treat_i$ is 0. $post_t$ of 1 (2015-2021) for the current and future years, and $post_t$ of 0 (2009-2015) for the previous years.

3.2.3. Open innovation

This article uses Katila and Ahuja [35] And Wang et al [36] The approach of using the ratio of joint patent applications and total patent applications of sample companies in t-1, t-2, and t-3 years as a measure of open innovation.

3.2.4. Enterprise digitization

This article uses data from Guotai An Database on the digital transformation of Chinese listed companies to measure their level of digitalization.

3.2.5. Control variables

We controlled for variables such as company age, company size, company capital structure, and urban population size, as shown in Table 1.

Table 1. Specific Variable Definition

type	name	Symbol	Variable definition
Dependent variable	Enterprise patent application Enterprise patent authorization	lnapp lnpat	Ln (sum of invention patent and utility model patent applications+1) Ln (sum of invention patent and utility model patent authorizations+1)
Mediating variables	Open innovation	Open	Joint patent applications/total number of patent applications
Adjusting variables	Enterprise digitization	lndig	Ln (frequency of digital transformation words in enterprise annual reports+1)
control variable	Enterprise scale	Size	Ln (total assets)
	Enterprise age	Age	Ln (observation year establishment year)
	Corporate capital structure	Cap	The asset liability ratio is equal to the total liabilities of the enterprise/the total assets of the enterprise multiplied by 100%
	Enterprise asset return rate	Ret	Asset return rate, equal to the enterprise's pre tax profit/average assets multiplied by 100%
	Corporate cash ratio	Cash	The cash ratio is equal to the enterprise's cash assets/current liabilities multiplied by 100%
	Enterprise Human Capital Return	Hum	The return on human capital is equal to the company's net profit/employee compensation and benefits multiplied by 100%
	Urban economic scale	Gdp	Ln (Gross Domestic Product of Cities)
	Urban population size	Pop	Ln (total urban population)

3.2.6. Sample selection and data sources

This article uses A-share listed companies in Shanghai and Shenzhen from 2009 to 2021 as samples, excluding financial companies, delisted companies, missing data, and ST and ST * samples, and finally obtains 27294 observations from 3268 listed companies. Enterprise data is sourced from CNRDS and CSMAR databases. In order to eliminate the influence of extreme values on the estimation results, all variables were truncated. This article adopts robust standard error estimation for all regressions.

3.2.7. Descriptive statistics

The descriptive statistical results show that compared with the "the Belt and Road" initiative, the average value of enterprise patent applications and authorizations after the "the Belt and Road" initiative has increased. The experimental group is larger than the control group, but the standard deviation of enterprise patent applications and authorizations in the experimental group has decreased, while the control group has increased, indicating that the "the Belt and Road" has a positive impact on enterprise innovation.

4. EMPIRICAL ANALYSIS

4.1. DID test Results and Analysis

Table 2 reports the DID regression results of whether the "the Belt and Road" initiative has promoted Chinese enterprise innovation. The results show that the "the Belt and Road" initiative has significantly promoted the increase in the number of patent applications of enterprises participating

in the "the Belt and Road" initiative. After considering the control variables at the enterprise level and the city level, the participation in the "the Belt and Road" construction has increased the number of patent applications of enterprises by about 12%.

Table 2. DID Inspection Results

Lnapp	(1)	(3)
Treat×post	0.162** (0.071)	0.122* (0.066)
Constant	1.526*** (0.031)	-9.113*** (1.003)
Controls	No	Yes
Year	Yes	Yes
Id	Yes	Yes
N	27293	27293
Adj-R2	0.270	0.321

Note: *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively. The values in parentheses represent robust standard errors, and the table below is consistent.

4.2. Parallel Trend Test

This article conducted a parallel trend test, and the test results are shown in Figure 2.

$$lnapp_{it} = d + \sum_{k=-4}^{k=6} \beta_k \times D_{i,t_0+k} + u_i + u_t + \varepsilon_{it}. \quad (7)$$

Among them, $D_{i,t_0+k}$is a series of dummy variables. t0 represents the first year that enterprise i is affected by the the Belt and Road Initiative, and k represents the kth year after the promulgation of Vision and Action. During the period of k<0 (2011-2014), $\hat{\beta}$ was relatively stable, indicating that there was no significant difference between the experimental group and the control group before that. However, since k=0 (2015), $\hat{\beta}$began to rise significantly, indicating that the "the Belt and Road" significantly promoted the innovation of enterprises participating in the "the Belt and Road".

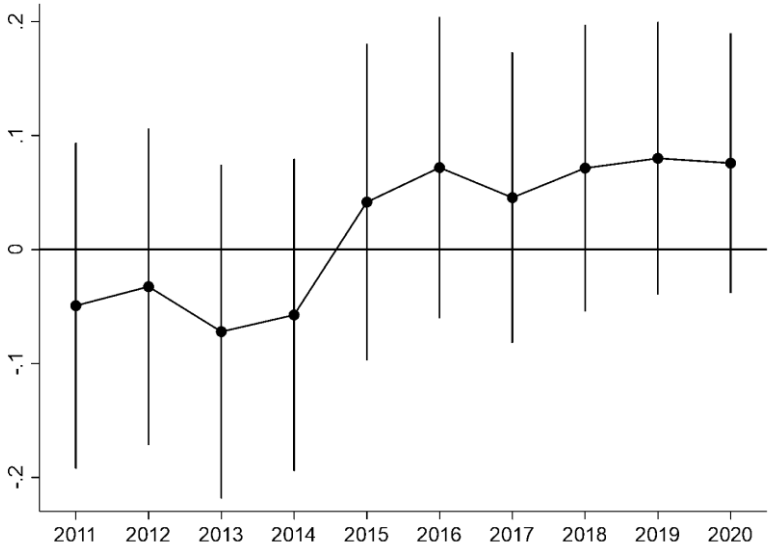

Figure 2. Parallel trend test result chart

4.3. Instrumental Variable Method

This article refers to Yu Changlin and Meng Xiangxu [18] When studying the approach of the "the Belt and Road" to enterprise innovation, whether the enterprise is an infrastructure industry is used as the tool variable of the policy grouping (Treat). The regression results are shown in Table 3. The results show that the "the Belt and Road" initiative can still promote enterprise innovation after addressing endogeneity.

Table 3. Regression results of instrumental variable method

variable	First stage regression	Second stage regression
	Treat×post (1)	Lnapp (2)
Iv×post	0.073***	
	(0.007)	
Treat×post		3.058*
		(1.799)
Controls	No	Yes
Year	Yes	Yes
Id	Yes	No
N	27293	27293
LMstatistic	52.98 (p-value=0.000)	
Fstatistic	54.659 (p-value=0.000)	

5. ROBUSTNESS TESTING

This article changes the indicators of enterprise innovation agency and conducts robustness tests using placebo tests. One is to use the natural logarithm of the total number of authorized invention patents and utility model patents plus one as the dependent variable. The results are shown in column (1) of Table 3. The second is to change the policy timeline. Advance the policy timeline by 1 year, 2 years, and 3 years respectively, and test it by constructing virtual time variables, as shown in columns (2) to (4) of Table 3. The third is to change the experimental group from the control group. 346 companies were randomly selected as the experimental group, and the coefficient of treat x post was observed, as shown in Figure 3. The core conclusion remains robust.

Table 4. Changes in Enterprise Innovation Agency Variables and placebo test Regression Results

Lnapp	(1)	(2)	(3)	(4)
Treat×post	0.111*			
	(0.065)			
Treat×post2014		0.105		
		(0.066)		
Treat×post2013			0.085	
			(0.068)	
Treat×post2012				0.085
				(0.075)
Constant	-7.535***	-9.103***	-9.088***	-9.074***
	(0.995)	(1.003)	(1.002)	(1.002)
Controls	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Id	Yes	Yes	Yes	Yes
N	27854	27293	27293	27293
Adj-R2	0.265	0.321	0.321	0.321

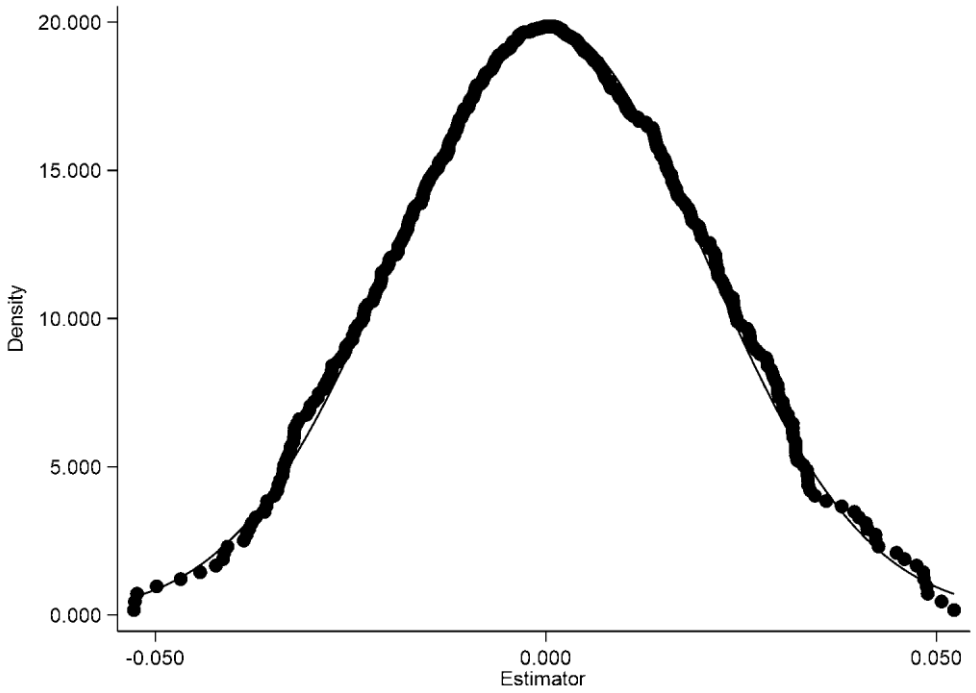

Figure 3. False estimation coefficient

6. MECHANISM VERIFICATION

6.1. Mediation Effect Analysis

The regression results are shown in Table 5. Among them, the regression coefficient of column (1) is 0.122, which means that the total effect of the "the Belt and Road" initiative on promoting enterprise innovation is 0.122. In column (2), the coefficient of the interactive item Treat × post is significant and positive, indicating that the "the Belt and Road" initiative has significantly promoted the open innovation of Chinese enterprises. The results in column (3) show that the regression coefficient of open innovation is 0.157 and significant at the 5% significance level, indicating that open innovation has a significant incentive effect on enterprise innovation, verifying hypothesis H1b.

Table 5. Results of Open Innovation Mediation Test

variable	Lnapp	Open	Lnapp
	(1)	(2)	(3)
Treat×post	0.122* (0.066)	0.021* (0.013)	0.118* (0.065)
Open			0.157** (0.066)
Constant	-9.113*** (1.003)	-0.101 (0.163)	-9.097*** (1.002)
Controls	Yes	Yes	Yes
Year	Yes	Yes	Yes
Id	Yes	Yes	Yes
N	27293	27293	27293
Adj-R2	0.320	0.006	0.321

6.2. Analysis of Moderated Mediating Effects

To test how enterprise digitalization can adjust the mediating effect between the "the Belt and Road" initiative and enterprise innovation (the first half path and the second half path), the results are shown in Table 6.

Table 6. Mediating effects with regulation

variable	Open	Lnapp
	(1)	(2)
Treat×post	-0.002 (0.016)	0.117* (0.065)
Lndig	0.001 (0.002)	0.009 (0.012)
Open		0.154** (0.068)
Treat×post×lndig	0.015** (0.007)	
Lndig×open		0.000 (0.002)
Constant	-0.081 (0.164)	-9.027*** (1.004)
Controls	Yes	Yes
Year	Yes	Yes
Id	Yes	Yes
N	27293	27293
Adj-R2	0.007	0.321

In column (1), the coefficient of the interactive term "Treat × post × lndig" between the "the Belt and Road" initiative and enterprise digitalization is 0.015, and in column (2), the coefficient of innovation openness Open is 0.154, both of which are significant at the level of 5%, indicating that the positive moderating effect of enterprise digitalization in the first half of the path is significant. The coefficient of the "the Belt and Road" initiative Treatment × post in column (1) and the coefficient of the interaction item Lndig × open of enterprise digitalization and open innovation in column (2. To sum up, if H2a is established and H2b is not, that is, the improvement of enterprise digitalization level can improve the incentive effect of the "the Belt and Road" initiative on enterprise open innovation, thus promoting enterprise innovation.

7. RESEARCH CONCLUSION

The research findings of this paper are as follows: (1) The "the Belt and Road" initiative has significantly promoted the technological innovation of participating enterprises. After a series of robustness tests such as placebo, replacement of dependent variables, and endogeneity, the conclusions remain unchanged. (2) The mediation effect shows that the "the Belt and Road" initiative can promote technological innovation of enterprises by promoting open innovation of enterprises. (3) The moderating intermediary effect shows that the higher the level of enterprise digitalization, the more open innovation of enterprises can be promoted by the "the Belt and Road" initiative, and then the technological innovation of enterprises can be promoted.

CONFLICTS OF INTEREST

The author promises that there is no conflict of interest in this article.

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