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THE INFLUENCE MECHANISM OF OUTWARD FDI REVERSE TECHNOLOGY SPILLOVERS ON CHINA'S GREEN INNOVATION

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Abstract. With rapid global development, outward foreign direct investment (FDI) has become a controversial issue, mainly focused on whether it is helpful to domestic green innovation, especially in developing countries. How does outward FDI reverse spillover technology to China, and does China's innate endowment restrict it? The relevant mechanisms remain unclear. Therefore, this study investigated the heterogeneous effect of absorptive capacity on the impact path of reverse technology spillovers of outward FDI on green innovation in China. A fixed-effects panel model and stepwise regression analyze the direct relationship between outward FDI and green innovation and the mediating relationship of absorptive capacity. Threshold analysis reveals the mutation point of the mediating effect of absorptive capacity among China's 31 provinces. Domestic green innovation is directly stimulated by more significant reverse technology spillovers of outward FDI. Absorptive capacity has an indirect impact as an intervening variable. The mediating effect will only make sense on one side of the threshold because the transformation effectiveness of green innovation is improved only by greater absorptive capacity, including adequate green financial support, more outstanding human capital, and a smaller technology gap. Moreover, it revealed significant regional heterogeneity in China.

Keywords: outward foreign direct investment, reverse technology spillovers, green innovation, absorptive capacity, mediating threshold effect.

JEL Classification: F21, O13, O15, O18, O31.

Introduction

Undoubtedly, outward foreign direct investment (FDI) has remained a global technology and development concern for decades. Recently, the flow and stock of outward FDI generated from developing countries have become unignorable in international activities. The

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reports of UNCTAD show that China's outward FDI flow ranked fourth globally in 2019, and it maintained the first position among developing countries, accounting for almost 30% of the total. Since 2009, Chinese outward FDI has surged to a new level, increasing 1.4 times in the overall outward FDI from 2009 to 2019. Outward FDI has become an effective way for developing countries to seek resources and catch up with cutting-edge technology (Piperopoulos et al., 2018). Meanwhile, implementing the Green Economic Transition and Development Strategy has forced China to accelerate the transformation of economic mode and green production. Under tight resource constraints and environment severe pollution, green innovation that emphasizes innovation-driven, energy-saving, and emission-reduction has attracted much attention and will play a more critical role.

Therefore, considering the particular period of green and sustainable economic transition, outward FDI is likely to have a considerable impact on upgrading China's green technology innovation level. Such outward FDI has significantly impacted home countries, known as the reverse technology spillover effect (Hao et al., 2020), which renews our interest in the pattern of its effect paths. As the environmental impact of economic activity is primarily determined by technology, this possible link could be crucial to the progression of society towards ecological sustainability, especially for China, the largest energy consumer, and which urgently aims to implement measures to seek coordination between economic development and pollution reduction (Pan et al., 2018). However, reverse technology spillover by outward FDI may not be absorbed by the home country because it likely depends on the original absorptive capacity (Siotis, 1999). Transfer and imitation can occur when the innate endowment of a region reaches a certain level, referred to as the threshold value. Therefore, this study explores the causality between outward FDI and domestic green innovation as thoroughly as possible and takes the role of absorptive capacity into account.

The seminal work of Kogut and Chang (1991) provides empirical evidence of the reverse technology spillovers arising from outward FDI. Japanese investment in the United States can spur innovation in manufacturing itself, thereby improving competitiveness. Partly in response to Kogut and Chang (1991), there is only mixed empirical evidence concerning positive reverse spillovers arising from outward FDI. Moreover, results on the impact of outward FDI on green innovation are also unclear. A certain degree of divergence may be attributed to the different absorptive capacities of the home countries. However, previous studies on absorptive capacities, such as green financial support, human capital, and government cost, generally focus on a single domestic country without considering regional or feature heterogeneity. In particular, to the best of our knowledge, there is no research on the threshold characteristic of the mediating effect of absorptive in the impact of outward FDI on green innovation. We discuss the literature in more detail in section 3. Thus, statistical evidence is needed to demonstrate the actual link between reverse technology spillovers of outward FDI and innovation.

We provide evidence of the determinants of green innovation activities in China. Our empirical investigation focuses on the mechanism by which outward FDI spillover technology reverses to the domestic country, including both the direct and indirect paths, and the threshold characteristic of the mediating effect achieved by absorptive capacity. We first examine the relationship between Chinese outward FDI and innovation, considering the intervening variables, using the stepwise regression method and the bootstrap test developed by Wen and Ye (2014). This allows us to explore the situation of outward FDI at the country level and construct the foundation for the follow-up study. We further test the threshold feature of intervening variables, including green finance, relative technology level, and human capital, providing evidence about how the home country's absorptive capacity contributes to reverse green technology spillovers. Moreover, we divided China into four regions, the eastern, western, central, and northeastern regions, to explore empirical results at the provincial level. Therefore, this study is significant in explicitly accounting for the direct and indirect causal links between innovation and outward FDI.

Against this background, this study adds to the literature in the following ways. First, we investigate the performance of green innovation when outward FDI impacts it. Thus, we employ the number of green patents as green innovation in the form of green patent applications and authorization to produce more accurate results in representing domestic green innovation. Previous studies tend to represent green total factor production (GTFP) as green innovation; it is fraught with inaccurate accounting for innovation features, thus producing spurious results that are unreliable for policymaking. Second, it adds to the existing literature on reverse green technology spillovers by characterizing the threshold mediating effect of absorptive capacity, which further provides a comprehensive picture of the structure. Unlike previous studies on the single direct causal relationship, we are particularly interested in uncovering contemporaneous direct and indirect causality via the threshold method based on the observed correlations. Finally, our study illustrates the distribution of whether Chinese provinces cross the thresholds of capacity to help understand the unbalanced level among the four regions of China.

The remainder of this paper is organized as follows. Section 1 briefly reviews the literature on the relationship between outward FDI and innovation. Section 2 describes the analysis of the mechanism. Section 3 explains our approach to measuring innovation, reverse technology spillovers of outward FDI, and absorptive capacity. This section also provides descriptive statistics. In Sections 4 and 5, we present, explain and discuss the results. Finally, concluding remarks are provided in the last section.

1. Literature review

From the perspective of reverse green technology spillover, this study examines the impacts of outward FDI on environmental innovation in 31 provinces. Further, we study the mediating effects and threshold effects of the host country's green financial level, relative technology level, human capital based on the technology gap theory and resource-based view.

Outward FDI provides transmission channels for environmental-friendly technologies (Zarsky, 1999) and advanced energy-saving practices (Albornoz et al., 2009) and has attracted the attention of academic circles for many years. Kogut and Chang (1991) first confirmed the critical assumption of outward FDI's reverse technology spillover to the home country, finding that Japan's outward FDI in the USA was mainly concentrated in technology-intensive industries, which can reversely improve Japanese technology. This pioneering work inspired exploring the reverse technology spillover effect of outward FDI. However, there is scant research studying the impact of outward FDI on green innovation in the home country, which can be divided into three categories.

Some scholars confirmed that outward FDI has a positive impact on green innovation. Outward FDI of developed countries is found to be a representative sample due to the dominant position among the global, transnational investment for a long time. Developed countries obtain reverse technology spillovers to expand their economy significantly by making full use of worldwide geographical advantages, which means they locate kinds of intensive industries globally (Desai et al., 2009; Herrigel, 2015; Simpson, 2012). Driffield et al. (2009) make a similar conclusion to Kogut and Chang (1991) using the UK manufacturing industry-level data. This pioneering work inspired the exploration of outward FDI. The positive effect of outward FDI is also found to respond to technology in other high-income countries. Estonia's manufacturing and service industries could improve their production level through outward FDI, which means the parent companies could benefit from it (Vahter & Masso, 2006). Among the OECD countries, G7 can be benefited more from outward FDI than non-G7 countries (Bitzer & Kerekes, 2008). Besides not only OECD countries, outward FDI of other highly competitive countries (Singapore, Israel, etc.) can increase the number of patents of the home country and improve the innovation level (Chang et al., 2013). As for emerging countries, especially China, scholars found much evidence focusing on positive green innovation. Gong et al. (2017) concluded that outward FDI plays a significant role in promoting the efficiency of green industrial innovation through the structural scale effect, optimization effect, and resource allocation effect. Jia et al. (2017) found that outward FDI, whether invested in developed or developing countries, could effectively promote the green innovation level of home countries. Using data from 11 provinces and cities in China's Yangtze River Economic Belt, Kong et al. (2019) showed that the reverse technology spillover of outward FDI by Chinese enterprises could significantly improve green technology innovation but was indirectly hindered by market segmentation. Zhu et al. (2019) believed that the positive impact of outward FDI on green innovation could affect neighboring provinces through the spatial spillover mechanism.

Contrary to the above view, some other scholars argued that outward FDI has no significant or negative impact on promoting the home country's green innovation level. For some countries, such as India and Bangladesh, the research results are not as expected. The overseas expansion activities of the Indian automobile industry are located in both developed and developing countries, but none have a positive reverse spillover effect. In other words, there is no significant evidence that Indian outward FDI can improve its technological level (Pradhan & Singh, 2008). Based on the DEA method's measurement of green technology innovation efficiency, Luo and Liang (2017) indicated that the R&D capital of outward FDI has a crowding-out effect on domestic investment, which impedes the upgrading of green technology innovation efficiency. Zheng and Ran (2018) calculated the green total factor productivity and found that outward FDI inhibits China's green innovation.

Finally, some hold that outward FDI has a non-linear effect on green innovation. Due to different research selections, such as the conditions of the home country and host country and the motivation for investment, the results also showed many large differences. Due to the different features of developing and developed countries, such as economy, industrial structure, and resource endowment, the motivation of their outward FDI seems to be significantly different, too. The investment motivation of developing countries (such as China) is often to seek strategic assets and make up for the competitive disadvantage in the international market (Fosfuri et al., 2001), while the developed countries aim at new, advanced technology (Zhou et al., 2019). Therefore, it is not rigorous to use the research conclusions of outward FDI from developed countries to represent that of developing countries. Moreover, the spillover effect on green innovation varies among developing countries. Several empirical studies shed light on the reverse spillover effect of developing countries and found that whether the reverse technology spillover effect exists is not sure. Even if developing countries can improve production efficiency through foreign investment, the promoting effect is different due to the differentiated characteristics themselves (Dreger & Herzer, 2013). The Indian automobile industry is failed to be proved that the innovation level could be benefited from both developed and developing countries (Pradhan & Singh, 2008). On the contrary, the outward FDI of Bangladeshi garment enterprises has a positive spillover effect on its parent company's productivity and production range (Kee, 2015). But for the other emerging developing economies with progressive potential, outward FDI could lead to technology transfer. Researchers find that these countries tend to choose developed countries as target investment places due to the strong demand for high-technology knowledge (Chen et al., 2012). And a few scholars try to explain this phenomenon as a nonlinearity relationship. Hu et al. (2016) empirically investigated the effects of outward FDI on green total factor productivity (TFP), showing a specificprovincial heterogeneity. Outward FDI promotes the green TFP of most provinces but also causes apparent adverse effects on some provinces. Based on China's provincial-level data, Yang et al. (2017) found that the impact of outward FDI on green TFP presents nonlinearity and shows significant regional differences.

Under the trend of globally sustainable development, it becomes necessary to improve the green innovation capacity of a country for sustainable development objectives. Technological innovation is considered a fundamental approach to transforming economic growth mode, which can invent new green products, help reduce pollution emissions, and improve the cleaner-production process. Thus, the innovation-driven and green development approaches to coordinate economic, societal, and environmental development are of broad interest to the sustainability community. Amendolagine et al. (2021) present a comprehensive review of green innovation. Then Cassiman and Golovko (2018) supported that investment flows promote the global innovation level. Some research also empirically investigated that green investment significantly improves green productivity using empirical green patents quantity and their business value data (Stiebale, 2016; Melane-Lavado et al., 2018). And some scholars analyze it at the micro-level, Maksimov et al. (2019) claim that MNEs can make the green transition more easily than other firms. Jia et al. (2017) used the amount of authorized green patent to represent green technology innovation, and proved that outward FDI with different motivations all has a positive impact on green innovation.

However, according to the literature review above, there is still much room for research on whether the reverse spillover of outward FDI could positively impact the green innovation of home countries. Moreover, the technological spillover effect of outward FDI mainly focuses on the green innovation transformation is few. Jia et al. (2017) is a representative research that explore green innovation using green patent, but we think that this research focuses on the external impact of environmental regulation and lacks a multi-angle study on the impact path of outward FDI. We extend outward FDI pieces of literature by analyzing its impact on the green innovation of the host country, which will have significant implications for policy-makers to formulate foreign investment policies. We establish how outward FDI overspills directly and indirectly affects the home green innovation effort. Consequently, the questions under consideration in this paper are: What are green spillovers derived from outward FDI? How does it happen? What factors or conditions can make the home countries prone to green innovation? To better answer these questions, it is vital to understand the complex interactions between outward FDI's spillover effect and innovation capacity.

The research results of the relationship between outward FDI and green innovative activity depend on the characteristics of the home country, such as the level of an economy, industrial intensity, and R&D capital expenditure. That is one of the reasons to explain the divergence that appeared in the underdeveloped home countries, while it nearly happened when it comes to the developed countries. Only when outward FDI is located in developed or developing countries with sound economic foundations, which will help absorb new knowledge effectively, can it spill technology to the home country (Li & Liu, 2012). Borenztein et al. (1998) called this phenomenon the "threshold effect". Developed countries are generally better in absorptive capacity, but other developing countries have significant differences. If we consider the comprehensive capabilities, developing countries could be divided into central countries, high-income countries, low-income countries or emerging countries, less developed countries, etc. Therefore, we hypothesize a non-linear relationship between outward FDI and the green innovation level of the home country. In other words, we speculate that only when the critical characteristics of the home countries reach a certain level can outward FDI play a role in promoting the technological called threshold effect.

Since the late 1970s, China has achieved remarkable economic progress, partly because of the technological progress that benefited from international investment, especially outward FDI. Chinese attitude towards international activities has experienced three stages: "attracting FDI," "expanding outward FDI," and "the combination of FDI and outward FDI." Therefore, using China as a research sample is of great research significance to clarify whether and how outward FDI could impact the home country. When foreign media mention the outward FDI from China, the highest GDP, and the enormous number of foreign investment in developing countries, they tend to focus on its impact on the host country (Zhou et al., 2019). There is only limited research focus on how Chinese outward FDI affects itself. However, a small line of studies shed light on Chinese outward FDI and its impact on Chinese technological innovation and productivity development without a unified conclusion due to research methods and samples. That means there is no irrefutable evidence that Chinese outward FDI contributes to domestic innovation efficiency, which is related to the development level of the host country (Piperopoulos et al., 2018), and the different outward FDI modes (Clegg et al., 2016). We explore the threshold characteristic between Chinese outward FDI and innovation using Chinese data on three absorptive capacities, financial development, relative technology level, and human capital during 2003–2017.

The financial system's development helps promote innovation performance (Alfaro et al., 2009). It plays an intermediary role in the process of technology commercialization (Choong, 2012). On the one hand, a sound financial system, a major fund source for multinational corporations, could help invest in constructing production facilities and the daily operation of enterprises in the host country. On the other hand, adequate funds provide financial support for R&D, contributing enterprises to absorbing and exchanging new technologies to their advantage (Hermes & Lensink, 2003). But when bringing Chinese financial development into the scope of the study, Chen (2011) found that an advanced financial system could not help the absorption of reverse technology spillovers. The probable reason could be that financial development will help outward FDI spillover only when it crosses the threshold (Li & Liu, 2012).

We take the relative technological level between the home country and the host country as a vital factor because of its impact on absorbing new technologies in the home country. Some research finds that overseas subsidiaries see high-tech corporations as a natural model for technology learning because of the technology gap. The larger the technological gap, the greater the space exists for the progress of technology-backward countries, which is conducive to the transfer of reverse technology spillovers (AlAzzawi, 2012). Conversely, the other scholars report a negative relationship of the same topic. They confirm that the technological gap is so large that it could not help the technology-backward countries learn, for they do not have enough learning ability to match the new technology. Besides, their backward markets and infrastructures will also constrain learning (Seyoum et al., 2015). Therefore, we speculate that the relative technological level on the two sides of the threshold has different effects.

Human capital is a significant capacity for the home country to identify, absorb and apply new knowledge (Li et al., 2016). Many scholars regard it as the absorptive capacity to investigate its influence on reverse technology spillovers of outward FDI. There is evidence that companies with a higher level of human capital learn technology faster than those with a lower level (Filippetti et al., 2017). However, human capital does not always play a positive role, similar to the above two absorptive capacities. For example, multinational enterprises in the United States can transfer technology to their home countries and profit from it, except when the human capital is below the threshold (Xu, 2000). The threshold phenomenon exists for developing countries (Borensztein et al., 1998).

Our study contributes to the existing literature in the following two aspects. First, we focus on the provincial green innovation level of home countries. Previous researches tend to study the performance of domestic technology level instead of green innovation, which has a stronger meaning of sustainability. Therefore, we adopted the number of green patent applications and green patent authorization to represent green innovation. Traditionally, total factor productivity (TFP), the efficiency of a country (region) in transforming input into output, is often used to express the technical level. TFP can reflect the quality of economic development, but it is not accurate enough to measure the internalization of outward FDI technology. In contrast, the number of green patents could directly represent the causal relationship between foreign technology and domestic innovation by reflecting the innovation and positive external effects of production. Second, we explore the threshold mediating characteristics of absorptive capacity. Previous studies have not reached a unified conclusion on whether the impact of outward FDI reverse technology spillovers on home country technology is positive or not. A very likely reason for it is the difference in national (regional) absorptive capacity. The following article will explore the mechanism of reverse technology spillovers of outward FDI by establishing the mediating threshold model, which provides a feasible way to solve the historical divergence. We choose three main absorptive capacities of tremendous research significance: financial development, relative technological level, and human capital.

2. Theoretical mechanism

To assess the robustness of the relationship between outward FDI and innovation, we take full consideration of the different influence paths and try to provide a theoretical basis for the follow-up empirical research. We now discuss these paths in more detail.

2.1. Direct influence mechanism of outward FDI reverse technology spillovers

The direct influence mechanism happens by a process from the micro to macro level. We will follow it and summarize the direct path from three progressive levels: enterprise, industry, and country.

Reverse spillovers at the micro-level mainly focus on Multinational Corporations' (MNCs) overseas investment behavior, which is expanded in two stages. On the one hand, the progress of mastering the advanced technology for the MNCs located in the host country: 1. The flow of talent is the first way for MNCs to learn new technology. Technology-intensive regions offer high-quality labor to match with high technology. Parent companies aiming to seek technology tend to set up subsidiaries in these regions. Specifically, employees of MNCs learn efficient management skills, new knowledge, and continuous learning ability. MNCs play the role of a bridge for the transfer of new technologies to employees of their home country through the flow of talent. 2. Imitating and following existing high-tech is a more efficient and less costly way for the R&D of MNCs rather than independent innovation. It is an essential way for enterprises to fit the strict production requirements of the host country and win the fierce market competition. 3. The environment of host countries is also conducive to learning new technologies; this is defined as the platform-sharing mechanism. Subsidiaries can enjoy advanced R&D equipment and property rights protection systems in a foreign environment, which could guarantee technology learning. 4. The process of acquiring advanced technology for the MNCs is accompanied by allocating R&D expenses (Mansfield, 1983). This means the acquisition of new technologies could induce subsidiaries to improve productivity, reduce production costs, form economies of scale, and then share the R&D costs of the parent company.

On the other hand, the parent company absorbs the new technology transferred by the subsidiary and applies it to production, called the R&D achievement return mechanism (Dunning, 1994. Dunning (1994) stresses the role played by the new technology transmitted by subsidiaries, and it can better adapt to the consumer preferences of the host market and improve its market competitiveness. He said that, simultaneously, talent flow and imitation would happen in the re-learn technology process of the parent company as well.

The influence of technological progress is not isolated. New technology mastered by MNCs at the micro-level will gradually spread to the industrial at the meso-level. When an enterprise in the industry achieves a substantial productivity increase due to technological promotion and gains more market share then this dividend will have an exemplary effect on other enterprises in the same industry. Other enterprises have to imitate the new technology or invest outward to avoid being eliminated by the market; The competition effect could explain the demonstration and imitation inside one industry. Only the fittest members who could carry out technological change will survive after the free competition of the industry-level market, which means technological progress finally rises from the enterprise level to the industrial level.

At the final stage, reverse technology spillovers of outward FDI on the meso level spread to the national macro level through the correlation effect between industries. When an industry reaches a new technology stage, upstream and downstream sectors have to innovate, aiming to match production and offer enough market to accept new products; After that, productivity will continue to expand until there is no new productivity growth point of existing industries, which will stimulate technological innovation and promote the birth of new industries; In addition, it is interesting that technology could spillover in space and have a demonstration effect on the surrounding areas.

2.2. Indirect influence mechanism of outward FDI reverse technology spillovers through absorptive capacity

Cohen and Levinthal (1989) put forward the concept of absorptive capacity for the first time in analyzing enterprise R&D. They show that R&D of enterprise could promote technology from both direct and indirect paths; that is, the investment of R&D can enhance learning, imitate, and transform foreign technology ability of enterprises, and finally improve the technological level of enterprises. Abramovitz (1986) emphasized the importance of the primary conditions of the state and enterprises, such as the infrastructure and innate technology level. He calls it the "social ability theory," which finds that these abilities do affect whether MNCs can obtain external technology smoothly. Following Cohen and Levinthal (1989), pieces of literature widely investigate the role of the absorptive capacity of the home country on the improvement of technology, such as human capital, development of the financial system, technological level, and economic growth. Similar trends are observed in trade, FDI, and other international activities. However, inventors are not found to respond to outward FDI.

Green finance is emerging in China, which can provide strong support for the development of green and low-carbon industries. However, the promotion of green finance to green innovation is inseparable from the influence of external factors. When outward FDI is located in a host country with higher environmental standards, implementing new technologies spilled by outward FDI in China will make financial support perform green-biased. If green finance is implemented effectively or has a particular scale, it will contribute to the innovative development of green industries. Green finance covers a variety of financial products. The most prominent one is green credit. Green credit has obvious financing penalties and investment inhibition effects. It can significantly reduce credit funds invested in high-polluting and high-energy-consuming industries and support environmentally. And it can encourage regional green innovation activities by promoting the application of clean energy and low-carbon technologies. Similarly, green investment and green insurance can promote green innovation by investing capital into green industries and providing preferential insurance. However, if developing countries do not implement green finance policies, or if green finance is full of unscientific distribution, the cost of innovation in green industries will be even more significant, which is not conducive to developing a low-carbon economy.

The relative technological level between the home country and the host country is also an influencer When the technological gap between the two countries is small, outward FDI enterprises can reach the entry standard of the host country without drastic technological innovation. The two similar markets allow enterprises to learn quickly and easily gain competitive advantages in new markets. However, the marginal benefits of technology transferred between countries are smaller in this situation because enterprises can achieve similar progress through their creation. On the contrary, when the technological level of the home country lags behind that of the host country, there is sufficient space for productivity improvement and technological progress. It is the technology gap itself that helps technical backward countries benefit from outward FDI.

Human capital is an essential factor affecting reverse spillovers. The higher the level of education, the stronger the R&D ability of employees. Employees who learn new technology more effectively help transform it into the enterprise's competitiveness. Besides, management with a strategic vision identifies functional skills and abandons useless knowledge hard to adapt to the market so that the enterprises can establish an efficient and green development mode by formulating a sustainable development strategy. Finally, the labor supply market that provides high-quality talents for plants tends to form industrial agglomeration areas. A shred of actual evidence is the success of Silicon Valley, which benefits from the scale economy by reducing production costs. Some of the Chinese high-tech regions also consider the positive role of accumulating technical talents. Bear all these in mind, and we bring human capital into the indirect influence path of reverse technology spillovers.

2.3. Threshold mediating characteristic of absorptive capacity

Absorptive capacity may not always play a mediating role. Due to the significant regional differences in Chinese, the reverse technology spillovers of outward FDI are not always fully absorbed by home countries. These differences perform as varying levels of absorptive capacity, including resource endowment, geographical location, and economic status.

Areas with lower absorptive capacity cannot absorb new technologies effectively and may even be hindered by "rejection reaction." On the one hand, if enterprises cannot obtain green financial support for R&D in time, limited R&D equipment and high-quality personnel will directly hinder the creation of new knowledge. Moreover, enterprises without modern management experience usually tend to expand production regardless of the adverse external effects caused by high pollution production. But they could only achieve fast growth because of the lack of social responsibility and adaptation to macroeconomic policies. Soon, this kind of company may be eliminated after the market transforms into technology-intensive production. On the other hand, one failure sample of an enterprise in the waste of R&D funds may have a negative demonstration effect on other enterprises. This adverse effect could even spread at a more comprehensive level. However, for the different regions, we find that imitation and green innovation are stimulated by high absorptive capacities, such as stable financial support, a high-quality labor supply, and a favorable policy of encouraging technological progress.

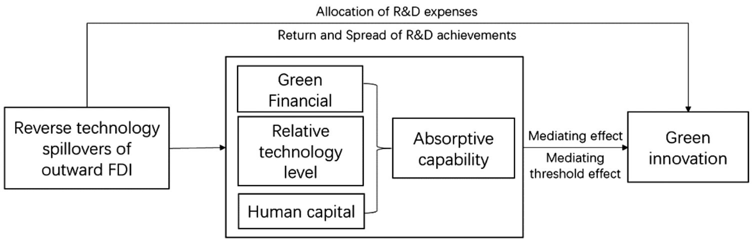

Figure 1. The influence mechanism of reverse green technology spillovers of outward FDI

From the analysis, we know that regions with a significant difference in absorption will perform differently in reverse technology spillovers, which means that the mediating effect of absorption variables has a threshold characteristic. When the absorptive capacity reaches the abrupt point, there will be a significant and sufficient jump; that is, the indirect influence path of outward FDI on home country technology needs to pass through the threshold of absorptive capacity before it can play a role.

The impact mechanism of outward FDI reverse technology spillovers on green innovation is shown in the following Figure 1.

3. Methodology methods and data

According to the theoretical mechanism, outward FDI could impact green innovation directly and indirectly, which will be empirically confirmed in the fourth and fifth chapters. The baseline regression in chapter 4 tries to analyze the linear relationship between the dependent and independent variable. And the threshold mediating regression in chapter 5 tests the nonlinear relationship. The empirical analysis could offer believable evidence for our research based on the theoretical framework.

3.1. Model

We analyze the relationship between reverse green technology spillovers of outward FDI and domestic green innovation over time using provincial-level data, which takes the form of Eq. (1):

$$GREENP_{it} = C + \alpha_1 SOF_{it} + \alpha_2 SM_{it} + \alpha_3 IS_{it} + \alpha_4 OPEN_{it} + \alpha_5 GOV_{it} + \varepsilon_{it} + \mu_t + \tau_i, \quad (1)$$

where i denotes industries and t years. $GREENP_{it}$ is a measure of green innovation using the number of green patent authorization or applications of province t in year i; The main explanatory variable SOF_{it} refers to reverse green technology spillovers of outward FDI; A set of control variables SM_{it}, IS_{it}, $OPEN_{it}$, and GOV_{it}, represent the R&D capital obtained through trade, industrial structure, openness and government expenditure of province t in year i, respectively; α_{1-5} are the parameters to be estimated; C is a constant term. μ_t is a year effect and τ_i is an individual (province) effect. Time effects (μ_t) are included to control for time-dependent determinants of innovation that are common to all provinces, such as changes in policy affecting overall innovation incentives. Finally, ε_{it} is a residual error term capturing all other effects.

Another extension of this study represents the indirect impacts of the reverse technology spillovers of outward FDI that have become an outstanding environmental assessment and monitoring variable in recent times. So, the study constructs a mediating model in Eq. (2) and Eq. (3).

$$Absorp_{it} = C + \beta_1 SOF_{it} + \beta_2 SM_{it} + \beta_3 IS_{it} + \beta_4 OPEN_{it} + \beta_5 GOV_{it} + \varepsilon_{it} + \mu_t + \tau_i; \quad (2)$$

$$GREENP_{it} = C + \gamma_1 Absorp_{it} + \gamma_2 SOF_{it} + \gamma_3 SM_{it} + \gamma_4 IS_{it} + \gamma_5 OPEN_{it} + \gamma_6 GOV_{it} + \varepsilon_{it} + \mu_t + \tau_i. \quad (3)$$

$Absorp_{it}$ in Eq. (2) and Eq. (3) refers to absorptive capacities: financial development (GFI_{it}), relative technical (RET_{it}), and human capital (HUM_{it}) of the province *t* in the year *i*.

We follow the existing literature (Wen & Ye, 2014) in estimating a mediating effect, using the stepwise regression method and supplemented by the Bootstrap test, shown in the Appendix Table A.1.

The analysis steps are as follows: 1. Run Eq. (1) and check whether the coefficient α_1 is significant or not. The sign indicates the existence of the total impact of outward FDI; 2. If both β_1 and γ_1 in Eq. (2) and Eq. (3) are significant, which proves the indirect effect, proceed to step 4. If either of β_1 or γ_1 is not significant, proceed to step 3; 3. The positive result of the Bootstrap test means the exist of mediating effect, proceed to step 4. Otherwise, there is no mediating effect; 4. The significant coefficient γ_2 in Eq. (3) means the existence of the direct effect, then carry out step 5. Otherwise, there is a complete mediating effect without direct effect; 5. If $\beta_1\gamma_1$ and γ_2 have the same sign, the partial mediating effect exists and the proportion of mediating effect is $\beta_1\gamma_1/\alpha_1$. If $\beta_1\gamma_1$ and γ_2 have different signs, there is no mediating effect.

3.2. Measures

3.2.1. Dependent variable

The study's dependent variable is green technology innovation (GREENP), measured by the green patent counts in each province from 2003 to 2017, instead of green total factor productivity (GTFP), which may be related to environmental technology, sustainable development, and energy-saving technology (Aghion et al., 2016). Specifically, green innovation was represented by the counts of authorized green patents (GREENP1) and applicated green patents (GREENP2). A patent portfolio represents the accumulation and reserve of technology knowledge (Ahuja & Katila, 2001). The count of patented green accurately reflects green innovation because it captures verified ecological innovation in industrial production and the innovation process (Usai, 2011). And authorized green patents are under the strict oversight of the China National Intellectual Property Administration (CNIPA) (Usai, 2011). Therefore, GREENP1 and GREENP2 could reflect the green innovation level scientifically and objectively.

3.2.2. Independent variable

We use the perpetual inventory method in calculating the reverse green technology spillovers of outward FDI (*SOF*) in application with the L-P method (Potterie & Lichtenberg, 2001):

$$SOF_{it} = (OFDI_{it} / OFDI_t) R_t^{of}; \tag{4}$$

$$R_t^{of} = \sum_{n}^{n} (OFDI_{jt} / GDP_{jt}) S_{jt}, \tag{5}$$

where *SOF* is calculated by Eq. (4). $OFDI_{it}/OFDI_t$ is the proportion of outward FDI stock in province *i* to China's outward FDI stock in year *t*. And R_t^{of} is the total technology capital acquired by China through outward FDI in year *t*, which is represented by Eq. (5). In Eq. (5), $OFDI_{jt}/GDP_{jt}$ is the proportion of Chinese outward FDI to the GDP of country j in year t, and S_{jt} is the R&D capital stock of country *j* in year *t*. We choose 26 OECD countries and regions as the host countries sample in which the most extensive stock of Chinese outward FDI is located, including Hong Kong, China, Israel, Japan, Singapore, Korea, Turkey, Belgium, Denmark, the United Kingdom, Germany, France, Ireland, Italy, the Netherlands, Spain, Austria, Hungary, Poland, Sweden, Russia, Czech Republic, Slovakia, Colombia, Mexico, Canada, the United States.

3.2.3. Absorptive variables

The absorptive capacity, or the ability to absorb external knowledge, is controlled by three measures: Green finance (*GFI*), Relative technical level (*RET*), and Human capital (*HUM*).

At present, there is no authoritative standard for the definition and measurement of green finance (Fu & Peng, 2020). In 2016, the "Guiding Opinions on Building a Green Financial System" jointly issued by the People's Bank of China and other seven national ministries defined green finance as an economic activity that supports environmental improvement, coping with climate change, and resource conservation and efficient use, that is, the financial services, such as project investment and financing, project operation, and risk management, offered by environmental protection, energy conservation, clean energy, green transportation, green building, and other fields.

This paper will scientifically construct a comprehensive index of green finance from three dimensions: green credit, green insurance, and green investment drawing on the definitions in the existing literature. Due to the lack of relevant data on the scale of provincial green credit, green credit is measured by the proportion of the interest expenditure of non-energy-consuming industries. It is obtained by subtracting the interest expenses of the six energy-intensive industries from the industrial industry. Green insurance uses agricultural insurance as a proxy variable, measured by the ratio of provincial agricultural insurance income to provincial total insurance income, which refers to the research of Yin et al. (2021). Green investment is measured by the total investment in environmental pollution control in each province. Based on Fu & Peng (2020), this paper uses the entropy method to measure the development level of green finance and normalizes the data before this. The entropy method is an objective weighting method for comprehensive evaluation based on the discrete degree of an index, which can effectively avoid the deviation caused by human factors.

Relative technology level (RET) is measured by the labor productivity ratio of China to host countries. If the RET value is less than 1, China's labor productivity is lower than that of the host countries. In this case, the larger the RET value, the smaller the technological gap between the home and host country. Conversely, if the RET value is greater than 1, the labor productivity of the host countries is relatively higher. In this case, a more enormous RET value means a larger technological gap. This paper uses the ratio of the regional GDP (after deflation and converted into U.S. dollars) to the number of employees to represent the labor productivity of provinces in China. We also choose 13 developed countries (regions), taking their average labor productivity value as foreign labor productivity: The United States, Britain, Germany, France, the Netherlands, Italy, Canada, Australia, Japan, South Korea, Singapore, Hong Kong, China, and China Taiwan.

Human capital (*HUM*) is a proxy for the labor force quality of a region. It was considered that Human capital as an absorptive capacity would significantly promote technology absorption and conversion, which will be tested in this paper. Following Barro and Lee (1993), human capital was computed as follows: HUM = pps×6 + pjs×9 + phs×12 + pcs×16, where pps, pjs, phs, pcs is the proportion of primary school, junior high school, high school, college, and above, including college, undergraduate, postgraduate, respectively.

3.2.4. Control variables

We include a variety of control variables that have been shown elsewhere to be significant determinants of innovation. Firstly, we include the stock of R&D capital obtained through trade (*SM*) as this is expected to be correlated with domestic green innovation. Facing the pressure from the imported products with higher technical levels or lower cost, enterprises and governments of home countries have to learn and imitate new technology, then produce suitably for the local market with higher technology. *SM* is also calculated using the perpetual inventory method:

$$SM_{it} = (IM_{it} / IM_t) R_t^m; \tag{6}$$

$$R_t^m = \sum_n^n (IM_{jt} / GDP_{jt}) S_{jt}. \tag{7}$$

Eq. (6) calculates SM_{it}, where IM_{it} / IM_t is the proportion of the import value of province i to the total import value of the country in the year t, and R_t^m refers to the R&D capital stock spillovers of international trade in the year t, which could be concluded by Eq. (7). R_t^m is the product of IM_{jt} / GDP_{jt}, the ratio of China's import value from country j to country j's GDP in year t, and S_{jt}, the R&D capital stock of country j in year t. We estimate Eq. (6) and Eq. (7) for 12 countries and regions with the most significant volume of trade with China: Japan, South Korea, Hong Kong, Taiwan, Singapore, Britain, Germany, France, Italy, the Netherlands, Russia, Canada, the United States, and Australia.

Secondly, we include the degree of openness (*OPEN*) as a determinant of innovation. We measure this as the ratio of annual import and export value to the GDP of each province. Many researchers find that an openness degree will directly affect whether countries actively participate in the international specialization, give full play to their factor endowments, and invest in plants worldwide. This paper will take full consideration of it.

Thirdly, industrial structure (*IS*) is measured as the ratio of the economy's tertiary sector to each province's GDP. Compared with the other two industries, which focus on resource-intensive industries, the tertiary sector of the economy is primarily technology-intensive industries. A rational industrial structure means a cleaner product and more efficient R&D due to an advanced tertiary sector. We therefore take IS as a control variable.

Finally, government expenditure (*GOV*) could affect innovation. Focus government expenditure on R&D is conducive to greening industrial production and increasing productivity. Hence, we measured it as the fiscal spending ratio to each province's GDP.

3.3. Data

We apply provincial panel data from 31 provinces, cities, autonomous regions, and municipalities in China from 2003 to 2017. Data related to China were from the "Statistical Bulletin of China's Foreign Direct Investment," "China Business Statistical Yearbook," and "China Industrial Statistical Yearbook." Data of countries except China were obtained from the OECD database and IMF Database. Other data were collected from the "China Statistical Yearbook," "Financial Statistics Yearbook," and "China Labor Statistics Yearbook."

Table 1 provides an analysis of the study's descriptive statistics. Overall, the sample has a small degree of dispersion and is representative. However, the standard deviation of some critical variables is significant, including *GREENP1*, *GREENP2*, and *SOF*, perhaps due to the regional heterogeneity. According to the descriptive statistics and distribution histograms of the variables, most of the variables have extreme value. To exclude singular values and improve the regression accuracy, all data is processed winsorized and took use of the logarithm of key variables *GREENP*, *SOF*, and *SM*.

Table 1. Descriptive statistics

Type of variable	Variable	Observations	Means	Std.Dev	Min	Max
Dependent variables	GREENP1	465	5.655	1.973	0	9.822
	GREENP2	465	4.281	1.911	0	8.519
Independent variables	SOF	465	10.03	2.537	1.437	15.65
Absorptive variables	GFI	465	1.543	0.409	0.117	3.538
	RET	465	0.107	0.073	0.0130	0.379
	HUM	465	9.025	1.357	3.030	13.39
Control variables	SM	465	7.618	1.928	1.799	11.40
	IS	465	3.722	0.188	3.353	4.389
	OPEN	465	0.317	0.401	0.0170	1.843
	GOV	465	0.237	0.182	0.0770	1.379

4. Empirical analysis of direct and indirect influence mechanisms

4.1. Baseline regression

Table 2 reports the ordinary least square (OLS) estimation results for the influence of *SOF* on green innovation by gradually adding control variables. Green innovation was represented by the number of green patent authorization (*GREENP1*). The model seems to perform very stably, with large enough Hadri LM statistics convincingly indicating that the models avoid pseudo-regression. The Hausman tests reject the original hypothesis, so we choose the individual and time fixed-effect model.

GREENP1 is estimated to positively impact *SOF* and maintain a significant level of 1% when adding the control variables. Hence this evidence suggests that reverse technology spillovers of Chinese outward FDI could promote the home country's green innovation and reflect the transformation of technology into green patents for domestic enterprises. This result same as Chang, Chen, and McAleer's (2013) finding in OECD countries and other low- and central-income countries in 1994–2005 that outward FDI can spillover technology reversely and improve innovation in host countries. We, therefore, verified the direct mechanism of reverse technology spillovers of outward FDI mentioned before: outward investment companies absorb technology abroad and transfer it back to China. Then, China improves the level of innovation by absorbing, demonstrating the technology, and finally internalizing it to its advantage.

Turning to the impact of control variables, *OPEN* has a significant, positive effect on *GREENP1*. It proves that the active policy of participating in the global value chain for labor division is conducive to technology development. Meanwhile, *IS* also positively affects the dependent variable, probably because if the proportion of pollution-intensive industries decreases or the tertiary industry develops well will help the application of new technologies. Besides, a positive correlation was also found between *SM* and *GREENP1*.

Taken together, the primary results above suggest that there is an association between reverse outward FDI green technology spillovers and domestic green innovation. On this basis, we will explore in-depth from the perspective of domestic absorption. The next step will figure out, when considering the differences in the absorption capacity of home countries, whether *SOF* remains to influence *GREENP*.

Table 2. The result of baseline regression

Variables	GREENP1				
	(1)	(2)	(3)	(4)	(5)
SOF	0.14*** (4.56)	0.129*** (4.19)	0.125*** (4.02)	0.136*** (4.35)	0.117*** (3.66)
OPEN		0.634*** (3.08)	0.602*** (2.88)	0.626*** (3.00)	0.392* (1.70)
GOV			0.769 (0.93)	0.444 (0.53)	0.713 (0.85)
IS				0.646** (2.24)	0.702** (2.44)
SM					0.163** (2.34)
C	1.754*** (7.70)	1.631*** (7,12)	1.542*** (6.21)	0.85*** (–0.78)	–1.981* (–1.66)
F-test	223.078***	213.947***	201.344***	192.268***	184.394***
Hausman test	46.52*** (0.000)	34.74*** (0.000)	40.56*** (0.000)	38.35*** (0.000)	26.44*** (0.000)
R2	0.889	0.891	0.891	0.893	0.894
Observations	465	465	465	465	465

Note: The significance levels refer to $p < 0.01$ (***), $p < 0.05$ (**) and $p < 0.1$ (*). T-values are shown in parentheses.

4.2. Mediating effect analysis of absorptive capacity

Reverse technology spillovers of outward FDI will cause the development of domestic green technology. However, it cannot happen automatically and depends on whether the home country can master new technologies and transform them into local productivity. Therefore, it is necessary to explore the mechanism of absorptive capacity in the process of *SOF* affecting *GREENP*. In this section, we analyze how *SOF* affected *GREENP* indirectly through absorptive capacity as intervening variables.

Of the absorptive variables within columns (1) and (2) of Table 3, the results suggest *GFI* as the intervening variable has a positive effect on *GREENP*, and the mediating effect accounted for 14.30%. It shows that the main explanatory variable SOF positively affects the intervening variable *GFI* at the level of 1%. The coefficients of *SOF* and *GFI* in Eq. (3) are both significant and positive, that is, *GFI* can help *SOF* improve green innovation through mediating effect.

Columns (3) and (4) of Table 3 report the estimation results of *RET* as the intervening variable, with a mediating ratio of 13.35%. Statistical analysis shows that the value of *RET* is all less than 1, which means the technology level of every Chinese region is behind that of the host country. In other word, Chinese transnational corporations that produce based on domestic technical standards are difficult to gain competitiveness in foreign markets.

Table 3. Regression results of mediating effect

Variables	GFI	GREENP1	RET	GREENP1	HUM	GREENP1
	(1)	(2)	(3)	(4)	(5)	(6)
SOF	0.034*** (2.59)	0.107*** (3.68)	0.003** (2.27)	0.103*** (3.26)	0.053** (2.20)	0.068** (2.41)
Absorptive variables		0.492** (3.11)		5.205*** (4.03)		0.291*** (5.11)
OPEN	0.105* (1.25)	0.238 (2.90)	−0.063*** (−7.31)	0.719*** (2.99)	0.266 (1.53)	1.000*** 4.70)
GOV	1.439*** (1.28)	0.179 (0.78)	−0.314*** (−9.99)	2.347** (2.55)	1.69*** (2.65)	−3.409*** (−9.27)
IS	0.339* (1.64)	0.579* (1.16)	0.023** (2.21)	0.584** (2.05)	0.048 (0.22)	0.182 (0.71)
SM	1.673* (3.30)	0.203*** (1.38)	0.001 (0.31)	0.159** (2.32)	−0.034 (−0.65)	−0.005 (−0.08)
C	−0.388*** (0.35)	−1.880 (−1.49)	0.01*** (0.23)	−2.034* (−1.74)	7.835*** (8.68)	−0.568 (−0.47)
F-test	74.352***	165.596***	233.962***	182.413***	77.296***	230.897***
Hausman test	30.01*** (0.000)	26.52*** (0.001)	72.04*** (0.000)	33.91*** (0.000)	24.40*** (0.000)	20.11*** (0.005)
R2	0.887	0.899	0.915	0.898	0.780	0.918
Observations	465	465	465	465	465	465

Note: The significance levels refer to $p < 0.01$ (***), $p < 0.05$ (**) and $p < 0.1$ (*). T-values are shown in parentheses. The control variables are included but not shown for saving space.

Enterprises that could adapt to strict production standards, such as more environmentally production and minimizing adverse external effects, could pass advanced technology back to the home country, thereby improving domestic green innovation.

Columns (5) and (6) take *HUM* as an intervening variable and exerts a mediating effect of 13.18%. *HUM* plays a significant and positive role in transforming reverse technology spillovers of outward FDI into green innovation. It may simply be because the higher the level of human capital, the higher the quality of labor and management personnel can be provided for production. Thus, skilled labor can efficiently learn and absorb new technologies fed back to their home country.

4.3. Robustness test

4.3.1. Replace the dependent variable

The number of green patent applications can also represent green innovation through reflecting learning and transforming new technologies process of the home country. To test if the primary results are robust and reliable, the explanatory variable was replaced by *GREENP2* in Eq. (1) and (3) and is presented in Table 4. It is apparent that SOF has a positive effect on green innovation. Moreover, three absorptive capacity variables also have a mediating effect, which is consistent with the original regression results. It is noticeable that though the coefficient of GFI is not significant in column (2) of Table 4, the Bootstrap test results in Table 1A show that the confidence interval of the indirect effect is [0.011, 0.025], which excludes 0. According to the mediating test method of Wen et al. (2014), GFI still has a significant and positive mediating effect, and the proportion is 2.15%, passing the robustness test.

Table 4. Result of robustness test

Test	Replace the dependent variable			
Variables	GREENP2			
	(1)	(2)	(3)	(4)
SOF	0.082*** (2.88)	0.074*** (2.78)	0.067*** (2.40)	0.046*** (1.85)
Absorptive variable (2) GFI, (3) RET, (4) HUM		0.053 (1.98)	5.612*** (4.93)	0.276*** (5.76)
Control variables	control	control	control	control
C	0.691 (0.65)	0.771 (0.62)	0.634 (0.61)	0.868 (0.86)
F-test	253.631***	249.035***	255.678***	241.074***
Hausman test	32.66*** (0.000)	30.01*** (0.000)	38.82*** (0.000)	23.65*** (0.001)
R2	0.921	0.921	0.925	0.921
Observations	465	465	465	465

Note: The significance levels refer to $p < 0.01$ (***), $p < 0.05$ (**) and $p < 0.1$ (*). T-values are shown in parentheses. The control variables are included but not shown for saving space.

4.3.2. Solve the endogeneity problem

We doubt whether or not there is an endogenous problem of reverse causality between SOF and GREENP. According to the international economics theory, domestic enterprises promote their technical level through demonstration and imitation, industrial association, and personnel flow by outward FDI reverse technology spillovers. However, outward FDI may tend to occur in regions with an inherently higher level of technology. That is to say, regions with a high level of technology will provide greater support in terms of funds and policies and have a stronger role in promoting the foreign investment of enterprises in the region. The technology level of the home country itself may affect the location of outward FDI and whether advanced knowledge could reverse spillover successfully.

To ensure the results are consistent with our theoretical analysis that Chinese outward FDI is aimed at seeking technology, we use the distance between host countries and China as an instrument variable to avoid the reverse causality problem. Distance is a vital factor when locating subsidiaries considering the cost of cross-border investment. It cannot affect domestic green innovation directly while impacting outward FDI. The paper uses logged distance*time to represent time-variant *Distance*. The 2SLS results of Anderson LM test and Cragg-Donald Wald F test at the first stage of regression rejected the null hypothesis of "insufficient identification of instrumental variable" and "the existence of weak instrumental variables" at the 5% significant level, respectively. It indicates that the selection of instrumental variables is reasonable. And the results of the second stage show that the positive impact of SOF on GREENP is still significant, so as the mediating effect of absorptive variables. The results are shown in Table 5. After considering the endogeneity problem, the empirical results are still robust.

Table 5. Result of robustness test

Test	Solve the endogeneity problem with 2SLS			
Variables	GREENP1			
	(1)	(2)	(3)	(4)
SOF	0.047*** (1.29)	0.030** (2.00)	0.020 (1.58)	0.015 (1.31)
Absorptive variable (2) GFI, (3) RET, (4) HUM		0.434*** (2.63)	0.197*** (2.57)	0.896** (2.71)
Anderson LM test (P-Value)	2.182*** (0.004)	1.225*** (0.008)	2.738*** (0.008)	0.916*** (0.007)
Control variables	control	control	control	control
Results of the first stage				
Distance×Year	–0.077** (2.13)	–0.058** (1.41)	–0.020* (2.47)	–0.019* (1.39)
F-test	97.379**	89.415**	81.368**	91.812**
Control variables	control	control	control	control
Observations	465	465	465	465

Note: The significance levels refer to $p < 0.01$ (***), $p < 0.05$ (**) and $p < 0.1$ (*). T-values are shown in parentheses. The control variables are included but not shown for saving space.

4.3.3. Consider the heterogeneity of outward FDI location selection

Different congenital conditions of the host countries may affect the location selection of foreign investment, thus affecting the credibility of the empirical results. Therefore, we consider the location selection heterogeneity to prove that the reverse technology spillover of OFDI remains a positive and significant impact. We divided the samples into two groups according to whether the 26 host countries and regions are coastal or not and conducted the reverse analysis of OFDI, respectively. SOF1 calculates coastal countries and regions, including Hong Kong, Israel, Japan, Singapore, Korea, Turkey, Belgium, Denmark, the United Kingdom, Germany, France, Ireland, Italy, the Netherlands, Spain, Poland, Sweden, Russia, Colombia, Mexico, Canada, and the United States. SOF2 calculates landlocked countries, including Austria, Hungary, the Czech Republic, and Slovakia. The results were shown in columns (1) and (2) of Table 6. The reverse spillover effect on the GREENP is significantly positive regardless of coastal or landlocked host countries.

The continents of the host countries may also interfere with outward FDI's location. Countries in the same continent have similar cultural habits and close geographic distances, which may contribute to a smooth investment and facilitate learning knowledge. Therefore, we divided the 26 host countries into three sample groups: Asia, Europe, and the Americas. The first group calculates the SOF of Asian countries and regions, including Hong Kong, Israel, Japan, Singapore, and Korea. The second group estimates SOF of European countries,

Table 6. Result of robustness test

Test	Coastal countries heterogeneity		Continent heterogeneity		
Variables	GREENP1				
	(1) Coastal	(2) Landlocked	(3) Asia	(4) Europe	(5) Americas
SOF	0.183*** (3.32)	0.108*** (2.43)	0.243*** (2.83)	0.137** (1.87)	0.173*** (2.16)
OPEN	0.575** (1.98)	0.288** (2.62)	0.504** (1.62)	0.522* (2.77)	0.407* (1.54)
GOV	0.615 (1.86)	0.151 (2.71)	0.485* (1.94)	0.394* (1.11)	0.262 (2.14)
IS	0.537** (2.09)	0.466** (2.42)	0.451** (3.98)	0.287 (3.74)	0.415 (2.89)
SM	0.296** (1.82)	0.155** (1.59)	0.318** (2.05)	0.556* (2.41)	0.222** (2.06)
C	−0.802* (−1.51)	−1.069* (−0.84)	−0.783** (−1.69)	0.665** (2.15)	0.584** (0.14)
F-test	188.166***	165.410***	224.659***	220.099***	210.564***
Hausman test	28.59*** (0.000)	19.16*** (0.000)	25.86*** (0.000)	20.61*** (0.001)	20.97*** (0.001)
R2	0.952	0.969	0.987	0.923	0.987
Observations	465	465	465	465	465

Note: The significance levels refer to $p < 0.01$ (***), $p < 0.05$ (**) and $p < 0.1$ (*). T-values are shown in parentheses.

including Turkey, Belgium, Denmark, the United Kingdom, Germany, France, Ireland, Italy, the Netherlands, Spain, Poland, Sweden, Russia, Austria, Hungary, Czech Republic, and Slovakia. The third group calculates the SOF of American countries, including Colombia, Mexico, Canada, and the United States. The results show that although the degree of impact varies, no matter which continent the host country is, SOF can always significantly affect GREENP. The results are shown in Table 6.

5. Threshold mediating effect analysis of absorptive capacity

As analyzed above, the absorptive capacity of countries with different development statuses does not necessarily contribute to technological development as *SOF* increases. Focusing first on China as a whole, the results above suggest that absorptive variables have a mediating effect. However, mediating characteristic probably performs insignificance when we consider provincial heterogeneity. Turning to the regional sample, some regions have favorable conditions, including adequate green finance, skilled labor, and ample room for growth, while others do not. The degree to which the reverse technology spillovers from outward FDI are effectively exploited may vary. Therefore, we will explore deeper from a time and space perspective. First, analyze the changes in the impact path in the short-term and long-term. As economic variables, absorptive capacities show an increasing trend over time. Using absorptive capacity as a threshold variable in the threshold model, explore the relationship between *SOF* and *GREENP* in different time intervals. Second, analyze the provincial distribution of the mediating effect on two sides of the threshold. The absorptive capacity is used as a mediating variable to test the mediating threshold effect. We want to verify whether the relationship between the absorption variable and green technology will have apparent mutation when the level of the absorption variable reaches a certain level. When absorptive capacity is on the one side of the threshold, it helps *SOF* promote green innovation, which will not happen on the other side.

In the following, we first refer to the method of Hansen (1999) to test the threshold number and threshold value of the three absorptive capacity variables. Secondly, with the thresholds of GFI, RET, and HUM as the boundaries respectively, the sample is divided into sub-samples, and the mediating effect test is carried out in the sub-samples to observe whether the mediation effect of absorptive capacity has abruptly changed after crossing the threshold. Suppose the results are in line with our expectation that the mediating effect will change. In that case, it can prove that different degrees of absorptive capacity have different degrees of influence on green innovation. The threshold model is established as follows:

$$GREENP_{it} = C + \delta_1 SOF_{it} \cdot I(Absorp_{it} \le \theta) + \delta_2 SOF_{it} \cdot I(Absorp_{it} > \theta) + \delta_{3-6} X_{it} + \varepsilon_{it} + \mu_t + \tau_t, \quad (8)$$

where the absorptive capacity variable refers to the financial level (GFI_{it}), relative technical level (RET_{it}) and human capital (HUM_{it}); θ denotes the threshold value to be estimated; $I(\cdot)$ is an indicator function: If the () is true, I takes 1, otherwise 0. X_{it} refers to four control variables including SM_{it}, IS_{it}, $OPEN_{it}$, and GOV_{it}.

5.1. The empirical analysis of threshold effect

5.1.1. Threshold estimate

To begin with, we first tested the number of thresholds and their value. Following the procedure put forward by Hansen (1999), it may be assumed one threshold, two thresholds, or three thresholds, respectively. Moreover, as a complementary, the bootstrap method overlaps the likelihood ratio test statistics 300 times and tests the threshold based on the p-value. As reported in Table 7, intervening variables *GFI*, *RET*, *HUM* all have a single threshold with a 1% significant level, while the double and triple thresholds are insignificant. Their value of threshold estimator is 0.720, 0.084, and 8.523, respectively. It means that after the absorptive capacities cross the threshold, there is a sudden change of the relationship between *SOF* and *GREENP*. In other word, the impact of outward FDI reverse technology spillover on green innovation will be different in the short-term before the threshold and the long-term after crossing the threshold.

Table 7. Threshold effect test

Threshold variables	Thresholds	Threshold estimator	Confidence interval	F-value	P-value
GFI	Single	1.526	[1.520,1.575]	27.459	0.010
	Double	1.526	[1.499, 1.531]	14.671	0.210
		1.587	[1.562, 1.590]		
	Triple	1.749	[1.650, 1.752]	5.724	0.429
RET	Single	0.084	[0.083, 0.085]	37.270	0.003
	Double	0.045	[0.043, 0.046]	10.240	0.357
		0.095	[0.084, 0.096]		
	Triple	0.069	[0.068, 0.070]	6.300	0.583
HUM	Single	8.523	[8.506, 8,532]	33.35	0.000
	Double	8.523	[8.503, 8.532]	10.05	0.327
		8.897	[8.834, 8.911]		
	Triple	8.922	[8.909, 8.947]	8.140	0.467

5.1.2. The results and analysis of the threshold effect

As reported in Table 8, when GFI is the threshold variable, SOF had a positive and significant effect on GREENP over time, regardless of GFI's level. However, after crossing the threshold, the influence coefficient decreased in the long term under a high level of GFI. The possible reason is that Chinese current green financial products have just started, designed for innovation activities in the foreseeable few years. Therefore, the financial market is lack of flexible and reliable innovation funding in the context of the unpredictable future economic and social situation. However, we only use GFI as a background to explore the effect of outward FDI reverse technology spillover in this section. It cannot make a conclusion about how GFI participates in the outward FDI spillover process as an influencing factor. Comprehensively observe three threshold variables, when RET and HUM are thresholds, the long-term influence coefficient increased by 19.6% and 27.7% respectively. And when it comes to GFI, the long-term influence coefficient was only 5.5% lower than that of short-term. Obviously, its change of the absolute value coefficient is relatively smaller. For this anomalous result, we must clarify how the growth of GFI affects the impact path over time. Therefore, GFI is included as a mediating variable to test the mediating threshold effect in the next section, which can validate and analyze GFI comprehensively.

When RET is the threshold, SOF have a positive impact on GREENP at a significant level of 1% in both the short and long term. However, in the short term before reaching the threshold, the SOF influence coefficient is 0.143. With the increase of time, the SOF influence coefficient increases to 0.171 after RET crosses the threshold. This means technology lacked countries are born with sufficient motivation to pursue advanced technologies. As time passes, when the technological gap narrows, the home country has high technology and masters continuous innovation ability. Outward FDI has a stronger impact on domestic green innovation at this time.

When HUM is the threshold, under the background of a low HUM level, SOF cannot significantly impact GREENP in the short term. While in the long run, the level of human capital is high and outward FDI has produced a positive and significant green technology reverse spillover effect. As a vehicle for creating and learning technologies, labor is key for the home country to learn and absorb new technologies efficiently. In the early stage, the Chinese labor force could not provide support for technology absorption. Over time, China has popularized compulsory education and continued to cultivate high-tech talents. So, the labor-capital has gradually improved, which makes the positive feedback effect to deepen the effects of SOF on GREENP.

Table 8. Estimation for the threshold regression model

Variables	GREENP	
Group (1)	GFI < 1.526	GFI ≥ 1.526
SOF	0.20*** (3.27)	0.189*** (1.40)
R^2	0.853	0.794
Observations	216	239
Group (2)	RET < 0.084	RET ≥ 0.084
SOF	0.143*** (2.92)	0.171*** (4.22)
R^2	0.739	0.899
Observations	220	245
Group (3)	HUM < 8.523	HUM ≥ 8.523
SOF	0.101 (1.29)	0.129*** (3.81)
R^2	0.733	0.910
Observations	133	332

Note: The significance levels refer to $p < 0.01$ (***), $p < 0.05$ (**) and $p < 0.1$ (*). T-values are shown in parentheses. The control variables are included but not shown for saving space.

5.2. The empirical analysis of mediating threshold effect

In this section, we will test *GFI*, *RET*, *HUM*'s threshold features, respectively. The total sample will be divided into two groups by the single threshold. Then assess each group to analyze whether the mediating effect of absorptive capacity changed across the threshold. The Hausman test displayed that all groups were significant, so we chose the fixed effect model.

In addition, in order to visualize the distribution of the absorptive capacity levels of the 31 provinces on both sides of the threshold, we plotted the provincial heterogeneity distribution figures of GFI, RET, and HUM, respectively. In addition, different icons are used in the spatial distribution figures to distinguish provinces in four regions, commonly referred to as the eastern, central, western, and northeastern regions. Because we found that the absorptive capacity levels of provinces within the same region are similar, while the differences between regions are significant. And the eastern region includes Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan in the east; the central region: Shanxi(jin), Anhui, Jiangxi, Henan, Inner Mongolia, Hubei, and Hunan; the western region includes Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shanxi(shan), Gansu, Qinghai, Ningxia, and Xinjiang; the northeastern region is Liaoning, Jilin, and Heilongjiang. Besides, representative provinces worth analyzing are highlighted in the figures.

5.2.1. Green finance

When the value of *GFI* is below threshold 1.526, the mediating effect does not exist. The regression coefficient of indirect effect is –0.011 with no significance, though the total impact and direct effect are significantly positive. Besides, the symbol between direct and indirect effect coefficient is opposite, and the bootstrap test also rejects the original hypothesis. But after crossing the threshold, the total, direct, and indirect effect all become significantly positive. *GFI* now could play a partial mediating effect, accounting for 15.81%.

Developed financial support can reduce financing costs and assist enterprises internalizing advanced technologies with green-bias financial products and stable financial institutions (Chen, 2011). Some of the Chinese provinces did not cross the green finance level threshold. Their markets lack financial products to provide stable financial support for applying new technologies, let al.ne green innovation. The results reveal that the mediating effect of *GFI* is significantly different on two sides of the threshold, which is reflected in the green financial development of Chinese provinces. Therefore, clarifying the spatial distribution heterogeneity of absorptive capacity is necessary for a deeper understanding of *GFI*'s impact. We use the mean value of absorptive capacity of 31 provinces, and divide them into four regions: eastern, central, western, and northeastern. Figure 2 shows the distribution of these provinces on the two sides of the threshold.

As can be seen from Figure 2, the eastern region has the most provinces across the threshold. *GFI* of Beijing is the highest and much higher than that of other provinces. In the east region, only Shandong and Hebei do not cross the threshold. These two provinces better give full use of their geographical advantages and stimulate financial market activity. However, the only northeastern province that crosses the threshold is Liaoning. Liaoning, located along the coast, can participate in international activities conveniently due to its developed port cities,

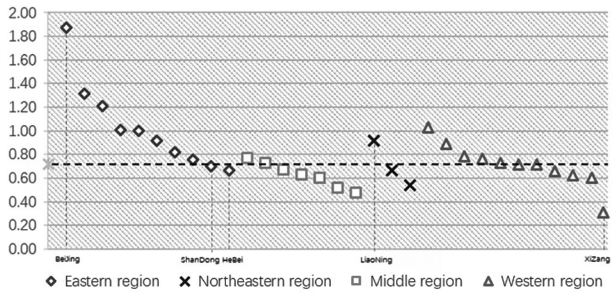

Figure 2. Spatial distribution of green finance level

such as Dalian. This is mainly because the eastern region has a relatively complete market system and smooth transmission mechanisms and plenty of green innovation enterprises and financial institutions with rather large green financial businesses. However, most central and western provinces have a low level of financial development and marketization. On the supply side, it is difficult for relevant financial institutions to effectively use disciplinary and incentive measures to efficiently allocate of financial resources. On the demand side, most enterprises are large-scale Limited, and the willingness to obtain green credit is not strong. Therefore, these provinces need to properly stimulate free competition in the green financial market, which is conducive to the absorption of green technology and promoting innovation in the long run.

5.2.2. Relative technical level

The sample group below the threshold of 0.084 of *RET* represents provinces with a relatively low level of technology and a more significant gap with foreign technology. In this group, the bootstrap test indicates the indirect effect is significant, with the same sign as the direct impact of 0.139. The mediating effect existed and accounted for 5.501%. Consequently, a more significant technological gap creates an opportunity to progress technology, which is conducive to absorbing reverse green technology spillovers without worrying about market saturation in a short period.

After *RET* crosses the threshold, both the stepwise regression method and the bootstrap test show the inexistent mediating effect. That is, the technology level of the two countries is too close to help knowledge transfer. Indeed, this point is emphasized by Findlay (1978), who use a theoretical model to research the relationship between technologically advanced countries and technologically backward countries. Therefore, the substantial technological gap may encourage backward countries to innovate, and the degree of technological penetration is more profound. Concerning the research on the relative level of technology, it seems that similar conclusions can be reached using data from other countries. Wang and Blomstrom (1992), using US data, confirm it.

We graph the distribution of *RET* value of each province on the two sides of the threshold in Figure 3. Eastern capital-intensive provinces, especially Beijing, Shanghai, Zhejiang, and Jiangsu, are above the threshold with a higher technological level. The only eastern province below the threshold is Hainan, a relatively developed tertiary industry, though dominated by

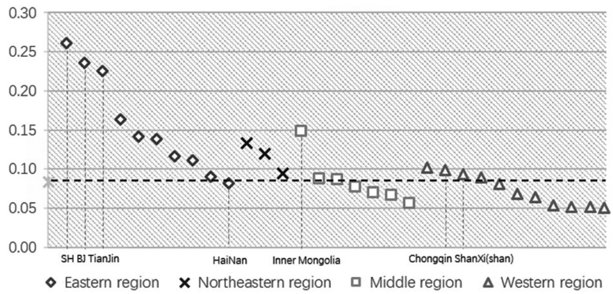

Figure 3. Spatial distribution of relative technology level

tourism with low technology content. There is no need to worry about the existing technology gap for most central and western provinces below the threshold. Backward regions will get positive feedback from technology-seeking outward FDI if they transform the pollution-intensive production into an environmental-friendly mode.

5.2.3. Human capital

As shown in Table 9, *HUM* will not perform the mediating characteristic until it crosses the threshold of 8.523. According to the stepwise method and the bootstrap test, the indirect effect coefficient is 0.019 and insignificant when below the threshold. After *HUM* crosses the threshold, the critical coefficient becomes significantly positive, and the proportion of mediating effect is 14.6%.

In line with the new economic growth theory, in which human capital is also included in the definition of the labor force, we confirm that human capital could affect economic growth as an endogenous growth variable, which is different from the neoclassical growth model. As for Chinese provinces that could not reach the *HUM* threshold, the mismatched technical personnel and modern managers will not allow the absorption even if the MNCs try to transform advanced technology back to their home country. This situation will not change until the labor force's education level and work proficiency reach a certain extent. Previous studies have demonstrated that human capital also makes sense in international trade and FDI, consistent with the present results. Helpman (1992) proved the threshold role of Human capital in technology spillover of international trade for the first time. International trade plays a greater role in promoting economic growth after crossing the threshold point. Borensztein et al. (1998) also evidenced that the host country's stock of human capital can help FDI promote economic growth.

Figure 4 shows the provincial distribution of human capital. Except for a few central and western provinces, most provinces can take advantage of *HUM* to absorb green technology. Provinces under the threshold include Anhui, Qinghai, Sichuan, Gansu, Guizhou, Yunnan, and Tibet. In contrast with coastal provinces, their population is relatively tiny, and education is far from excellent, according to the Chinese 7th National Census Report. Therefore, better work opportunities and living standards in eastern provinces will likely increase the brain drain in the west of China. It would effectively support the educational system harder and stimulate market dynamism to provide high-quality talents for technological innovation.

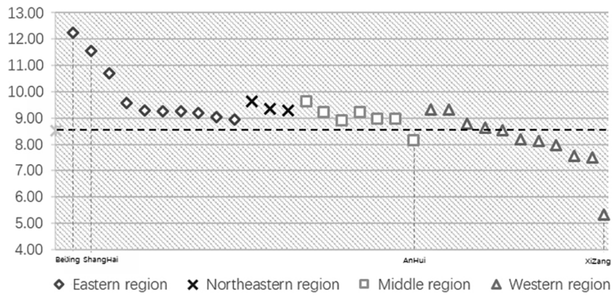

Figure 4. Spatial distribution of human capital

Table 9. Estimation for the mediating threshold regression model

Group (1)	GFI < 1.526		GFI ≥ 1.526	
Variables	GFI	GREENP	GFI	GREENP
GFI		0.775 (1.52)		0.586* (1.20)
SOF	–0.014 (–0.88)	0.194*** (4.61)	0.051*** (4.78)	0.109** (2.07)
R^2	0.637	0.850	0.963	0.901
Observations	216	226	239	239
Group (2)	RET < 0.084		RET ≥ 0.084	
Variables	RET	GREENP	RET	GREENP
RET		7.867 (1.51)		0.964 (0.68)
SOF	0.001 (0.81)	0.139*** (2.84)	0.003 (1.42)	0.168*** (4.13)
R^2	0.916	0.742	0.912	0.900
Observations	220	220	245	245
Group (3)	HUM < 8.523		HUM ≥ 8.523	
Variables	HUM	GREENP	HUM	GREENP
HUM		0.784*** (3.60)		0.219*** (2.81)
SOF	–0.024 (–0.69)	0.12 (1.62)	0.086*** (3.39)	0.11*** (3.23)
R^2	0.758	0.766	0.751	0.912
Observations	133	133	332	332

Note: The significance levels refer to $p < 0.01$ (***), $p < 0.05$ (**) and $p < 0.1$ (*). T-values are shown in parentheses. The control variables are included but not shown for saving space.

Conclusions and policy implications

This study empirically investigated the hypothesis that reverse technology spillovers of outward FDI stimulated investment in green innovation and calculated the mediating threshold effect of the absorptive capacity of China. Using annual data from China's 31 provinces from 2003 to 2017, we first examined the path and intensity of reverse spillover effects in the domestic market based on the FE model and stepwise regression method. Such a framework allows us to explore the reverse green technology spillovers emanating from the host country to China in terms of simultaneous direct and indirect impacts. Moreover, our study tests the probable mediating effect by characterizing the threshold feature of absorptive capacity and considers regional heterogeneity as well.

The main empirical results indicate that the connectedness between the main variables is positive. However, it differs depending on absorptive capacity, confirming that the condition of domestic regions should be considered in the spillover measure. More precisely, we find that the indirect impact of reverse spillover effects will not be pronounced until the Chinese market reaches a certain point of absorptive capacity.

Further analysis indicates that three absorptive capacities, green finance, relative technical level, and human capital, all have a single threshold. Green finance only has a positive mediating effect after it crosses the threshold, as does human capital. Regions with developed financial support mainly gather in the eastern region, while 24 provinces possess high-quality human capital. As for the relative technical level, different from traditional research, a large technology gap below the threshold value could help the outward FDI transform new knowledge. The ideal situation of most coastal provinces does not require explanation; more attention should be paid to the areas with significant technology gaps, especially Hainan, an eastern province, and a few provinces in the central and western regions.

We, therefore, highlight the most prominent policy implications derived from our findings. First, China's unbalanced distribution of absorptive capacity implies a high need for practical efforts by governments to address innovation problems. Instead of the one-size-fits-all approach, policies should be designed according to local conditions based on the tone of encouraging outward FDI. Thus, maintain a positive attitude toward foreign knowledge in the eastern region and lead the technology while offering to develop backward areas with appropriate support for crucial industries and guiding the flow of investment focus to technology-intensive sectors. Specifically, policies aimed at long-term cultivation plans for high-tech talents, taking full advantage of the vast technology gap to invest abroad, and encouraging multiple green finance products to be pretty used in the environmental industries are vital. On the other hand, MNCs should be able to self-innovate and continuously create in the face of treacherous international market conditions with fierce competition and unpredictable risks. It is critical for employees of MNCs to have sufficient ability to learn, communicate, and cooperate effectively with colleagues from the host country.

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Author contributions

Methodology, B.Q. and L.G.; software, Y.G. and L.G.; validation, B.Q., Y.G. and L.G.; writing-original draft preparation, Y.G. and L.G.; writing-review and editing, Y.G., and L.G.; visualization, Y.G., L.G. and J.Z; supervision, B.Q., L.G., Y.Z. and J.Z.; project administration, B.Q., L.G. and J.Z. All authors have read and agreed to the published version of the manuscript.

Disclosure statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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APPENDIX

Table A.1. The result of the bootstrap test

Dependent variable	GREENP2	GREENP1			
Independent variable	GFI	GFI < 0.720	RET < 0.084	RET ≥ 0.084	HUM < 8.523
Indirect effect	0.053*	–0.32*	–0.041*	–0.008	0.004
_bs_1	1.88	–1.85	–1.67	–0.68	0.38
Direct effect	0.201**	0.236***	0.214***	0.275***	0.038
_bs_2	3.79	4.55	3.80	4.35	0.52
Normal-based [95% Conf. Interval]	[0.011,0.025]	[–0.065,0.002]	[0.090,0.007]	[–0.032,0.015]	[–0.015,0.022]
	[0.110,0.243]	[0.125,0.338]	[0.103,0.324]	[0.151,0.399]	[–0.105,0.180]

Note: The significance levels refer to $p < 0.01$ (***), $p < 0.05$ (**) and $p < 0.1$ (*). T-values are shown in parentheses. The control variables are included but not shown for saving space.