The impact of Foreign Direct Investment in Research and Development on the innovation output of Indian firms

MASTER OF SCIENCE (RESEARCH) THESIS

By

RUCHITA SHARMA

DISCIPLINE OF ECONOMICS

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CANDIDATE'S DECLARATION

I hereby certify that the which is work being presented in the thesis entitled **The Impact of Foreign Direct Investment in Research and Development on the Innovation Output of Indian Firms** in the fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (RESEARCH)** and submitted in the **DISCIPLINE OF ECONOMICS, Indian Institute of Technology Indore**, is an authentic record of my work carried out during the time period from July 2022 to May 2024 under the supervision of Prof. Ruchi Sharma, Professor, Discipline of Economics, Indian Institute of Technology.

The matter presented in this thesis has not been submitted by me for the award of any other degree of this or any other institute.

Signature of the student with date
(Ruchita Sharma)

This is to certify that the above statement made by the candidate is correct to the best of my/our knowledge.

24/5/24

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12/11/24

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Signature of Convener, DPGC with date

Signature of Head of Discipline with date

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Needless to say, I alone am responsible for any remaining error.

Ruchita 24/05/24.

May 2024 **Ruchita Sharma**

Abstract

Using the firm-level data, this research investigates the impact of Foreign Direct Investment in Research and Development (FDI-R&D) on firms' innovation output in the Indian context during 2010-2020. We hypothesize that foreign investment brings intangible knowledge about the recent technological advancements, international scientific practices, and working culture of global laboratories to domestic firms and thus improves the innovation performance of such firms after controlling for other firm characteristics. The major challenge in conducting the empirical studies is the selection problem as productive efficient host country firms are likely to attract foreign investments. Hence, we employ Propensity Score Matching (PSM) and Difference in Differences (DID) to capture the influence of foreign investment on innovation output namely patents. After controlling the selection problem, we find that firms with FDI-R&D patent more than the non-FDI-R&D firms. We also find that FDI-R&D plays an important role in improving the quality of the innovation output of a firm. Also, R&D expenditures of FDI-R&D firms play a significant role in the innovation output of these firms. We also found that the majority of FDI-R&D inflows are concentrated in natural sciences & engineering, pharmaceuticals, and clinical research, highlighting India's focus on Science, Technology, and Engineering (STE) fields. Over half (55%) of the firms engage in patenting, with a significant number filing at the United States Patent and Trademark Office (USPTO). States with high innovation scores (Karnataka, Maharashtra, etc) also house the most FDI-R&D firms, suggesting a two-way relationship between a state's innovation environment and its attractiveness for FDI-R&D. Younger FDI-R&D firms (10-20 years old) exhibit higher patent filing activity compared to older firms (20-30 years old), suggesting a potential link between firm age and innovation output.

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ACRONYMS

ATT	: Average Treatment Effect
DID	: Difference in Differences
DPIIT	: Department for Promotion of Industry and Internal Trade
FDI	: Foreign Direct Investment
FDI-R&D	: Foreign Direct Investment into Research and Development
FEMA	: Foreign Exchange Management Act
FERA	: Foreign Exchange Regulation Act
GFA	: Gross Fixed Asset
GOI	: Government of India
IMF	: International Monetary Fund
IV	: Instrumental Variable
MNC	: Multinational Corporation
MNE	: Multinational Enterprise
PSM	: Propensity Score Matching
R&D	: Research and Development
RBI	: Reserve Bank of India
UNCTAD	: United Nations Conference on Trade and Development

1 Introduction

1.1 The Context

In today's fiercely competitive and ever-changing global arena, innovation is no longer a luxury - it's a matter of survival. Firms must constantly adapt and evolve to navigate turbulent market conditions, and resource reallocation plays a crucial role in this process. The traditional focus on factor endowments like land and labor is no longer the primary determinant of international competitiveness (Romer, 1990; Posner, 1961; Vernon, 1966). The baton has been passed to scientific and technological prowess, as evidenced by the fact that advanced economies hold a staggering 22% share of global R&D spending. This stark reality presents a significant challenge for emerging economies.

To close the gap with their developed counterparts, foster growth, and truly compete on the global stage, emerging economies must ramp up their investment in R&D. This can be achieved through a two-pronged approach: domestic efforts and leveraging for FDI.

While domestic initiatives are essential, the sheer scale of resources required for significant R&D advancement often necessitates looking beyond national borders. Here, FDI by MNEs emerges as a critical source of financial muscle for developing economies. The nature of FDI itself has transformed, shifting from a focus on mere economic exploitation and trade to one that drives innovation, technology transfer, and access to a global talent pool through the establishment of R&D centres in host countries. This shift is reflected in the rising tide of FDI-R&D, which accounted for a whopping 32% of global R&D spending in 2022 (UNCTAD, 2023).

Developing nations are actively participating in this trend. China, the world's second-largest recipient of FDI, witnessed a 5% increase in FDI-R&D inflows in 2022 (UNCTAD, 2023). India, with its large pool of skilled professionals, growing domestic market, and government initiatives aimed at fostering innovation, is becoming an increasingly attractive destination for FDI-R&D. India has also increased its FDI-R&D inflows over the past decade. This influx of resources is further bolstered by a rise in India's domestic R&D expenditure (Gross Expenditure on R&D or GERD), which has climbed from 0.56% to 0.89% of GDP between 2005 and 2020 (Department of Science and Technology of India, 2023).

FDI-R&D holds immense promise for developing economies. Studies by scholars like Freeman (1995) and Pearce and Papanastassiou (1999) highlight its potential to foster vibrant networks between local and foreign researchers and firms. This cross-pollination of expertise can lead to a rich exchange of knowledge and ideas, as emphasized by Vrontis and Christofi (2021). Furthermore, FDI-R&D can be a powerful economic engine, creating jobs and propelling growth, as evidenced by Malik (2019). Additionally, Basant and Mani (2012) point to the positive impact of FDI-R&D on local firms, fostering a competitive environment that spurs innovation.

However, despite the surge in FDI-R&D inflows over recent decades, the full extent of its benefits for host countries remains nebulous within academic circles. While theoretical frameworks abound, empirical evidence to support these claims is often lacking.

To understand this phenomenon fully, it's crucial to examine the evolution of FDI theory itself. Early models, such as Location Theory (1930s), focused primarily on cost advantages, with firms drawn to resource-rich regions with low labor costs. The subsequent Internalization Theory, championed by Hymer and Dunning in the 1960s and 1970s, shifted the focus to firm-specific advantages and transaction costs, highlighting the benefits of internalizing operations compared to relying on external market transactions. Dunning's OLI (Ownership, Location, Internalization) Paradigm of the 1980s further refined this view, proposing a comprehensive framework for understanding FDI based on three key advantages: ownership of unique assets, location-specific advantages, and the ability to manage internalization costs effectively.

The late 20th century witnessed further theoretical advancements. Strategic Asset Seeking Theory (1999) recognized FDI driven by the acquisition of strategic assets like technology, knowledge, and talent, even in the absence of immediate cost benefits. Network Formation Theory (2000s) emerged, viewing FDI as a tool for building global networks, accessing new markets, resources, and partners, and capitalizing on agglomeration economies (clustering of firms in specific locations). This theoretical evolution mirrored the changing modes of FDI itself. Early modes like exporting and portfolio investment laid the groundwork for the rise of licensing, franchising, and subsidiary operations in the 20th century. Joint ventures emerged as a risk-sharing strategy, while FDI with a significant ownership and control component solidified the current definition of FDI used by various international bodies.

The combined force of domestic efforts and strategic leveraging of FDI-R&D is fostering a thriving innovation ecosystem in India, a model that other developing economies can emulate to ensure their place in the ever-evolving global marketplace.

This research delves into the critical question of how FDI-R&D influences the innovation output of firms in developing economies, specifically focusing on India. A key challenge in analysing FDI's impact lies in the potential for self-selection bias. Firms that attract foreign investment for R&D activities might possess inherent characteristics that make them more innovative to begin with. To address this issue and ensure the validity of our findings, we employ two robust empirical tools: propensity score matching (PSM) and the difference-in-differences (DID) method.

Propensity Score Matching (PSM) technique aims to create a control group that closely resembles the treatment group (firms with FDI-R&D) in all observable characteristics except for the presence of FDI-R&D itself. By doing so, we can isolate the true causal effect of FDI-R&D on innovation output. PSM enjoys widespread acceptance in the field, with Wang et al. (2018) advocating for its use as a benchmark for addressing self-selection bias in studies involving non-experimental data.

Difference-in-Differences (DID) method compares changes in outcomes (innovation output) between two groups: firms with FDI-R&D (treatment group) and firms without FDI-R&D (control group). The comparison is made before and after the introduction of FDI-R&D (treatment). By controlling for firm characteristics, DID allows us to isolate the impact of FDI-R&D on innovation output, mitigating the influence of confounding variables. Angrist and Pischke (2009) provide a comprehensive framework for utilizing the DID method.

Our study leverages data on 298 FDI-R&D firms identified in a report on FDI-R&D (2020). These firms constitute the core sample for our analysis. We have studied these firms by negative binomial regression to establish the causal relation. Due to data limitations and econometric issues, we employ PSM and DID methodologies. We aim to quantify the average treatment effect of FDI-R&D on innovation output. The analysis not only confirms that firms with FDI-R&D exhibit higher innovation output but also demonstrates the robustness of our findings under various assumptions about the underlying empirical models. Furthermore, we quantify the average treatment effect after controlling for relevant firm and industry-level variables.

This research contributes significantly to the ongoing debate surrounding FDI-R&D. Given the potential for FDI-R&D to bolster innovation in developing economies like India, our findings provide valuable support for policies that encourage such investments.

The present study underscores the critical need for more focused research on FDI-R&D. While its importance and inflows are on the rise, a comprehensive understanding of how FDI-R&D impacts innovation output remains elusive. The intricate interplay of knowledge transfer, technology spillovers, and collaborative efforts triggered by foreign investment in R&D activities shapes the innovative capabilities of recipient firms, as highlighted by Yue et al. (2022).

Our analysis paves the way for identifying specific mechanisms through which FDI-R&D influences a firm's capacity to generate innovative solutions. This knowledge is crucial for formulating customized strategies that cater to the unique characteristics of different firms, considering factors such as industry sector, firm size, and existing technological expertise. Ultimately, a detailed understanding of the firm-level impact of FDI-R&D is essential for designing effective policies that promote positive outcomes, facilitate knowledge transfer, and mitigate potential risks associated with FDI-R&D activities.

1.2 Definition Structure

Defining FDI: The concept of Foreign Direct Investment (FDI) and its significance in the Indian economy has been well-documented. According to UNCTAD, FDI involves a long-term relationship and persistent interest and control by a resident entity in one economy, referred to as the foreign direct investor, in an enterprise located in another economy, known as the FDI enterprise or affiliate enterprise. The statistics on cross-border mergers and acquisitions, including those involving businesses with foreign affiliates and the same host economy, contribute to understanding FDI dynamics (Thomson Financial). In the context of FDI statistics, the Organization for Economic Co-operation and

Development (OECD) emphasizes three main components: financial flows, income, and positions. Financial flows capture debt and equity investments between related parties within a specific period. Income represents the return on equity and debt investment to the direct investor during a specific period. Positions refer to the value of accumulated direct investment at a specific point in time, also known as the stock of FDI.

FDI composition typically encompasses three distinct components. The initial component involves the influx of foreign equity capital, which augments the host country's capital stock, encompassing assets such as plants and machinery. This component is often referred to as greenfield investment. The second component entails the reinvestment of profits by FDI enterprises, where the accumulated earnings of existing foreign companies operating within a specific country are plowed back into their operations. Lastly, the third component encompasses the acquisition of established enterprises by foreign investors, achieved through either mergers or takeovers. This type of investment is commonly known as brownfield investment. It should be noted that the final form of FDI, brownfield investment, does not directly contribute to the expansion of productive capacities in the host countries. The ambiguity surrounding the definition of FDI in India can be attributed to two primary factors: determining the "nationality" of acquiring and acquiring firms and defining the concept of "control" in the context of FDI.

When it comes to assigning nationality to multinational firms operating in India, challenges arise due to their complex organizational structures and global presence. Many MNCs have subsidiaries, joint ventures, or manufacturing facilities in multiple countries, including India. For instance, companies like Honda, which originated in Japan, have established a significant presence in India with manufacturing plants and operations. Determining the nationality of such companies becomes intricate as they are often deeply integrated into the local economy, making it difficult to categorize them solely based on their country of origin or where they were initially founded. The government generally considers the country of origin or the place where the company is headquartered as a basis for assigning nationality, but the process remains subject to interpretation and debate.

The second aspect of ambiguity in FDI definition pertains to the concept of "control." The Indian government has specific guidelines and regulations in place to monitor and regulate FDI in various sectors. These guidelines often specify the maximum percentage of ownership that foreign investors can hold in Indian companies across different industries. The thresholds for ownership are determined based on factors such as strategic importance, national security concerns, and sector-specific policies. In sectors deemed critical to national security or strategic interests, the government may require that control remain with domestic entities, even if foreign investors hold a certain percentage of ownership. This approach ensures that key decision-making powers and strategic control are retained within the country. However, despite these regulations, determining the actual extent of control exerted by foreign investors can be challenging. Ownership percentages alone may not accurately reflect the level of influence or decision-making power held by foreign entities. In some cases, foreign investors may have significant control over a company's operations and strategic direction, even with a minority ownership stake. On the other hand, there may be instances where foreign investors hold a substantial ownership stake but have little to no influence or control over the company's management and operations. This discrepancy between ownership percentages and actual control poses a challenge in defining and assessing the true nature of FDI in India.

Defining Innovation:

Innovation, the lifeblood of economic growth and societal advancement, has captivated the minds of economists, and management scholars. Schumpeter (1934) placed innovation at the very heart of economic dynamism, defining it as the "carrying out of new combinations." This encompasses not just the creation of entirely new products, but also the exploration of new markets, novel sources of raw materials, and innovative organizational structures. Schumpeter's concept of "creative destruction" highlights how innovation disrupts existing industries with superior offerings, propelling economic progress.

Building upon Schumpeter's foundation, Freeman (1982) emphasized the critical role of technology in the innovation process. He defined innovation as "the successful introduction of a new good or service, a new process, a new market, a new form of industrial organization," with a particular focus on advancements in technology. However, the true essence of innovation extends beyond the realm of technology alone. Dosi (1982) proposed the broader concept of "technological paradigms," recognizing that innovation encompasses not just the technical aspects but also the skills, knowledge base, and social practices that surround a particular technology. These interwoven elements collectively shape the way technology is developed, implemented, and ultimately utilized.

The OECD Oslo Manual (2005) provides a valuable framework for understanding the multifaceted nature of innovation by classifying it into four distinct forms: product, process, organizational, and market innovation. Product and process innovation are intrinsically linked to technological advancements, where technology refers to the application of advanced machinery, equipment, and techniques. Product innovation, or the introduction of a new product or service with significantly improved functionalities, is a critical determinant of a firm's performance (Damanpour and Gopalakrishnan, 2001). By introducing novel offerings, product innovation facilitates the identification of opportunities to generate above-average profits, serving as a powerful pathway for firms to achieve and sustain profitability (Nambisan, 2003).

In conclusion, innovation is a multi-dimensional phenomenon that transcends mere technological advancement. It is a complex interplay of ideas, knowledge, skills, and practices that fuels economic growth and societal progress. Understanding the various forms of innovation and their underlying dynamics is crucial for both firms seeking to thrive in a competitive marketplace and policymakers aiming to foster a vibrant and innovative ecosystem.

Defining FDI-R&D:

FDI-R&D refers to the investment of resources by foreign corporations into the R&D services and activities of a firm or country. These R&D services encompass a broad spectrum, including basic, applied, and experimental endeavors focused on product and process development. The scope extends beyond the physical sciences to encompass social sciences, humanities, and innovative operating systems. Furthermore, it includes commercially driven research activities in fields like electronics, pharmaceuticals, and biotechnology.

The International Monetary Fund (IMF) provides clear guidelines (BOP Manual 6) for distinguishing between two key entities: foreign-affiliated R&D centres and FDI-R&D enterprises. The handbook emphasizes the importance of classifying each entity based on the percentage of equity share ownership held by the foreign investor. An enterprise can be categorized as a fellow enterprise, an associate, or a subsidiary depending on the ownership stake.

India's foreign investment policy has undergone a significant evolution alongside the nation's growing economy. A pivotal moment came in 2010 with the issuance of a consolidated FDI policy by the Department for Promotion of Industry and Internal Trade (DPIIT). This policy broadly defined any non-resident investment in an Indian firm as FDI. It further emphasized that a "lasting interest" is not necessarily contingent upon a minimum holding percentage of equity shares or voting rights in the investee firm. This approach stands in stark contrast to established international best practices, as highlighted by Dhar and Rao (2020).

The current DPIIT FDI policy guidelines in India present an additional layer of complexity. While they permit 100% FDI in R&D activities via an automatic route, they fail to explicitly address FDI-R&D itself. The policy simply states that FDI into R&D is allowed. Furthermore, the FDI newsletter, while providing FDI inflow data with investor firm information, lacks details on shareholding percentages.

To address this data gap, Joseph et al. (2019) have developed a multi-criteria screening approach for identifying FDI-R&D firms. This approach considers factors such as foreign investors, investee firms, investment amounts, and the specific investment items or activities involved. However, firm-level FDI-R&D inflow data often relies on foreign inflows that mention "R&D" or related phrases in their descriptions. This creates a discrepancy between the data collected and the R&D service definitions outlined in the IMF's BOP Manual 6. Undoubtedly, some inflows likely support R&D activities even if they are not explicitly labeled as such within the investment specifications. For instance, an R&D-focused investor might invest in an enterprise dedicated to R&D, but the investment details might not explicitly mention R&D.

In conclusion, considering the complexities discussed above, we adopt a refined definition of FDI-R&D: an investment by a foreign entity in the R&D operations and services of a host country firm (Joseph et al. 2019), with the foreign entity holding ownership power. Furthermore, we advocate for the identification of FDI-R&D firms based on the well-established R&D service definitions provided in the IMF's BOP Manual 6. This standardized approach will enhance data accuracy and facilitate a more comprehensive understanding of FDI-R&D's impact on host economies.

1.3 History of FDI policy framework

Foreign firms have access to the sizable Indian market as well as to fresh, affordable manufacturing options due to the economy's opening up. As a result, FDI inflows have been steadily increasing ever since; notably, after 2000, greater simplification of the laws governing FDI led to enormous FDI inflows into the economy (Joseph et al., 2019). The Indian economy has solidified its spot on the global list of the top FDI destinations.

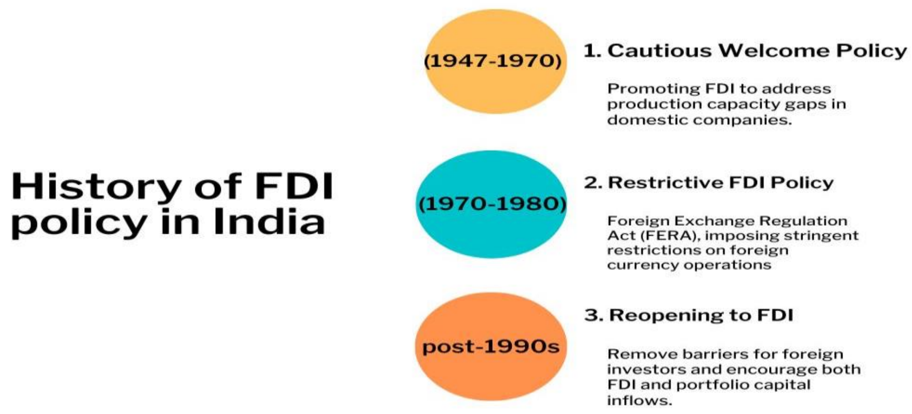

Figure 1 History of FDI Policy in India

As highlighted in Figure 1 Indian economic history has seen 3 phases of FDI policy (Rao and Dhar 2011) (Khachoo 2015, an unpublished manuscript).

1. Cautious Welcome Policy (1947-1970): The early years of the 1950s did not see any foreign enterprise gaining majority ownership in an industry. In 1961 Seeing the gaps in the production capacity of domestic companies, the Indian government (GOI) began to promote FDI in new production

facilities as well as in regions where domestic output was insufficient to satisfy local demand. FDI inflows significantly increased between 1957 and 1963 (Kudaisya, 2011).

2. Restrictive FDI Policy (1970-1980): GOI established the Foreign Exchange Regulation Act (FERA) in the early 1970s, which rigorously limited operations using foreign currencies and managed currency import and export. The Foreign Exchange Management Act (FEMA), which took its place in 1999 after the statute was abolished and rewritten, somewhat loosened foreign exchange regulations and lifted numerous barriers to international investment. Under the FERA, foreign corporations were not permitted to own more than 40% of the stock. Yet, the government had the last say over exemptions.
3. Reopening to FDI post-1990s: GOI to remove the hurdles in the path of foreign investors both at the stage of entry and later in the process of establishing the venture. Along with relaxing the FDI regime, parallel steps were taken to allow foreign portfolio investments into the Indian stock market through the mechanism of foreign institutional investors. India, thus, adopted a two-pronged strategy to encourage foreign investment: one to attract FDI and two to stimulate the inflows of portfolio capital to ease out the financing constraints faced by Indian enterprises. This was achieved by streamlining the procedures and removing earlier investment caps in certain sectors.
4. Recent evolutions in policy: The slow development and high inflation that the economy suffered in 2012 may be to blame for the decline in inflows. It is thought that FDI in India has been discouraged by the sluggish pace of environmental and land acquisition policy reforms, as well as a delay in opening industries like real estate, retail, and insurance to 100% FDI. To stop the further decline in inflows, the government launched several efforts before the end of 2012. For instance,

it eased regulations for FDI in petroleum refining and single-brand retailing while allowing FDI into multi-brand retailing. The GOI significantly loosened its restrictions on FDI in aviation and television broadcasting while also approving 100% foreign ownership in the telecommunications sector. Due to these regulatory changes and some more parallel actions, inflows into India increased by more than 5% over the previous year, reaching $36.86 billion in 2013–14.

In 2014–15, India received $45.14 billion in FDI, a remarkable 25% increase over the previous fiscal year (FDI Newsletter 2015). In 2015–16, FDI numbers were at $55.48 billion, a 23% increase over the prior fiscal year (FDI Newsletter 2016). This increase in FDI inflows is likely a result of the "Make in India" program, a government initiative intended to boost inflows and promote innovation by constructing world-class manufacturing facilities and safeguarding intellectual property rights. The Department of Industrial Policy & Promotion (DIPP) recently released data showing the total FDI inflows from 2021-22 $54.10 billion was reported. The FDI limit in the defense manufacturing sector was increased from 49% to 74% under the automatic route. FDI above 74% will require government approval.

Beyond regulatory reforms to facilitate FDI in India, the government has implemented various initiatives and capitalized on emerging FDI trends to directly and indirectly attract greater foreign capital inflows. These efforts include government programs like the 2020 Production-Linked Incentive (PLI) scheme designed to incentivize electronics manufacturing in India. Additionally, the 2019 amendment to the FDI Policy permitted 100% FDI under the automatic route for coal mining activities, aiming to boost FDI inflows in this sector. Furthermore, the government liberalized FDI in the digital sector to 26%, seeking to bridge the digital divide and enhance nationwide digital connectivity.

Evidently, successive governments over the years, particularly after 1991 reforms, not only continued with the liberal policies to attract foreign investors but also expanded the space for such investments.

1.4 History of FDI-R&D in home and host countries

The rise of FDI-R&D presents a complex scenario with both opportunities and challenges for both host and home countries.

Host Countries: A Beacon of Growth

For developing countries acting as hosts, FDI-R&D injects a much-needed boost to their economies. The influx of investment brings with it a wealth of benefits. Firstly, it creates a significant job market for skilled scientists and engineers, fostering domestic talent development. Secondly, the establishment of R&D centers by MNCs leads to knowledge transfer, as local researchers gain exposure to cutting-edge technologies and methodologies. This fosters domestic innovation capabilities in the long run. Additionally, MNCs often cater to local market needs during R&D, leading to the development of products and services that directly benefit the host country's population. Finally, FDI-R&D can act as a catalyst for infrastructure development, as MNCs often require upgrades in areas like communication and transportation.

However, host countries must navigate certain challenges. There's a concern that MNCs might prioritize low-end R&D activities, neglecting the development of high-tech capabilities within the host nation. Additionally, ensuring effective knowledge transfer and fostering collaboration between domestic and foreign R&D centers requires strategic government policies.

Home Countries: Balancing Innovation and Offshoring

For developed nations acting as home countries, FDI-R&D presents a strategic decision. While it offers cost advantages by leveraging a more affordable talent pool abroad, it also raises concerns about potential knowledge leakage and the erosion of the home country's innovation base. Companies must strike a balance, ensuring that core R&D activities remain within the home country while strategically utilizing R&D centers abroad to drive specific research agendas. Overall, FDI-R&D presents a win-win scenario for both host and home countries, provided they navigate the associated challenges effectively. Host countries should focus on maximizing knowledge transfer and fostering domestic innovation ecosystems, while home countries need to ensure a strategic balance in their R&D efforts across borders. Through collaboration and policy foresight, FDI-R&D can become a powerful tool for accelerating global innovation and fostering shared prosperity.

1.5 Trends of FDI-R&D in the world and India

The landscape of R&D has undergone a significant transformation in recent decades globally. Traditionally, R&D was viewed as a domestic endeavor, with companies focusing their innovation efforts within their home countries (Dunning and Lundan, 2009). However, the turn of the millennium witnessed a remarkable shift – the rise of FDI-R&D. This phenomenon, characterized by MNCs establishing R&D centers in developing economies, has fundamentally reshaped the geography of global innovation.

In the late 90s, the concept of establishing R&D facilities in developing countries was largely absent. Developed nations, with their established research infrastructure and talent pool, were the natural breeding grounds for innovation. However, the equation began to change around the 2000s. Developing economies like

India and China emerged as attractive destinations for MNCs seeking to expand their R&D footprint. This shift was driven by several compelling factors.

Firstly, these countries boasted a vast pool of skilled scientists and engineers. The talent gap in developed nations, coupled with the rising cost of R&D operations, made developing economies a more cost-effective option. Additionally, the burgeoning domestic markets in these countries presented a significant opportunity for MNCs to develop products and services tailored to local needs. This localization strategy not only promised increased sales but also fostered deeper customer understanding.

The early 2000s witnessed a surge in FDI-R&D. By 2005, India, with its robust IT infrastructure and talent base, had become the third most sought-after location for establishing R&D centers, following in the footsteps of China and the USA (UNCTAD, 2023). This trend has continued, with FDI-R&D becoming a significant driver of economic growth in many developing nations.

However, the focus of FDI-R&D hasn't been uniform across all sectors. Specific industries, particularly those capitalizing on advancements in information technology (IT) and pharmaceuticals, have witnessed a more pronounced influx of investment (Joseph et al 2019). This sectoral concentration can be attributed to the presence of a skilled workforce readily adaptable to these domains, as well as the potential for cost savings in IT-driven R&D activities.

Despite the evident benefits, the rise of FDI-R&D isn't without its challenges. While MNCs contribute to knowledge transfer and job creation in host countries, concerns linger regarding the nature of R&D activities being undertaken (Sandhya et al.2011). Critics argue that MNCs might prioritize low-end research tasks in these locations, neglecting cutting-edge innovation that could propel the host country's domestic technological capabilities.

In conclusion, the history of FDI-R&D is a story of remarkable transformation. From its nascent beginnings to its current role as a key driver of innovation in developing economies, FDI-R&D has fundamentally reshaped the global innovation landscape. As this trend continues, navigating the challenges and maximizing the opportunities presented by FDI-R&D will be crucial for both host countries and MNCs to ensure a future characterized by shared prosperity and groundbreaking innovation.

1.6 Objectives

Many developing countries attract foreign investment in an attempt to improve the innovation output of firms. However, it is ambiguous whether firms learn from the inflows of foreign investment into R&D, and if they do, which firms derive more benefits in the innovation output. It is also equally unclear about the determinant of innovation output in FDI-R&D firms. Moreover, there seems to be no consensus on where the FDI-R&D manifests predominantly, i.e. which measure of firm performance (innovation or productivity) is mostly affected by FDI.

So, keeping in view the ambiguities lingering over the causal relationship mechanism, the thesis explores whether FDI-R&D impacts the innovation output of a firm after controlling other factors that affect innovation output. The thesis has two particular objectives.

- To analyze the impact of FDI-R&D on the innovation output of firms.
- To understand the determinant of innovation output based on firm characteristics.

1.7 Methodology

For the empirical analysis, firstly, we delve into descriptive analysis and find the basic relationship between firm characteristics and innovation output. Further. for empirical analysis, we employ panel data analysis. We encountered some econometric issues such as FDI firms with equity participation from foreign companies may attract investment due to their specific characteristics leading to the self-selection problem. To address the selection bias, this study uses empirical tools such as propensity score matching (PSM) and the difference in differences (DID). We also highlight the basic assumptions and practical measurement issues related to each methodology. These methods are advocated in the empirical current literature as Wang et al. (2018), and LaLonde (1986) considered PSM as a benchmark for experimental data and self-selection bias problems. At the same time, the DID method compares changes in outcomes between the treatment group (firms receiving FDI-R&D) and the control group (firms not receiving FDI-R&D) before and after the treatment (Angrist and Pischke, 2009) after controlling firm characteristics.

1.8 Contribution of the study

The thesis is an addition to the existing literature that examines the existence of FDI-related innovation output of the host developing nation. It differentiates between foreign R&D centers and FDI-R&D firms which provide helpful insights for business operations. It also provides a detailed analysis of the definition challenges in the FDI-R&D in India. Focused research on FDI-R&D, as proposed in this study, is much needed because, despite its growing importance and increasing inflows, a broader understanding of the impact of FDI-R&D on innovation output is still lacking in literature. The intricate dynamics of knowledge transfer, technology spillovers, and collaborative efforts due to foreign investment in R&D activities shape the innovative capabilities of the recipient firms (Yue et al., 2022). Thus, the present analysis allows for the identification of specific mechanisms through which FDI-R&D influences a firm's ability to generate quality innovative solutions. Further, a perspective is crucial for formulating customized strategies tailored to the unique characteristics of different firms, considering factors such as industry type, firm size, and technological expertise. Lastly, a detailed understanding of the firm-level impact to design effective policies that encourage and facilitate positive outcomes while addressing potential risks associated with FDI-R&D.

1.9 Outline of the thesis

This thesis is divided into six chapters. Chapter 1 provides a brief introduction to the study. Chapter 2 reviews the literature followed by Chapter 3 which describes the research framework and hypothesis development. Chapter 4 presents the baseline econometric model and discusses the various econometric issues inherent in the data. Chapter 5 covers the empirical analysis and Chapter 6 provides the conclusion and discusses policy implications.

Chapter 2 conducts a broad survey of the theoretical and empirical literature on the FDI and innovation by foreign affiliates in host countries. It further defines the basic concept of FDI-R&D and distinguishes between FDI-R&D firms and foreign R&D centers. While focusing on the existing empirical analysis of the dimensions of FDI-R&D. Apart from documenting the main theoretical and empirical contributions of FDI and innovation, this chapter also elaborates on the importance of FDI-R&D from the perspective of home countries as well as host countries. The chapter reviews theoretical and empirical studies, both at the micro and macro level, on inward-FDI-related innovation. This survey aims to identify the main factors determining the FDI-R&D in host countries. The chapter concludes by presenting the main arguments and empirical evidence reported by the FDI literature supporting the existence of the positive effect that foreign investment has on the innovation output of the host country firms. But have sparse results on FDI-R&D and innovation output relationship.

Chapter 3 begins with a discussion on the research gaps found while reviewing the literature on FDI, FDI-R&D, and innovation. Identifying and defining FDI-R&D is a major concern in this field of study. Further if FDI plays an important role in the country's technological advancement, then investment specifically for R&D could have more impact on the innovation output. This chapter further develops the hypotheses to be tested in this thesis. The chapter concludes by presenting a research framework on FDI-R&D and innovation output.

Chapter 4 lays out the methodological framework of the thesis. Based on the research objectives, it sets out a common conceptual framework to analyze FDI-R&D and innovation output and adopts a specific econometric strategy for empirically examining each of the research objectives. Besides addressing various econometric issues related to the model and the data, it provides a description of the sample and its distribution across industries. The chapter further elaborates on the various data sources employed, as well as highlighting the data cleaning process to arrive at the final sample. Moreover, it presents a description of the variables and the methods used in their construction.

Chapter 5 sets the stage for the empirical analysis. By employing a logistics regression model, we select the control group via PSM for the analysis. The chapter identifies the firm characteristics that influence a firm's innovation output and explores whether these factors are controlled and the actual impact of FDI-R&D on innovation output. Specifically, it investigates the impact of FDI-R&D on the firm innovation output after controlling firm characteristics via the DID method. This chapter also includes a cross-sectional regression of the FDI-R&D firm's innovation output for further robustness and validity of results.

The final chapter begins with a summary of the previous chapters and underlines their findings. It then suggests further directions for research in these areas and tackles some policy implications arising from the empirical results of the thesis.

2 Review of literature

2.1 Introduction

There is a significant body of theoretical literature on MNCs. Most of these theoretical models on MNCs and their effects on the home countries only started to emerge in the early 1900s. An early example of FDI was the East India Company. In this chapter, we take stock of FDI theories. These theories answer some of the important questions often raised about foreign firms and their operations such as what makes the firms conduct FDI, why they prefer FDI over exporting and arms-length transactions, what makes them choose a particular mode of entry while venturing into foreign markets and how they sustain in host countries where conditions are different from those in the home country market. Apart from reviewing the theoretical literature on the existence of FDI to FDI-R&D, the chapter also provides an overview of the various strands of empirical research on the spillovers generated by the MNCs while operating in the host countries. Theories on FDI along with explaining why firms go multinational offer the theoretical basis for the knowledge spillovers generated by the activities of MNCs in the host country. Here the concept of technology transfer comes into the picture as a benefit for a firm engaging in FDI. This technology transfer can involve established production methods, product designs, or even cutting-edge research and development processes. Emphasis on technology transfer allows us to see the significance of FDI specifically aimed at R&D activities in the host nation. It is reasonable, therefore, to analyze the factors that can play a significant role in the generation of innovation output in FDI-R&D firms in host countries. This chapter aims to provide a theoretical background to explain both the perspective of FDI-R&D by home and host countries. The main objective is to provide a comprehensive analysis of FDI from different theoretical perspectives and to pinpoint to di(similarities) of each conceptual and empirical approach.

The structure of the chapter is as follows: The next section is devoted to explaining various theories on FDI and presents a critique of them. Section 2.3 explains theories on innovation and how it has evolved over the period with the various definitions and transmission. Section 2.4 provides a review of the different strands of the existing empirical literature on FDI and knowledge spillover and innovation output in Indian context. Section 2.5 emphasis on the importance of FDI-R&D in the development of innovation systems at cross country, country, industrial level, and at last firm level.

2.2 Theories of FDI

The importance of, and growing interest in, the causes and consequences of FDI has led to the development of several theories that try to explain why MNCs conduct FDI, where they choose to locate their production, and how they choose a particular entry mode. Theories explaining FDI have emerged from different fields such as economics, and international business points of view. Furthermore, this explains the divergence in the motivation of MNCs from resource exploitation to asset-seeking strategy. This section aims to provide an overview of some of the important theories emanating from the various fields mentioned above. In general, FDI theories can be divided into many strands:

2.2.1 The neoclassical theory

The neoclassical theory of portfolio flows views MNCs as an arbitrageur of capital in response to changes in interest rate differentials (Nurkse, 1933; Ohlin, 1933; Iversen, 1935). The underlying principle of the neoclassical theory is that firms invest overseas in an attempt to equate the marginal return on capital with its marginal cost. The theory rests on the basic presumption of risk neutrality, which implies that FDI is a perfect substitute for domestic investment. Relaxing the assumption of risk neutrality Tobin (1958) and Markowitz (1959) in their portfolio diversification theory, assert that FDI occurs as a means of reducing the average risk of international transactions. A similar view is shared by the Heckscher-Ohlin model (1919; 1933), which postulates that foreign investments are determined by differences in factor endowments existing across locations and that capital moves out from the areas where its marginal productivity is low (capital-abundant areas towards the areas where marginal productivity of capital is high (capital scarce areas).

MacDougall (1960) and Kemp (1964) again assumed that capital moves to the capital-scarce countries with expected higher returns. However, it lies in the hands of countries to manipulate the returns on capital by imposing taxes on capital mobility and thereby enhancing their welfare. MacDougall's (1960) model predicts that foreign capital penetration, whether in the form of FDI have had many benefits for the host countries. These benefits would include more jobs for the local workforce, improvements in domestic productivity levels, local firms acquiring technical know-how from much more advanced foreign firms, adopting more efficient methods of production and generation of new knowledge.

In summary, all the above approaches are based on the strong assumptions of perfect capital mobility and technology across nations, the absence of any transaction costs, and the homogeneity of inputs. These assumptions are unlikely to hold in the real-world context. The neoclassical theories although they explain the reasons for capital mobility have completely ignored the role of firms in facilitating the flow of capital across regions. Moreover, empirical studies estimating the relationship between relative rates of return in several countries and the allocation of FDI among them found no support for this hypothesis (Aggarwal, 1980).

2.2.2 Internalization theory

Internalization describes the firm's existence as an organizational style that coordinates activities more effectively than its principal rival in the market. The firm's boundaries are determined at the point where the costs of further internalizing markets outweigh the benefits.

The concept of internalization is a broad principle used to understand how organizations function and how big they should be. It's particularly helpful for studying MNCs. Internalization theory focuses on figuring out the boundaries of a company and how those boundaries change depending on the situation. It doesn't by itself explain everything about organizations, but it becomes more powerful when combined with other ideas. For instance, by combining internalization theory with trade theory, we can understand where a company might choose to locate its operations. When it's used with organizational theory, it helps explain why companies form partnerships with each other in different countries. Internalization theory can even be used with theories about innovation to predict the kinds of industries a company might operate in. This principle applies not just to a company's physical location but also to other boundaries, such as the types of products it makes (which is usually studied separately as product diversification). When internalization theory is combined with ideas about entrepreneurship, it allows us to consider the role of culture.

Organizations often rely on outside suppliers for various things they need. A key question is whether it might be better to produce these things themselves. In management, this is called the "make-or-buy decision," and in economics, it's referred to as "backward integration." A MNC that decides to make its supplies is an example of backward integration, and this can be seen in what's called "resource-seeking investment." Similarly, many organizations use outside companies to sell their products or to modify them before they reach the final customer. This is called "forward integration." In the area of distribution management, this relates to the concept of "channel leadership," which refers to whether a company that makes a product should also control the wholesalers and retailers that sell it. In international trade, this means a company might decide to set up sales subsidiaries in other countries to manage how their products are sold there. In general, most organizations deal with a variety of intermediate goods and services that they use or create in the course of their work. Internalization theory focuses on the markets for these intermediate goods and services. Companies typically cannot internalize the markets for the raw materials they use or the final products they sell.

Internalization theory is based on the idea that people make rational choices. People who are trying to make a profit will take control of intermediate product markets when the benefits outweigh the costs. For companies, this means internalizing these markets up to the point where the benefits and costs are equal. When a company does this successfully, they earn an economic rent, which is the amount of money they make by internalizing these markets that is greater than what it would cost them to use outside suppliers.

2.2.3 OLI Paradigm

However, there have been several theories embedding the internationalization process of companies. Of all the theories, Dunning's eclectic theory (1977), thus far, is the most relevant and well-recognized model for explaining why firms internationalize. The model integrates the previous theories of internalization and attempts to provide a general analytical framework to explain the motives behind the internationalization process. One of the main conduits through which internationalization, as the theory maintains, is the FDI. The decision to invest overseas is largely associated with ownership-specific advantages (O), location advantages (L), and internalization advantages (I). Of these, the locational advantage is what determines the hosts for the international activities of MNC firms. In other words, locational advantage serves as a key in determining which countries are most suitable to host the MNCs. To attract global investments, the host country can engineer its competitive advantage by changing the relative attractiveness of various locational factors over time.

The three main locational factors that MNCs look into before investing overseas are (i) economic advantages comprising quantity and quality of factor endowments, scope and size of the market, and transport and telecommunication costs; (ii) political advantages which include public policies specific to MNCs, trade, and international production; and (iii) social and cultural advantages which encompass factors like geographical distance between home and host countries, language and cultural diversity, general attitude towards foreigners and free enterprise.

In the OLI paradigm, possession of firm-specific assets constitutes the basis for firms becoming MNCs. The process of internationalization gives rise to many difficulties for firms engaging in international production. These difficulties mainly arise from the lack of knowledge about the foreign markets. MNCs may be oblivious to the consumer choices in the host country, ignorant of business practices prevalent over there, and unaware of labor market conditions and regulations existing in the host country. These obstacles often entail extra costs to be borne by the foreign firms willing to invest in host locations.

The firms need to possess some kind of comparative advantage to reduce the extra costs associated with relocating the production facilities overseas. Such advantages are often referred to as firm-specific assets and include things like patents, trademarks, brand names, superior knowledge and technology, distribution networks, and managerial practices. Intangible assets are believed to be of great importance in the decision to invest abroad as these are easier to transfer to foreign affiliates than tangible assets.

The third important element in the decision to internalize is the internationalization advantage. Indeed, firms possessing ownership-specific advantages have many ways to tap foreign markets and minimize the costs associated with serving foreign markets. For instance, MNCs can serve foreign markets through exports, licensing, franchising, or subcontracting, or through internalizing the transactions. However, there are certain disadvantages associated with the first two modes of serving overseas markets. For example, firstly MNCs sometimes cannot adequately serve the foreign markets through exports because either of high trading costs or huge demand for products existing in the host country. Secondly, in arm's length market transactions, there are market failures mainly due to opportunism by agents, and firms may fear unwanted loss of knowledge assets. Thirdly, the capability perspective focuses on the difficulties inherent in international technology transfer (Kogut and Zander, 1993). Varying levels of modifiability, teachability, and complexity of knowledge assets may impede inter-firm technology transfer through arm's-length contracts. Therefore, to avoid any issues related to market transactions, MNCs instead bypass them by internalizing transactions between headquarters (HQs) and overseas subsidiaries (Buckley, Clegg, and Wang, 2002). In sum, Dunning's OLI model defines MNCs' ownership-specific advantages and addresses how MNCs' superior technological assets are transferred to subsidiaries and sometimes become available across borders for countries other than the home country.

2.2.4 Asset-seeking theory

The OLI paradigm provides a comprehensive framework for analyzing FDI, while the asset-seeking theory delves deeper into a specific type of FDI motivated by the acquisition of valuable assets. The OLI paradigm might have helped pave the way for the development of the asset-seeking theory by highlighting the role of transaction costs and strategic advantages in FDI decisions.

The 1980s and 1990s witnessed a surge in research and theoretical development regarding asset-seeking FDI. Pioneering works by Caves (1982) and Teece (1986) explicitly introduced the concept of asset seeking as a distinct motivation for FDI. Caves (1982) identified the acquisition of technological know-how and marketing capabilities as key assets driving FDI. Teece (1986) emphasized the role of strategic assets, such as technological expertise, managerial skills, or distribution networks, in influencing FDI decisions. The asset-seeking theory remains a relevant framework for understanding contemporary FDI trends. In a globalized economy characterized by rapid technological advancements and intense competition, the acquisition of strategic assets can be a critical strategy for firms to maintain a competitive edge. Here are some contemporary applications: 1) Mergers and Acquisitions (M&A) Activity: The theory can help explain the surge in cross-border M&A activity driven by the desire to acquire R&D capabilities, access new technologies, or expand market share (Pereira et al., 2019; Deng and Yan, 2015). 2) Emerging Markets: Asset-seeking FDI is often prevalent in emerging economies where established local firms might possess valuable assets like well-developed distribution networks or local market knowledge that are attractive to foreign investors (Amal, 2011). 3)Knowledge Spillovers: While the focus is on acquisition, the theory acknowledges that asset-seeking FDI can also lead to knowledge spillovers as the investing firm integrates the acquired assets into its operations.

As R&D-focused FDI gained prominence, scholars further refined the asset-seeking theory to encompass the specific nuances of acquiring R&D assets. In the mid-1980s, a distinct shift emerged in how MNEs were understood. This new perspective recognized MNEs as far more intricate and multifaceted in their strategic outlooks, a characteristic captured by terms like "heterarchy" (Hedlund, 1986) and "transnational" (Bartlett and Ghoshal, 1989). This phase was marked by a growing recognition of the interplay between different internationalization strategies. Companies were increasingly pursuing both "home-base augmenting" approaches, where they leverage foreign knowledge to strengthen their home base capabilities, and "asset-seeking" strategies, where they establish R&D facilities abroad to tap into specific resources or markets. This contrasted with the earlier focus on "home-base exploiting" strategies, where MNEs primarily utilized their existing knowledge base at home, and "asset-exploiting" strategies, where they exploited existing R&D facilities abroad. These evolving strategies intertwined with national and regional patterns of knowledge accumulation. Research on innovation systems delved into the complex interplay between institutions, universities, and firms within a particular region or country. Additionally, advancements in economic geography shed light on the significance of location and the benefits of clustering (agglomeration economies) in attracting FDI-R&D activities. These studies emphasized the importance of location at both national and sub-national levels. Zahra et al. (2000) proposed the concept of a "technological opportunity window," highlighting how firms might use FDI-R&D to gain access to emerging technologies and shorten their innovation cycles. Cantwell and Mudambi (2005) explored the role of "geographic proximity" in R&D acquisitions, suggesting that firms might prefer acquiring R&D assets located close to their existing R&D centers to facilitate knowledge transfer and collaboration. Also, the rise of open innovation strategies, where firms collaborate with external partners to accelerate innovation, makes acquiring R&D assets through FDI even more attractive. However, the theory has also received criticisms: such as the asset-seeking perspective focuses too narrowly on acquisitions and may not fully capture the broader range of motivations behind FDI, such as market seeking or resource seeking. The specific assets being sought, and their value can be difficult to quantify, making empirical testing of the theory challenging.

The asset-seeking theory has become a cornerstone for understanding a specific type of FDI motivated by the acquisition of valuable assets. Its historical development reflects the evolving nature of global competition and the strategic importance of knowledge and technology in the contemporary business landscape.

2.3 Theories of innovation

Innovation is the process of bringing an invention, discovery, or understanding regarding a new device, process, or system to market. As such, it applies to new goods, processes, and services, as well as new markets, supply sources, and organizational structures. Innovation is frequently confused with invention, but the two are fundamentally distinct. An invention occurs when a new concept for a product, method, or service is first conceived. Innovation, on the other hand, refers to the process of moving from the original invention to its first successful commercialization (Lane and Flagg, 2010; Despa, 2014; Sener et al., 2017). As such, innovation is both a transformational process and an outcome. Innovations can be differentiated along a continuum from incremental to radical and can be new to the world, new to a country, or new to an organization. While radical innovations receive the most attention from management scholars, the accumulation of incremental improvements as innovations diffuse and adapt is a vitally important, and often overlooked, source of strategic differentiation.

Joseph Schumpeter (1934) stands as a giant in the study of innovation. He argued that capitalist economies are inherently dynamic, propelled forward by a relentless process he termed "creative destruction." This concept posits that innovative firms constantly disrupt established markets and industries with new goods, production methods, markets, raw materials, and organizational structures. Initially, Schumpeter explained innovation as driven by the "acts of will" of enterprising individuals, the quintessential entrepreneurs. However, his later work acknowledged that innovation had become institutionalized within the R&D departments of large corporations. While Schumpeter's emphasis on the transformative power of innovation remains highly relevant, his treatment of it as a singular event, rather than a continuous process, has limitations. This focus on the dramatic "aha moment" of discovery may overestimate the significance of radical innovations and the disruption they cause to established players. Additionally, Schumpeter may have been overly optimistic about the ease of overcoming the technological and market uncertainties inherent in the innovation process.

By the 1950s, Schumpeter's focus on R&D had evolved into a "science-push" model of innovation. This model suggests that groundbreaking innovations primarily emerge from fundamental research conducted in academic settings (Martin, 2012; Cohendet and Simon, 2017). This perspective held some validity in the post-war era when new markets were opening up for science-intensive technologies like plastics and antibiotics. Furthermore, the lack of established industrial infrastructure and competition meant that new products could be successfully launched without a strong focus on marketing. (Rothwell, 1992). However, the science-push model struggles to explain several key aspects of innovation. Firstly, it often fails to account for the many innovations with minimal scientific underpinnings. Secondly, numerous studies have shown that universities often rank lower than suppliers and customers in terms of being a crucial source of knowledge for innovation. Finally, the model overlooks instances where technologies are demonstrably functional and commercially available before a robust scientific understanding of their underlying principles is established. The Wright Brothers achieved powered flight before the science of aerodynamics was fully developed, and steam engines were in use well before the field of thermodynamics came into being (Schooner and Castellano, 2016). Even today, the exact mechanisms of many common anesthetics remain a mystery. As competition intensified in the 1960s and 1970s, marketing assumed a more prominent role in the innovation process. This shift gave rise to the "market-pull" model, which posits that innovations are primarily driven by changes in consumer demand. Schmookler (1962) provided some initial support for this perspective, analyzing historical patent data that suggested shifts in demand often preceded significant inventive activity.

However, theories solely focused on demand, assuming readily available technical capabilities, faced fierce criticism from Mowery and Rosenberg (1979). These scholars emphasized that a lack of technological understanding can be a significant barrier to innovation, regardless of the strength of demand. Additionally, they pointed out the inherent difficulty in clearly articulating and quantifying customer needs. Mowery and Rosenberg (1979) proposed a more nuanced view, arguing that innovation is best understood as a "matching process" that effectively bridges the gap between technological advancements and market requirements. This concept received strong backing from various detailed empirical studies examining the factors behind innovation successes and failures (Rothwell, 1977). It also informed the influential "chain-linked" model developed by Kline and Rosenberg (1986). This model incorporates feedback loops between R&D, production, marketing, and sales, acknowledging the crucial role of organizational learning in enhancing firm performance. The focus of innovation research and practice has since expanded beyond the confines of individual firms to encompass the interconnected web of suppliers, customers, and entire supply chains. Despite this evolution, the core idea remains remarkably consistent: innovation is an inherently uncertain, iterative learning process that strives to effectively match technological advancements with the ever-changing needs and demands of customers.

The historical development of innovation theory, highlights the strengths and limitations of the "science-push" and "market-pull" models. It emphasizes the importance of Mowery and Rosenberg's "matching process" concept, which acknowledges the crucial role of both technological advancement and customer needs in driving successful innovation. Finally, it acknowledges the shift towards a more holistic view of innovation that considers the interconnectedness of firms within their broader ecosystems.

2.4 FDI studies in Indian context

Indian research on FDI spillovers for domestic firms has grown significantly, particularly after economic reforms in 1991. Pre-liberalization studies generally showed positive impacts of FDI on domestic R&D and productivity. For example, Desai (1980) found that foreign technology boosted domestic R&D in India, a view supported by other researchers. Similarly, studies by Lall and Mohammad (1983) and Nayyar (1983) suggested a link between FDI and export orientation in developing countries' manufacturing sectors.

However, post-liberalization research presents a more nuanced picture. While some studies like Kathuria (2001) provides empirical evidence of the positive impact of foreign firms on the productivity of domestic firms in India. They employ a stochastic frontier analysis to estimate the impact of foreign firms on Indian manufacturing firms' productivity. Similarly, Kathuria (2004) found that scientific firms get a positive spillover from FDI than non-scientific firms. In contrast, Kathuria (2008) studied the impact of FDI on the R&D investment of medium and high-tech manufacturing firms and found a negative impact of FDI on the R&D investment in the period of 1994-96, whereas no effect in 1999-2001. Another study by Kathuria (2010) found no evidence of spillovers across all sectors, others suggest positive impacts under specific conditions. For instance, Behera (2015) highlights the importance of a firm's absorptive capacity, arguing that only firms able to utilize transferred knowledge benefit from FDI. Similarly, Marin and Sasidharan (2010) differentiate between "competence-creating" and "competence-exploiting" foreign subsidiaries, suggesting the former have a positive influence regardless of domestic absorptive capacity. The study also explores the mechanisms of spillover effects. Franco and Sasidharan (2010) posit that imitation, rather than demonstration effects, drives export spillovers in India. Their findings also emphasize the importance of in-house R&D for domestic firms to capture positive spillovers from foreign firms.

2.5 FDI-R&D and Innovation:

MNEs engaged in FDI well before the 19th century, driven by the pursuit of new markets and resources in economies. In academic literature, theoretical explanations for FDI have evolved over the years. Initially, the Internalization Theory (Hymer, 1960) focused on internalizing activities for cost advantages. FDI surged after World War II (Edwards, 1989; Lipsey et al., 1999) as companies established international subsidiaries or joint ventures to gain ownership, location, and internalizing cost advantages (Dunning, 1977). Resource-centric and market-seeking considerations became the focus of theories that laid the groundwork for licensing, franchising, and subsidiaries in the late 20th century. The Strategic Asset Seeking Theory (1999) recognized FDI driven by acquiring strategic assets like technology, knowledge, and talent, even without immediate cost benefits. Network Formation Theory (2000s) views FDI as a tool for building global networks, accessing new markets, resources, and partners, and leveraging agglomeration economies.

In the 21st century, FDI has been increasingly prioritized by foreign R&D firms (Rubera and Kirca, 2012; Pisano, 2015) to access talent pools and promote innovation (Le Bas and Sierra, 2002). Later, MNEs showed a growing interest in FDI-R&D specifically in emerging countries (Grosse, 2019). This shift has been spurred by the globalization of R&D by developed countries (Castelli and Castellani, 2013; Dunning and Lundan, 2009). Scholars have identified MNEs' asset-seeking and knowledge-creation efforts as major motivations for R&D internationalization (Dunning and Narula, 1995; Le Bas and Sierra, 2002; Cantwell and Mudambi, 2005; Bartlett and Beamish, 2018). The decision to offshore R&D activities is influenced by various factors, including location advantages (e.g., skilled labor) and labor cost savings (Demirbag and Glaister, 2010). Studies have further distinguished between "home-base augmenting" strategies that leverage emerging market R&D to complement existing capabilities, and "home-base exploiting" strategies that aim to reduce costs by outsourcing R&D activities (Dunning and Narula, 1995). These studies highlight the home country's perspective and supply-side motivations for engaging in FDI-R&D, particularly in emerging economies.

From the host country's perspective, FDI-R&D presents a potential game-changer, particularly for developing economies.

Until the late 1990s, such investment was uncommon, leaving these countries struggling to bridge the technological gap. However, the impact of FDI-R&D on boosting a nation's innovation output remains a topic of debate among scholars. While studies exploring the link between FDI, productivity, and innovation suggest positive outcomes (Cociu et al., 2017; Patra and Krishna, 2015; Malik, 2020; Zhou et al., 2022), highlighting technology transfer and enhanced domestic firm productivity, the true picture is more nuanced. Knowledge transfer, a key motivator for attracting FDI, seems to influence technological growth differently across nations. AlAzzawi (2012) suggests that for developing countries ("followers"), both inward and outward FDI can stimulate innovation. Conversely, for developed economies ("leaders"), outward FDI drives innovation, while inward FDI primarily intensifies competition. Similarly, Erdal and Gocer (2015) link FDI to increased patenting activity in developing Asian economies, underlining its potential to foster growth and high-tech production where capital and technology are scarce. Studies in Southeast Asia also offer mixed results. Lin et al. (2015) find a positive correlation between FDI and product innovation (measured by patents) in Taiwanese firms, with the impact of FDI exceeding other trade variables like import and export. However, Hoang et al. (2021) report a limited effect of FDI on technological innovation within Vietnamese firms. Other studies (Lipsey, 2004; Stiebale and Reize, 2008; Bergman, 2006) also find no clear positive relationship between FDI and innovation output. Therefore, the impact of FDI-R&D on a host country's innovation appears to be contingent on its unique characteristics and the nature of its firms.

3 Conceptual Framework and Empirical Framework

3.1 Introduction

After an in-depth analysis of the literature, this chapter identifies the gap in the available literature. The importance of FDI-R&D and how it is transformed from various ideas of internationalization to ideas of knowledge creation and asset-seeking motivation. Later on, to bridge the gap in the literature, we hypothesize that FDI specifically with R&D motivation has a positive impact on the innovation output of a firm. Based on the FDI role mentioned in the literature and various aspects of its relationship with innovation output we conceptualize the framework of the research.

The rest of the chapter is structured as follows: Section 3.2 discusses the gap in literature. Section 3.3 provides hypothesis development and lastly, section 3.4 elaborates the conceptual framework of the research.

3.2 Gaps in Literature

The impact of FDI-R&D on a firm's innovation output deserves careful examination. This is because FDI can bring in not only capital but also valuable resources like technological expertise and knowledge spillovers. These spillovers can occur through interactions between foreign and domestic researchers, fostering a more innovative environment. If FDI in general plays a significant role in propelling a country's technological advancement, then FDI specifically focused on R&D activities could have an even greater impact on a firm's ability to generate new ideas and products. This is because such investment would directly translate into increased resources for R&D, potentially leading to breakthroughs and patentable inventions. However, to fully understand the innovation landscape in India, it's crucial to go beyond just FDI-R&D. We also need to consider the specific characteristics of Indian firms that might influence their innovation output. These characteristics could include factors like a firm's size, industry sector, existing R&D capabilities, location of the firm, and export capabilities (Cohen and Klepper, 1996; Grando and Belvedere, 2006; Kumar and Saqib, 1996; Pradhan, 2003). By analyzing these internal firms' attributes alongside the influence of FDI-R&D, we can gain a more comprehensive understanding of what drives innovation in the Indian context. This study emphasizes the potential benefits of FDI-R&D in quality and quantity of innovation output. Also acknowledges the need to consider firm characteristics, and highlights the importance of understanding the specific context of India's innovation ecosystem.

3.3 Hypothesis development

The risk associated with FDI-R&D is undeniable, but a closer look reveals a complex dynamic with potential drawbacks for host countries. While the influx of foreign investment in R&D activities promises numerous benefits, the true beneficiaries may not always be the host nations. Sandhya et al. (2011) raises concerns about home-country firms leveraging FDI-R&D primarily as a means to access talent and resources in the host country. This "resource-seeking" behaviour, coupled with the potential repatriation of intellectual property (IP) developed through R&D efforts, can limit the long-term advantages for the host nation. In essence, the innovation generated might not stay within the host country, hindering its domestic knowledge base and technological progress.

The existing body of research on FDI and innovation offers valuable insights, but a critical gap emerges when we focus specifically on firms whose core business is R&D (FDI-R&D firms). Unlike the traditional focus on manufacturing sectors, FDI-R&D firms necessitate a distinct analytical approach due to their inherent emphasis on knowledge creation and innovation. This gap is further accentuated when considering the perspective of the host country. The current scholarship primarily investigates the motivations and benefits of FDI-R&D from the viewpoint of the home country firms (Dunning, 1977; Bartlett and Beamish, 2018). The impact on developing economies, which are increasingly becoming magnets for FDI-R&D activity, remains understudied. While Joseph et al. (2019) shed light on the presence of FDI-R&D firms in India, their research lacks empirical evidence to establish a causal link between FDI-R&D and innovation output. This lacuna presents a compelling opportunity to delve into the unique dynamics of FDI-R&D firms and their influence on innovation at the firm level in developing economies.

At the same time, the existing literature acknowledges the positive aspects of FDI. Foreign investment can act as a conduit for intangible knowledge transfer, introducing domestic firms to the latest technological advancements, international scientific practices, and the working culture of global R&D labs (Basant and Fikkert, 1996; Kathuria, 2001; Fujimori and Sato, 2015; Nuruzzaman et al., 2019). These knowledge spillovers can significantly enhance the innovation performance of domestic firms. Therefore, it is crucial to analyse the impact of FDI-R&D on the innovation output of firms in developing economies. Furthermore, if FDI plays a significant role in a country's technological advancement, then targeted investments specifically for R&D could hold even greater potential for boosting innovation output. Additionally, understanding the specific firm characteristics that influence innovation output within the Indian context is essential for formulating effective policies.

Drawing upon this existing literature on FDI-R&D and its connection to overall FDI's impact on innovation, we hypothesize that:

H_0: There is no significant difference between the innovation output of FDI-R&D firms and non-FDI-R&D firms after controlling firm-level characteristics.

H_1: There is a positive significant difference between the innovation output of FDI-R&D firms and non-FDI-R&D firms after controlling firm-level characteristics.

3.4 Conceptual framework: FDI-R&D and Innovation

The first problem that researchers face in deriving the FDI-R&D and innovation output relationship is the challenging task of measuring innovation. For reasons of data availability, the empirical works, thus far, have mostly used two measures to gauge innovation activity: R&D spending and patent counts. Both of these innovation measures, although frequently used in the empirical literature, have positive and negative attributes. As pointed out by Hall (2011) both R&D and patents as indicators of innovation largely relate to technological innovation and are best suited for measuring innovation. R&D expenditure as an input to innovation symbolizes a decision variable measuring the size or level of innovation activity at the firm level. It, however, is unable to represent the innovation success. The advantage of R&D spending is that it is comparable across firms, industries, and countries because it is denominated in currency units. The patent counts as a measure of innovation scores over R&D expenditure in the sense that, unlike R&D, it can capture successful innovations and therefore can be treated as a better proxy of innovation output. As argued by Griliches (1990), patents can be used as either an output or an input indicator of innovative efforts. When patent statistics are used as an output measure these are an indicator of the success of the underlying inventive activity, while when patents are used as an input measure, they represent efforts that have been put into the creation of a new product or process and, as such, patents are related to R&D expenditure statistics. The problem inherent in patent counts is that only a few of them are associated with highly valuable inventions and most describe inventions of little value. Another issue with patents counts as a measure of innovation relates to is their sectoral variability, i.e. the extent of their innovation coverage varies by sector, with sectors like biotechnology and ICT having higher patenting levels than sectors.

Coming to the relationship of FDI-R&D and innovation output, as discussed in the literature, this causal relationship is not straightforward for firms. The impact is complex and influenced by various factors at the firm, industry, and country levels. Simply investing in innovation activity and R&D activity does not guarantee positive innovation outcomes (Sandhya et al., 2011). Many factors play a critical role, depending on the specific firm, industry, and national environment. For instance, firm characteristics such as a strong absorptive capacity, which is the ability to learn and utilize new knowledge from external sources, can significantly influence how effectively a firm benefit from FDI-R&D. Size of the firm could create a positive impact on the output and help absorptive capacity. Industry sectors in which the firm belongs play an important role in the innovativeness of the firm. Additionally, country-level factors, such as the strength of intellectual property rights protection, can affect the innovation environment and the returns on FDI-R&D investments as well as risk associated with them.

By considering this wider context, we try to develop a framework that captures the complex interplay of these factors and their influence on the relationship between FDI-R&D and innovation output. This framework can be envisioned as a multi-step model comprised of several equations that depict the sequential relationships between these variables.

Within the model, industry-level variables are introduced as exogenous factors, meaning they independently influence the impact of FDI-R&D on innovation. The first equation acts as a foundation, employing logistic regression to identify firms with similar characteristics but not receiving FDI-R&D activities. This enables a more focused comparative analysis. This equation uses firm-level characteristics like size, age, and industry sector to calculate the probability of a firm engaging in FDI-R&D.

The second equation delves into the innovation output itself. Figure 2 shows the relationship between FDI-R&D and innovation output. The rectangular box in the middle of the diagram represents FDI-R&D as a treatment for firms. The left side of the diagram shows "YES" which means the firms that receive FDI-R&D. The right side shows "NO" which means the firms that do not receive FDI-R&D. The arrows depict links between the firm's innovation output and FDI-R&D while controlling for other relevant firm characteristics (diamond box). These control variables might include the firm's own R&D expenditure, size, location, and export activity. Given the potentially different nature of data used in each equation (as depicted in

Figure 2), we will need to employ different statistical techniques to derive reliable estimates. The specific empirical strategies used, and the potential issues associated with them will be addressed in the next chapter.

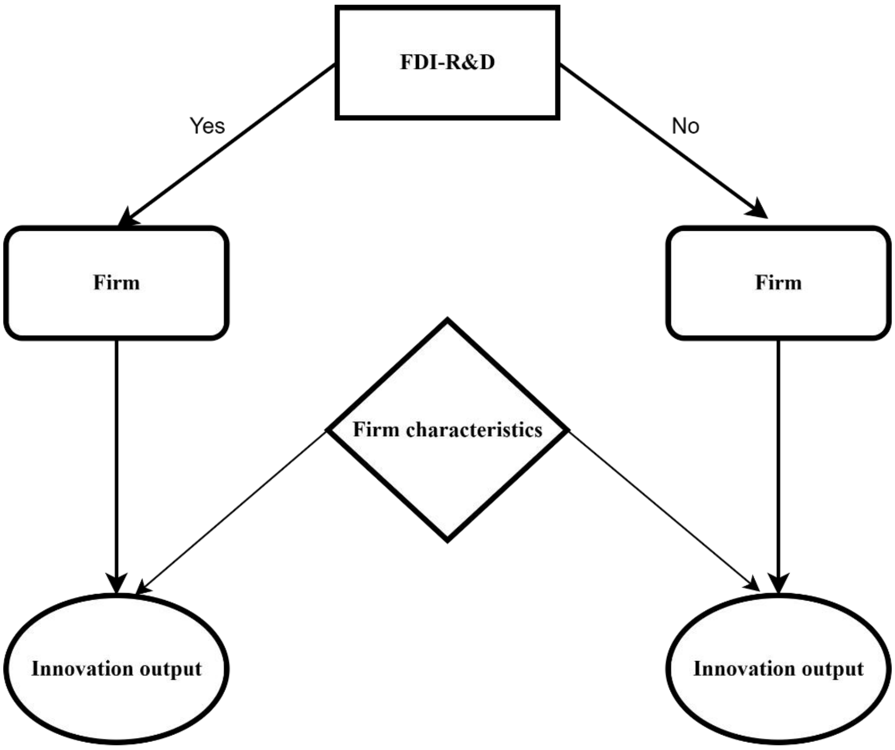

Figure 2 Conceptual framework of research

4 Econometric Specification and Data

4.1 Introduction

While the conceptual framework lays the groundwork, the empirical analysis provides crucial evidence to understand the true impact of FDI-R&D on innovation output. This chapter addresses the methodological framework, identification strategy, and data used to evaluate the effect of FDI-R&D on the innovation output of firms in India. We employ propensity score matching (PSM) and Difference-in Differences (DID) framework to account for the specific issues related to data selection. We also highlight the basic assumptions and practical measurement issues related to each methodology. The specific issues of evaluation include the selection bias and endogeneity issue while estimating the effect of FDI-R&D on innovation output.

The rest of the chapter is structured as follows: Section 4.2 discusses empirical strategy based on the objective of the study and innovation output equation. Section 4.3 discusses the issues of selection bias and the endogeneity associated with data and FDI-R&D. Section 4.4 provides the empirical frameworks used to evaluate the impact of FDI-R&D on innovation output. Along with detailed review of the various measurement tools and techniques. Sections 4.5 and 4.6 outline the data sources and the definitions of variables used in the study, respectively.

4.2 The Empirical Strategy

For the study, we started with a descriptive analysis of the whole data set available in the report of PSA 2020, consisting of 298 firms. The firms have certain characteristics based on their information available at MCA21 and CMIE prowess. We explore the data based on detailed descriptive analysis. After the initial analysis, we shift to panel data regression analysis to establish the causal relationship between FDI-R&D and innovation output.

The major challenge in conducting the empirical studies is the selection problem as productive and efficient host country firms are likely to attract foreign investments. Selection of FDI-R&D firms from the whole population is quite challenging due to the lack of standards in the definition of FDI-R&D and identification methodology. We have utilized the data set which is already given by the PSA report 2020. The selection of data sets from a predefined set, not from the population, creates the problem of selection bias in the analysis of causal relationships. Another issue that we face in our empirical analysis is the problem of endogeneity. It arises when one or more explanatory variables in the model are correlated with the error term. In the presence of endogeneity, the usual OLS estimates tend to be biased. Endogeneity is driven by several factors like omitted variable bias, simultaneous causality bias, and errors-in-variables bias, all of which affect the consistency of estimates.

We review various methods for the analysis of the treatment effect of FDI-R&D on innovation output. Our empirical strategy has two stages: Firstly, for comparative analysis and to account for selection bias, the model requires a set of firms that are non-FDI-R&D. Such firms will constitute a control group for the causal analysis. For the selection of this control group, researchers have used various methods such as randomization, regression discontinuity, and propensity score matching. The randomization method includes randomly assigning participants to either the treatment group (receiving the intervention) or the control group (not receiving it) without considering other characteristics (Cochran, 1972). This method isn't feasible for this study, because the dataset is already defined as a treatment group in the PSA report 2020. Further, for selecting a control group, randomization causes problems in comparative analysis without matching similarity among treatment and control group characteristics. Regression Discontinuity is employed when treatment assignment is based on a cut-off score or threshold. Individuals just above the cut-off receive the treatment, while those just below do not, creating a natural control group (Hahnet al., 2001; Jacob et al., 2012). This method is not feasible in the present context because the period of study is 2010-2020. It is a limited period to set the cut-off score and identify the threshold point of change in innovation output.

PSM gained prominence in literature through influential works by Dehejia and Wahba (1999, 2002), who assessed PSM using LaLonde's (1986) experimental data as a benchmark. They demonstrated that PSM outcomes closely resembled those obtained from experimental settings, which are regarded as the gold standard in literature. The second stage of analysis involves finding out the average treatment effect (ATE) of the FDI-R&D. ATE is the difference between what would have the innovation output if the firm received FDI-R&D and what would have the innovation output if the firm did not receive FDI-R&D but everything else such as other firm characteristics had been the same. Innovation output as well as FDI-R&D can be affected via other unobservable characteristics of firms. We selected our control group by matching their size, age, and industry. These variables are used in the matching process by many scholarly studies based on PSM (Srivastava, 2022; Cozza et al., 2015; Haudi et al., 2020).

Many studies have applied majorly three approaches to take care of the issue of endogeneity and selection bias in calculating the ATE. These approaches are instrumental variable (IV) regression, dynamic regression model, and DID regression. Busom (2000) mentions that IV regression models will not account for the problem of endogeneity because the available data set used in the study is limited to finding instruments that are strong and valid.

Raymond et al. (2013) used a dynamic regression model to analyze the relationship between innovation and productivity in Dutch and French manufacturing firms. This model creates the problem of heterogeneity with the small time series and does not control the effects of other firm characteristics which might affect the innovation output of the firm. DID compares changes in outcomes between the treatment group (firms receiving FDI-R&D) and the control group (firms not receiving FDI-R&D) before and after the treatment (Angrist and Pischke, 2009).

Among the above-mentioned techniques and based on the survey of different methods, we propose to employ PSM and DID for our analysis. Also, these two methods are most widely used in the existing empirical literature. Moreover, given the specific constraints of data, these are feasible methods for the analysis in the present study.

4.2.1 The innovation output equation

The next equation in our model is an innovation function which specifies the relationship between innovation outputs (i.e. the number of patents granted to a firm) to FDI-R&D along with a set of covariates which among others include the R&D expenditure of the firm, firm size, firm total exports, and other firm and industry-specific variables. The patent grant is essentially a count variable taking on non-negative integer values. The discrete non-negative nature of the patent counts makes linear regression models (LRMs) unable to provide the best fit of the count data. Hence, such models are deemed to be inappropriate to handle count variables. The ineptness to handle counts is the underlying assumption of LRM such as the normality of residuals and linear adjustment of the data that is no longer fulfilled.

$$Y_{it} = \beta \cdot T_{it} + \alpha_i + \tau_t + X_{it} + \varepsilon_{it}$$

Y_{it} is innovation output (number of patents held by firm *i* in a year *t*), α and τ are unit and time fixed effects, T_{it}s treatment FDI-R&D in firm *i* and time *t*, X_i is a control variable such as sales, R&D expenditure, and exports of i firm, $\mathcal{E}i$ is some idiosyncratic error. The coefficient of interest is, as always, β. Now that treatment Ti turns on at different times for different units *i*.

4.3 Econometric issues

4.3.1 Identification and Selection

Issues of selection bias

The characteristics of firms that get FDI-R&D are likely to differ from those that do not apply. These differences are mainly due to the high absorptive capacity and past innovation activities of the firms (Czarnitzki et al., 2001). Due to these inherent characteristics, the FDI-R&D firms have potentially more innovation capabilities than non-FDI-R&D. Hence, the existence of FDI-R&D and selected from a report with specific characteristics of the firm should consider the selection bias that arises due to the data collected from the report not from the whole population. In the case of Hall and Maffioli (2008) also point out that a simple comparison of innovation outcomes of recipients and non-recipients leads to selection bias and misleading the estimation effect of the policy.

Endogeneity issues

Another concern that we face in our empirical analysis is the problem of endogeneity. It arises when one or more explanatory variables in the model are correlated with the error term. In the presence of endogeneity, the usual OLS estimates tend to be biased. Endogeneity is driven by several factors like omitted variable bias, simultaneous causality bias, and errors-in-variables bias, all of which affect the consistency of estimates. In the presence of endogeneity, an estimate may appear to adequately reflect the hypothesized relationship under study, but it will be inconsistent and will not reflect the true population parameter because the observed correlation may be far off from the true relation; that is, the true relation could be higher, lower, zero, or of a different sign from the observed association.

Endogeneity is a likely concern in this study as well and hence needs specific attention. There is a possibility that some of the variables are endogenous. For instance, foreign investors tend to invest in sectors with a higher level of R&D or high level of innovation output and hence FDI-R&D may gravitate towards such sectors giving rise to reverse causality and hence to the endogeneity in the model.

There is also the concern of endogeneity due to confounding FDI policy changes in India during 2010–2020. The FDI-R&D inflow could have coincided with other domestic policy changes that had a differential effect on firms. The endogeneity and selection bias may arise at model construction as well as in the estimation phase (Cerulli, 2010).

The econometric evaluation offers different ways of tackling endogenous variables and to overcome the selection bias. Researchers use micro-level data (panel data and industry-level data) to control the cross-sectional effects and temporal variations in estimating the effect of fiscal incentives. Over the last two decades, researchers have also employed more comprehensive ‘non-structural’ models to eliminate the endogeneity and selection bias, based on the availability and type of data. These techniques include (i) regression with controls; (ii) fixed effects or DID models; (iii) sample selection models; (iv) instrument variable (IV) estimators; and (v) non-parametric matching of treated and untreated firms. The selection models and IV estimators are used if at least one valid exclusion restriction or instrumental variable is available. In our study, it is difficult to find an instrumental variable that affects the likelihood of the firms getting FDI-R&D but does not correlate with the outcome variable (Patenting). Non-parametric matching methods are used to control the potential selection issues when the Selection of the FDI-R&D firm is not random. It estimates the counterfactual situation, where how much the FDI-R&D recipient firms would have innovated if they did not have FDI-R&D. The DID approach is used to compare the before and after effects of treatment. Among the different micro-econometric approaches, PSM and DID are considered efficient approaches that provide a reliable evaluation of the causal effect between investment and firm innovation.

4.4 Empirical methodology

4.4.1 Propensity Score Matching (PSM)

Matching techniques have been extensively utilized in literature to address self-selection issues. The main idea is to identify, from a large control group (comprising non-FDI-R&D firms or non-treated firms), those firms that share similar observable characteristics with the treated firms before the treatment. By creating this comparable group, any differences in outcomes can be solely attributed to the treatment. However, a challenge with matching methods arises while considering all relevant covariates (denoted as X) because it may lead to the "curse of dimensionality." This implies that it can be difficult to find a counterpart for each treated firm that matches precisely (Caliendo and Kopeinig, 2008). To tackle this issue, Rosenbaum and Rubin (1983) suggest using balancing scores, denoted as p(X), which match firms based on their probability of attracting FDI-R&D. This approach is known as PSM. Various PSM estimators differ in defining the neighborhood, who have a similar PS value, for each treated individual, handling the widespread support issue, and assigning weights to these neighborhoods. The kernel matching method is most widely chosen for matching. Unlike other algorithms, the kernel matching method employs all observations from the comparison group. Specifically, it is a non-parametric estimator that uses a weighted average of all control group firms to construct the counterfactual outcome for treated firms. Like other matching methods, it involves a trade-off between bias and variance. This method has high bias due to the potential inclusion of poorly matched observations, but low variance because it incorporates more observations (Caliendo and Kopeinig, 2008).

Scholars such as Smith and Todd (2005) have criticized PSM for its sensitivity to the choice of data subsample and covariate selection. Similarly, Angrist and Pischke (2008) expressed reservations about PSM, highlighting the lack of standardization in the procedure. Consequently, other matching algorithms are tested for robustness checks at the Authors' discretion. Compared to other strategies like instrumental variables or regression discontinuity design, matching methods are often deemed less optimal because they do not allow direct control of unobserved characteristics. As previously mentioned, unobservable are only accounted for if the assumption that firms with similar observables have similar unobserved characteristics is plausible. Having said so, it is also true that PSM is still useful when there is no treatment randomization opportunity. In the case of this research, for instance, this method allows to deal with self-selection issues and thus reveals insightful information on the relationship between FDI-R&D and innovation outcome.

Econometric setup of PSM: The first step for a PSM process is the estimation of the propensity scores based on the set of covariates chosen. Therefore, the initial step involves selecting an appropriate functional form for the model. This analysis adopts a logit model. Caliendo and Kopeinig (2008) point out that for binary treatment, probit and logit estimation yield similar results. Equation (1) represents the predicted probability of the treatment, estimated with a logit model.

$$P\ (\text{FDI-R\&D} = 1) = \Phi(Xi) \qquad \textbf{(1)}$$

Equation (1) indicates the probability of the firms implementing the treatment given the Xi set of firm-specific characteristics, such as the size of the firm, age of the firm, and the industry (i.e. NIC 2008 at five digits) of the firms between 2010-2020. The choice of covariates to add when estimating the propensity scores is important as only variables that influence both the treatment decision and the outcome variables should be included if one wants to avoid bad control biases. In contrast, covariates that are influenced by the treatment (or its anticipation) must be excluded. Equation (1) thus gives the propensity scores for each firm, which is the probability of attracting FDI-R&D given the set of covariates are results of a logistic regression equation (2) of PSM.

$\beta = \exp (\beta_o + \beta(Age_{it}) + \beta_2 (GFA_{it}) / \{\exp (\beta_o + \beta(Age_{it}) + \beta_2 (GFA_{it})) + 1\}$

$$OR = e\wedge^{(\beta_o + \beta(Age_{it}) + \beta 2\ (GFA_{it}))} / e\wedge^{(\beta_o + \beta(Age_{it}) + \beta 2\ (GFA_{it})) + 1} \quad \text{.....(2)}$$

If p, the probability of having FDI-R&D, is given in the above equation then $(1 - \beta)$ is the probability of not having FDI-R&D, now $\beta/(1- \beta)$ is simply the odds ratio in favor of FDI-R&D the ratio of the probability that a firm will get FDI-R&D to the probability that it will not get FDI-R&D. With the estimated probability the matching procedure of FDI-R&D firm to non-FDI-R&D firm. The second step is the choice of the matching algorithm used to estimate the ATE.

4.4.2 Difference-in-Differences Approach

To find the ATE of FDI-R&D on innovation output (patents filed by firms). DID is one of the most popular research designs used to evaluate the causal effects of interventions (Angrist and Pischke, 2009). The DID method compares changes in outcomes between the treatment group (FDI-R&D firms) and the control group (non-FDI-R&D) before and after the treatment. By comparing the change in innovation outcomes over time between the treatment and control groups, the DID approach can help to isolate the causal effect of FDI-R&D on innovation outcomes. First, the firms having FDI-R&D given by PSA report an already defined treatment group for analysis. The required control group is found through the PSM process which includes 65 firms that are non-FDI-R&D firms. Firm-level FDI-R&D does not occur in the same period for all the firms. The time for treatment for the treated group is staggered and treated at multiple periods. Because of this reason, study used staggered DID regression, also known as generalized DID with fixed effects and multiple periods (Callaway and Sant'Anna, 2021). To be clear about the assumptions of staggered DID we are going to make some notation.

Notation

- Y_{it} is the firm i's observed innovation output at time t.
- Y_{it} (0) is the firm *i*'s innovation output, (0) notates that this is the innovation output of the firm *i* in period *t* when it does not receive FDI-R&D.
- Y_{it} (g) is the innovation output of the firm *i* in period *g* when it receives FDI-R&D.
- G_i is the time when firm *i* becomes treated (often *groups* are defined by the time when a firm becomes treated; hence, the G notation).
- C_i is an indicator variable for whether firm *i* is in a never-treated (non-FDI-R&D) group.
- D_{it} is an indicator variable for whether firm *i* has been treated by time *t*.
- X_i vector of covariates.

For firms in the never-treated group, $Y_{it}=Y_{it}(0)$ in all time periods. For firms in other groups, we observe $Y_{it}=1\{G_i>t\}Y_{it}(0)+1\{G_i\leq t\}Y_{it}(G_i)$. In words, we observe untreated potential innovation output for firms that have not yet participated in the treatment, and we observe treated potential innovation output for firms once they start to participate in the treatment (and these can depend on *when* they became treated). Implicit in this notation there is a no treatment anticipation assumption, which can be relaxed as discussed in Callaway and Sant'Anna (2021).

The main assumption of Staggered DID

Staggered Treatment Adoption Assumption

Recall that Dit=1 if a firm i has been treated in time t and Dit=0 otherwise. Then, for t=1,T−1=1,..., , Dit=1⟹Dit+1=1.

It implies that once a firm participates in the treatment, it remains treated. Since it is hard to analyze non-staggered treatment setups without further restricting heterogeneity across time, groups, treatment sequences, etc. we focus on staggered DID.

Parallel Trends Assumption based on never-treated firms

For all g=2,...,T, t=2,...,T with t≥ ,

$E[Yt(0)-Yt-1(0)|G=g]=E[Yt(0)-Yt-1(0)|C=1]$

This extension posits that the average untreated potential innovation output for the initial treatment group (denoted by g) and the control group (never treated) would have exhibited identical trajectories in all periods following the treatment implementation ($t \geq g$), absent the intervention itself.

Parallel Trends Assumption based on not-yet treated firms

For all g=2,...,T=2...,, s,t=2...,T=2,..., with t≥g≥ and s≥t

$E[Yt(0)-Yt-1(0)|G=g]=E[Yt(0)-Yt-1(0)|Ds=0,G\neq g]$

This assumption states that one can use the not-yet-treated by time s (s≥t) firms as valid comparison groups when computing the ATE for the group first treated in time g. In general, this assumption uses more data when constructing comparison groups. While this approach leverages a larger dataset for constructing comparison groups, it may introduce limitations, as Marcus and Sant'Anna (2021) point out, by potentially obscuring pre-treatment variations between the groups. Given this assumption, the staggered DID equation for estimation is as follows:

$$Y_{it} = \beta \cdot T_{it} + \alpha_i + \tau_t + X_{it} + \varepsilon_{it} \qquad (3)$$

Y_{it} is innovation output (i.e., log of a number of patents held by firm i in a year t), α and τ are unit and time fixed effects, T_{it}s treatment FDI-R&D in firm i and time t, X_i is a control variable under log transformation such as sales, R&D expenditure, and exports of i firm, Ei is some idiosyncratic error. The coefficient of interest is, as always, β. Now that treatment Ti turns on at different times for different units i.

4.5 The database

We used the PATseer database for the firm's patent data. For firm-level data for the FDI-R&D firms in India. PATseer is a patent database known for its comprehensive global coverage and advanced search functionalities, to collect firm patent data for analysis. Information on FDI-R&D firms is available in the report on FDI in R&D (2020). This report database is published by the PSA, a government think tank established in 2018 that advises the Prime Minister and cabinet on science and technology matters. The report provided a list of 298 firms that are attracting FDI-R&D. These 298 firms are the main sample for the research. Information about firm-level data is collected from CMIE Prowess data and MCA21. On CMIE Prowess, data for 64 FDI-R&D firms is available out of 298 firms. After the matching process, we have 64 non-FDI-R&D firms. With this, we have data for 128 firms' datasets for finding the causal relationship between FDI-R&D and the innovation output of these firms. Lastly, individual firms' annual reports are thoroughly studied to find the year existence of FDI-R&D of these firms.

4.6 Construction and description of variables.

4.6.1 Variable specification for FDI-R&D equation for PSM

From above the discussion on empirical strategy the foremost step is to find a control group via PSM and use logistic regression to solve the problem of selection bias and endogeneity in the data set. The variables of the model are discussed as follows:

Dependent variable

Probability of FDI-R&D: The dependent variable is a dichotomous variable taking the value one if a firm has FDI-R&D at time *t* and otherwise the value zero. FDI-R&D refers to the investment made by foreign companies in the R&D activities of firms.

Independent variables:

Size: Larger enterprises possess more resources and are better equipped to engage in global markets. Large firms can allocate more towards marketing, R&D, and globalization (Cohen and Klepper, 1996). Many researchers used firms' gross fixed assets as an indicator of firm size. Information regarding the firm's gross fixed assets was collected from CMIE Prowess.

Age: A company will accumulate experience and knowledge which is necessary to innovate (Sørensen and Stuart, 2000). The age of a firm is expected to have a positive influence on its motivation to participate as it will have resources to conduct R&D. Older firms in India are more R&D intensive (Sasidharan and Kathuria, 2011) and so, may be more likely to attract FDI-R&D. The age of the firm is calculated as the difference between the present year and the firm incorporation year.

Industry: Industries with strong growth prospects, substantial profit margins, and favorable regulatory environments are attractive to investors. Sectors like pharmaceuticals, high-tech, and financial services, known for technical innovation and demand, draw FDI (Bergman, 2006). Firm industry groups are based on the 5-digit NIC code 2008.

Follow Table 1 for information about the variable used in PSM and logistic regression equation along with their definition and data sources.

Table 1 Variables for PSM equation

Outcome Variables	**Definition**	**Source of Data**
FDI-R&D	A dummy variable =1 if a firm is having FDI in R&D and 0 otherwise	Annual reports of firms
Independent	**Definitions**	**Source of Data**
Firm size	Log (Gross fixed assets of the firm)	CMIE (Prowess)
Industry	Firm NIC groups based on NIC 2008	CMIE (Prowess)
Age	The difference between the present year and the year of incorporation of a firm	MCA21

4.6.2 Variable specification for innovation output equation for DID regression

The next step is to find the average treatment effect of FDI-R&D on innovation output by DID regression.

Dependent variable:

Innovation output: The dependent variable, a patent application filed by firm *i* at time *t***,** is a count variable. The OECD Oslo Manual (2005) established four distinct forms of innovation: product, process, organizational, and market innovation. Product and process innovation are intimately linked to technological advancements where technology refers to the utilization of advanced machinery and equipment. Product/service innovation, that is the introduction of a new product or service with considerably improved performance qualities, is a critical determinant of firm performance (Damanpour and Gopalakrishnan, 2001). Product innovation also facilitates the identification of opportunities to generate above-average profits and serves as a pathway for firms to achieve profitability (Nambisan, 2003). The systematic way of capturing product innovation and output of R&D investment is a patent (Grosse, 2019). Following Griliches (2009) patent data has gained popularity for empirical research on innovation, technological change, firms' strategies, and performance. A patent is a document that describes an invention and gives the inventor the exclusive right to make, use, and sell the invention for a limited period. Some scholars argue that patents are not the best way to measure innovation because they capture only the results of R&D activity that can be patented, leaving out the rest of the innovations (Grosse, 2019). However, most researchers agree that patents are one of the most important indicators of innovation, even though there is no perfect measure (Archibugi and Pianta, 1996; Reddy, 2000; Rubera and Kirca, 2012). We consider patents as the best proxy for innovation output because we are capturing innovation by FDI-R&D firms that are largely concentrated in patent-sensitive sectors like automobile, biotechnology, pharmaceuticals, natural sciences, engineering, etc. Data for individual firm patent information is taken from the PATseer database from 2010 to 2020.

Treatment variable:

FDI-R&D: The key independent variable is a dichotomous variable taking the value one if a firm has FDI-R&D at time *t* and otherwise the value zero. FDI-R&D refers to the investment made by foreign companies in the R&D activities of firms. Information related to this variable is taken from the DPIIT FDI newsletter for the year of getting FDI-R&D and individual firm annual reports available on CMIE prowess.

Covariates:

- **Location:** Industrial clusters in specific locations, as noted by Stewart & Ghani (1991), facilitate knowledge exchange among firms. Firms within such clusters are more likely to participate and innovate more due to the influence of neighboring companies (Ferreira et al., 2017). Information regarding firm location is taken from their headquarters location given by CMIE Prowess. It is a binary dummy variable. It takes a value of 1 if the firm location is in the defined industrial cluster (Delhi, Pune, Hyderabad, Mumbai, Bengaluru) otherwise it takes a value of 0.
- **Firm size:** According to the theory of Schumpeter (1950), large firms have the wherewithal (large scale of production and capacity, infrastructure in marketing, finance, and R&D) to exploit new technology larger enterprises possess more resources and are better

equipped to engage in global markets. The large firm showed a significant positive relationship with the innovation output of the firm. For this study, we collected information regarding the firm's sales from CMIE Prowess.

- **Type of industry:** Industries with rapid growth prospects, substantial profit margins, and favorable regulatory environments are more innovative (Bronzini, 2015). Moreover, it is well recognized that the sources, speeds, and rates of technological development differ among industrial sectors (Pavitt, 1984). We considered a firm industry group based on the 4-digit NIC code 2008.
- **R&D spending:** The amount a firm spends on R&D can be a critical factor, as it signals the firm's commitment to innovation and the development of new products or services. According to Papanastassiou et al. (2020), R&D expenditures are one of the key factors in determining a firm's technological capabilities and innovative capacity. Firms that invest heavily in R&D are seen as having a higher potential for future growth and profitability (Harris et al. 2011; Zhou et al. 2022). For this study, we collected information regarding R&D spending from CMIE Prowess.
- **Total exports:** The relationship of exports with innovation has been explored by Kumar and Siddarthan (1994) and Shepherd (2017). They stated that exporters are more likely to introduce a new product than non-exporting firms. This relationship has been explored with innovation at country-level analysis which found a positive relationship between the two. Infirm-level studies, Aghion (2018) states that exports have a positive impact on the innovation of French firms. There are some reasons behind this relationship highlighted by Seenaiah

and Rath (2018). Firstly, firms that have skilled labor as well as superior technologies that allow them to produce greater production. Increased productivity constantly drives them to pursue greater levels of innovation. Second, increasing export intensity boosts these enterprises' competitiveness, causing them to behave differently than competitors. More competitive firms are likely to innovate. With this understanding, we considered total exports of goods and services by the firms as a control variable for the model, and information regarding total exports is collected from CMIE Prowess. Follow Table 2 for information about the variables used in DID regression along with their definition and data sources.

Table 2 Outcome and Control Variables

Outcome Variables	**Definition**	**Source of Data**
No. of Patents	Log (Patent+1), where Patent is the number of patents held by the firm for the years 2010-2020	PATseer
Independent and Treatment variables	**Definitions**	**Source of Data**
FDI-R&D	A dummy variable =1 if a firm is having FDI in R&D and 0 otherwise	Annual reports of firms
Control Variables		
Location	A dummy variable =1 if a firm is located in the industrial cluster, 0 otherwise	CMIE (Prowess)
Total Exports	Log (Sum to exports of goods and services of the firm)	CMIE (Prowess)
Firm size	Log (Total sales of the firm)	CMIE (Prowess)
Industry	Firm NIC groups based on NIC 2008	CMIE (Prowess)
R&D Exp	Log (Total R&D exp of the firm)	CMIE (Prowess)

5 Empirical Results and Discussions

5.1 Introduction

In this chapter, we present the results of the evaluation regarding the impact of FDI-R&D on the innovation output of FDI-R&D firms during 2010-2020. Using PSM and DID, we evaluate the change in innovation output due to FDI-R&D. In the PSM framework, we find the control group (non-FDI-R&D) firm by using logistic regression. DID framework considers the timing of FDI-R&D and compares the innovation output of FDI-R&D and non-FDI-R&D firms. As per the discussions in the previous chapter, we estimate the impact of FDI-R&D on outcome variables of patent applications.

The rest of the chapter is organized as follows: Section 5.2 provides a descriptive analysis of the data. Section 5.3. estimation results of the propensity score (PSM). Section 5.4 provides the estimation results of Difference-in-Difference (DID).

5.2 Descriptive statistics for all 298 firms

This section provides a detailed analysis based on the list of firms available in the PSA report (2020). We collected the data for this section from MCA21 for firm-level data, and the PATseer database for patent-level data.

Further, we explored the relation between firm location, patent filed, and innovation index of states. We find the location of patent filing at different patent offices. Lastly, we also delve into the relationship between firm age and the patent-filed FDI-R&D firms.

5.2.1 Sector-wise Distribution of FDI-R&D inflows

After the collection of information provided by PSA 2020. It was found that out of 298 firms, 76 firms are receiving FDI-R&D in the natural sciences and engineering sector or activity. Followed by 55 firms belonging to the clinical research sector, 49 firms are from pharmaceuticals, 42 firms are from Information and Communications Technology (ICT), rest are from medical devices, renewable energy, automobiles, and design. Information on the number of inflows for these sectors' FDI-R&D firms is hard to aggregate from this source due to inconsistency in the reporting of data. For some firms, the amount of inflow shown on the source is zero.

5.2.2 Distribution of Location of FDI-R&D firms along with Innovation Index of states

The India Innovation Index, a crucial benchmark, highlights states like Karnataka, Maharashtra, Haryana, Telangana, and Tamil Nadu as top performers (Innovation Index report 2021) (see Figure 3). Interestingly, the location-wise distribution of FDI-R&D firms mirrors this ranking. Karnataka, boasting the highest innovation score, also houses the largest number of FDI-R&D firms. This strong correlation suggests that location plays a significant role in attracting FDI-R&D.

Furthermore, the presence of FDI-R&D firms appears to be a critical driver for boosting a state's innovation index. These firms bring not only capital but also cutting-edge technologies, global R&D expertise, and knowledge transfer opportunities. This fosters a vibrant innovation ecosystem, attracting further research talent and local R&D investments. Study by Tan et al. (2023) explored the Chinese context and even quantify this positive impact, demonstrating that FDI-R&D significantly enhances a region's innovation capabilities. Therefore, a two-way relationship exists between a state's innovation index and its ability to attract FDI-R&D. By fostering a strong innovation ecosystem through supportive policies, skilled workforce development, and robust infrastructure, states can become magnets for FDI-R&D.

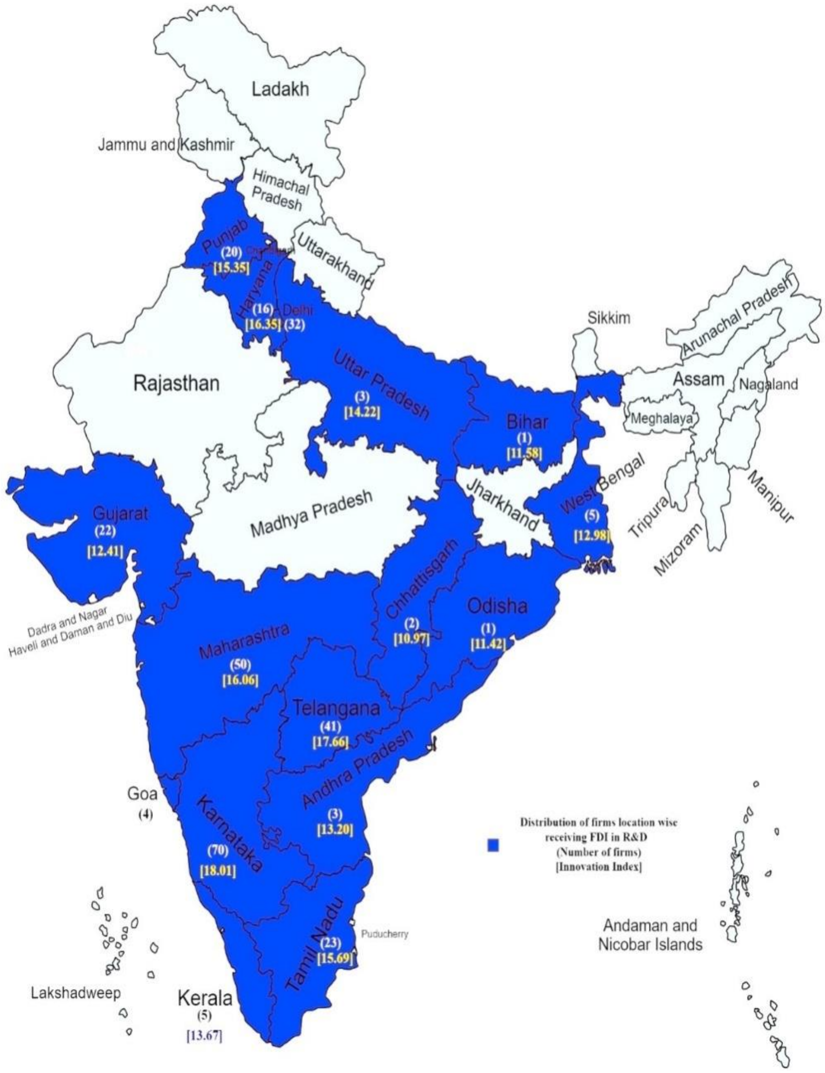

Figure 3 Total firms based on location of headquarters in India with Innovation Index

5.2.3 Distribution of FDI-R&D firm with patent filed

Figure 4 Analysis of patent filings across Indian states reveals a notable geographical disparity in innovative activity. States like Maharashtra, Karnataka, and Punjab emerge as leaders, evidenced by the considerably higher number of patent applications filed by firms headquartered within their borders. This observation aligns with existing innovation indices for Indian states, where these same states consistently rank at the top (refer Figure 3). This synergy between patent filings and innovation rankings suggests a flourishing innovation ecosystem within these states, likely driven by a robust FDI-R&D investment.

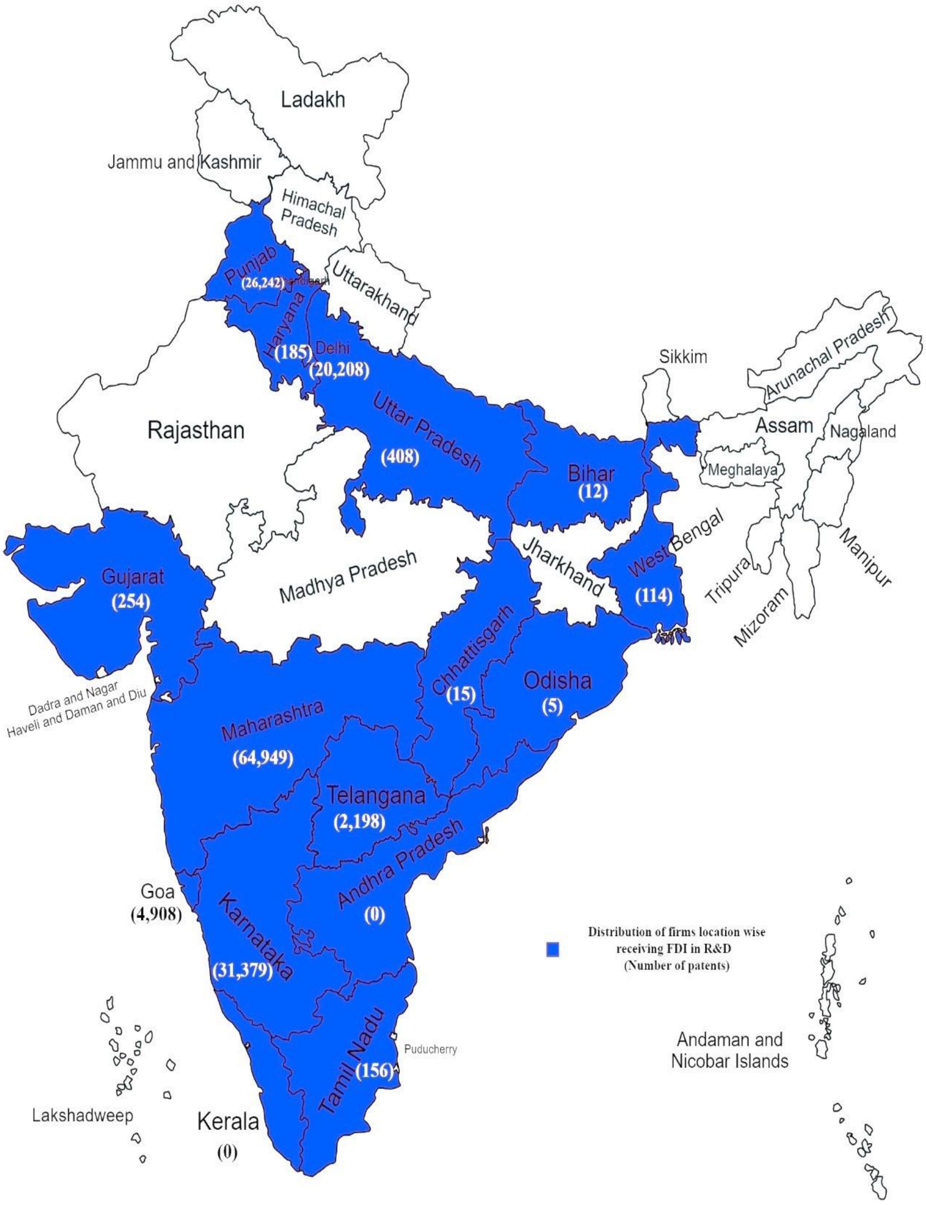

Figure 4 Location-wise FDI R&D firms with Number of Patents

5.2.4 Patenting information of FDI-R&D firms

Figure 5 shows that out of 298 firms, 161 firms are involved in filing patents, which is 55 percent of the total firms included in the sample. In

Figure 6 highlights that out of the total 161 firms involved in patenting activity, 77 firms are patenting only at IPO, 39 firms are patenting at IPO as well as other foreign patent offices. While 53 firms are patenting at USPTO or foreign patent offices.

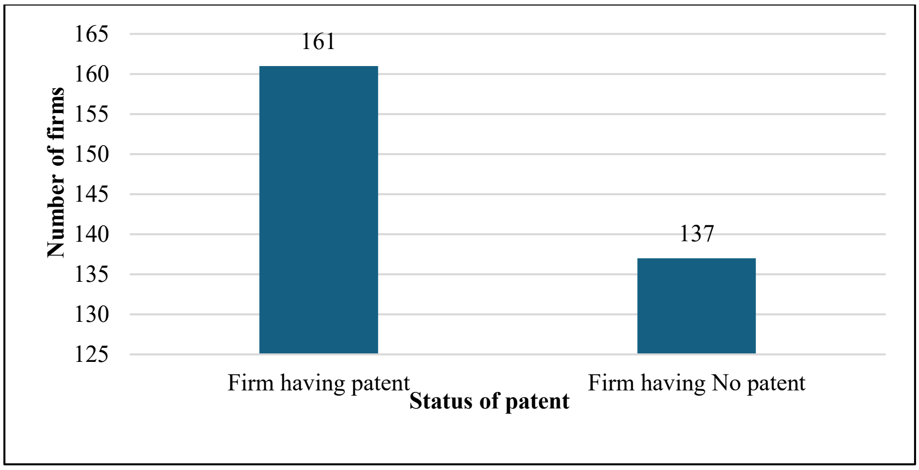

Figure 5 Patents filled by FDI-R&D firms.

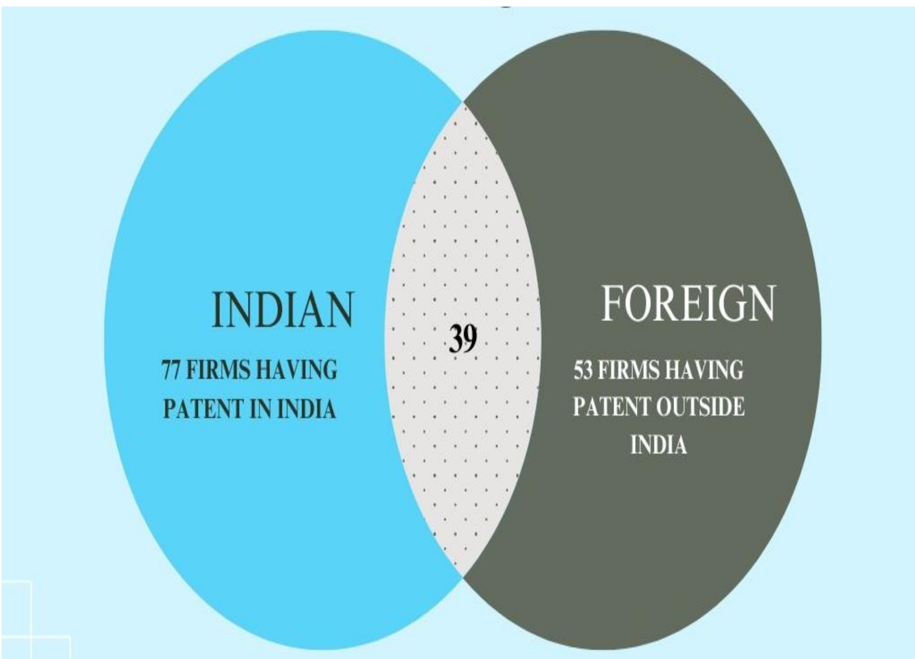

Figure 6 Patent registered by FDI-R&D firm at IPO or other patent offices

Our analysis is based on the total number of patent applications filed by 298 firms. We found information for about 148,613 patents. Data consists of patent applications filed by the parent firm including the name of the Indian FDI-R&D firm and subsidiaries in India.

5.2.5 Destination of patents filed

Figure 7 shows the region-wide distribution of the patenting firms. Most firms file patents at USPTO

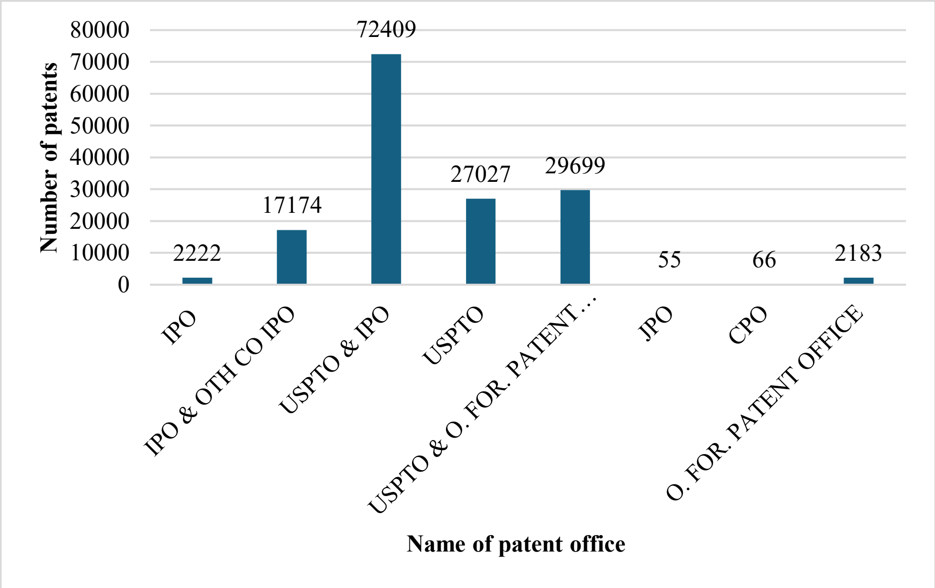

Figure 7 Region wise Distribution of the patents of FDI R&D firms

followed by IPO. It also shows that the number of patents filed at the China Patent Office (CPO) and Japan Patent Office (JPO) is low. In terms of choosing a patent filing method, the parent companies rather than the subsidiary companies decide on most applications that deal with international filing. Also, the subsidiary businesses are not free to choose where to file a patent (DST report, 2022). The FDI-R&D firms indicate that these firms are actively attracting R&D investment in natural sciences and engineering, pharmaceuticals, and clinical sectors which are STE (i.e., Science Technology, and Engineering) fields. According to patenting information, many firms are generating innovation output and filing patents, which are filed at USPTO.

5.2.6 Relation between firm age and patent filling by FDI-R&D firm

The age of a firm can be a significant factor influencing its R&D activities. This is particularly relevant when examining FDI-R&D within a host country. This is evidenced by data on a sample of 298 FDI-R&D firms registered in India (Figure 8). A clear majority (200 out of 298) fall within the 10–20 year age bracket. Furthermore, patent filing activity reveals a distinct trend within this age group. Among these 200 firms, 97 actively file patents, while the remaining 103 do not. In contrast, the data for firms aged 20-30 years shows a smaller sample size (31 firms), with a more balanced distribution of patent filing activity (24 filing patents and 7 not filing). These observations suggest a potential link between the age of an FDI-R&D firm and its innovation output, as measured by patent filing activity.

This analysis paves the way for further investigation into the relationship between firm age and innovation within the context of FDI-R&D firms. Several potential explanations for the observed trend warrant exploration. Younger firms (10-20 years old) may be more driven by innovation due to their focus on establishing a market presence and competitive advantage. They might exhibit greater agility and willingness to experiment with new technologies and ideas. In contrast, older firms (20-30 years old) may have established routines and procedures that, while fostering efficiency, can also lead to a certain degree of inertia, hindering their ability to adapt and innovate at the same pace. Additionally, the resource allocation strategies of younger versus older firms could differ. Younger firms might dedicate a larger portion of their resources to R&D activities, whereas older firms might prioritize other areas like production optimization or market expansion.

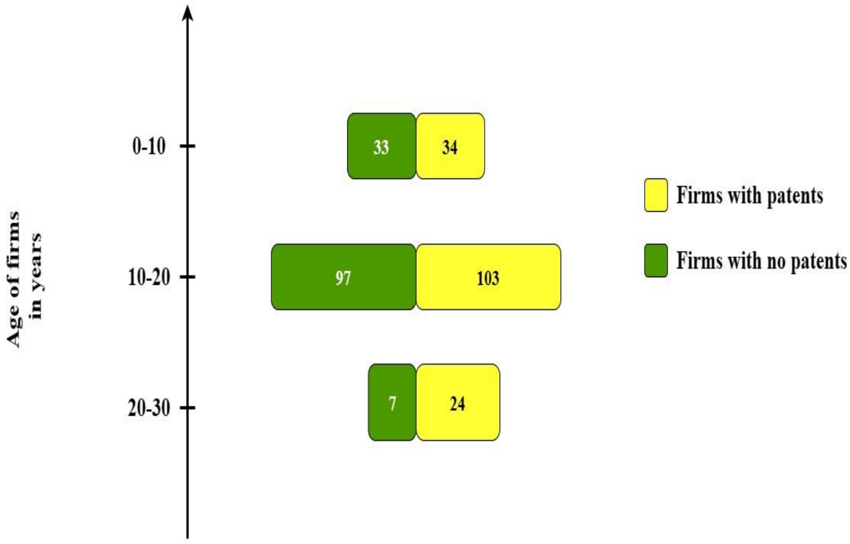

Figure 8 Firm age and patent filling by FDI R&D firms

Furthermore, Table 3 and Table 4 present the mean, standard deviation, and Pearson for all variables for FDI-R&D This shows that the mean age of firms is 12. The average number of patents granted to FDI-R&D firms is 65. Further, to know the aspects of multicollinearity, we perform a correlation test, and the results are given in Table 4. The correlation matrix rules out the possibility of multicollinearity because none of the variables are highly correlated except PATENT and FDI-R&D.

Table 3 Summary statistics of FDI-R&D firms

VARIABLE	Obs	Mean	Std. dev.	Min	Max
Ln(SALES)	649	1.74	1.54	0	4.88
Ln(R&D EXP)	649	0.30	0.79	0	3.28
Ln(GFA)	649	2.33	1.04	0	5.07
Ln(PATENT+1)	649	0.73	0.83	0	3.25
Ln(EXPORTS)	649	2.46	3.154	0	11.01
AGE	649	11.07	5.08	1	27
Proportion of USPTO	649	0.39	0.42	0	1

Note: Sales, R&D expenditure, GFA, and Exports are in million rupees.

Table 4 Correlation among the variables of the study

Variables	**FDI-R&D**	**Patents**	**Sales**	**R&D exp**	**Exports**	**GFA**	**Location**
FDI-R&D	1						
Patents	0.331	1					
Sales	0.032	0.047	1				
R&D exp	0.156	0.071	0.236	1			
Exports	0.009	0.057	0.263	0.226	1		
GFA	0.151	0.131	0.155	0.300	0.182	1	
Location	0.059	-0.302	0.113	0.092	0.041	-0.152	1

Key observations from descriptive statistics:

- The majority of FDI-R&D inflows are concentrated in natural sciences & engineering, pharmaceuticals, and clinical research, highlighting India's focus on Science, Technology, and Engineering (STE) fields.
- Over half (55%) of the firms engage in patenting, with a significant number filing at the United States Patent and Trademark Office (USPTO).

- States with high innovation scores (Karnataka, Maharashtra, etc.) also house the most FDI-R&D firms, suggesting a two-way relationship between a state's innovation environment and its attractiveness for FDI-R&D.
- Younger FDI-R&D firms (10-20 years old) exhibit higher patent filing activity compared to older firms (20-30 years old), suggesting a potential link between firm age and innovation output.

5.3 Empirical results

Having established a comprehensive understanding of our data through descriptive analysis. We now proceed to investigate the causal relationship between FDI-R&D and the innovation output of the firm. To resolve the econometrics issues in the empirical analysis as discussed in chapter 4 section 4.3. First, we will employ the PSM model to identify a suitable control group. This technique will allow us to match firms with similar characteristics. Following the identification of the control group, we will utilize DID regression to estimate the ATE of FDI-R&D on innovation output. To further refine the analysis, we categorize the data based on the timing of FDI-R&D receipt. Firms receiving FDI-R&D between 2010-2020 are classified as interval-treated firms, while those with FDI-R&D established before 2010 and continuing throughout 2010-2020 are always treated firms. This distinction enables us to explore potential variations in the effect of FDI-R&D based on its duration.

5.3.1 Empirical results of FDI-R&D equation for PSM

To resolve the econometrics issues of selection bias in the empirical analysis as discussed in Chapter 4 section 4.3. We find the control group (i.e., non-FDI-R&D firm) via logistic regression model by following equation 2 with independent variables; age, gross fixed assets (GFA), and industry (i.e. NIC 2008 at 5 digits) and dependent variable FDI-R&D. The results are given in Table 4 where it is evident that both age and GFA are statistically significant predictors of FDI-R&D. For every one-unit increase in age, the log-odds of FDI- R&D decrease by a factor of 0.81, holding GFA constant. Hence, it depicts that younger firms are more likely to attract FDI-R&D with a large propensity as compared to older firms. Similarly, for a one unit increase in GFA the odds of FDI-R&D increase by a factor of 1.285. In other words, for every unit increase in GFA the log-odds of FDI-R&D increase by 0.285, holding age constant. The model also suggests that the intercept term is statistically significant, meaning that there is a significant difference in the log of odds of FDI-R&D even when both age and GFA are equal to zero. Overall, the model suggests that age and GFA have a significant impact on the probability of FDI-R&D.

After the matching based on kernel matching methods, the propensity score of the treatment and control group shares the common support (Figure 9). It ranges from 0 to 0.6 propensity score, which means that the range of scores for which it is possible to find a match between a treatment and a control firm. The overlap shows that a match is possible for the firm. We also include other matching methods as robustness checks, namely 1-3 nearest neighbour matching (NNM 1-3), 1-5 nearest neighbour matching (NNM 1-5), and kernel matching. Since the standard error in the kernel matching procedure is the lowest, we selected the kernel matching procedure. The selected matching procedure finds the participants and non-participants with equal or similar propensity scores or probability of participating. However, there should not be any systematic differences between the participants and the non-participants in terms of unobserved characteristics that may influence the participation in the FDI-R&D. The matching is feasible only when the observations in both groups with similar propensity scores and the propensity scores are based on similarly observed covariates. The use of common support ensures the comparability of the two groups. First, we estimate the propensity score, defined as the conditional probability of receiving a treatment given the pre-treatment firm's characteristics as follows: if there is no overlap in the propensity score distribution, then it would not be possible to find a match and the analysis would not be valid. After this process of selection of the control group, the data set comprised 126 firms (59 FDI-R&D firms and 65 non-FDI-R&D firms). On this basis, ATE via DID has been done. Figure 10 shows the parallel trend among the treated and control groups.

Table 5 Logistic regression results (Dependent variable FDI-R&D=1 or 0)

VARIABLES	Model 1
Ln(GFA)	0.285***
	(0.0154)
Age	-0.0945***
	(0.00488)
Constant	-4.235***
	(0.102)
Observations	64,021

*Notes: Robust standard errors are shown in parentheses. Here, ***, **, and * denotes that the coefficients are statistically significant at 1%,5%, and 10% respectively. (Log-likelihood ratio:0.0365)*

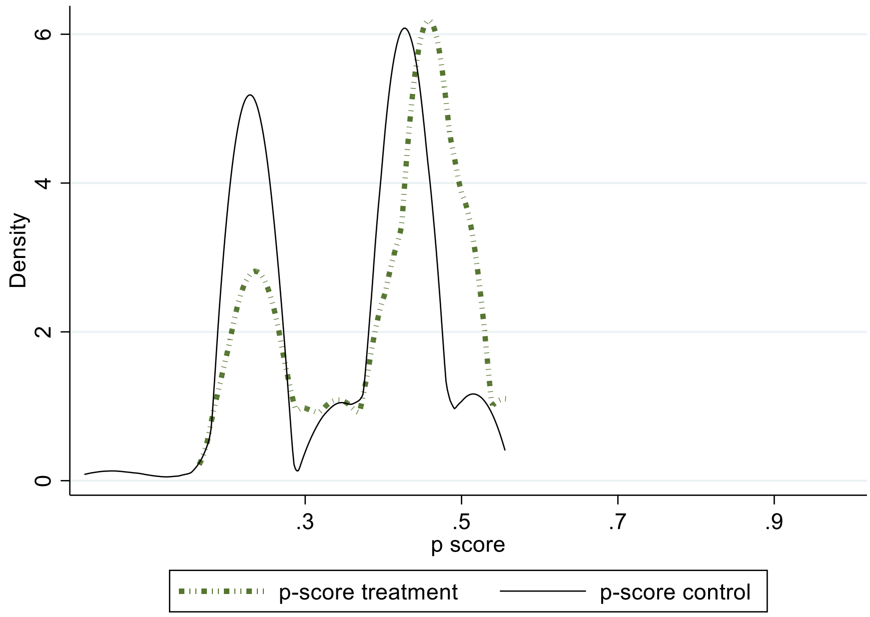

Figure 9 Estimated propensity score- Kernal distribution demonstrating common support after matching-2010-20.

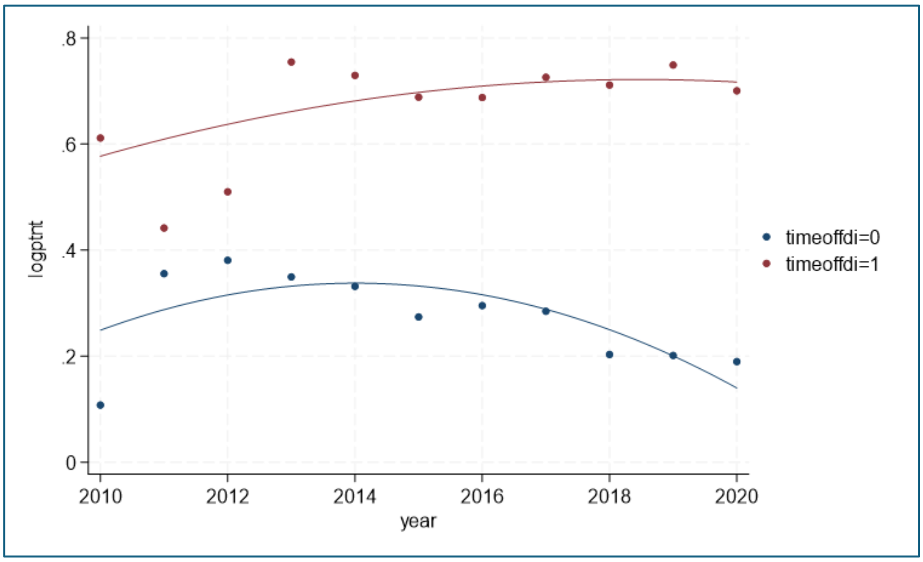

Figure 10 Staggered DID parallel trend assumption

5.3.2 Empirical results of innovation output equation for DID regression

Main results: DID regression analysis via equation (3) the results (see Table 6 **Error! Not a valid bookmark self-reference.**) are that the FDI-R&D firms have significant differences in their innovation output from non-FDI-R&D firms. In column I, the ATE of FDI-R&D on innovation output shows a 9.09% increase in patents without any firm-level control variable. In column II, ATE of FDI-R&D on innovation output is reduced but positive at 9.06% after including sales as a control variable, also sales have a positive impact on innovation output. In column III the effect was again positive and significant at a 5% level on innovation output with a 9.09% increase in patents with firms having FDI-R&D after controlling sales as well as R&D expenditure. Also, R&D expenditure has a positive impact on innovation output at a 10% significance level. In column IV the results, after considering all the firm-level characteristics, show that the presence of FDI-R&D has a positive impact on the innovation output of the firm. It also says that 9.10 % more patents are filed by FDI-R&D firms than by non-FDI-R&D firms. In other words, FDI-R&D firms are likely to have a more innovative output than non-FDI-R&D.

Table 6 DID regression results (dependent variable ln(patents+1))

VARIABLES	I	II	III	IV
FDI-R&D	0.0909**	0.0906**	0.0909**	0.0910**
	(0.0373)	(0.0397)	(0.0384)	(0.0388)
CONTROLS				
Ln(Sales)		0.000246	-0.00343	-0.00160
		(0.0123)	(0.0121)	(0.0108)
Ln(R&D exp)			0.0309*	0.0310*
			(0.0159)	(0.0165)
Ln(Total exports)				-0.00174
				(0.00856)
Constant	0.4006***	0.396***	0.393***	0.393***
	(0.0125)	(0.0219)	(0.0210)	(0.0219)
Firm fixed effects		YES	YES	YES
Industry effects		YES	YES	YES
Observations		1,311	1,311	1,311

*Notes: Robust standard errors are shown in parentheses. Here, ***, **, and * denotes that coefficients are statistically significant at 1%,5%, and 10% respectively. Standard errors adjusted for 21 clusters at the industry level at 4 Digit NIC 2008.*

Results of FDI-R&D on Innovation Output for interval treated vs never treated.

This analysis is based on FDI-R&D firms that received treatment (i.e. FDI-R&D) in between the period of the above analysis (2010-2020) which means that the firms received the treatment between the period of 2010-2020. These firms are compared to never treated group or control group same as above analysis. We found that (see Table 7) have significant differences in their innovation output from non-FDI-R&D firms.

Column I, the ATE of FDI-R&D on innovation output shows a 07.2% increase in patents without any firm-level control variable. In column II, the ATE of FDI-R&D on innovation output is positive at 07.2% after including sales as a control variable, also sales have a negative and insignificant impact on innovation output. In column III, the effect was reduced but remain positive and significant at a 10% level on innovation output. The coefficient of FDI-R&D (07.1%) shows an increase in patents with firms having FDI-R&D after controlling sales as well as R&D expenditure. Also, R&D expenditure has a positive impact on innovation output at a 10% significance level. In column IV the results, after considering all the firm-level characteristics, show that the presence of FDI-R&D has a positive impact on the innovation output of the firm. It also says that 07.1 % more patents are filed by FDI-R&D firms than by non-FDI-R&D firms. In other words, After receiving FDI-R&D, firms have more innovation output than non-FDI-R&D.

Table 7 DID regression results with interval treated vs never treated group (dependent variable ln(patents+1))

VARIABLES	I	II	III	IV
FDI-R&D	0.072*	0.072*	0.071*	0.071*
	(0.0389)	(0.0367)	(0.0367)	(0.0368)
CONTROLS				
Ln(Sales)		-0.00637	-0.0125	-0.0162
		(0.0138)	(0.0133)	(0.0118)
Ln(R&D exp)			0.0612*	0.0611*
			(0.0418)	(0.0415)
Ln(Total exports)				0.00346
				(0.00527)
Constant	0.397***	0.1676 ***	0.388***	0.387***
	(0.0272)	(0. 0186)	(0.0301)	(0.0298)
Firm fixed effects		YES	YES	YES
Industry effects		YES	YES	YES
Observations	979	979	979	979

*Notes: Robust standard errors are shown in parentheses. Here, ***, **, and * denotes that coefficients are statistically significant at 1%,5%, and 10% respectively. Standard errors adjusted for 21 clusters at the industry level at 4 Digit NIC 2008*

Results of FDI-R&D on Innovation Output for always treated vs never treated firms.

After the analysis of some-time treated vs never treated firms, we proceed for the analysis based on FDI-R&D firms that always received treatment (i.e. FDI-R&D) in the period 2010-2020. It means that the firm always received the treatment from 2010-2020. These firms are compared to never treated group or control group same as above analysis. We employed fixed effect DID for this group. We found that (see Table 8) have significant differences in their innovation output from non-FDI-R&D firms.

Column I, the ATE of FDI-R&D on innovation output shows a 10.7% increase in patents without any firm-level control variable. In column II, the ATE of FDI-R&D on innovation output is positive at 10.7% after including sales as a control variable, also sales have a positive impact on innovation output. In column III the effect was again positive and significant at a 1% level on innovation output with a 10.7% increase in patents with firms having FDI-R&D after controlling sales as well as R&D expenditure. Also, R&D expenditure has a positive impact on innovation output at a 5% significance level. In column IV the results, after considering all the firm-level characteristics, show that the presence of FDI-R&D has a positive impact on the innovation output of the firm. It also says that 10.7 % more patents are filed by FDI-R&D firms than by non-FDI-R&D firms. In other words, firms that consistently received FDI-R&D from 2010 to 2020 have a significantly higher level of innovation output compared to firms that never received FDI-R&D. This is evidenced by a 10.7% increase in patents filed by FDI-R&D firms even after controlling for factors like sales, exports and R&D expenditure.

Table 8 DID regression results with always treated vs never treated group (dependent variable ln(patents+1))

VARIABLES	I	II	III	IV
FDI-R&D	0.107***	0.107***	0.107***	0.107***
	(0.0251)	(0.0251)	(0.0251)	(0.0251)
CONTROLS				
Ln (Sales)		-0.0064	-.0082	-0.0005
		(0.0138)	(0.0168)	(0.0152)
Ln(R&D exp)			0.0134**	0.0134**
			(0.0013)	(0.0015)
Ln(Total exports)				0.0067
				(0.0071)
Constant	0.530***	0.533***	0.539***	0.534***
	(0.0272)	(0. 0186)	(0.0301)	(0.0298)
Firm fixed effects		YES	YES	YES
Industry effects		YES	YES	YES
Observations	847	847	847	847

*Notes: Robust standard errors are shown in parentheses. Here, ***, **, and * denotes that coefficients are statistically significant at 1%,5%, and 10% respectively.*

Discussion on Impact of firm level characteristics on innovation output.

From the results of table 6, 7 and 8, the results of firm-level characteristics remain consistent, R&D expenditure of the firm has a positive and significant impact on innovation output that is consistent with the findings of Ambrammal and Sharma (2014), Chadha (2009), and Kanwar and Singh (2018). R&D expenditure plays a significant role in improving innovation in a firm. At its core, R&D expenditure allows companies to build the essential resources for innovation (Fritsch and Franke, 2004; Del Canto and Gonzalez, 1999; Berchicci, 2013). It funds the hiring and training of talented researchers, engineers, and scientists (Heitor et al., 2014; Karhan, 2017).

Our results show that firm size has a negative and insignificant impact on innovation output. In line with the theory of Schumpeter (1950), large firms have the wherewithal (large scale of production and capacity, infrastructure in marketing, finance, and R&D) to exploit new technology. Whereas literature has shown that large firms showed a significant positive relationship with the innovation output of the firm (Arvanitis, 1997; Gopalakrishnan and Bierly, 2006; Miles and Darroch, 2006; Grando and Belvedere, 2006). Additionally, existing infrastructure, including manufacturing capabilities and distribution channels, can be readily leveraged to bring innovations to the market faster (Acs and Audretsch, 1991). However, Kijkasiwat and Phuensane (2020) found the negative effect of firm size on the relationship between innovation and firm performance. Plehn-Dujowich (2009) also emphasized that small firms are more innovative than large firms as they obtain more patent counts. The results are mixed in the literature. The negative and insignificant relationship between firm size and innovation output could be due to the challenge of measuring innovation output. Moving forward, a more nuanced understanding considers factors accurately assessing the impact of firm size on innovation output.

Characteristics such as exports have a negative and insignificant impact on innovation output. Our results do not evidence a relationship between the two. In line with Sharma and Ambrammal (2015) found a negative relationship between export and patenting in India. Murthy and Alam (2014) state that there is no direct relationship between exports and patenting. However, Kumar and Siddarthan (1994) and Shepherd (2017) found that exporters are more likely to introduce a new product than non-exporting firms. This relationship has been explored with innovation at country-level analysis that reveals a positive relationship between the two. Infirm-level studies, Aghion (2018) states that exports have a positive impact on the innovation of French firms. There are some reasons behind this relationship highlighted by Seenaiah and Rath (2018). Firstly, firms that have skilled labor as well as superior technologies that allow them to produce greater production. Increased productivity constantly drives them to pursue greater levels of innovation. Second, increasing export intensity boosts these enterprises' competitiveness, causing them to behave differently than competitors. More competitive firms are likely to innovate. Therefore, there are mixed results for the Indian case itself. Moreover, Filippettiet al. (2011) stated "If a country is highly exporting it is likely to have a high innovation performance. Conversely, firms and countries that are innovative are more likely to be able to penetrate international markets and/or take up investment opportunities in foreign locations". This means that the relationship between innovation output and export behavior might be affected by the possibility of a two-way causation between innovation and exports, since a firm with high innovation output may tend to export more.

Impact of FDI-R&D on Quality Improvement in Innovation Output.

The results thus far suggest that FDI-R&D acts as a stronger driver of innovation output. Building on these findings, we now explore the impact of FDI-R&D on the quality of innovation output. Quality is measured as the proportion of patents filed at the USPTO relative to the total number of patents filed in a given year. As shown in Table 9, Column I present the ATE of FDI-R&D on the proportion of USPTO patents. It indicates a 15.04% increase in USPTO patents without controlling for any other variables. In Column II, the ATE on innovation output is reduced but remains positive at 12.27% after including sales as a control variable. This suggests that sales also have a positive impact on patent quality. Column III shows a continued positive and statistically significant effect (at the 5% level) on innovation output. Firms with FDI-R&D experience a 12.27% increase in USPTO patents even after controlling for both sales and R&D expenditures. Finally, Column IV incorporates all firm-level characteristics, and the results confirm that FDI-R&D has a positive impact on a firm's innovation output. This translates to an estimated 12.27% increase in USPTO patents filed by FDI-R&D firms compared to non-FDI-R&D firms. In simpler terms, firms engaged in FDI-R&D are likely to exhibit a higher quality of innovation output compared to those without.

Table 9 DID regression results (dependent variable USPTO patent / total Patent filed)

VARIABLES	I	II	III	IV
FDI-R&D	0.1504***	0.1227**	0.1227**	0.1224**
	(0.04526)	(0.0442)	(0.0441)	(0.4334)
CONTROLS				
Ln(Sales)		0.0171**	0.01679**	0.0104
		(0.0063)	(0.0065)	(0. 0074)
Ln(R&D exp)			0.0028	0.0266*
			(0.0098)	(0.0092)
Ln(Total exports)				0.0060*
				(0. 0030)
Constant	0. 1904***	0.1676 ***	0. 1672***	0. 1650***
	(0. 0150)	(0. 0186)	(0.0183)	(0.0219)
Firm fixed effects		YES	YES	YES
Industry effects		YES	YES	YES
Observations		1,311	1,311	1,311

*Notes: Robust standard errors are shown in parentheses. Here, ***, **, and * denotes that coefficients are statistically significant at*

1%,5%, and 10% respectively. Standard errors adjusted for 21 clusters at the industry level at 4 Digit NIC 2008.

The key findings provide evidence that FDI-R&D activities significantly boost a firm's innovation output. Even after controlling all factors that impact innovation output, the resulting impact of FDI-R&D remains positive and significant. FDI-R&D not only improves the innovation output of the firm, but it also enhances the quality of innovation output done by the firm. The firms that received FDI-R&D before the year 2010 (that are always treated group in our analysis) found that they have the highest (10.7% more than non-FDI-R&D firms) impact on the innovation output of the firm. If the firm received FDI-R&D after 2011 they have 7.1% more innovation output than non-FDI-R&D firms. It suggests that FDI-R&D has a long-term impact on the innovation output of firms. The positive influence of internal R&D expenditure is also reaffirmed. The findings regarding firm size and exports highlight the need for further research to develop more nuanced measures for capturing the impact of these factors on innovation.

6 Conclusion

6.1 Introduction

This thesis evaluates FDI-R&D and its impact of FDI-R&D on the innovation activity of the firms in India. Using the firm-level data from 2010 to 2020, we evaluate the changes in the innovation output of the FDI-R&D firms. We use the Propensity Score Matching (PSM) and Difference-in-Differences (DID) framework to account for the issues of selection bias and endogeneity. The thesis considers innovation output measured through patents proxied by the IPO and USPTO patent applications. It provides new insights into the relationship between FDI-R&D and innovation in the context of emerging economies like India. The thesis includes a general introduction, followed by a brief outline of the FDI-R&D mechanism in India, a literature review, methodology, two core chapters of empirical findings, and a conclusion chapter. This chapter summarizes the thesis, and its major findings, provides policy recommendations, and discusses the contributions and limitations of the study undertaken.

The rest of the chapter is organized as follows: Section 6.2 presents a summary of the thesis. Section 6.3 gives an overview of the key findings and offers policy implications, and Section 6.4 presents the key limitations and direction for future research.

6.2 Summary

This section summarizes the major findings, provides some policy recommendations, and gives a short outlook for further research. In the engine of economic progress, innovation stands as the fuel. For nations seeking to climb the economic ladder, robust R&D capabilities are paramount. However, nurturing such a complex ecosystem requires substantial financial backing. This is where FDI steps in, offering a crucial financial injection. Take India for instance, the Indian government actively promotes FDI-R&D to bridge the gap between domestic resources and its ambitious growth targets for 2047.

The benefits of FDI-R&D extend far beyond mere financial aid. MNCs establishing R&D centers bring with them a treasure trove of cutting-edge technologies and expertise. This knowledge, through a process called "technology spillover," studied extensively in the literature, permeates the local workforce and institutions, fostering a culture of domestic innovation. Moreover, FDI creates fertile ground for developing a highly skilled workforce. Jobs in research, engineering, and other technical fields associated with these projects not only benefit the immediate project but also equip the local talent pool with invaluable expertise. This skilled workforce then becomes a catalyst for further innovation, creating a virtuous cycle of progress.

However, nurturing this beneficial environment requires a strategic approach by host countries. Defining FDI-R&D and the method of identifying and reporting FDI-R&D need special attention. Further, a robust analysis of whether the presence of FDI-R&D activities fosters innovation in host countries' firms is required. Additionally, fostering the determinants of innovation output of such firms. By understanding the mechanisms, host countries can ensure that the benefits of FDI in R&D reach far and wider, enriching the domestic innovation landscape. FDI-R&D presents a powerful opportunity for host countries to cultivate a thriving innovation ecosystem. FDI acts as a potent accelerant for economic growth. This justifies the need for this thesis. The thesis contributes to the existing sector-wise FDI literature on the following: 1) The thesis examines various literature on the definitional framework of defining FDI-R&D and gives insight into the selection and identification of FDI-R&D firms. 2) The analysis of firm characteristics threw light on the determinant of FDI-R&D and innovation output of host countries' firms. 3) It provides empirical analyses for analyzing the impact of FDI-R&D on the innovation output of a firm after controlling firm-level variables. 4) Lastly explore the role of FDI-R&D in improving the quality of innovation output, so that they file their patent at USPTO.

The empirical challenge is to reliably measure the causal effect of the FDI-R&D on firm innovation activity. We analyze the relationship through panel data analysis. One key concern in this respect is potential endogeneity and self-selection. Because of the information on the FDI-R&D firm was given PSA Report 2020. The selection of the firm has been done based on some identification criteria which might be endogenous to its innovation performance.

To address the selection bias and endogeneity concern, we adopt a PSM and DID setting and evaluate how the innovation output of FDI-R&D firms varies from non-FDI-R&D firms. In the PSM framework, we used a non-parametric matching approach to control the possible selection bias and compared the innovation activities of the FDI-R&D firms to a matched control group of the non-FDI-R&D firms. The PSM is based on the conditional assumption that there is no unobserved difference between the treated firms and the control firms of non-FDI-R&D firms that are associated with the outcome of interest. In the DID setting, we study the timing of FDI-R&D inflow and evaluate how the changes in firm innovation output occurred due to FDI-R&D.

In PSM framework, we construct a counterfactual using observational data. The PSM uses the unit's observed characteristics to calculate the propensity score, which is the predicted probability of a unit receiving treatment, and then matches each unit in the treatment group with one or more control units on the propensity score. To calculate the propensity score, we have identified the factors that contribute significantly to determining the firm's participation in the FDI-R&D. The selection of these covariates is made based on the existing empirical studies in India. Building on the literature, we use a number of firm characteristics such as, age of the firm, firm size and industry to which the firm belongs. The PSM balances the pre-treatment covariates between the treated and control units and in doing so, reduces the bias in the estimation of treatment effects. We use nearest neighbor matching, where the individual firm from the comparison group is chosen as a matching partner for a treated individual firm that is closest in terms of propensity score obtained 64 firms as control group from the covariates. We also use other matching methods such as 1-1 Nearest Neighbor Matching (1-1 NNM), 1-3 Nearest neighbor matching (1-3 NNM), 1-5 Nearest neighbor matching (1-5 NNM), and Kernel matching as robustness checks.

In a DID setting, we examine how innovation output changed after the firm got FDI-R&D. The DID framework estimates the average effect of the FDI-R&D on innovation outcomes of the firm while assuming that, in the absence of FDI-R&D, the changes in innovation outcome between the FDI-R&D and the non-FDI-R&D would remain the same. We examine the timing of FDI-R&D, exploiting the fact that firms vary by year of getting FDI-R&D. We found that the firms receiving FDI-R&D after 2010 are having a lower impact. Also, we control for the firm and industry fixed effect to deal with the endogeneity and self-selection issues. The industry variations are estimated with the sector dummy variables. Building on the literature, we control firm and industry characteristics in the estimation.

6.3 Overview of findings and their policy implications

6.3.1 Findings

Our results are in conformity with previous studies on FDI-R&D at the country level. This aligns with the concept of knowledge spillovers, where the presence of foreign R&D activities fosters a transfer of knowledge and expertise to host countries' firms. The multifaceted relationship between FDI-R&D and innovation output. While knowledge spillovers undoubtedly play a role, our research highlights the additional influence of firm-level characteristics on innovation output. Even after controlling for the characteristics, the positive impact of FDI-R&D persists. This suggests that certain firm-specific qualities can further amplify the innovation output of firms. One such key characteristic is a firm's R&D expenditure. Our analysis reveals that firms with higher internal R&D investments tend to experience a greater positive impact from FDI-R&D on their innovation output. This indicates a synergistic effect. Firms with a robust internal R&D foundation are better positioned to absorb, integrate, and leverage the knowledge and technology transferred through FDI-R&D collaborations. The key observations from descriptive statistics explained some more firm characteristics. It shows that the majority of FDI-R&D firms are located in states that have high innovation indexes. Also, the same has the highest number of patents filed. The relationship between AGE and patenting shows that younger firms (10-20 years old) may be more driven by innovation due to their focus on establishing a market presence and competitive advantage. They might exhibit greater agility and willingness to experiment with new technologies and ideas. In contrast, older firms (20-30 years old) may have established routines and procedures that, while fostering efficiency, can also lead to a certain degree of inertia, hindering their ability to adapt and innovate at the same pace.

The results confirm that the timing of FDI-R&D plays a vital role in the firm innovation output. We classified two categories of treated firms. Firstly, those FDI-R&D firms that received FDI-R&D before 2010 are always treated firms. The interval-treated firm that received FDI-R&D between the period of 2010-2020. They have a positive impact of FDI-R&D on the innovation output of the firm but the impact is lower than the always-treated firm. This means that FDI-R&D has a long-term impact on the innovation output. These results also indicated similar results as main DID results suggested that firms with higher R&D expenditure are better able to benefit from the FDI-R&D than ones with lower R&D expenditure. A firm's internal R&D investment acts as a catalyst, allowing it to fully exploit the opportunities presented by FDI-R&D collaborations.

Results on the quality of innovation output show that FDI-R&D firms are more capable of patenting their innovation output at USPTO than non-FDI-R&D firms. If initially, the firm registered their patents at other than USPTO and after receiving FDI-R&D they started filing patents at USPTO shows a potential improvement in the innovation output of the firm. FDI-R&D may provide access to superior resources and expertise, enabling the firm to develop innovations that meet the USPTO's stringent patentability criteria. Secondly, the global recognition and legal protection offered by USPTO patents could be particularly attractive for firms seeking to expand their market reach.

6.3.2 Policy Recommendation

From a policymaker's point of view: First, FDI policy has to provide a clear framework that defines FDI-R&D activities. This will guide us in effectively selecting and identifying companies engaged in R&D that are receiving foreign investment. Second, Based on the established definition, we must gather data on the equity share component of FDI inflows specifically directed towards R&D activities. This data will be essential for tracking trends and making informed policy decisions regarding FDI-R&D.

This is the first study on the impact of FDI-R&D in the host countries. The results have shown positive results as well. Policymakers should encourage knowledge spillovers from FDI-

R&D firms to local firms and institutions. This can be achieved by promoting collaboration between foreign and domestic firms, as well as by investing in education and training programs that will help local workers to absorb new technologies and knowledge. It is found that FDI-R&D is having a positive impact on improving the quality innovation. Firms should be encouraged through incentives to have FDI in R&D activities. Governments should invest in developing a highly skilled workforce to support the growth of the innovation ecosystem. This includes investments in STEM education, as well as programs that provide workers with the skills they need to collaborate with foreign firms and participate in global innovation networks.

6.4 Limitations of the study

The thesis has some limitations that are mainly driven by data constraints. Indeed, while the dataset is representative of the total population, it does not contain information on all firms available in the PSA report 2020. As a second limitation, the present analysis does not consider the country of origin of the foreign investors. While we are aware that such characteristics do influence the output, the dataset did not allow us to control the country of origin of the foreign investors. Moreover, no distinction could be made between the entry mode chosen by the foreign investors (either merger and acquisition or Greenfield investment). Once again, this is due to data constraints. This thesis also does not consider other innovations such as process innovation as the focus was on innovations that can be patented. Yet, another limitation of the thesis relates to the use of patent grants as a proxy for innovation. However, such measures have some weaknesses. Employing patents as a proxy to capture and innovation in this research carries the potential risk of misrepresenting innovation activity. However, even though all these limitations may have the consequence of misrepresenting innovation activity, a large body of research has used patents as a proxy for firm innovation. Nevertheless, we believe that the present work aids a comprehensive first study on FDI-R&D and innovation output in the host country as well as the Indian context.

The study though has come up with an important policy implication and opens some avenues for future research. The present study needs to be extended to explore the impact of different FDI entry modes in the R&D sector.

7 References and Appendix

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