Firm-Level Trade Responses to Intellectual Property Reforms: A Quasi-Natural Experiment

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Firm-Level Trade Responses to Intellectual Property Reforms: A Quasi-Natural Experiment

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Abstract

This study leverages India's Patent (Amendment) Act, 2002, as a quasi-natural experiment within a difference-in-difference (DiD) setting to provide the firm-level evidence on the causal mechanism through which enhanced patent protection affect firms' export behaviour and integration to global value chains (GVCs). Exploiting detailed firm-level data from the universe of Indian manufacturing firms, we classify firms as high-tech if their average technology adoption expenditure—proxied by spending on R&D and technology transfer—during the pre-reform period (1996–2001) exceeds the industry median, designating them as the treatment group. Firms below this threshold are classified as low-tech firms (the comparison group).

Empirical results reveal compelling evidence: post-reform, high-tech firms experienced a 17% increase in exports and an 18% rise in both of raw material and aggregate imports relative to comparison group. These findings highlight the critical role of technological intensity in shaping firms' response to IPR reforms, with significant implications for trade and integration into the GVCs. Moreover, the study identifies a negative relationship between tariffs and trade performance, suggesting that trade liberalization—through reduced tariff barriers—complements IPR reforms by facilitating access to advanced inputs and enhancing global supply chain integration. The study helps us to understand that robust IPR frameworks not only incentivise domestic innovation but also enable firms to access advanced global inputs, thereby augmenting their production capacities, and enhancing export competitiveness.

The findings carry significant policy implications, particularly for developing economies striving for industrial upgrading. An integrated policy framework that aligns IPR reforms with broader trade and industrial strategies is essential. Policymakers should consider reducing tariff barriers on technology-intensive inputs and implementing targeted incentives to boost R&D adoption among low-tech firms, alongside maintaining strong IP enforcement and regulatory stability. Collectively, these measures can bolster domestic innovation, enhance export competitiveness, and promote deeper integration into the global market.

JEL codes: *F00, F14, O30, O32, O34*

Keywords: *Exports, Imports, Intellectual property rights, R&D, Technology Adoption*

1. Introduction

For developing economies, the establishment of robust intellectual property rights (IPR) frameworks serves as a cornerstone for achieving multiple strategic objectives. These frameworks not only safeguard investments in research and development (R&D) but also attract foreign direct investment (FDI) and facilitate the integration of domestic firms into global value chains (GVCs). Recognizing the transformative potential of such policies, India has pursued a coordinated strategy to align IPR reforms, innovation incentives, and trade policies, fostering an ecosystem conducive to high-tech growth and enhanced export competitiveness.

India's commitment to fostering industrial R&D and innovation is evident in a series of government initiatives implemented over the years. Key among these is the R&D Tax Incentive under Section 35 of the Income Tax Act, 1961, which provides tax deductions for companies investing in R&D. Section 35(2AB), introduced in 1995, initially allowed a 200% deduction on in-house R&D expenditures, which was later revised to 150% in 2017 and further reduced to 100% in 2020[1]. Additionally, Sections 35(1)(ii) and 35(1)(iii) permit deductions for contributions to scientific research institutions and donations for social science research, significantly encouraging private sector participation in innovation. Programs such as the National Innovation Foundation (NIF), established in 2000, and the Innovation in Science Pursuit for Inspired Research (INSPIRE), launched in 2008, have played pivotal roles in promoting grassroots innovations and nurturing young scientific talent. More recently, the National Quantum Mission (2023), with a budget allocation of USD 0.72 billion[2], underscores India's ambition to emerge as a global leader in quantum technologies.

The Union Budget 2024-25 further reinforces this commitment, with substantial allocations for R&D. A notable initiative is the establishment of the Anusandhan National Research Foundation (ANRF), which has been allocated USD 6 billion for the period 2023-2028[3]. This funding aims to bolster India's R&D capabilities and bridge the gap between fundamental research and its commercial applications, thereby accelerating innovation-driven economic growth. Collectively, these initiatives reflect India's sustained efforts to build a robust, innovation-centric economy. Press Information Bureau, Government of India. (2023).

Complementing these measures are institutional reforms in IPRs, which gained momentum during India's economic liberalization in the early 1990s. Faced with a balance-of-payments crisis in 1991, India joined the World Trade Organization (WTO) and initiated the alignment of its domestic intellectual property laws with the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement. Although India was granted a ten-year transition period to comply with TRIPS standards, the reform process was marked by significant debate and political resistance[4], highlighting the challenges of reconciling global commitments with domestic priorities.

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[1] Ministry of Finance, Government of India, Income Tax Act, 1961: Section 35, accessed December, 2024, https://www.incometaxindia.gov.in

[2] Press Information Bureau, Government of India. (2023). Cabinet approves National Quantum Mission. Retrieved from https://pib.gov.in

[3] Government of India (GoI), Union Budget 2024-25: Innovation, Research & Development, July 24, 2024, accessed November, 2024, https://static.pib.gov.in/WriteReadData/specificdocs/documents/2024/jul/doc2024726354301.pdf

[4] A change in government in 1998 facilitated the first set of reforms. The Bhartiya Janata Party (BJP), previously opposed to patent law, came to power in March 1998. The new Prime Minister, who had led a parliamentary

A pivotal moment in this journey was the enactment of the Patents (Amendment) Act, 2002, which fundamentally overhauled India's patent system[5]. The Act introduced product patents across all technological fields, extended patent durations from 14 to 20 years, and streamlined the application process to ensure compliance with TRIPS requirements. It also broadened the definition of "invention" to encompass a wider range of innovations while limiting the government's ability to exploit patented inventions. These reforms resolved long-standing policy uncertainties, providing firms with the necessary incentives to invest in advanced technologies and capitalize on the strengthened intellectual property regime.

Building on this context, this paper examines the impact of India's IPR reforms on firm-level export behaviour, employing a Difference-in-Differences (DiD) analytical framework. Comparing pre- and post-reform performance of high-tech and low-tech firms, the study offers a nuanced understanding of how IPR reforms influence export dynamics. The approach allows for causal inference by controlling for potential confounding factors that might otherwise obscure the relationship between IPR reforms and firm performance.

This study makes several key contributions to the literature. First, it establishes a causal link between IPR reforms and firm-level export performance, providing granular insights into how patent reforms reshape export strategies—a dimension underexplored in existing studies that predominantly focus on macro-level outcomes. Second, the study addresses a critical gap by examining the relationship between IPR reforms and firm-level imports, shedding light on how such reforms influence sourcing strategies, production processes, and integration into global supply chains. We hypothesize differential effects across high-tech and low-tech firms, positing that high-tech firms, which rely on advanced machinery and R&D-intensive inputs, may experience a more pronounced increase in imports compared to their low-tech counterparts. Strengthened IP protection is expected to incentivize high-tech firms to invest in advanced production capabilities, thereby driving industrial upgrading and enhancing their participation in global trade networks. By focusing on firm-level dynamics, particularly in the context of India's rising share in global exports and imports since its WTO accession, the study offers a contemporary perspective on the impact of patent reforms in the post-TRIPS era, contrasting with earlier studies such as Branstetter et al. (2011), which examined the pre-TRIPS period.

A distinctive feature of our methodology lies in the identification of a quasi-natural experiment—the Patents (Amendment) Act of 2002—which offers a unique opportunity to evaluate the impact of stronger IPRs on trade. This legislative reform substantially increased firms' expected returns on R&D investments while mitigating uncertainties surrounding future profitability. Analysing the effects of this policy change, we demonstrate how stronger IPRs shape firms' market entry strategies, bolster their competitiveness in global markets, improve export performance, and facilitate deeper integration into international trade networks.

walkout over the 1995 Amendment, conducted a nuclear test shortly after assuming office, straining relations with the West and triggering sanctions. To avoid further foreign policy conflicts, the government, despite its prior stance, agreed to proceed with patent reforms. The opposition Congress party, having signed the TRIPS agreement in 1995, did not resist the reforms (Reddy and Chandrashekaran, 2017, p. 60).

[5] The enactment of the Patents (Amendment) Act, 2002, marks a seminal shift in India's intellectual property landscape, fundamentally realigning the nation's patent framework with global standards. Prior to the amendment, India's patent regime was largely characterized by a focus on process patents, which allowed domestic firms to modify production techniques without infringing on foreign patents. However, the 2002 Act introduced product patents across all technological fields, thereby extending patent protection beyond mere processes.

The major findings reveal that high-tech firms—those with greater pre-reform investments in R&D and technology transfer—benefited disproportionately from the IPR reforms. These firms exhibited significant improvements in export performance relative to their low-tech counterparts, emphasizing the role of prior technological capabilities in leveraging stronger IPRs. Furthermore, the reforms prompted an increase in the share of imported advanced components among high-tech firms, highlighting the complementary relationship between patent reforms and the adoption of advanced inputs. These results suggest that stronger IPRs not only stimulate domestic innovation but also enhance firms' competitiveness in global markets by encouraging the integration of advanced imports into their production processes. This dual effect underscores the complex interplay between domestic innovation policies and global trade dynamics, offering valuable insights for policymakers seeking to balance these objectives.

Our study establishes a clear causal link between IPR reforms, technological upgrading, and trade, contributing to the broader understanding of how policy changes can create an enabling environment for firms to thrive in competitive international markets. The findings emphasize the importance of complementing IPR reforms with sustained investments in R&D and technology to maximize their impact. As India continues its transition toward becoming an innovation-driven economy, these insights provide critical guidance for crafting policies that align national economic ambitions with global competitiveness standards.

The remainder of the paper is structured as follows: Section 2 reviews the existing literature on the relationship between IPR reforms and trade, highlighting the study's contributions to this body of work. Section 3 details the data sources, including firm-level export behaviour, the classification of firms by technological intensity, and key variables such as patent reforms, R&D investments, and trade activity. Section 4 outlines the methodology, focusing on the DiD approach and the quasi-natural experiment framework. Section 5 presents the empirical findings, examining the effects of patent reforms on export margins and firm-level imports. It situates these findings within the broader literature, exploring the mechanisms through which IPR reforms influence innovation and trade. Finally, Section 6 concludes with key takeaways and policy implications, emphasizing the role of stronger IPR frameworks in enhancing trade and backward participation with the global supply chains.

2. Patent Reforms and Trade: Existing Scholarship

Since the 1990s, many developing countries have undertaken significant reforms to their patent laws, driven by both domestic imperatives to protect innovation and external pressures from technologically advanced nations seeking stronger intellectual property (IP) protections for their exports (Maskus, 2012). A key catalyst for these reforms has been the TRIPS Agreement under the World Trade Organization (WTO), which established minimum patent standards and necessitated substantial changes in patent laws, particularly in developing countries. These changes have sparked extensive debates regarding their implications for access to affordable medicines, the costs of reverse engineering, and the potential for technology transfer.

A central focus of the literature has been the impact of patent reforms on international trade patterns. Early studies, such as Maskus and Penubarti (1995), examined whether variations in the strength of patent rights across countries influence trade flows. Subsequent research by Smith (1999, 2001), Co (2004), Park and Lippoldt (2003), and Ivus (2010) expanded this analysis, exploring the broader economic implications of IPR reforms.

While much of the existing scholarship has focused on the impact of patent reforms in developing countries on trade with advanced economies—particularly in terms of enhancing IP protection and boosting demand for foreign goods and technologies—this perspective overlooks a critical dimension: the firm-level effects of these reforms within developing countries. Our study addresses this gap by examining firm-level responses to IPR reforms, offering granular insights into how such reforms reshape export strategies. Furthermore, we extend the discourse by exploring the often-overlooked relationship between patent reforms and firm-level imports, thereby providing a more comprehensive understanding of trade, innovation and value chain dynamics.

Strengthening patent rights can enhance firms' export capacity and their demand for advanced components and technologies through multiple channels. For instance, countries undertaking IPR reforms often experience increased international trade in goods and services, higher FDI by multinational enterprises (MNEs), and greater licensing of technology and intangible assets. These dynamics enable firms to absorb and adapt foreign technologies, leading to improvements in domestic productivity and innovation (Yang and Maskus, 2009; He and Maskus, 2012). Stronger IPRs not only facilitate the sourcing of advanced goods and technological inputs but also enhance intra-firm technology transfers and arm's-length licensing agreements. Consequently, these reforms expand the stock of knowledge available to local producers, enabling them to develop new products and create platforms for exports (He and Maskus, 2012).

Technology spillovers, both intentional (through market transactions) and unintentional (via operational exposure to MNEs), further bolster local capabilities. These spillovers improve product quality and reduce production costs for export goods (Javorcik, 2004b; Lopez, 2008). Stronger IPRs also mitigate appropriability hazards by reducing the risks of technology misappropriation and imitation. Lower risks encourage firms to invest in innovation, develop new export-oriented product varieties, and enhance the quality of existing goods for international markets (Amiti and Khandelwal, 2013).

Another critical channel is the reduction of sunk costs associated with entering export markets. Substantial foreign-market entry costs require firms to generate sufficient expected profits to justify initial investments. By increasing economic returns and reducing uncertainties about future export profits, stronger IPRs influence firms’ market entry strategies and improve their long-term survival and export potential (Aw et al., 2011).

IPR reforms also significantly influence firms' import behaviour, particularly in IP-intensive sectors, through several mechanisms. First, such reforms drive technology upgrades and input sourcing, prompting firms to import high-quality inputs, intermediate goods and capital equipment, thereby fostering innovation and production efficiency. For instance, Chile's patent reforms demonstrated a positive impact on the importation of machinery and technology-intensive inputs by domestic firms, driven by the need to upgrade production capabilities in line with stronger IP laws (Hall and Helmers, 2013). Similarly, Maskus (2012) emphasizes that patent reforms in developing economies encourage backward integration into GVCs, often necessitating imports of IP-intensive goods that are either unavailable domestically or inefficient to produce locally. Second, stronger IP rights enable firms to access new markets or expand within existing ones, increasing the demand for imported inputs to support enhanced production capacity. Third, patent reforms often shift firms' focus toward sourcing IP-compliant inputs, necessitating imports of specialized goods not readily available domestically. Finally, these reforms impact both the extensive and intensive margins of imports: initially

encouraging new firms to enter global markets and source inputs internationally, and over time, leading existing importers to scale up and diversify their imports.

3. Data Description

3.1. Firm-Level Data

We utilize the PROWESS database, maintained by the Centre for Monitoring the Indian Economy (CMIE). This comprehensive dataset covers publicly listed Indian companies and a representative sample of private firms with audited annual reports. The database accounts for over 70% of the organized sector's industrial output, 71% of corporate tax contributions, and 95% of excise tax collections by the Indian government (Topalova and Khandelwal, 2011). Its extensive use in academic research, as evidenced by studies such as Ahsan and Mitra (2014), Khachoo and Sharma (2016), and Chakraborty and Raveh (2018), underscores its value for analysing firm-level dynamics and economic policies.

PROWESS provides detailed firm-level data aligned with the Indian National Industrial Classification (NIC) from 1989 onwards. It includes financial variables such as sales, exports, imports, gross value added (GVA), assets, R&D expenditure, licensing and royalty expenses, profits, and other firm-level financial metrics. Additionally, the database contains information on firm ownership, industry affiliation, product groups, incorporation year, plant and headquarter locations. Spanning approximately 27,400 companies—including over 10,000 manufacturing firms—the dataset covers 108 four-digit NIC industries grouped into 23 two-digit sectors, enabling robust longitudinal analyses of firm behaviour (Bhattacharya et al., 2021).

A key strength of PROWESS lies in its detailed technology investment data, including R&D expenditures and royalty payments for technology transfer, as mandated under Section 217 of the Companies Act. These data enable us to classify of firms into high- and low-technology categories, particularly in the pre-reform period. Furthermore, PROWESS uniquely disaggregates import data into categories such as raw materials, spares and components, final goods, and capital goods. This granularity facilitates a nuanced examination of import trends over time. Compared to alternative sources like the Annual Survey of Industries (ASI), the panel structure of PROWESS allows for in-depth analysis of firm behaviour over time, making it particularly useful for studying the effects of policy changes, such as intellectual property reforms. Its breadth and granularity make PROWESS an indispensable resource for exploring technology adoption, trade dynamics, and firm-level responses to economic reforms.

Tariff data are sourced from the World Integrated Trade Solution (WITS) database, which provides global trade and tariff information mapped to the International Standard Industrial Classification of All Economic Activities (ISIC) at the four-digit level, adhering to ISIC Revision 3. For our analysis, we compiled data on India's Most Favoured Nation (MFN) tariffs for ISIC four-digit product categories and matched them with firm-level data categorized under NIC-2008 using a text-based mapping approach. For example, ISIC Rev. 3 code 1511, representing "Production, processing, and preserving of meat products," was hand mapped to NIC-2008 subclass 1010, which denotes the same activity. This ensures consistency across international and national industrial classifications, enabling an integrated analysis of sector-specific tariffs and their impacts on firm-level dynamics.

All variables, except tariffs and categorical variables, are measured in millions of Indian Rupees (INR) to ensure consistency and facilitate meaningful comparisons across firms.

Appendix A provides a detailed list of the variables used in the analysis, along with their definitions and, where applicable, the formulas or sources for their construction. Table 1 presents summary statistics for key firm-level variables, including outcome measures and firm characteristics. These statistics provide insights into the scale, distribution, and variability of the data, aiding in identifying potential outliers and underlying patterns.

Table 1: Descriptive Statistics (PROWESS Data)

Variable	Mean	Std. dev.	Min	Max
Outcome Variables				
ln(exports)	4.30	2.17	0.00	13.28
ln(total imports)	3.62	2.48	0.00	13.79
ln(raw material imports)	4.19	2.03	0.00	13.68
ln(spares and stores imports)	2.18	1.76	0.00	9.64
ln(final good imports)	3.37	1.95	0.00	11.95
ln(capital good imports)	2.67	1.84	0.00	10.22
Firm-level Characteristics				
ln(debt)	5.55	1.87	0.00	12.54
ln(profits after tax)	9.76	0.13	0.00	11.83
ln(tariffs)	3.24	0.64	0.00	5.61
ln(age)	3.14	0.72	0.00	4.98
ln(gross value added)	6.28	1.68	0.00	14.21
ln(technology adoption exp.)	1.75	1.61	0.00	8.98
ln(r&d)	1.21	1.48	0.00	8.98
ln(technology transfer)	0.84	1.38	0.00	8.82
tech-share	0.02	0.14	6.00	10.27

The typical firm exports goods worth approximately e^(4.30) ≈ 73.8 million INR. Similarly, the average firm's total imports amount to e^(3.62) ≈ 37.2 million INR. Among disaggregated import categories, firms predominantly import raw materials compared to final goods and capital goods, emphasizing the critical role of intermediate inputs in production. Firms in the dataset have an average age of 23 years, with a wide range from new entrants to long-established firms. Average expenditure on technology adoption is 5.75 million INR, while mean expenditures on R&D (3.35 million INR) and technology transfer (2.32 million INR) remain relatively low, reflecting uneven innovation capacity across firms. This disparity suggests that only a fraction of firms actively invest in research and technological upgrading, which may have long-term implications for competitiveness and GVC integration. Tariff measures reflect the level of trade protection during the sample period, with an average tariff rate of 24.5%, indicating substantial tariff barriers that could shape firm-level trade behaviour by influencing import costs and export competitiveness. With a mean of approximately INR 1.02 million, the tech-share ratio ranges from INR 6.00 to 10.27 million, reflecting significant diversity in how firms allocate resources to technology adoption relative to their GVA.

3.2 Firm Classification

We investigate patterns of exporter and importer behaviour by categorizing firms into two distinct groups: high-tech and low-tech. The classification is based on the methodology

established in previous works, including Aghion et al. (2005), Branstetter et al. (2006), and Bhattacharya et al. (2021). These studies emphasize the importance of firms' technological capital stock in determining their classification. For this analysis, we focus on firms' technology adoption expenditure prior to the implementation of the 2002 Patents Act.

High-tech firms are identified as those whose average expenditure on R&D and technology transfer—collectively referred to as "technology adoption expenditure"—between 1990 and 2001 (pre-treatment period), expressed as a percentage of their GVA, exceeds the industry median. Firms falling below this threshold are categorized as low-tech. This approach enables a nuanced understanding of how technological capabilities influence firm-level export and import behaviours.

Our dataset initially includes 12,633 firms observed over a 12-year period, resulting in a total of 151,596 firm-year observations. Following data cleaning and the exclusion of firm-year observations with missing or misreported data on technology adoption expenditures, the final sample comprises 13,462 firm-year observations, representing 2,544 unique firms over the period 1996–2007. Among these firms, 38% are classified as high-tech, while the remaining 62% are categorized as low-tech. This classification is based on firms' technology adoption expenditures relative to their gross value added (GVA), providing a meaningful segmentation of firms into technology-intensive and non-technology-intensive categories for the purposes of this study.

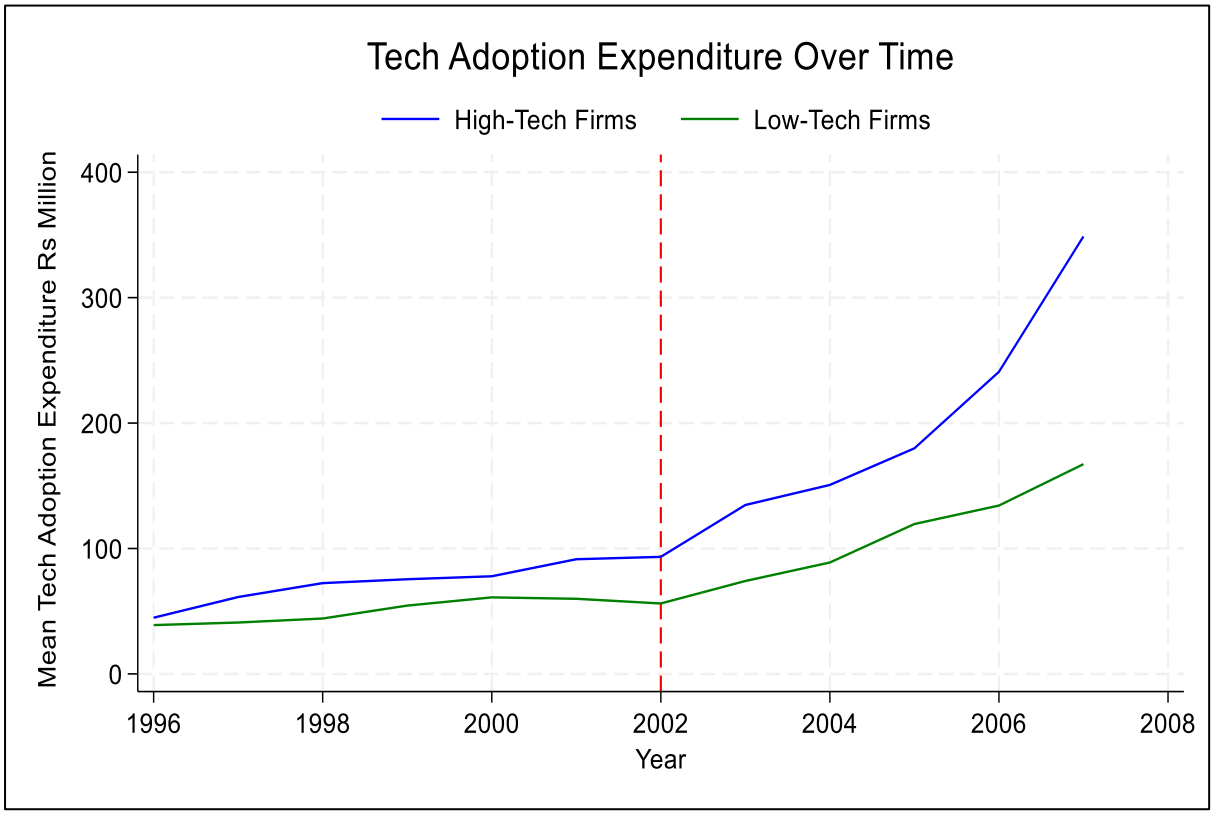
The pronounced skewness in this distribution reflects the broader economic reality that only a small subset of firms allocate substantial resources to R&D and technology transfer. This phenomenon can be explained by several interrelated factors. Innovation entails significant fixed and sunk costs, carries substantial risks, and is characterized by inherent uncertainty, which discourages many firms, particularly smaller ones, from undertaking such investments (Hall and Lerner, 2010). Larger firms, benefiting from economies of scale, are better positioned to absorb these costs and undertake R&D (Cohen and Klepper, 1996). Additionally, the appropriability of innovation returns depends on robust IP regimes, without which firms face risks of imitation and knowledge spillovers, reducing their incentives to innovate (Mansfield, 1986). Industry-specific characteristics further contribute to this disparity, as high-tech sectors like pharmaceuticals and aerospace are inherently more R&D-intensive than traditional industries like textiles or agriculture (Pavitt, 1984). The skewness is also reinforced by path dependence, as firms with a history of technological investment develop absorptive capacities that enable continuous innovation, while others face higher barriers to entry in R&D (Cohen and Levinthal, 1990). In developing economies, institutional constraints such as weak financial systems and limited government support exacerbate the challenges for low-tech firms (Fu, Pietrobelli, and Soete, 2011). This asymmetry, though stark, is expected given the resource-intensive nature of technological advancement and the structural barriers faced by most firms, underlining the need for targeted policies to foster innovation across sectors and firm sizes.

Our primary dependent variable is the intensive margin of exports, which measures the annual value of products exported by a firm to international markets. This focus on the intensive margin allows us to examine export behaviour among firms already engaged in international trade, as opposed to the extensive margin, which concerns whether a firm begins exporting. By analysing this margin, we aim to understand how technological capital influences export dynamics, particularly in response to changes in IP regulations such as the 2002 Patents Act.

To estimate the impact of the 2002 Patents Act, high-tech firms are treated while as low-tech firms act as control group. The differential response to the policy change serves as the causal

effect on the intensive margin of exports and import demand. To establish that the observed differences between high-tech and low-tech firms are causal, we rely on the assumption of parallel trends. Specifically, we assume that, in the absence of the reform, high-tech and low-tech firms follow similar trends in key variables such as technology adoption expenditure and exports. This assumption is crucial for attributing the divergence in outcomes between the two groups to the reform, rather than to pre-existing differences in their growth trajectories.

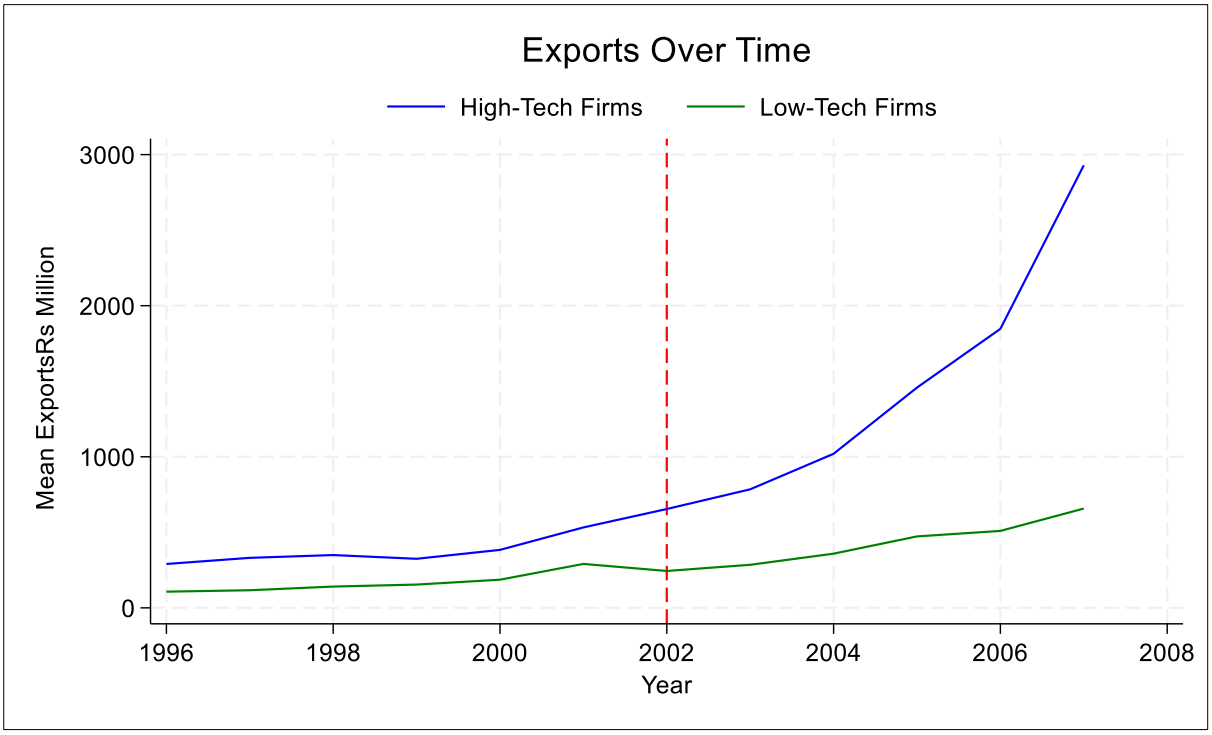
Figure 1: Year-wise Average Technology Adoption Expenditure of High-tech and Low-tech firms



Source: PROWESS

Figure 1 illustrates technology adoption expenditures for Indian firms from 1996 to 2007. It shows that, prior to 2002, expenditures for both high-tech and low-tech firms are comparable, supporting the idea that both groups followed similar trends. However, after 2002, high-tech firms experienced a more than threefold increase in technology adoption expenditures, while low-tech firms saw only a modest rise. This shift suggests that the reform disproportionately affected high-tech firms, driving their technology adoption expenditures upward. Figure 2 depicts the average exports of high-tech and low-tech firms over the same period. Both groups saw some growth in exports before the reform; however, the post-reform increase was largely concentrated among high-tech firms, while low-tech firms experienced only a modest rise in exports. This divergence in export growth patterns further underscores the significant role the reform played in fostering technological advancement and export growth, particularly among high-tech firms. Together, these visual patterns from Figures 1 and 2 intuitively suggest a link between the patent reform, technology adoption, and firm-level export growth, providing evidence that the reform had a disproportionate positive impact on high-tech firms compared to their low-tech counterparts.

Figure 2: Year-wise Average Exports of High-tech and Low-tech firms



Source: PROWESS

4. Empirical Strategy

To evaluate whether the 2002 IPR intervention led to an expansion in trade activities, we follow the methodology outlined in Branstetter et al. (2006, 2011). This approach tracks individual firms over time, examining changes in their export and import activities around the reform period. The analysis controls for firm-specific and industry-level characteristics, as well as concurrent policy changes that may affect the outcomes. The basic specification compares the export and import performance of high-tech firms (treatment group) with low-tech firms (control group), expressed as follows:

$$Y_{it} = \beta_0 + \beta_1 IPR_{02} + \beta_2 Htech_{96-01} + \beta_3 (IPR_{02} Htech_{96-01}) + \grave{\boldsymbol{X}}_{it}\alpha_t + \varepsilon_{it} \qquad (1)$$

Here, i represents an individual firm, and t denotes the year. Y_{it} is the outcome variable, such as the value of exports or imports for firm i in year t. The variable IPR_{02} is a post-reform dummy, taking a value of 1 for years on and after the implementation of the Patents (Amendment) Act, 2002 (i.e., 2002–2007), and 0 for the pre-reform period (1996–2001).

The variable $Htech_{i,96\text{-}01}$ is a dummy indicating whether firm i is classified as high-tech based on its technology adoption expenditure relative to the industry median during the pre-reform period (1996–2001). Firms with above-median technology adoption expenditure are assigned $Htech_{i,96\text{-}01} = 1$ (treatment group), while those below the median are assigned $Htech_{i,96\text{-}01} = 0$ (control group).

The interaction term $IPR_{02}{*}Htech_{i,96\text{-}01}$ (or its coefficient β_3) is the key variable of interest. It captures the differential response of high-tech and low-tech firms to the IPR reform in terms of exports or imports. Specifically, β_3 measures the extent of between-firm inequality in trade

outcomes following the IPR shock. Given that high-tech firms are likely to benefit more from stronger IPR protection, we expect β_3 to be positive.

The vector $\grave{\boldsymbol{X}}_{it}$ includes firm- and industry-level controls that influence trade outcomes. At the industry level, we control for tariffs to account for trade barriers faced by the domestic firms. At the firm level, we include controls for firm age, as older firms typically have greater experience, established market access, and stronger supplier networks, which facilitate their trade activities. Total assets are included to account for firm size, as larger firms are better positioned to invest in R&D, innovation, and technology, enhancing their export competitiveness and ability to source high-quality inputs globally. We also control for firm-level profits (as more profitable firms tend to engage more in trade), and firm debt (as high leverage may constrain export expansion but enable financing for imports). The error term (ε_{it}) accounts for random variations.

4.1.Rationale for Differential Effects

The IPR reforms strengthened legal protections for innovation, enabling firms to appropriate a larger share of returns on R&D and technology investments. High-tech firms, with their advanced technological capabilities, are better positioned to leverage stronger IPRs to scale innovation, enhance product quality, and meet global standards, making them more competitive in export markets. Their absorptive capacity allows them to integrate new knowledge faster, improving productivity and cost efficiency, which further boosts exports (Lileeva & Trefler, 2010). On the import side, high-tech firms require specialized inputs, technology, and capital goods, which become more accessible through strengthened IPR regimes that encourage technology transfer and licensing (Eaton & Kortum, 2002). In contrast, low-tech firms, lacking R&D investments and absorptive capacity, struggle to capitalize on these reforms, limiting their trade expansion. Empirical evidence from post-IPR reform economies, such as China and India, confirms that export growth and technology imports are concentrated among firms with pre-existing technological capabilities (Hu & Jefferson, 2009). Overall, IPR reforms create an enabling environment where firms with existing technological capabilities gain a comparative advantage, reinforcing the observed empirical trend that high-tech firms benefit disproportionately in terms of trade expansion following such legal changes.

4.2. Summary Statistics

Table 2 provides a comparison of the mean values of key variables before and after the reform, highlighting changes in R&D, technology adoption expenditure, exports and various types of imports. The positive shift in the means suggests potential increases in investment and international trade activity post-reform.

Table 2: Summary Statistics: Prowess data

Variables	Pre-reform Mean (1996-2001)	Post-reform Mean (2002-2007)
ln(r&d)	1.15	1.26
ln(technology transfer)	0.79	0.89
ln(technology adoption exp.)	1.66	1.83
ln(exports)	3.99	4.55

ln(total imports)	3.53	3.69
ln(raw material imports)	3.93	4.42
ln(spares and stores imports)	2.11	2.24
ln(final good imports)	3.11	3.57
ln(capital good imports)	2.50	2.81

The statistics in Table 3 reveal significant differences between low-tech and high-tech firms before and after the 2002 IP reform. High-tech firms show higher mean values in key indicators such as R&D, technology transfer, technology adoption expenditure, and exports, particularly after the reform, suggesting that these firms are more engaged in technology-intensive activities. In contrast, low-tech firms exhibit smaller changes across these variables. Additionally, high-tech firms increased their imports, particularly of raw materials, likely to support advanced production processes, while low-tech firms reduced their imports, possibly shifting toward domestic sourcing. These findings highlight the heterogeneous impact of the reform, indicating that high-tech firms are better positioned to leverage enhanced intellectual property protections and related policy changes.

Table 3: Summary Statistics by Firm Type: Prowess data

Variables	Pre-reform Mean (1996-2001)		Post-reform Mean (2002-2007)	
	Low-tech	*High-tech*	*Low-tech*	*High-tech*
ln(r&d)	0.81	1.41	0.89	1.77
ln(technology transfer)	0.33	1.14	0.64	1.23
ln(technology adoption exp.)	1.01	2.15	1.34	2.49
ln(exports)	3.97	4.01	4.36	4.78
ln(total imports)	3.57	3.50	3.32	4.21
ln(raw material imports)	3.98	3.89	4.24	4.62
ln(spares and stores imports)	2.11	2.11	2.21	2.27
ln(final good imports)	3.27	2.98	3.71	3.44
ln(capital good imports)	2.55	2.46	2.74	2.89

5. Results

5.1. Impact of IPR Reform on the Intensive Margin of Exports

We begin with estimating equation (1) where the outcome variable is the log of firm exports and key independent variables are IPR_{02}, $Htech_{96\text{-}01}$, and their interaction. Estimates reported in Table 4 reveal that firms exposed to the 2002 IPR reforms experienced a statistically significant export increase of approximately 33% (Specification I). This impact remains significant, showing a 17% rise in exports when firm-level controls are included (Specification II), suggesting that engagement with the IPR reform positively influenced the intensive margin of exports. The coefficient on $Htech_{i,96\text{-}01}$ suggest that treatment group did not exhibit a statistically significant difference in export performance relative to the control group before the reform. However, the interaction term, $IPR_{02} \times Htech_{96\text{-}01}$, capturing the causal effect of the IPR reform on high-tech firms, is both positive and significant. This indicates that high-tech firms benefiting from the IPR reform saw an additional export growth of approximately 48% (Specification I) and 15% (Specification II) relative to low-tech firms. These results highlight

that strengthening IPR regimes can serve as an effective tool for promoting exports, particularly in knowledge-intensive and high-tech sectors.

The findings align with the theoretical insight that stronger intellectual property protection boosts firms' incentives to innovate, commercialize their products, and expand internationally, particularly in innovation-driven sectors. Enhanced IP protection safeguards intangible assets against imitation and infringement, encouraging greater investment in R&D and product development. Furthermore, domestic IPR reforms reduce the risk of exports being labelled as counterfeit in international markets, facilitating easier market entry and competition based on innovation. Strengthening domestic IPR laws enhances the global credibility of a country's exports, fostering trust with foreign buyers, distributors, and partners, thereby driving export growth. Our results are consistent with the findings of Branstetter et al. (2006), Falvey et al. (2006), Qian (2007), and Moser (2013), who document that improvements in domestic IP protection are associated with increased exports, particularly in sectors reliant on technological advancements, such as electronics and pharmaceuticals.

In addition to policy exposure, firm-level characteristics play a crucial role in export performance. Our estimations show that firm age is positively associated with exports, aligning with theoretical expectations that experience, stability, and market positioning drive export success. Increased expenditure on R&D and technology transfer is also positively associated with higher exports, suggesting that innovation and technological advancement enhance export performance. The significant coefficient on firm debt implies that firms with access to debt capital are better able to finance their expansion into export markets.

Our key control variable, tariff levels, accounting for trade policy barriers, suggests that firm exports respond negatively to higher tariffs. The coefficient on log(tariffs) confirms that a rise in import tariffs results in a drastic decline in firm exports. This finding highlights the adverse impact of higher tariffs on export performance, emphasizing the importance of trade liberalization in promoting firms' access to international markets.

Table 4: Basic Estimates on Intensive Margin of Exports

Variables	*ln(exports)*	
	(I)	(II)
IPR_{02}	0.327	0.172
	(0.064) ***	(0.059) **
$Htech_{i,96\text{-}01}$	0.033	-0.143
	(0.125)	(0.098)
$IPR_{02}*Htech_{i,96\text{-}01}$	0.483	0.154
	(0.089) ***	(0.078)**
ln(age)		0.365
		(0.0621) ***
ln(tariff)		-0.399
		(0.038)***
ln(profit)		0.192
		(0.182)
ln(r&d)		0.234
		(0.024)***
ln(tech-transfer)		0.094
		(0.024)***
ln(debt)		0.237
		(0.021)***

constant	3.935	0.454
	(0.093)***	(1.801)
N	9,597	9,597

Standard errors in parentheses are clustered by firm id. * denotes 1% significance level (p < 0.01), ** denotes 5% significance level (p < 0.05), and * denotes 10% significance level (p < 0.10).*

To ensure robustness, we explore alternative specifications, with estimates reported in Table 5. Unlike the basic method, which provides a direct before-after comparison, the 'diff' command offers detailed DiD results, including both pre- and post-treatment comparisons. Before the reform, the difference in log(exports) between treated and control firms was 0.034, statistically insignificant, confirming that their pre-reform export levels were comparable—supporting the common trend assumption. After the reform, this difference increased to 0.571, statistically significant at the 1% level, indicating a substantial export boost for treated firms. The DiD estimate of 0.483 further confirms that the policy intervention had a positive and significant impact on firm exports.

Table 5: Diff-in-Diff Estimates

Outcome Variable		*ln(exports)*
Before		
	Control	3.936
	Treated	3.969
	Diff(C-T)	0.034
		(0.125)
After		
	Control	4.263
	Treated	4.780
	Diff(C-T)	0.571
		(0.125) ***
Diff-in-Diff		0.483
		(0.107) ***

Standard errors in parentheses are clustered by firm id. * denotes 1% significance level (p < 0.01), ** denotes 5% significance level (p < 0.05), and * denotes 10% significance level (p < 0.10).*

5.1.1. Addressing Potential Concerns

While the results provide strong evidence of the causal effect of the IPR reform on firm exports, three key concerns must be addressed before we can take our findings seriously: (a) omitted variable bias**,** (b) differential time trends**,** and (c) reverse causality**.** These issues, if left unaddressed, could undermine the validity of our causal inferences and lead to misleading conclusions about the impact of the reform.

Omitted variable bias could arise if unobserved firm- or industry-specific factors that influence export performance are not accounted for, potentially confounding the estimated impact of the IPR reform. Our baseline specification already accounts for this by systematically including firm (e.g., age, R&D expenditure, debt, profits) and industry characteristics (e.g., tariffs) individually. While we have not yet included their interaction terms with the $Htech_{96\text{-}01}$ dummy, we intend to do so later to further capture heterogeneity in firm responses and ensure a more comprehensive analysis.

Differential time trends pose another challenge, as differences in export performance between high-tech and low-tech firms could be driven by pre-existing trends rather than the IPR reform

itself. To address this, we conduct a pre-trend analysis to verify whether the treatment group and control group followed parallel export trajectories before the policy change. A lack of significant differences in pre-reform trends would support the validity of our approach.

Reverse causality remains a concern, as firms' export behaviour—particularly in high-tech sectors—could have influenced the timing or design of the IPR reform rather than the reform affecting exports. To rule out this possibility, we perform exogeneity tests to examine whether key factors closely associated with exports, such as technological capability, R&D intensity, or technology transfer, had any predictive power over the enactment of the reform. These checks help establish that the observed effects are driven by the IPR reform rather than pre-existing firm characteristics or policy endogeneity.

5.1.2. Pre-Trend Analysis

To validate the parallel trends assumption, we first examine whether high-tech and low-tech firms exhibited similar export trends in the pre-reform period (1996–2001). While Table 5 provides initial evidence that high-tech firms were not significantly different from their low-tech counterparts, we further establish this by estimating a constant linear time trend model with an interaction term for high-tech firms. Additionally, we use year dummies to assess whether export trends between the two groups were parallel. If no significant differences in trends are found, this strengthens the validity of the DiD approach. To formally test this assumption, we estimate the following specification:

$$Y_{it} = \beta_0 + \beta_1 Time_t + \beta_2 \left(Htech_{i,96-01} * Time_t\right) + \grave{X_{it}}\alpha_t + \gamma_t + \delta_i + \varepsilon_{it} \qquad (2)$$

Where, $Time_t$ is a linear time trend variable (for example, the number of years since 1996 to 2001). β_1 the coefficient on $Time_t$ represents the overall linear time trend for all firms and β_2 the coefficient on the interaction term $\left(Htech_{i,96-01} * Time_t\right)$ captures differential time trend. If β_2 is statistically significant, this indicates that high-tech firms had a different trend that low-tech firms before the reform. If no significant differences in trends are found, it supports the parallel trends assumption, which is crucial for the validity of the DiD estimator used in post-reform analyses. The specification (2) also includes year fixed effects (γ_t) to control for time-specific shocks, as well as firm fixed effects (δ_i) to account for unobserved heterogeneity. The error term (ε_{it}) allows for random variations.

Estimates from Column (2) in Table 6 suggest that the coefficient on the interaction of time trend with $Htech_{i,96-01}$ dummy does not provide strong evidence that high-tech firms had a systematically different export trajectory compared to low-tech firms before the reform. Furthermore, the interaction of $Htech_{i,96-01}$ with year dummies indicates that the pre-reform export trends of high-tech and low-tech firms were largely parallel, with one exception: in 1997, high-tech firms exhibited significantly lower exports relative to low-tech firms. The coefficients for other years (1996, 1998, 1999, 2000) are statistically insignificant, reinforcing that there were no systematic differences in export trends between the two groups during these years. This finding supports the parallel trends assumption, validating the framework adopted for assessing the causal impact of the IPR reform.

Table 6. Pre-reform (1996-200) time trends in exports of high-tech & low-tech firms

Variable	*ln(exports)*	
	(I)	(II)
$Time_t$	-0.048	
	(0.093)	
$Htech_{i,96-01}$*$Time_t$	0.024	
	(0.026)	
$Htech_{i,96-01}$*$year_{96}$		-0.084
		(0.130)
$Htech_{i,96-01}$*$year_{97}$		-0.198
		(0.118)*
$Htech_{i,96-01}$*$year_{98}$		0.008
		(0.106)
$Htech_{i,96-01}$*$year_{99}$		-0.005
		(0.916)
$Htech_{i,96-01}$*$year_{00}$		0.035
		(0.078)
$Htech_{i,96-01}$*$year_{01}$		-
Firm controls	yes	yes
FE	yes	yes
N	4,122	4,122
R^2	0.182	0.204

Standard errors in parentheses are clustered by firm id. * denotes 1% significance level (p < 0.01), ** denotes 5% significance level (p < 0.05), and * denotes 10% significance level (p < 0.10).*

5.1.3. Assessing Exogeneity of the 2002 Patent Reform

A critical concern in our identification strategy is establishing the exogeneity of the timing of the 2002 IPR reform with respect to the activities of Indian manufacturing firms. A potential threat to validity arises if high-tech firms lobbied for the Patents (Amendment) Act, 2002 to secure disproportionate benefits from its enactment. To test for such lobbying effects, we conduct additional robustness checks following the methodology of Khandelwal and Topalova (2011).

Specifically, we examine whether the interaction of the tech dummy ($Htech_{i,96-01}$) and the reform dummy (IPR_{02}) is correlated with firm and industry characteristics that could have influenced the implementation of the 2002 reform. If lobbying occurred, one would expect variables such as the exports, R&D, technology transfer, tech-adoption and firm size—a proxy for firms' influence and resource allocation for lobbying—to predict the timing or design of the reform.

We estimate the following regression:

$$Htech_{i,96-01} * IPR_{02} = \alpha_0 + \hat{Z_{it}}\alpha_t + Cntrls_{it} + \gamma_t + \delta_i + \varepsilon_{it} \qquad (3)$$

Where $\hat{\boldsymbol{Z}}_{it}$ represents a vector of firm characteristics that can possibly influence the reforms, $Cntrls_{it}$ includes additional firm level controls, γ_t denotes year fixed effects, and δ_i represents firm fixed effects.

The interaction term in Table 7 is statistically insignificant across all specifications, indicating no causal relation between firm characteristics and the enactment of the 2002 reform. This suggests that the timing of the reform was not systematically influenced by lobbying efforts or strategic behaviour by high-tech firms. We, therefore, conclude that the observed effects on exports are driven by the IPR reform itself, rather than endogenous lobbying or strategic firm behaviour.

Table 7. Endogeneity of 2002 Patent Reforms

	IPR_{02}*$Htech_{i,96-01}$				
	(I)	(II)	(III)	(IV)	(V)
ln(exports)	0.005				
	(0.012)				
ln(r&d)		-0.021			
		(0.028)			
ln(technology transfer)			-0.017		
			(0.012)		
ln(technology adoption exp.)				-0.024	
				(0.016)	
ln(total assets)					0.037
					(0.041)
other controls$_i$	yes	yes	yes	yes	yes
firm FE	yes	yes	yes	yes	yes
year FE	yes	yes	yes	yes	yes
N	2,436	2,522	2,522	2,522	2,522
R^2	0.137	0.134	0.133	0.134	0.131

Standard errors in parentheses are clustered by firm id. * denotes 1% significance level (p < 0.01), ** denotes 5% significance level (p < 0.05), and * denotes 10% significance level (p < 0.10).*

5.2. Impact of IPR Reform on the Intensive Margin of Imports

Our results indicate that while the 2002 IPR policy reform significantly boosted firm exports, it did not have a notable impact on the imports of raw materials, component parts, or final goods for the full sample. Instead, a decline in overall imports and capital goods imports across all firms was observed, as reflected in specifications II and V of Table 8.This finding aligns with the Technology Adaptation Hypothesis, which suggests that stronger IPR protection encourages domestic firms to develop or adopt local alternatives instead of relying on foreign technology imports. Maskus (2000) finds that IPR reforms facilitate technology transfer without requiring direct imports of capital goods, while Hall & Helmers (2019) show that stricter IPR laws promote domestic innovation, reducing dependence on imported technologies. These results underline the broader impact of IPR reforms, not only in fostering export growth but also in strengthening domestic technological capabilities.

Our estimates also find theoretical support in the Market Power Theory of IPR. Stronger patent laws enhance the bargaining power of foreign technology suppliers, enabling them to raise prices or limit technology licensing. This discourages firms from importing capital goods, reducing total imports. Branstetter et al. (2006) find that when IPR protection strengthens, technology transfer increasingly occurs through FDI and joint ventures rather than direct imports. Similarly, Schneider (2005) shows that stronger IPR protection leads firms to substitute imports with domestic innovation or foreign collaborations.

The cost-push effect of IPR protection appears to be relevant in the case of capital goods imports, as stricter IPR regimes increase licensing fees and patent royalties, making imported capital goods more expensive. Maskus & Penubarti (1995) find that stronger IPR protection raises the cost of technology-intensive imports, thereby reducing demand for capital goods. Similarly, Lai & Qiu (2003) argue that rising patent-related costs lower the demand for imported machinery and equipment. Thus, IPR reforms shift firms' sourcing strategies, encouraging local alternatives and increasing reliance on FDI and joint ventures, ultimately leading to a decline in capital goods and total imports.

An important finding of this study is the differential response of high-tech firms to these reforms. High-tech firms exhibit an increase in their raw material and overall imports post-reform. The coefficient of interest, $IPR_{02}*Htech_{i,96\text{-}01}$, shows that the policy intervention led to an approx. 18% rise in both raw material and aggregate imports among these firms (specifications I and V in Table 8).

The policy reform likely facilitated greater access to specialized raw materials and intermediate goods, which high-tech firms had previously struggled to obtain due to regulatory barriers. A more predictable IPR environment may have encouraged multinational firms to license more freely, driving demand for imported intermediates. Additionally, the reform likely increased firms' confidence in engaging with global supply chains, reducing risks and encouraging investment in raw materials to enhance productivity and innovation.

High-tech firms, with their greater absorptive capacity, integration into GVCs, and advanced technological capabilities, are better positioned to capitalize on such reforms. These attributes allow them to scale up imports and seize opportunities in r&d, and production. Thus, IPR policy interventions can significantly shape sourcing decisions, particularly in technology-intensive sectors, by easing access to specialized inputs and fostering deeper integration into global production networks.

Beyond IPR policy reforms, other firm-specific and policy-related determinants also influence raw material imports. Firm age positively affects import behaviour, suggesting that older firms, with their well-established supply chains and networks, have a greater capacity to source raw materials internationally. Similarly, firm-level characteristics such as expenditure on R&D and technology transfer strongly influence the intensive margin of imports. Firms also appear to finance their imports through debt. In contrast, higher import tariffs significantly reduce all import categories, highlighting the critical role of trade policy in shaping firm-level sourcing decisions.

Overall, these findings highlight that IPR policy changes can shape firms' global supply chain integration, particularly for high-tech firms, while tariff reductions on essential inputs could further enhance firms' global competitiveness and participation in GVCs.

Table 8: Estimates on Disaggregated Import Categories

Variables	(1) *ln(raw material imports)*	(II) *ln(spares & component imports)*	(III) *ln(capital goods)*	(IV) *ln(final goods)*	(V) *ln(total imports)*
IPR_{02}	0.003	-0.022	-0.153	0.110	-0.111
	(0.058)	(0.065)	(0.068)**	(0.169)	(0.045)**
$Htech_{i,96\text{-}01}$	-0.118	-0.038	-0.243	-0.396	0.172
	(0.083)	(0.097)	(0.075)**	(0.210)*	(0.084)**
IPR_{02}*	0.187	-0.077	0.058	0.071	0.178
$Htech_{i,96\text{-}01}$	(0.071)**	(0.086)	(0.082)	(0.207)	(0.062)**
log(age)	0.136	0.163	-0.056	0.084	0.174
	(0.048)***	(0.055)***	(0.040)	(0.112)	(0.049)***
ln(tariff)	-0.407	-0.239	-0.377	-0.419	-0.337
	(0.039)***	(0.045)***	(0.048)***	(0.105)***	(0.036)***
ln(profit)	0.262	0.235	0.390	1.327	0.331
	(0.197)	(0.174)	(0.311)	(0.788)*	(0.240)
ln(r&d)	0.213	0.180	0.255	0.084	0.293
	(0.021)***	(0.023)***	(0.020)***	(0.052)	(0.021)***
ln(tech-transfer)	0.132	0.155	0.160	0.126	0.151
	(0.020)***	(0.020)***	(0.021)***	(0.050)**	(0.019)***
ln(debt)	0.252	0.188	0.349	0.039	0.301
	(0.020)***	(0.022)***	(0.019)***	(0.046)	(0.020)***
constant	0.369	-1.218	-2.390	-9.233	-1.679
	(1.951)	(1.741)	(3.066)	(7.771)	(2.369)
N	9,176	6,107	6,404	1,636	12,782

Standard errors in parentheses are clustered by firm id. * denotes 1% significance level (p < 0.01), ** denotes 5% significance level (p < 0.05), and * denotes 10% significance level (p < 0.10).*

6. Conclusion

A robust IPR mechanism is indispensable for fostering innovation, R&D, and the integration of domestic firms into GVCs. India's strategic alignment of IPR reforms with its trade and innovation policies has created an environment conducive to high-tech growth and trade expansion. Through initiatives such as the ANRF and other institutional reforms, India has prioritized industrial R&D and innovation, particularly in high-tech sectors. The sustained allocation of resources toward R&D underlines India's commitment to building a sustainable, innovation-driven economy, ensuring its competitiveness in an increasingly interconnected global market.

The analysis of the impact of India's IPR reforms on firm-level export behaviour reveals the transformative role of these policy changes, particularly for high-tech industries. Using a DiD approach, we demonstrate that strengthened IPRs significantly enhance export performance, with high-tech firms experiencing disproportionate gains. The reforms also facilitated increased imports of advanced inputs and intermediate goods, highlighting a complementary relationship between IPR reforms and GVC integration. These findings suggest that stronger IPR protections not only incentivize innovation but also deepen firms' participation in global trade, enhancing their competitiveness.

However, the analysis also reveals significant heterogeneity in firms' responses to the 2002 Patents Act reform. High-tech firms, with their pre-existing investments in technology, saw substantial increases in both technology adoption and export growth post-reform. In contrast,

low-tech firms exhibited more modest improvements, underscoring the uneven impact of IPR reforms. This disparity highlights the need to foster technological capabilities across all sectors and firm types, as technological investment is a critical driver of export competitiveness and economic growth.

The study also highlights the broader impact of trade liberalization on export and import activities. The negative relationship between tariffs and export performance emphasizes the importance of reducing trade barriers alongside strengthening IPR protections to maximize the benefits of both. Furthermore, the complementary role of imports in driving export performance is evident: stronger IPR protections encourage firms to source specialized inputs from global markets, enhancing their production capabilities and enabling deeper integration into GVCs. This suggests that policies promoting the importation of advanced inputs and technologies, alongside robust IPR reforms, can lead to a more dynamic and competitive export sector.

In addition to the differential impact on high-tech and low-tech firms, our results highlight the importance of firm-specific characteristics such as age, R&D expenditure, and debt in influencing export outcomes. Older firms, with their established networks and experience, were more likely to benefit from IPR reforms, as were firms investing more in R&D and technology transfer. This reinforces the notion that access to innovation and foreign technology is crucial for expanding export capabilities. Additionally, firms with higher debt levels demonstrated greater flexibility in financing their entry into foreign markets, pointing to the financial considerations critical for sustained export growth.

Based on these findings, we recommend that policymakers continue to strengthen IPR frameworks, particularly in high-tech sectors, to foster innovation and enhance global competitiveness. Efforts should also be made to lower trade barriers and reduce tariffs, which will complement IPR reforms and facilitate the expansion of trade activities. To maximize the benefits of these policies, targeted support for low-tech firms is essential, as they may struggle to leverage the full potential of IPR reforms without additional investment in technology and R&D.

While IPR reforms alone may not be sufficient to stimulate trade, they should be integrated into a comprehensive policy framework that includes trade liberalization and measures to support the efficient importation of advanced goods. By doing so, India can strengthen its export performance and GVC integration, particularly in high-tech sectors, and solidify its position as a global innovation and trade leader.

Appendix A

Variable	Definition
Exports	Value of goods exported by a company on a Free on Board (FOB) basis, as disclosed in its Annual Report.
Import of raw materials	Represents the value of raw materials imported by a company on a Cost, Insurance, and Freight (CIF) basis, as disclosed in its financial statements.
Import of spares & stores	This data field, as reported in Prowess, captures the CIF value of imported stores and spares based on company disclosures.
Import of finished goods	This data field, as reported in Prowess, captures the CIF value of finished goods imported by the company based on its disclosures.
Import of capital goods	This data field captures the value of capital goods, which include plant & machinery, furniture & fixtures, transport equipment, intangible assets, and other equipment or accessories required either directly or indirectly for the production of goods or the provision of services.
Overall imports	This sum provides the total CIF-based import value for a company, covering all four major import categories listed above.
Age	Firm age is calculated by subtracting the year of incorporation from the reference year (e.g., a firm incorporated in 2000 would be 7 years old in 2007).
Debt	In the Prowess database, company debt typically refers to the total liabilities or borrowings reported by a company, which may include both short-term and long-term debt. This can encompass loans, bonds, and other financial obligations a company owes.
Profit	This variable reflects the net profit of the company after deducting all expenses, taxes, and interest from its total income. It is a key indicator of a company's financial performance.
R&D	It is the total of R&D in the capital account and current account. R&D in the Capital Account refers to expenses capitalized as assets, usually for long-term projects like developing patents or technology, while R&D in the Current Account refers to expenses recognized as costs in the period incurred, typically for ongoing research activities.
Technology Transfer	It is a calculated field, aggregating the values of royalties, technical know-how fees, and license fees paid by domestic firms annually to access intellectual property, technology, or expertise they do not own or have developed themselves. These payments are made for the right to use patents, trademarks, proprietary technology, or other intellectual property.
Technology Adoption	Technology adoption expenditure is the sum of expenditure on R&D and technology transfer, which includes royalties, technical know-how fees, and license fees.

Gross value added	GVA (Gross Value Added) is calculated by subtracting the value of raw materials consumed, other inputs like fuel consumption, spares, and stores consumption from a company's sales.
Tech-share	Tech-share is a ratio variable computed by dividing a company's technology adoption expenditure (including R&D and technology transfer costs) by its GVA (Gross Value Added).
Tariffs	Import tariffs refer to the MFN tariffs imposed by Indian customs on ISIC 4-digit product categories, hand-mapped with firm-level data categorized under NIC-2008. This data is sourced from the World Integrated Trade Solution (WITS) database, which provides global trade and tariff information mapped to the ISIC Rev. 3 classification at the 4-digit level.

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