The Impact of Reverse Technology Spillover from Subsidiaries on Parent Firms' Environmental Sustainability: Mediating Role of Research and Development Spending

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Abstract

This study examines how multinational enterprises (MNEs) seek technological capabilities (TC) through reverse technology spillover to improve their environmental performance (EP) in India, an emerging economy. MNEs utilize the technological knowledge of advanced economies by creating subsidiaries in those regions to obtain and incorporate TC in their home country. Based on previous studies, we utilized the subsidiary's patent citations as a proxy for reverse technology spillover. We suggest that a subsidiary's patent citation positively impacts the parent's EP in its home country. We find no support for a direct relationship based on the 120 MNEs panel data analysis from 2009 to 2023. We address endogeneity concerns in our primary analysis. However, the parent company's R&D spending mediates the subsidiary's patent citation and the parent's EP relationship. Our findings offer a new perspective on the current research regarding technology transfer effects in developing economies. Moreover, our results have significant practical and policy implications. The results substantiate the notion that multinational enterprises (MNEs) might augment the innovation efficacy of their parent company by employing global growth via the creation of subsidiaries within advanced economies. The study's findings demonstrate that creating subsidiaries in developed markets is a successful way for businesses to experience reverse technology spillover as it exposes them to cutting-edge information and tools that are unavailable domestically.

Keywords: Reverse Technology Spillover, R&D spending, environmental performance, patent citations.

Introduction

In the ever-changing industrial environment, a narrative arises about companies in developing markets dealing with environmental sustainability challenges (Ciravegna, Luciano Fitzgerald & Kundu, 2013). Notwithstanding their utmost initiatives, these companies encounter substantial obstacles in adopting sustainable practices at a local level and developing the required technologies within their own country or locally. Consequently, they choose an unconventional approach, such as establishing branches in advanced economies.

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Indian parent companies, once the main drivers for the country's economic expansion, are now facing a critical juncture. Shukla and Mahapatra (2015) state that environmental degradation in India has become a significant and urgent issue, with the projected annual cost of environmental deterioration being INR 3.75 trillion ($80 billion). The environmental deterioration issue still prevails in emerging Asian economies like India, and there is a need to resolve or tackle that challenge (Yu et al., 2023).

Considering these issues, Indian parent corporations are endeavouring to overcome the difficulties associated with evaluating the environmental effects and implementing standards by setting up subsidiaries in advanced economies. These subsidiary companies give access to cutting-edge technology and facilitate the dissemination of information and experience to the parent companies (Awate et al., 2015). As a result, the subsidiary companies often surpass their parent companies in revenue growth and volume (Lo & Tan, 2020). However, this technique is not devoid of a distinct array of challenges. The environmental sustainability of these parent firms in rapidly developing Asian countries is a matter of concern as they struggle to balance their growth goals with the need to address the environmental challenges they face. Furthermore, environmental sustainability encompasses the evaluation of both energy consumption and environmental contamination throughout the process of economic advancement, hence adhering more closely to the requirements of superior and enduring economic expansion (Sun et al., 2023).).

Given that manufacturing contributes significantly to India's energy consumption and pollution, it is crucial to enhance the sector's sustainability and facilitate its transition towards environmentally friendly practices to achieve high-quality economic development in the economies. R&D investment plays a crucial role in closing the gap between the technological skills of subsidiaries and parent firms in this particular environment (Athreye et al., 2016; Iwasa & Odagiri, 2004). In recent years, there has been an increase in the seek and use of advanced technology and innovations. That is due to the increasing concerns posed by global warming and environmental deterioration (Kunapatarawong & Martínez-Ros, 2016; Miao et al., 2017). However, sustainability is essential, and the need for green growth has become increasingly important (Hickel & Kallis, 2020). Technological advancement facilitates green growth (Danish & Ulucak, 2020; Fang et al., 2022). Nevertheless, it is vital to note that innovation typically incurs significant costs. Hence, the primary concern is whether green innovation can enhance economic growth while upholding its ecological advantages. Scientific and technological advancements can contribute to developing an organization's environmental sustainability. Within the framework of economic globalization, it might be challenging for a country, particularly a developing one, to achieve a complete technological edge only via autonomy. Accessing foreign technology spillovers through various routes might enable developing countries to use their "late-mover advantage" and accomplish technological catch-up and modernization (Sarker & Serieux, 2022). International technology spillovers occur through three primary channels: trade, FDI, and OFDI (Brandão & Ehrl, 2019; Salim et al., 2017).

However, developing economies typically face challenges in accessing cutting-edge technology at the worldwide forefront, primarily due to the safeguarding efforts of advanced countries (Peerally et al., 2022). When compared to the previous two methods, the reverse technology spillover achieved by OFDI can be more focused and proactive (Z. Wang et al., 2021). OFDI has recently grown in importance as a way for businesses throughout the globe, especially those in emerging economies, to integrate into global markets and access advanced technology and other vital resources. (Fahad et al., 2022; Kogut & Chang, 1991). China has lately intensified its efforts to bolster its involvement with the global community through the recruitment of foreign investment and the facilitation of the internationalization of local companies (Bai et al., 2020).

Many studies have examined reverse technology spillovers (RTS). This topic has several gaps in the literature. Previous studies have not studied how reverse technological spillovers affect energy efficiency, intensity, and environmental sustainability in rising Asian nations. Missing the advantages of lowering energy intensity reduces the benefits of saving energy and moving to an ecologically friendly economy (Chu, 2024; J. Wang et al., 2023). Moreover, little attention has been given to the interrelationship between reverse technology spillover, energy intensity, and environmental sustainability, highlighting the need for additional research to address and improve this knowledge gap (Lin et al., 2023). Researchers often evaluate the RTS because of the wide range of host countries and various forms of foreign investments. Developed economies are often seen as the nations that can accommodate RTS. Nevertheless, there is a lack of emphasis on whether RTS may be obtained from foreign investment activities in developing countries. Furthermore, there is a lack of studies on the distinction between foreign investments based on industrial intensity, specifically technology- and resource-intensive ones.

In 1960, Hymer proposed the idea of foreign direct investment (FDI), published in his book "The International Operations of National Firms: A Study of Direct Foreign Investment" in 1976. Hymer first presented this theory in his PhD dissertation. Hymer's theory challenged the traditional economic theory, which assumed that capital would flow from capital-rich to capital-poor countries through the market mechanism. Instead, Hymer argued that large multinational corporations (MNCs) controlled the flow of capital, which monopolized specific advantages, such as technology, brand recognition, or management skills, and thus engaged in FDI to maintain their market position (Hymer, 1976).

Existing studies on international investments consistently demonstrate the presence of reverse technology spillovers caused by OFDI energy intensity and environmental sustainability (Y. He et al., 2023; Q. Wang et al., 2023; W. Zhang et al., 2022). Kogut and Chang (1996) suggested that the primary reason for foreign investment in Japan was to acquire technological spillovers from the US, particularly in companies that heavily rely on technology. Later, it was established that outward foreign direct investment (OFDI) significantly facilitates technology transfer across borders. Potterie and Lichtenberg (2001) introduced the notion of international research and development (R&D) capital. Subsequently, their focus shifted towards analyzing the impact of reverse technology spillovers on economic growth, stimulating technological innovation (Pan et al., 2020), and optimizing the industrial structure (Jiang et al., 2020). Spillovers of OFDI emerge when more effective knowledge, technology, and information are acquired in the host country and transferred back to the home country, improving the technical level due to overcoming geographical limits.

The study's primary purpose is to determine if parent companies in developing economies, such as India, benefit from technological spillovers from their subsidiaries in more established economies. The study also addressed the question of how the R&D efforts of parent companies moderate the connection between patent citations and environmental sustainability. The study's primary objective is to examine reverse technology spillover from subsidiaries to parent corporations and its impact on environmental sustainability. The opposite effect of subsidiary patent citations on parent corporations' R&D investment is also examined. Another objective is determining how parent businesses' R&D investment mediates the relationship between subsidiary patent citations and environmental sustainability.

We use a panel dataset consisting of 120 Indian-origin multinational firms (MNEs) and their subsidiaries in developed nations, covering the time from 2009 to 2023. In order to evaluate the technical prowess of the parent firm inside its home market, we depend on allocating resources towards research and development (R&D) activities. Research and development spending measurement is calculated by dividing R&D expenditures by revenue (Chiu et al., 2015; Lu & Beamish, 2001). We count subsidiary patent citations to evaluate technological skills in a developed market. Chen et al. (2012) used subsidiary company patent citations to measure technology diffusion. We also assess India's environmental sustainability using the parent firms' environmental performance scores. A combined research strategy uses ESG ratings to analyze a company's environmental performance (Ismai et al., 2020). We concentrate on the relationship between parent businesses' R&D spending and technical resources in their subsidiaries' markets. This study advocates utilizing empirical models to measure reverse technology spillover's influence on environmental sustainability. We employ instrumental variable methods, and Hausman tests to assess host market technology measure homogeneity. A two-step GMM estimator was utilized to analyze and evaluate our hypotheses. Ullah et al. (2018) handle endogeneity concerns such as unobserved panel heterogeneity, simultaneity, and dynamic endogeneity using a two-step GMM estimator. Our study confirms our fundamental hypothesis: Western subsidiaries transfer technology to growing Asian economies. Parent firms' R&D investments also improve environmental performance. The study also emphasizes the role of parent businesses' R&D spending in controlling the link between subsidiary patent citations and parent companies' environmental performance in developing nations like India.

Businesses may successfully experience reverse technology spillover by establishing subsidiaries in developed markets (Driffield et al., 2016). The research reveals how subsidiaries in developed countries help enterprises experience reverse technology spillover. It gives them access to cutting-edge knowledge and technologies that are inaccessible locally. Therefore, the contribute in many ways. The study significantly contributes to several critical aspects of the existing body of knowledge. Our analysis adds to the existing research on reverse technology spillover effects on the technological abilities of parent multinational businesses in Asian economies. Most studies have focused on how foreign direct investment (FDI) in emerging markets (EMs) affects the technical advancement of businesses in those host economies (V. Z. Chen et al., 2012a; Y. Zhang et al., 2010).

Furthermore, existing literature has indicated that inward foreign direct investment (FDI) has a propensity to bring about knowledge spillovers that positively impact local businesses in emerging markets (EMs) as host markets. That can be achieved by improving their technological skills (Cantwell, 1989). Previous studies like Driffield and Love (2003) have examined spillover effects' impact on foreign subsidiaries. However, there is a lack of literature and evidence exploring potential reverse technology spillover advantages from subsidiaries in developed markets to parent companies in emerging Asian economies.

Additionally, the role of R&D spending in mediating the relationship between subsidiaries' technological capabilities and parent firms' environmental sustainability has not been examined. Furthermore, it provides a possible rationale for why certain companies gain more significant advantages from specific spillovers than others and links these variations to the attributes of the acquired information. This finding is intriguing because it fills a gap in the literature on R&D spillovers, as the topic has never been addressed in this way. Finally, this study presents suggestive evidence of the impact of reverse technology spillover from subsidiaries on the environmental sustainability of parent firms in emerging Asian economies. It also examines whether the R&D spending of parent firms mediates this relationship.

Below is an outline of the part that follows in the paper: The formulation of hypotheses and an in-depth review of the current literature are presented in Section 2. It primarily examines how parent businesses' R&D expenditure is affected by patent citations, the impact of R&D spending on the environmental sustainability of parent companies, and the role of R&D spending as a mediator between patent citations of subsidiaries and the environmental sustainability of parent companies. Section 3 encompasses a theoretical framework, a source of data, and a technique for doing analysis. Section 4 comprises an examination and discourse on the findings. Section 5 of the research paper presents the study's final findings, constraints, and practical implications.

Literature Review

Process of Reverse Technology Spillover

Foreign technology spillovers obtained through OFDI include three phases: acquisition, transfer, and dissemination (Y. Li et al., 2022; Su & Li, 2021). Multinational businesses have three approaches for obtaining sophisticated technologies in the host country during the technology acquisition stage. M&A deals involving international borders are a significant cause for alarm. Mergers and acquisitions (M&A) or greenfield investments may overcome prohibitive restrictions in advanced economies and enable the purchase of cutting-edge technology (J. Li, 2022; Zhou et al., 2021). This technique efficiently transfers the purchased company's essential assets, such as patents, manufacturing processes, and scientific research and development, to the subsidiary in the country where it was bought. International research and development cooperation is also essential. Setting up research and development centers and partnering with local universities allows international corporations to access innovative technology and resources abroad. This method helps grasp cutting-edge technology. Another essential factor is industrial agglomeration (R. Wu & Lin, 2021). Through outward foreign direct investment (OFDI), multinational corporations may access technology-intensive industrial clusters in the host country to interact with the latest advancements in their sectors. Moreover, they can use cutting-edge technology by communicating and learning from other businesses inside the cluster.

The host country subsidiary must exchange its information, technical expertise, and R&D results with the parent business during technology transfer (Berry, 2014; Driffield et al., 2016). The parent firm adopts and integrates this technology into manufacturing and operations. The government of the home nation might urge the parent firm to aggressively facilitate the transfer of innovative technology and skills from the foreign subsidiary to the home country. That is possible with macro-level policy incentives. For instance, governments can reward local multinational businesses that invest in innovative technology in industrialized nations. It lowers investment costs and boosts profits for these companies. Enterprise-level micro-transmission relies on two-way personnel interchange. The parent business might send domestic experts abroad for training (P. Wang et al., 2004). After returning, professionals might use their overseas expertise in domestic manufacturing and product research and development. The parent business can also hire exceptional abroad subsidiary employees to boost domestic collaboration and innovation (Belderbos, 2001, 2003). That enhances technology transfer and improves the home country's capacity to adopt it.

During the technology diffusion stage, it is crucial for the parent company to carefully evaluate and select foreign technologies that align with the needs and circumstances of the home country. The parent firm must modify the technologies to satisfy specific needs and incorporate them into every manufacturing phase (Birkinshaw & Hood, 1998). It will provide a strong foundation for technological innovation and implementation. This advanced technology will be integrated into the operating procedures of multinational firms and the broader industry. Value embodiment is achieved via reverse technology spillover during the local optimization process.

Patent Citations and R&D Spending

Getting a patent can give companies a distinct market advantage, allowing them to outperform their competitors and improve their overall business performance (Altinn, 2022). The ability to obtain patents allows companies to gain exclusive rights to market their inventions. It hinders opponents from manufacturing or marketing the copyrighted technology, providing the firm a unique competitive edge and drawing in a broad customer demographic (Bache & Spilde, 2021). Patent citations empower firms to safeguard their product designs by preventing competitors from copying them (Hanel, 2006). So, it is widely recognized as the primary driver of competitiveness. Researchers assert that patents can significantly enhance a company's worth, while a surge in filings for innovation patents can positively impact business outcomes. According to recent Korean research, corporate patent holdings influence company performance (M. He & Pérez Estébanez, 2023; Jin & Kim, 2021). Lee (2020) also found that patents significantly increase a company's worth. However, there is a lack of information regarding the correlation between patent citations and R&D investments. There is a possibility that the patent citations of subsidiaries can impact the R&D spending of parent firms. However, additional investigation is necessary to empirically test the proposed hypothesis and uncover the exact nature of this relationship. This connection can demonstrate the technological spillover. We derive the following hypothesis from the preceding discussion:

Hypothesis 1: There is a positive and significant impact of patent citations of subsidiaries on the R&D spending of Indian parent firms.

Effect of Reverse Technology Spillover on Environmental Performance

Studies have shown that technology spillover from foreign direct investment can significantly impact local environmentally friendly production efforts (Dai et al., 2021; F. Wu et al., 2022). The primary impact of influence involves R&D feedback: OFDI endeavours can assist parent companies in acquiring knowledge, emulating, and ultimately implementing state-of-the-art green manufacturing technologies in the host countries. Nevertheless, adopting foreign technology can enhance the competitiveness of local enterprises, enabling them to sustain or grow their market presence. Reverse technology spillovers by OFDI will improve environmental sustainability in Asia's emerging economies, fostering corporate growth and adaptation (Shao et al., 2024; Yang et al., 2020).

Impact on cost allocation: Manufacturing enterprises must increase their spending on research and development to sustain their technical advantages (Ito & Pucik, 1993). Nevertheless, the exorbitant expenses associated with research and development are placing significant financial strain on businesses utilizing antiquated manufacturing techniques. OFDI has the potential to boost income, open new global markets, and lower R&D costs for these companies (Huang, 2013; Jannis et al., 2018). If we choose to invest in a country open to foreign capital, the host government may help in terms of tax and fiscal policies to help distribute research and development costs. The plan to promote Indian-made products has received significant financial backing and strong support from the government. Investing in foreign markets can be a more convenient way to overcome technological obstacles and access advanced production resources from other countries. This approach allows enterprises to safeguard their valuable technology. OFDI also facilitates the recruitment of skilled professionals from the host country, allowing home-nation enterprises to optimize local production resources and develop environmentally friendly production capabilities. With significant OFDI accelerating domestic capital flight, production connections may shift resource allocation (You & Solomon, 2015).

Most importantly, companies may leverage innovation and R&D money. Substantial independent R&D firms will suffer more from crowding out. Foreign investors may lose money due to OFDI fears. Companies may struggle to develop autonomously due to limited domestic R&D funding (Foray et al., 2012). Effect of external dependency: OFDI's reverse technological spillover may help enterprises innovate, but it may also lead to overreliance on foreign technology. Some organizations employ foreign staff to oversee the core production link without integrating cutting-edge technology to speed up operations and boost efficiency.

Studies have also shown an association between R&D spending and the environmental sustainability of businesses. For example, Paramati et al. (2020) examined the long-term link between R&D spending and environmental sustainability. The reliance on foreign technology would push local firms to fall behind cutting-edge foreign technologies, undermining parent businesses' environmental sustainability in their home countries. In consideration of the above, we hypothesize the following:

Hypothesis 2: There is a positive and significant impact of R&D spending of parent firms on environmental performance in India.

Mediating Role of R&D Spending of Parent Firms

Knowledge spillover occurs when an innovator gains insights from the study of others without compensating them through multiple means like IFDI that may favourably affect local firms' innovation (Branstetter, 2006). It may happen in several ways. First, MNEs should provide technical support and other methods like reverse engineering to show that new technologies are feasible. Therefore, the need for MNEs to provide local input may raise local enterprises' backward and forward operations. Through interactions with international companies, local businesses may get knowledge about the designs of cutting-edge products and technologies.

Furthermore, experienced managers and proficient workers employed by multinational enterprises (MNEs) could transition to domestic companies or establish their enterprises because of human capital mobility or turnover in the labour market. These employees' or managers' use of technology may improve the innovative capabilities of their companies (Cheung & Lin, 2004). However, the overall impact on environmental sustainability remains to be determined through the mediating mechanism of parent companies' R&D spending in developing Asian economies.

Thirdly, through assessing and monitoring the outcomes of multinational enterprises' research and development initiatives, illustrating the impact of foreign direct investment may stimulate the inventive endeavours of domestic companies. Consequently, local parent firms may be more adept at conducting their inventive endeavours. Inward foreign direct investment (FDI) could negatively impact local firms by monopolizing markets, drawing business away from local competitors, and replacing domestic suppliers with foreign suppliers, thereby reducing productivity and creativity. These changes have already been shown. Nevertheless, they also open new avenues for discovering novel scenarios and relationships. These channels proved to be mediums of the spillover.

Moreover, studies have found a relationship between R&D investments and firms' environmental sustainability. One study looked at the correlation between R&D investment and environmental sustainability over the long term (Paramati et al., 2020). They found that spending more on research and development in the nations they studied led to a considerable decrease in carbon dioxide emissions and an increase in the use of renewable energy. The studies have shown inconsistent evidence of both positive and negative effects on local enterprises' performance due to the existence of foreign Investment (Görg & Greenaway, 2004). However, the literature does not emphasize or identify parent companies and their subsidiaries' role in exchanging knowledge and technology through a reversal technological spillover.

Additionally, knowledge-seeking FDI is more focused on enhancing firm-specific advantages by acquiring new information than maximizing an MNE's current ownership advantage (Dunning & Lundan, 2009). Emerging-market multinational companies (EMMNEs) use OFDI in a developed market to spill over knowledge and their technical capabilities domestically (V. Z. Chen et al., 2012a). Research has shown that economies with more advanced technology tend to attract investment from technologically underdeveloped states, which helps with knowledge acquisition (Florida, 1997; Kogut & Chang, 1991). It was also pointed out by Kogut and Chang (1996) that Japanese companies entered US industries that had better research and development capabilities than Japan. Suppose a foreign market has a better-educated workforce and higher spending on research and development than the multinational business's home market. In that case, the multinational firm will likely establish research and development facilities there.

According to the Springboard concept, EMNEs exploit international growth as a starting point to acquire strategic assets and overcome their market limitations. According to the springboard theory, EMNEs primarily set up R&D abroad to gain knowledge from developed nations' experiences with cutting-edge technology (Luo & Tung, 2007). The R&D capabilities' mediating function is often disregarded when discussing the reverse spillover effects of the technical innovation of foreign subsidiaries. Regardless, to determine how the geographical spread of EMNEs' business settings affects the innovation efficiency of their parent enterprises, Zhao et al. (2022)

classify their R&D internationalization as intense. Prior studies have investigated the function of research and development spending as a mediator between environmental standards and performance, with a view toward changes in the strictness of these rules (J. Zhang et al., 2022). Research and development spending was shown to have a moderating role. Several scholarly articles have investigated the possible role of research and development spending in influencing several firm-level and national issues. Nevertheless, the existing research lacks sufficient evidence about the impact of corporate R&D expenditure on the correlation between environmental sustainability and reverse technological spillover.

Evidence for the hypothesized association is lacking in the literature. Thus, research and development expenditures transfer technological expertise from subsidiaries to parent firms, affecting their environmental performance. However, no research has examined the predicted mediating effect. R&D investment and company performance were the study's primary emphasis. Research and development-intensive companies will likely practice sustainability and do well (Alam et al., 2019; Arimura et al., 2007).

Additionally, firms may significantly impact their subsidiaries' environmental sustainability efforts (S. Balasubramanian & Shukla, 2020; Tatoglu et al., 2014). Considering the potential impact of R&D expenditure on environmental performance outcomes and the influence of parent companies on these outcomes, it is reasonable to assume that this spending acts as a mediator between patent citations and environmental performance at subsidiaries. Additional investigation is necessary to empirically confirm this concept and define the nature of this link. Thus, studies are required to investigate how parent companies' R&D spending mediates the relationship between environmental sustainability and patent citations from subsidiaries. The following hypothesis is developed concerning the previously described discussion:

Hypothesis 3: There is a mediating effect of the R&D spending of parent firms on the relationship between patent citations and the environmental performance of Indian parent firms.

Framework of the Study

The conceptual framework of the research is outlined in the following Figure 1. This conceptual structure illustrates how the dependent and independent variables in the study are connected. In this study, environmental performance is the dependent variable, while the R&D of parent firms is the independent variable. Moreover, the patent citations of subsidiaries are also used as an independent variable in model 1, where the reverse technology spillover is identified. Similarly, the following figure also illustrates the mediation relationship between the subsidiary's patent citations and environmental performance.

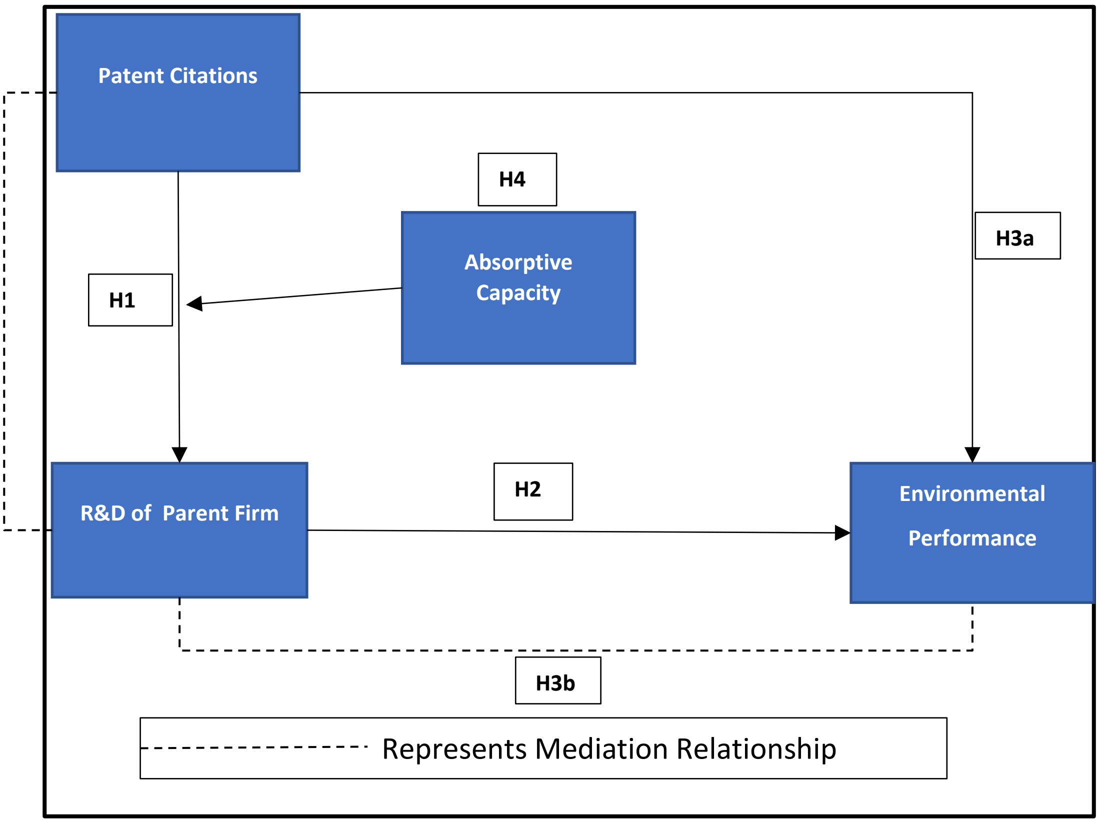

Figure 1: Framework of the Study

Methodology and Models Specification

Sample and Data Description

Our sample consists of 120 Indian multinational parent firms and their subsidiaries from developed markets from 2009 to 2023. We used specific criteria to finalize our selection for analyses. We only included enterprises of Indian origin and their subsidiaries in developed countries in our panel. We acquired the firm-level data from Orbis databases (Orbis Companies, Orbis Intellectual Property), ESG reports, and published financial and annual reports. In Table 1, we mentioned the data sources and explained the variables used in the study. The data source and description are provided in Table 1 below.

Table 1

Data Sources and Description

Variables	Symbol	Measurement	Source

R&D Spending (Parent)	R&D_PRT	R&D spending is measured as a percentage of total expenses in this study.	Financial Statements and Orbis Databases.
Patent Citations of Subsidiaries	PAT_CIT	Total number of patent citations approved in a particular year.	Orbis Intellectual Property Database.
Absorptive Capacity	ABS_CAP	It is measured as the higher the level of human capital in different studies.	Financial Statements and Orbis Databases.
Environmental Performance	ENV_SCORE	The environmental performance is measured as the ESG score assigned to a specific firm based on its performance over a specific year.	ESG Reports of Firms.
Firm Size	FRM_SIZE	Firm size is measured as the logarithm of the dollar value of total assets	Financial Statements and Orbis Databases.
Firm Age	FRM_AGE	The logarithm of the number of years since incorporation	Financial Statements and Orbis Databases.
Financial Position	FIN_POS	It is measured as the ratio of current assets to current liabilities and total assets to total liabilities.	Financial Statements and Orbis Databases.
Firms Profitability	FRM_PROF	The profitability variable is a firm's	Financial Statements and

		total profit for a specific year.	Orbis Databases.
Official Language	OFF_LANG	One is assigned if both countries share the same official language, and 0 is assigned otherwise.	Financial Statements and Orbis Databases.

We also considered the companies that provided their financial reports on their websites. We were limited in our sample selection and used firm-level panel data from 2009 to 2023. We categorized the chosen organizations into several industrial sectors in Table 2. We classified enterprises into sectors using a two-digit SIC code due to the considerable variation in the number of firms between industries.

Table 2

Selected Firms Description

Industry	SIC	Number of firms
Mining Extraction Companies	1	15
Food, Tobacco, Apparel, Furniture	2	22
Primary Manufacturing, Industries, Electronics	3	71
Wholesale, Restaurants	5	12
		120

Measurement and Description of Variables

Independent and dependent variables

The variables were selected after careful consideration of the conceptualization of each construct by the researcher; nonetheless, it is standard practice for researchers to use somewhat different measurements for the same construct. It is particularly true for massive constructs (Geyskens et al., 2006).

A host market's technical capabilities are determined by accounting for its industry-adjusted patent citation count. The research focuses on the relationship between parent company R&D expenditures and the number of patent citations made by subsidiaries in the host market. Chen et al. (2012) measured technology spillover using the patent citations of subsidiaries.

R&D spending is the sum of all expenditures and capital investments in creative projects to expand human knowledge in all its forms. This variable was determined by Jui-Chih and Hsing-Chin (2014) by contrasting the R&D spending of parent firms with their total assets. Therefore, research and development spending is measured as R&D spending divided by revenue (Chiu et al., 2015; Lu & Beamish, 2001). Using Baysinger and Hoskisson (2017) and Markides and Ittner (1994) as references, we used R&D spending as a proxy for parental enterprises' technological capabilities. The study employs the Environmental performance score as a proxy for environmental sustainability in this study. That is the ESG score assigned to a firm based on its overall sustainable yearly performance. Using ESG scores as a proxy for environmental sustainability is a common research practice, as it provides a standardized and widely accepted measure of a firm's environmental performance.

Control Variables

At the company level, we started with five control variables. Initially, it is vital to acknowledge that more prominent companies possess a higher ability to allocate resources towards research and development (R&D) initiatives. To account for this, we considered the firm's size by measuring the logarithm of the dollar value of total assets. Additionally, previous research has indicated that younger companies exhibit greater adaptability and a stronger focus on innovation (N. Balasubramanian & Lee, 2008; Hansen, 1992). To account for this, we included firm age as a variable, measured as the logarithm of the years since incorporation.

Furthermore, based on previous research indicating a correlation between a company's financial stress and its R&D expenditure (Hall & Mansfield, 1971; Ozkan, 2010), we incorporated a firm-level variable that captures the company's financial situation. One way to determine the financial condition of a business is to divide its total assets by its total liabilities. The companies' financial accounts indexed in the BvD Orbis database provide all the data we need at the firm level. In addition, we also consider the profitability of firms. Additionally, we consider the official language of firms operating in two different countries. If the official languages of both nations are the same, then one will be allocated; if not, zero. We incorporated year and industry-fixed effects into our analysis to account for variations across industries and over time. The definitions of these variables can be found in the above Table 1.

Models Specification

While testing our hypothesis, we used a generalized method of moments (GMM) estimator, a two-stage system. Ullah et al. (2018) conducted a study addressing endogeneity problems using a two-step Generalised Method of Moments (GMM) estimator. These endogeneity concerns included unobserved panel heterogeneity, simultaneity, and dynamic endogeneity. Unobserved panel heterogeneity is often expected during the process of managing panel data. A panel data set is a collection of observations made on several cross-sectional entities, such as businesses or industries, over time (Coakley et al., 2006). In addition, the studies on environmental sustainability may not be able to account for all the factors that impact environmental performance, including those that are not easily measurable. These unfair conditions can lead to increased worries about endogeneity.

Additionally, the relationship between reverse technology spillover and environmental performance could be susceptible to potential challenges of reverse causality. Therefore, a two-step GMM estimator can be utilized as it offers greater robustness and efficiency in dealing with heteroskedasticity and autocorrelation (Blundell & Bond, 2000). We utilized the following regression models to examine our proposed hypotheses.

$$Parent\ R\&D\ Spending_{i,t} = \beta_0 + \beta_1 Parent\ R\&D\ Spending_{t-1} + \beta_2 Patent\ Citations_{i,t} + \beta_3 control\ factors_{i,t} + Year\ effect_{i,t} + Industry\ effect_{i,t} + \varepsilon_{i,t} ----1$$

For hypotheses 2 and 3, the following regression is used.

$$Environemtnal\ Performance_{i,t} = \beta_0 + \beta_1 Environemtal\ Performance_{t-1} + \beta_2 R\&D\ Spending_{i,t} + \beta_3 control\ factors_{i,t} + Year\ effect_{i,t} + Industry\ effect_{i,t} + \varepsilon_{i,t} ----2$$

$$Environemtnal\ Performance_{i,t} = \beta_0 + \beta_1 Environemtal\ Performance_{t-1} + \beta_2 Patent\ Citations_{i,t} + \beta_3 control\ factors_{i,t} + Year\ effect_{i,t} + Industry\ effect_{i,t} + \varepsilon_{i,t} ----3a$$

$$Environemtnal\ Performance_{i,t} = \beta_0 + \beta_1 Environemtal\ Performance_{t-1} + \beta_2 Patent\ Citations_{i,t} + \beta_2 R\&D\ Spending_{i,t} + \beta_4 control\ factors_{i,t} + Year\ effect_{i,t} + Industry\ effect_{i,t} + \varepsilon_{i,t} ----3b$$

Diagnostic tests are conducted before implementing the two-step GMM estimator to assess validity. Testing for autocorrelations using AR (1) and AR (2), as well as conducting the Sargan test by Sargan-

Hansen (Kiviet & Kripfganz, 2021), provides statistical reliability for the given models. The explanation includes over-identifying limitations. The findings indicate no significant second-order correlation, as the coefficient estimates for Arellano-Bond (AR (2)) are not statistically significant. Similarly, the Sargan-Hansen test of over-identification provides further evidence that there is no second-order autocorrelation, the variables are exogenous (with no endogeneity present), and the instruments used are robust.

Empirical Results

Descriptive Statistics and Correlation

Study findings, including descriptive statistics and relationships, are shown in Table 3. It is commonly accepted that a correlation value of less than 0.7 indicates multicollinearity when applied to the two variables in question. Another metric for multicollinearity is the variance inflation factor (VIF). Because it determines whether the variables used in regression studies are multicollinear, VIF is a trustworthy indicator of multicollinearity (Micheal & Abiodun, 2014; Shrestha, 2020). The variance inflation factor (VIF) for a regression model variable is equal to the entire model variance ratio divided by the variance of the model that includes that single independent variable. Based on the data in Table 3, the VIF for each variable is much lower than the acceptable threshold of 10. It strongly supports the argument that our model does not have multicollinearity. Table 3 also gives descriptive data for the variables. Descriptive statistics analysis only provides the variables' mean and standard deviation values.

Table 3: Descriptive Statistics, VIF, and Correlation Matrix

Variables	Mean	S/D	VIF	1	2	3	4	5	6	7	8	9
EP (1)	70.34	7.52	2.79	1.00								
Patent Citations (2)	4.52	1.38	1.91	0.45**	1.00							
R&D Spending of Parent (3)	5.43	1.63	1.54	0.33**	0.22***	1.00						
Absorptive Capacity (4)	3.62	1.45	1.84	0.12**	0.10***	0.07***	1.00					
Firm Size (5)	3.02	1.12	2.23	-0.11**	-0.10**	0.10**	0.10**	1.00				
Official Language (6)	0.71	0.35	2.77	0.05*	0.05*	0.04*	0.04*	0.20*	1.00			
Firm Age (7)	4.34	1.54	2.31	0.01**	0.01**	0.10***	0.10***	0.10***	0.10*	1.00		
Current ratio (8)	2.28	0.66	2.53	0.32**	0.30***	-0.19***	-0.20**	-0.20**	-0.19**	-0.17**	1.00	
Firm Profitability (9)	5.67	1.76	2.71	-0.09**	0.19***	-0.32**	0.18**	0.16**	-0.11*	-0.14**	-0.15**	1.00

**Patent Citations, R&D Spending, Absorptive Capacity, Firm Size, and Firm Age are log transformations.*

Findings and Discussions

Table 4 provides an overview of the findings of the GMM estimation technique. To begin, the EP (-1) has a beneficial influence on environmental performance that is statistically significant due to its positive nature. It supports our argument that the lag value contributes significantly to the environment's performance in the current year. The results shown in Table 4 summarise the findings of our study on the impact that patent citations of subsidiaries have on parent firms' R&D spending in model 1 to find out the reverse technology spillover in Indian firms. However, patent citations do not directly affect parent firms' environmental performance. Based on the results, we found no effect of subsidiaries' patent citations on environmental performance in India. In addition, we evaluated the mediation analysis. The mediation study of parent companies' research and development expenditure on the relationship between patent citations of their subsidiaries and environmental sustainability in emerging Asian economies like India was shown to have significant and positive impacts. Through a process known as technology spillover, the environmental sustainability of parent companies is also impacted by the technological capabilities of subsidiaries in host countries only through parent firms' research and development spending.

In addition, the findings of the GMM estimate are also provided in Table 4, which may be seen here. The first thing to note is that the EP (-1) has a positive and statistically significant influence on the EP. It lends credence to our contention that the lag value significantly impacts the current year's environment performance. Model 3 summarises the findings of our study of the mediating influence that the R&D spending of parent firms has on the patent citations and environmental performance of emerging Asian firms. Among the emerging economies in Asia (India), we discovered that the expenditure of parent companies on research and development had a significant influence on environmental sustainability.

Table 4

SYS-GMM Regression Results

	Model 1 (Parent R&D)		Model 2 (Parent EP)		Model 3 (Parent EP)			
	ß	S/E	ß	S/E	ß	S/E	ß	S/E
Parent R&D Spending (t-1)	0.782***	0.136	--------	-------	--------	--------	--------	--------
EP (t-1)	--------	--------	0.643***	0.147	0.777***	0.134	0.763***	0.130
Patent citation (Subsidiary)	0.141**	0.024	-------	-------	0.223	0.118	0.314**	0.038

Parent R&D Spending	--------	--------	0.247***	0.057	--------	--------	0.118***	0.015
Parent Firm Size	0.071**	0.031	0.083***	0.033	0.076**	0.042	0.091**	0.043
Official Language	0.0022	0.002	0.004	0.003	0.0002	0.001	0.0038	0.003
Parent Firm Age	0.084**	0.041	0.065***	0.021	0.0882**	0.040	0.078**	0.035
Current Ratio	0.072***	0.024	0.048***	0.014	0.064**	0.036	0.067**	0.029
Firm Profitability	0.023**	0.007	0.034**	0.006	0.024***	0.008	0.021**	0.009
Year fixed effect	Yes		Yes		Yes		Yes	
Industry fixed effect	Yes		Yes		Yes		Yes	
Observations	1800		1800		1800		1800	

$P < 0.05$ = *, $P < 0.01$ = **, $P < 0.001$ = ***

In addition, the mediation analysis results are shown in Table 4. We examined the mediation analysis of parent companies' expenditure on research and development on the relationship between patent citations of subsidiary businesses and environmental sustainability in emerging Asian developing economies. We found the full mediating impact of research and development spending of parent firms. Through reverse technology spillover, the environmental performance of parent companies is also impacted by the technological capabilities of subsidiaries situated in host countries. There is no considerable evidence of the direct influence of patent citations by subsidiaries on parent firms' environmental performance. They develop meaningful and constructive relationships with one another only through the mediating role of research and development spending of parent firms.

Additional Analysis

The Moderating Role of Absorptive Capacity

We started by examining the influence of subsidiary patent citations on parent companies' research and development spending in India. We conducted tests to examine the direct influence of parent firms' absorptive capacity on their R&D expenditure. Next, we examined how the absorptive capacity of parent firms influences the connection between patent citations and R&D spending.

The findings in Table 4 indicate no significant impact of patent citations from subsidiaries on the environmental performance of parent firms in India. Nevertheless, we looked at the direct impact of subsidiary patent citations on parent businesses' R&D spending while further investigating the moderating impacts of absorptive ability. We found a significant and promising relationship between patent citations and the R&D spending of parent firms. Reverse technology spillover from subsidiaries to parent enterprises is significantly impacted by the extent of absorptive ability, according to our results. The reverse technology spillover from developed economy subsidiaries is amplified by enhanced absorptive ability. Furthermore, in developing Asian economies, our research shows that parent companies often benefit from technology that has trickled down from their subsidiaries. We conducted empirical tests to examine the impact of absorptive capacity on the relationship between patent citations and R&D spending of parent companies with this objective in mind. Given the presence of two constructs related to R&D spending, we conducted separate regressions for each interaction term to ensure accurate estimation without any bias. In our study, we examined the relationship between patent citations and R&D spending of parent firms, considering the moderating role of absorptive capacity. We regressed four different models to obtain empirical evidence. Our study also incorporated control factors like those utilized in our models.

To examine the influence of absorptive capacity on the relationship between patent citations and R&D spending of parent firms, we incorporated these variables into our model to investigate their direct effect on R&D spending. The findings indicate a positive correlation between both variables and R&D spending. The findings indicate a clear link between the number of patent citations from subsidiaries and the amount of R&D spending by parent companies in emerging Asian economies. Our primary emphasis is on interaction terms, as we want to investigate the moderating effect of these factors in the positive relationship between patent citations and the R&D expenditure of parent corporations. The findings suggest a notable correlation between the interaction term of absorptive capacity and patent citations.

Table 5

Moderating Role of Absorptive Capacity

	R&D Spending		*Ln*R&D Spending	
	1	2	3	4
Patent Citations	0.093**	0.093**	0.093**	0.093**
Absorptive Capacity		0.096***		0.092***
Patent Citations*Absorptive Capacity		0.046***		0.054***
Firm characteristics	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes
Industry effect	Yes	Yes	Yes	Yes
Observations	1800	1800	1800	1800

P < 0.05 = *, P < 0.01= **, P < 0.001 = ***

The findings of interaction terms between patent citations and absorptive capacity are also reported in Table 5. The interaction term has a statistically significant impact. These results provide further evidence that the absorptive capacity of enterprises has enhanced the correlation between patent citations and R&D expenditure in developing Asian nations.

Conclusion

The findings delve into whether and how emerging market MNEs might improve their technological capabilities through knowledge acquisition and sharing from developed economies. The need of emerging economies to acquire knowledge is a well-known driver of FDI in established economies (Braconier et al., 2001; Luo & Tung, 2007b; Rui & Yip, 2008). There is a lack of research on whether investments like these provide beneficial knowledge spillover effects that boost the technical capacities of multinational corporations in developing countries and influence environmental sustainability. Our study adds valuable insights to this topic. We discussed how emerging economies actively pursue advanced knowledge from abroad. To better absorb and utilize this knowledge, they also tend to increase their domestic research and development investments. It allows them to combine external knowledge with existing knowledge to drive innovation and improve environmental sustainability. Therefore, the enhanced technological capabilities of subsidiaries lead to the advancement of the technological capabilities of parent firms operating in emerging economies. We employed and analysed a panel dataset of 120 multinational enterprises (MNEs) from India from 2009 to 2023. Our study strongly suggests that multinational enterprises (MNEs) may benefit from investing in host economies with abundant technology resources to accelerate their technological growth. This research shows that MNEs in developing markets may do well to make these kinds of investments. Our investigation revealed a significant association between parent corporations in emerging Asian economies boosting their R&D spending after receiving knowledge transfers from subsidiaries in more technologically advanced nations.

Parent businesses' technical skills in developing markets are enhanced when they invest in the host country with considerable technology expertise. The parent company may do its part to protect the environment by investing in economies that invest a lot in research and development and have a high patent rate. Compared to other information types, patent knowledge is more visible and accessible for opponents to comprehend (Cummings & Teng, 2003; Minbaeva, 2007).(Cummings & Teng, 2003; Minbaeva, 2007). Therefore, we opted to utilize patent citations to examine and detect the reverse technology spillovers from subsidiaries to parent firms in emerging Asian economies. In addition, patents serve as a form of documented and technological capabilities that can be exchanged in a public marketplace (Cummings & Teng, 2003; Minbaeva, 2007). Businesses with a global reach might theoretically use established markets as a springboard to host nations' patent citation databases and other resources. However, to acquire valuable and hidden R&D input knowledge, emerging markets MNEs must establish a presence in the host economies and actively engage with experts in established economies (Kogut & Chang, 1996; Lyles & Salk, 1996). Thus, establishing subsidiaries in that place can facilitate the acquisition of cutting-edge technological expertise that can be shared with parent companies in emerging economies.

Implications of the Study

The study has significant implications for the practices encompassing technology seeking through subsidiaries in developed economies. To expand their knowledge base effectively, MNEs from emerging Asian economies should proactively engage in foreign direct investment in markets filled with technological resources in their respective industries. Our research suggests that it is essential to view the availability of technical resources in a particular market. The level of technological capabilities in the industry within developed economies can substantially generate reverse spillovers in emerging Asian economies. Our study illustrates an essential finding for parent firms in emerging Asian economies. When seeking technology from technologically advanced countries to enhance their capabilities in the home market, it is advisable to prioritize subsidiaries that prioritize innovation and have greener practices. The approach boosts technological capabilities and improves environmental sustainability in the home country. We found that emerging Asian economies have the potential to enhance their technological capabilities by leveraging reverse technology spillovers and knowledge transfer from subsidiaries operating in technologically advanced countries. To take advantage of reverse technology spillovers, multinational companies in emerging Asian economies must focus on enhancing their ability to absorb and apply advanced technologies in their domestic markets.

Research Limitations and Future Directions

Due to several limitations, this study needs to be further examined, ideally using more thorough data and data on EMMNEs from nations other than those in the sample. This section outlines several of the study's shortcomings and suggests some potential lines of inquiry for further research. This study did not examine industry or province-level spillovers within the same nation. Future studies might investigate how parent companies are affected by reverse technology spillover depending on why they invested. Future studies can be conducted by addressing these limitations. This research may be further developed by adding more explanatory factors about technology spillovers and R&D spillovers to parent businesses. Determining the reverse technology spillover that developed economies experience because of brownfield investments. Future research may employ the panel of solely MNEs that invested in brownfields in developed economies. The impact of reverse technology spillovers using various methodological analytical methodologies on environmental sustainability in other growing Asian economies.

References

Alam, M. S., Atif, M., Chien-Chi, C., & Soytaş, U. (2019). Does corporate R&D investment affect firm environmental performance? Evidence from G-6 countries. *Energy Economics*, *78*, 401–411. https://doi.org/10.1016/J.ENECO.2018.11.031

Altinn. (2022). *Patents*. Start and Run Business. https://www.altinn.no/en/start-and-runbusiness/planning-starting/protection-%0Aof-rights/patents/

Arimura, T., Hibiki, A., & Johnstone, N. (2007). An empirical study of environmental R&D: what encourages facilities to be environmentally innovative. *Environmental Policy and Corporate Behaviour*, 142–173.

Athreye, S., Batsakis, G., & Singh, S. (2016). Local, global, and internal knowledge sourcing: The trilemma of foreign-based R&D subsidiaries. *Journal of Business Research*, *69*(12), 5694–5702. https://doi.org/10.1016/J.JBUSRES.2016.02.043

Awate, S., Larsen, M. M., & Mudambi, R. (2015). Accessing vs sourcing knowledge: A comparative study of R&D internationalization between emerging and advanced economy firms. *Journal of International Business Studies*, *46*(1), 63–86. https://doi.org/10.1057/JIBS.2014.46/METRICS

Bache, C., & Spilde, E. (2021). *The effect of patents on financial constraints: An empirical analysis of Norwegian companies 2009-2018*. Norwegian School of Economics.

Bai, Y., Qian, Q., Jiao, J., Li, L., Li, F., & Yang, R. (2020). Can environmental innovation benefit from outward foreign direct investment in developed countries? Evidence from Chinese manufacturing enterprises. *Environmental Science and Pollution Research*, *27*(12), 13790–13808. https://doi.org/10.1007/S11356-020-07819-Z/TABLES/8

Balasubramanian, N., & Lee, J. (2008). Firm age and innovation. *Industrial and Corporate Change*, *17*(5), 1019–1047. https://doi.org/10.1093/ICC/DTN028

Balasubramanian, S., & Shukla, V. (2020). Foreign versus local firms: implications for environmental sustainability. *Benchmarking: An International Journal*, *27*(5), 1739–1768. https://doi.org/10.1108/BIJ-12-2019-0526/FULL/PDF

Baysinger, B., & Hoskisson, R. E. (2017). Diversification Strategy and R&D Intensity in Multiproduct Firms. *Academy of Management Journal*, *32*(2), 310–332. https://doi.org/10.5465/256364

Belderbos, R. (2001). Overseas innovations by Japanese firms: an analysis of patent and subsidiary data. *Research Policy*, *30*(2), 313–332. https://doi.org/10.1016/S0048-7333(99)00120-1

Belderbos, R. (2003). Entry mode, organizational learning, and R&D in foreign affiliates: evidence from Japanese firms. *Strategic Management Journal*, *24*(3), 235–259. https://doi.org/10.1002/SMJ.294

Berry, H. (2014). Knowledge Inheritance in Global Industries: The Impact of Parent Firm Knowledge on the Performance of Foreign Subsidiaries. *Academy of Management Journal*, *58*(5), 1438–1458. https://doi.org/10.5465/AMJ.2013.0724

Birkinshaw, J., & Hood, N. (1998). Multinational Subsidiary Evolution: Capability and Charter Change in Foreign-Owned Subsidiary Companies. *Academy of Management Review*, *23*(4), 773–795. https://doi.org/10.5465/AMR.1998.1255638

Blundell, R., & Bond, S. (2000). GMM Estimation with persistent panel data: an application to production functions. *Econometric Reviews*, *19*(3), 321–340. https://doi.org/10.1080/07474930008800475

Braconier, H., Ekholm, K., & Knarvik, K. H. M. (2001). In search of FDI-transmitted R&D spillovers: A study based on Swedish data. *Review of World Economics*, *137*, 644–665.

Brandão, L. G. L., & Ehrl, P. (2019). International R&D spillovers to the electric power industries. *Energy*, *182*, 424–432. https://doi.org/10.1016/J.ENERGY.2019.06.046

Branstetter, L. (2006). Is foreign direct investment a channel of knowledge spillovers? Evidence from Japan's FDI in the United States. *Journal of International Economics*, *68*(2), 325–344. https://doi.org/10.1016/J.JINTECO.2005.06.006

Cantwell, J. (1989). *Technological innovation and multinational corporations*. Blackwell Publishing Ltd.

Chen, C. (2018). Impact of China's outward foreign direct investment on its regional economic growth. *China & World Economy*, *26*(3), 1–21.

Chen, V. Z., Li, J., & Shapiro, D. M. (2012a). International reverse spillover effects on parent firms: Evidence from emerging-market MNEs in developed markets. *European Management Journal*, *30*(3), 204–218. https://doi.org/10.1016/J.EMJ.2012.03.005

Chen, V. Z., Li, J., & Shapiro, D. M. (2012b). International reverse spillover effects on parent firms: Evidence from emerging-market MNEs in developed markets. *European Management Journal*, *30*(3), 204–218.

https://doi.org/10.1016/J.EMJ.2012.03.005
Cheung, K. Y., & Lin, P. (2004). Spillover effects of FDI on innovation in China: Evidence from the provincial data. *China Economic Review*, *15*(1), 25–44. https://doi.org/10.1016/S1043-951X(03)00027-0
Chiu, S.-K., Lo, F.-Y., & Susy, Y. (2015). Taiwanese Foreign Direct Investment in Southeast Asia: An Empirical Investigation of the OLI Framework. *Journal of Economics and Management*, *11*(2), 127–141. https://ideas.repec.org/a/jec/journl/v11y2015i2p127-141.html
Chu, L. K. (2024). Towards achieving energy transition goal: How do green financial policy, environmental tax, economic complexity, and globalization matter? *Renewable Energy*, *222*, 119933. https://doi.org/10.1016/J.RENENE.2023.119933
Ciravegna, Luciano Fitzgerald, R., & Kundu, S. (2013). *Operating in emerging markets: A guide to management and strategy in the new international economy*. FT Press.
Coakley, J., Fuertes, A. M., & Smith, R. (2006). Unobserved heterogeneity in panel time series models. *Computational Statistics & Data Analysis*, *50*(9), 2361–2380. https://doi.org/10.1016/J.CSDA.2004.12.015
Cummings, J. L., & Teng, B. S. (2003). Transferring R&D knowledge: the key factors affecting knowledge transfer success. *Journal of Engineering and Technology Management*, *20*(1–2), 39–68. https://doi.org/10.1016/S0923-4748(03)00004-3
Dai, L., Mu, X., Lee, C. C., & Liu, W. (2021). The impact of outward foreign direct investment on green innovation: the threshold effect of environmental regulation. *Environmental Science and Pollution Research*, *28*(26), 34868–34884. https://doi.org/10.1007/S11356-021-12930-W/TABLES/13
Danish, & Ulucak, R. (2020). How do environmental technologies affect green growth? Evidence from BRICS economies. *Science of The Total Environment*, *712*, 136504. https://doi.org/10.1016/J.SCITOTENV.2020.136504
Driffield, N., & Love, J. H. (2003). Foreign Direct Investment, Technology Sourcing, and Reverse Spillovers. *The Manchester School*, *71*(6), 659–672. https://doi.org/10.1046/J.1467-9957.2003.00372.X
Driffield, N., Love, J. H., & Yang, Y. (2016). Reverse international knowledge transfer in the MNE: (Where) does affiliate performance boost parent performance? *Research Policy*, *45*(2), 491–506. https://doi.org/10.1016/J.RESPOL.2015.11.004
Dunning, J. H., & Lundan, S. M. (2009). The Internationalization of Corporate R&D: A Review of the Evidence and Some Policy Implications for Home Countries1. *Review of Policy Research*, *26*(1–2), 13–33. https://doi.org/10.1111/J.1541-

1338.2008.00367.X
Fahad, S., Bai, D., Liu, L., & Dagar, V. (2022). Comprehending the environmental regulation, biased policies and OFDI reverse technology spillover effects: a contingent and dynamic perspective. *Environmental Science and Pollution Research*, *29*(22), 33167–33179. https://doi.org/10.1007/S11356-021-17450-1/TABLES/8
Fang, W., Liu, Z., & Surya Putra, A. R. (2022). Role of research and development in green economic growth through renewable energy development: Empirical evidence from South Asia. *Renewable Energy*, *194*, 1142–1152. https://doi.org/10.1016/J.RENENE.2022.04.125
Florida, R. (1997). The globalization of R&D: Results of a survey of foreign-affiliated R&D laboratories in the USA. *Research Policy*, *26*(1), 85–103. https://doi.org/10.1016/S0048-7333(97)00004-8
Foray, D., Mowery, D. C., & Nelson, R. R. (2012). Public R&D and social challenges: What lessons from mission R&D programs? *Research Policy*, *41*(10), 1697–1702. https://doi.org/10.1016/J.RESPOL.2012.07.011
Geyskens, I., Steenkamp, J. M., Benedict, E., & Kumar, N. (2006). Make, Buy, or Ally: A Transaction Cost Theory Meta-Analysis. *Https://Doi.Org/10.5465/Amj.2006.21794670*, *49*(3), 519–543. https://doi.org/10.5465/AMJ.2006.21794670
Görg, H., & Greenaway, D. (2004). Much Ado about Nothing? Do Domestic Firms Benefit from Foreign Direct Investment? *The World Bank Research Observer*, *19*(2), 171–197. https://doi.org/10.1093/WBRO/LKH019
Hall, D. T., & Mansfield, R. (1971). Organizational and Individual Response to External Stress. *Administrative Science Quarterly*, *16*(4), 533. https://doi.org/10.2307/2391771
Hanel, P. (2006). Intellectual property rights business management practices: A survey of the literature. *Technovation*, *26*(8), 895–931. https://doi.org/10.1016/J.TECHNOVATION.2005.12.001
Hansen, J. A. (1992). Innovation, firm size, and firm age. *Small Business Economics*, *4*(1), 37–44. https://doi.org/10.1007/BF00402214/METRICS
He, M., & Pérez Estébanez, R. (2023). Exploring the impact of R&D intensity, human capital, patents, and brand value on small and medium enterprises (SMEs) business performance. *Economic Research-Ekonomska Istrazivanja* , *36*(1). https://doi.org/10.1080/1331677X.2023.2181839
He, Y., Zuo, H., & Liao, N. (2023). Assessing the impact of reverse technology spillover of outward foreign direct investment on energy efficiency. *Environment, Development and Sustainability*, *25*(5), 4385–4410.

https://doi.org/10.1007/S10668-022-02204-X/FIGURES/10
Hickel, J., & Kallis, G. (2020). Is Green Growth Possible? *New Political Economy*, *25*(4), 469–486. https://doi.org/10.1080/13563467.2019.1598964
Huang, S. C. (2013). Capital outflow and R&D investment in the parent firm. *Research Policy*, *42*(1), 245–260. https://doi.org/10.1016/J.RESPOL.2012.04.018
Hymer, S. H. (1976). *The International Operations of National Firms: A Study of Direct Foreign Investment*. The MIT Press. https://mitpress.mit.edu/9780262080859/the-international-operations-of-national-firms/
Ismai, N., Isa, M. A. M., Rahman, N. H. A., & Mazlan, N. F. (2020). Sustainability Performance Using Environmental, Social and Governance (ESG) Scores: Evidence from Public Listed Companies (PLCS) In Malaysia. *International Journal of Accounting, Finance and Business (IJAFB)*, *5*(30), 183–194.
Ito, K., & Pucik, V. (1993). R&D spending, domestic competition, and export performance of Japanese manufacturing firms. *Strategic Management Journal*, *14*(1), 61–75. https://doi.org/10.1002/SMJ.4250140107
Iwasa, T., & Odagiri, H. (2004). Overseas R&D, knowledge sourcing, and patenting: an empirical study of Japanese R&D investment in the US. *Research Policy*, *33*(5), 807–828. https://doi.org/10.1016/J.RESPOL.2004.01.002
Jannis, A., Philip, A., Anthony, A., & Panicos, D. (2018). *Global Investment Competitiveness Report 2018*.
Jiang, M., Luo, S., & Zhou, G. (2020). Financial development, OFDI spillovers, and upgrading of industrial structure. *Technological Forecasting and Social Change*, *155*, 119974. https://doi.org/10.1016/J.TECHFORE.2020.119974
Jin, S., & Kim, D. (2021). The Effects of Patents on the Relationship between R&D Activities and Business Management Performance: Focus on South Korean Venture Companies. *Journal of Open Innovation: Technology, Market, and Complexity*, *7*(4), 210. https://doi.org/10.3390/JOITMC7040210
Jui-Chih, W., & Hsing-Chin, H. (2014). The Association between the Operating Efficiency of Taiwanese FDI Enterprises in Mainland China and the Investment Performance of Their Parent Companies. *Chinese Studies*, *2014*(03), 100–112. https://doi.org/10.4236/CHNSTD.2014.33014
Kiviet, J. F., & Kripfganz, S. (2021). Instrument approval by the Sargan test and its consequences for coefficient estimation. *Economics Letters*, *205*, 109935. https://doi.org/10.1016/J.ECONLET.2021.109935
Kogut, B., & Chang, S. J. (1991). Technological capabilities and Japanese foreign direct investment in the United States. *Review*

of Economics & Statistics, *73*(3), 401–413. https://doi.org/10.2307/2109564

Kogut, B., & Chang, S. J. (1996). Platform investments and volatile exchange rates: Japanese electronic companies' direct investment in the US. *The Review of Economics and Statistics*, 221–231.

Kunapatarawong, R., & Martínez-Ros, E. (2016). Towards green growth: How does green innovation affect employment? *Research Policy*, *45*(6), 1218–1232. https://doi.org/10.1016/J.RESPOL.2016.03.013

Lee, J. (2020). Do patents lead to an increase in firm value? Evidence from Korea. *KDI Journal of Economic Policy*, *42*(3), 33–52.

Li, J. (2022). Can technology-driven cross-border mergers and acquisitions promote green innovation in emerging market firms? Evidence from China. *Environmental Science and Pollution Research*, *29*(19), 27954–27976. https://doi.org/10.1007/S11356-021-18154-2/TABLES/7

Li, Y., Zhang, X., Jin, C., & Huang, Q. (2022). The Influence of Reverse Technology Spillover of Outward Foreign Direct Investment on Green Total Factor Productivity in China’s Manufacturing Industry. *Sustainability*, *14*(24).

Lin, S., Long, X., Huang, J., & Gao, R. (2023). Green technology diversification, technology vertical spillovers, and energy intensity in Chinese cities. *Energy for Sustainable Development*, *76*, 101281. https://doi.org/10.1016/J.ESD.2023.101281

Lo, F. Y., & Tan, R. (2020). Determinants of international subsidiaries’ performances: A multi-level perspective of the subsidiary and parent company. *International Journal of Emerging Markets*, *15*(4), 746–766. https://doi.org/10.1108/IJOEM-06-2019-0445/FULL/PDF

Lu, J. W., & Beamish, P. W. (2001). The Internationalization and Performance of SMEs. *Strategic Management Journal*, *22*(6–7), 565–586. https://doi.org/10.1002/SMJ.184

Luo, Y., & Tung, R. L. (2007a). International expansion of emerging market enterprises: A springboard perspective. *Journal of International Business Studies*, *38*(4), 481–498. https://doi.org/10.1057/PALGRAVE.JIBS.8400275/METRICS

Luo, Y., & Tung, R. L. (2007b). International expansion of emerging market enterprises: A springboard perspective. *Journal of International Business Studies*, *38*(4), 481–498. https://doi.org/10.1057/PALGRAVE.JIBS.8400275/METRICS

Lyles, M. A., & Salk, J. E. (1996). Knowledge acquisition from foreign parents in international joint ventures: An empirical examination in the Hungarian context. *Journal of International Business Studies*, *27*(5), 877–903. https://doi.org/10.1057/PALGRAVE.JIBS.8490155/METRICS

Markides, C. C., & Ittner, C. D. (1994). Shareholder Benefits from

Corporate International Diversification: Evidence from US International Acquisitions. *Journal of International Business Studies*, *25*(2), 343–366. https://doi.org/10.1057/PALGRAVE.JIBS.8490204/METRICS

Miao, C., Fang, D., Sun, L., & Luo, Q. (2017). Natural resources utilization efficiency under the influence of green technological innovation. *Resources, Conservation and Recycling*, *126*, 153–161. https://doi.org/10.1016/J.RESCONREC.2017.07.019

Micheal, V. A., & Abiodun, A. A. (2014). Estimation of regression coefficients in the presence of multicollinearity. *Social and Basic Sciences Research Review*, *2*(10), 404–415.

Minbaeva, D. B. (2007). Knowledge transfer in multinational corporations. *MIR: Management International Review*, 567–593.

Ozkan, N. (2010). Effects of financial constraints on research and development investment: an empirical investigation. *Applied Financial Economics*, *12*(11), 827–834. https://doi.org/10.1080/09603100110050734

Pan, X., Li, M., Wang, M., Chu, J., & Bo, H. (2020). The effects of outward foreign direct investment and reverse technology spillover on China's carbon productivity. *Energy Policy*, *145*, 111730. https://doi.org/10.1016/J.ENPOL.2020.111730

Paramati, S. R., Alam, M. S., Hammoudeh, S., & Hafeez, K. (2020). *The long-run relationship between R & D investment and environmental sustainability : Evidence from the European Union member countries*. 1–18. https://doi.org/10.1002/ijfe.2093

Peerally, J. A., Santiago, F., De Fuentes, C., & Moghavvemi, S. (2022). Towards a firm-level technological capability framework to endorse and actualize the Fourth Industrial Revolution in developing countries. *Research Policy*, *51*(10), 104563. https://doi.org/10.1016/J.RESPOL.2022.104563

Potterie, V. P. D. L., & Lichtenberg, F. (2001). Does Foreign Direct Investment Transfer Technology Across Borders? *The Review of Economics and Statistics*, *83*(3), 490–497. https://doi.org/10.1162/00346530152480135

Rui, H., & Yip, G. S. (2008). Foreign acquisitions by Chinese firms: A strategic intent perspective. *Journal of World Business*, *43*(2), 213–226. https://doi.org/10.1016/J.JWB.2007.11.006

Salim, A., Razavi, M. R., & Afshari-Mofrad, M. (2017). Foreign direct investment and technology spillover in Iran: The role of technological capabilities of subsidiaries. *Technological Forecasting and Social Change*, *122*, 207–214. https://doi.org/10.1016/J.TECHFORE.2015.09.012

Sarker, B., & Serieux, J. (2022). Foreign-invested and domestic firm attributes and spillover effects: Evidence from Brazil. *Journal of Multinational Financial Management*, *63*, 100719. https://doi.org/10.1016/J.MULFIN.2021.100719

Shams Aaghaz, Q., Md, D., Khan, I., Pankaj, D., Gupta, K., & Faizi, M. N. (2024). The Challenges of India's Economy Shift from Economic Growth to Green Growth. *Journal of Informatics Education and Research*, *4*(1), 168. https://doi.org/10.52783/JIER.V4I1.536

Shao, Y., Li, J., & Zhang, X. (2024). Outward foreign direct investment and green technology innovation: A company and host country perspective. *Technological Forecasting and Social Change*, *203*, 123379. https://doi.org/10.1016/J.TECHFORE.2024.123379

Shrestha, N. (2020). Detecting Multicollinearity in Regression Analysis. *American Journal of Applied Mathematics and Statistics*, *8*(2), 39–42.

Shukla, P., & Mahapatra, D. (2015). Environmental and Resource Policy in India. In *The Routledge Handbook of Environmental Economics in Asia* (1st ed., p. 38). Routledge.

Su, R., & Li, L. (2021). Reverse Technology Spillover Effect of FDI in Manufacturing Industry: An Analysis Based on the Impact of Technology Gap. *Macroeconomics*, *7*, 66–78.

Sun, Y., Tang, Y., & Li, G. (2023). Economic growth targets and green total factor productivity: evidence from China. *Journal of Environmental Planning and Management*, *66*(10), 2090–2106. https://doi.org/10.1080/09640568.2022.2061335

Tatoglu, E., Bayraktar, E., Sahadev, S., Demirbag, M., & Glaister, K. W. (2014). Determinants of voluntary environmental management practices by MNE subsidiaries. *Journal of World Business*, *49*(4), 536–548. https://doi.org/10.1016/J.JWB.2013.12.007

Ullah, S., Akhtar, P., & Zaefarian, G. (2018). Dealing with endogeneity bias: The generalized method of moments (GMM) for panel data. *Industrial Marketing Management*, *71*, 69–78. https://doi.org/10.1016/J.INDMARMAN.2017.11.010

Wang, J., Usman, M., Saqib, N., Shahbaz, M., & Hossain, M. R. (2023). Asymmetric environmental performance under economic complexity, globalization, and energy consumption: Evidence from the World's largest economically complex economy. *Energy*, *279*, 128050. https://doi.org/10.1016/J.ENERGY.2023.128050

Wang, P., Tong, T. W., & Koh, C. P. (2004). An integrated model of knowledge transfer from MNC parent to China subsidiary. *Journal of World Business*, *39*(2), 168–182. https://doi.org/10.1016/J.JWB.2003.08.009

Wang, Q., Wang, R., & Liu, S. (2023). The reverse technology spillover effect of outward foreign direct investment, energy efficiency, and carbon emissions. *Environment, Development and Sustainability*, 1–23. https://doi.org/10.1007/S10668-023-

03323-9/TABLES/6
Wang, Z., Zhang, L., & Han, L. (2021). Knowledge-seeking and firm international performance: Evidence from Chinese multinational enterprises. *International Review of Financial Analysis*, *77*, 101823. https://doi.org/10.1016/J.IRFA.2021.101823
Wu, F., Fu, X., Zhang, T., Wu, D., & Sindakis, S. (2022). Examining whether government environmental regulation promotes green innovation efficiency—evidence from China's Yangtze River economic belt. *Sustainability*, *14*(3), 1827.
Wu, R., & Lin, B. (2021). Does industrial agglomeration improve effective energy service: An empirical study of China's iron and steel industry. *Applied Energy*, *295*, 117066. https://doi.org/10.1016/J.APENERGY.2021.117066
Yang, Z., Ali, S. T., Ali, F., Sarwar, Z., & Khan, M. A. (2020). Outward foreign direct investment and corporate green innovation: An institutional pressure perspective. *South African Journal of Business Management*, *51*(1). https://doi.org/10.4102/SAJBM.V51I1.1883
You, K., & Solomon, O. H. (2015). China's outward foreign direct and domestic investments: An industrial level analysis. *China Economic Review*, *34*, 249–260. https://doi.org/10.1016/J.CHIECO.2015.02.006
Yu, Y., Xu, Y., & Zhao, X. (2023). Environmental management is done by examining the technical factors of carbon emissions in South Asian economies. *Journal of Environmental Management*, *342*, 118123. https://doi.org/10.1016/J.JENVMAN.2023.118123
Zhang, J., Yang, Z., Meng, L., & Han, L. (2022). Environmental regulations and enterprises innovation performance: the role of R&D investments and political connections. *Environment, Development and Sustainability*, *24*(3), 4088–4109. https://doi.org/10.1007/s10668-021-01606-7
Zhang, W., Li, J., & Sun, C. (2022). The impact of OFDI reverses technology spillovers on China's energy intensity: Analysis of provincial panel data. *Energy Economics*, *116*, 106400. https://doi.org/10.1016/J.ENECO.2022.106400
Zhang, Y., Li, H., Li, Y., & Zhou, L. A. (2010). FDI spillovers in an emerging market: the role of foreign firms' country origin diversity and domestic firms' absorptive capacity. *Strategic Management Journal*, *31*(9), 969–989. https://doi.org/10.1002/SMJ.856
Zhao, X., Yi, C., Zhan, Y., & Guo, M. (2022). Business environment distance and innovation performance of EMNEs: The mediating effect of R&D internationalization. *Journal of Innovation & Knowledge*, *7*(4), 100241. https://doi.org/10.1016/J.JIK.2022.100241
Zhou, K., Kumar, S., Yu, L., & Jiang, X. (2021). The economic policy

uncertainty and the choice of entry mode of outward foreign direct investment: Cross-border M&A or Greenfield Investment. *Journal of Asian Economics*, *74*, 101306. https://doi.org/10.1016/J.ASIECO.2021.101306