ISID Institute for Studies in Industrial Development
An institution of Indian Council of Social Science Research (Ministry of Education)
Policy Research to Foster India's Industrial Transformation

285
WORKING PAPER

Firms' R&D Activities in Indian Organised Manufacturing Sector: Are Tech-SMEs Different?

Shailender Kumar Hooda

October 2024

ISID Working Paper 285

Firms' R&D Activities in Indian Organised Manufacturing Sector: Are Tech-SMEs Different?

Shailender Kumar Hooda

ISID Institute for Studies in Industrial Development
An institution of Indian Council of Social Science Research (Ministry of Education)
4 Vasant Kunj Institutional Area, New Delhi – 110 070
Phone: +91 11 2689 1111 | *E-mail:* info@isid.org.in | *Website:* https://isid.org.in

October 2024

Firms' R&D Activities in Indian Organised Manufacturing Sector: Are Tech-SMEs Different?

Shailender Kumar Hooda[*]

[Abstract: *Given the crucial role of enhancing investment in Research and Development (R&D) to drive innovation, improve competitive performance, and foster industrial growth through technological advancements, this study investigates the current status, quantum, and trends in R&D investment behaviour at the firm level within India's organized manufacturing sector. By using unit-level data of Annual Survey of Industries (ASI), study provides nationally representative estimates of R&D propensity and intensity, distinguishing it from prior research constrained by data availability. The study assesses the contributions of small and medium size (SMS) versus large firms in R&D investments across various technology levels in the registered manufacturing sector. Our unique dataset makes this the first research to explore the impact of industry concentration and government incentives such as product-subsidy on R&D activities and intensity for SMS and large units using Cragg double-hurdle model and Heckman selection model, while accounting for other firm-level characteristics. Findings indicate that while overall R&D spending and activity levels are on the rise, though R&D intensity see a declining trend. Notably, SMS firms demonstrate higher R&D intensity in both low- and high-tech sectors compared to larger firms, though their intensity have been dwindling in the wake of pandemic, especially in high-tech industries segment. R&D spending in pharmaceutical industry now accounts for more than half of the overall organized manufacturing sector's R&D, while the recent decline in R&D spending within the motor vehicle industry is concerning. The double-hurdle regression analysis shows that larger firms, those with foreign capital, and those in high-tech industries are more likely to engage in R&D and invest more in it. Factors such as firm age and location in high-industrial activity concentration areas also significantly influence R&D investment. Although the product-subsidy coefficients were positive, they were less significant in impacting the R&D engagement likelihood, suggesting that while subsidies can support R&D, their direct impacts are often limited. However, firms receiving subsidies on a larger number of products experienced a significant positive influence on their R&D activities. For SMS firms, the results indicate that they may benefit more from subsidies and technology imports, pointing towards potential policy interventions to enhance their R&D efforts.*]

Keywords: *Manufacturing, R&D behaviour, R&D intensity, SMEs, Technology Intensity, Industrial Concentration, Product-Subsidy, India*

[*] Shailender Kumar Hooda, Associate Professor, ISID. Email: hooda@isid.org.in

Acknowledgements: This paper was presented in the ISID internal seminar and at the Winter School 2024 of the Delhi School of Economics held from December 12-14, 2024. The author is grateful to the ISID faculty, working paper committee members and reviewers, as well as and conference's participants and Chair, for their valuable suggestions. This work is result of an ICSSR-sponsored project titled "Fostering Medical Device Industry of India: Issues, Challenges and the Way Forwards." I am thankful to the ICSSR for providing financial support.

1. Introduction

Globally, there is increasing recognition of the importance of enhancing investment in Research and Development (R&D) to drive innovation, boost competitive performance, and support industrial growth through technological advancement (Griliches, 1979). Studies have highlighted that R&D plays a crucial role in generating the know-how necessary for producing high-quality products and improving efficiency, which is essential for long-term competitiveness and innovation. Additionally, technological self-reliance is vital for absorbing, adapting, and upgrading imported technologies (Cohen and Levinthal, 1989). Thus, investment in R&D by the industry becomes critical for industrial transformation and for its future expansion.

It is important to acknowledge that firms engage in R&D activities at different scales depending on their financial strength, ability to handle global competition, and resilience to shocks such as pandemics. In general, larger firms often possess substantial resources that enable them to undertake expensive and risky innovation projects, whereas smaller firms may struggle to do so (Schumpeter, 1942). They (large) are typically better equipped to manage global competitive pressures due to their superior strategic assets and resources, whereas small and medium enterprises (SMEs) often face greater vulnerability (Etemad, 2004; Fishman and Rob, 1999; Basant 1997). However, in advanced economies, particularly within high-tech sectors, SMEs are viewed as crucial drivers of economic and employment growth and are essential for achieving the desired structural transformation of economies (Nunes et.al., 2012). Research from these economies emphasizes that R&D investment is especially vital for high-tech SMEs (Stam and Wennberg, 2009; Lee, 2005). R&D investment by SMEs not only supports the creation of new products and more efficient production processes but also promotes strategic cooperation between firms (Nunes et. al., 2012). These interactions enhance knowledge spillovers (Coad and Rao, 2008) and improve absorptive capacity (Cohen and Levinthal, 1989). Conversely, SMEs in developing countries often have limited financial and intangible resources compared to larger firms. In country like India, SMEs face additional challenges from evolving policy regimes, such as restrictions on traditional reverse engineering practices and reduced benefits under modern industrial policies, including fewer exemptions from price controls, product reservations, and preferences in government procurement (Pradhan, 2011). Nevertheless, there is growing recognition of the crucial role SMEs play in developing economies (Morris et. al., 2001), including in India[1], as small technology start-ups frequently driving important innovations. A similar type of connotation was reported in Arrow (1962) that competitiveness can leads to enhanced innovation capability among small firms, whereas the larger entities may not lead the direction of innovation towards real technological change. Similarly, it is reported that although large firms usually invest more in R&D due to their ability to manage fixed costs and risks, SMEs can often advance technological change more rapidly due to their

[1] MSMEs in India makes a significant contribution with around 30% in national GDP, 49.5% in country's export and employment to around 120 million persons in 2019-20 (GOI, PIB, 2024).

greater agility (UNCTAD, 2005). Moreover, the need for SMEs to adapt to rapidly changing consumer preferences, shorter product life cycles, and increasing quality standards underscores the importance of their technological upgradation. Even otherwise, it is important to explore how micro and small businesses, often viewed as marginal and non-innovative, are participating in innovative activities, as discussed in Baumann & Kritikos (2016).

Indian policymakers, since the early years of Independence, have also emphasized the vital role of technology and innovation in tackling the country's development challenges and have stressed the importance of domestically generated technology. In addition to creating various state agencies to foster innovation across nearly all sectors of the economy, the government has also encouraged the private sector to invest in innovation and in-house R&D through a range of policy measures (Das and Joseph, 2010). Since 1973, India has been paying special attention towards encouraging R&D activities within industrial units through a scheme that grants official (with DST-Department of Science and Technology) recognition to in-house R&D units[2]. The purpose of this scheme is to offer liberalized import facilities for the procurement of equipment, components, raw materials, and other essentials needed for R&D to the registered units. These provisions aim to facilitate technology updates, enhance manufacturing processes, introduce new products and processes, and develop import substitutes. Such incentives are likely to have motivated industries to establish their own in-house R&D units to conduct R&D activities. In addition, a recent report of the Office of Economic Advisory Council to Prime Minister (EAC-PM) on “Research and Development Expenditure Ecosystem: The Way Forward,” highlighted the role of different size-class enterprises in doing R&D. It indicates that medium and large company registered in India should allocate a minimum percentage of their turnover to R&D (GOI, 2019 EAC-PM)[3].

In addition, the Government of India provides subsidies to registered manufacturing firms for specific products, particularly to reduce import dependency, enhance exports, and contribute to industrial growth. Such provisions are expected to positively impact firms' R&D activities[4] by enhancing their financial support and creating a competitive environment that drives innovation. These are also expected to enhance a firm's ability to invest in R&D by strengthening its financial position and encourage them to pursue

[2] A scheme for granting recognition to in-house R&D units in industrial sector to both private and public funded R&D laboratories was initiated by the Department of Science and Technology (DST) in 1973. This activity is being dealt by the Department of Scientific and Industrial Research (DSIR) since 1984 (GOI 2019-20)

[3] Before this EAC-PM report, the Indian Prime Minister had emphasised on to build a strong research ecosystem in the country and felt the need to add Jai Anusandhan in the current Jai Jawan, Jai Kisan, Jai Vigyan slogan, during his inaugural address at Indian Science Congress (ISC) organised between 3-7 January, 2019 (https://pib.gov.in/Pressreleaseshare.aspx?PRID=1558459).

[4] Though, a direct R&D subsidy is more likely to boost R&D, but such subsidy may also encourage R&D activities of firm.

innovative projects. Recently, India introduced the Production-Linked Incentives (PLI) scheme, which seeks to lower production costs and further reduce import dependence while enhancing exports. In the renewed and expanded focus of PLI scheme, the industry advocates for greater emphasis on R&D[5]. However, the extent to which these incentives and subsidies have achieved their intended goals requires thorough examination.

This paper contributes to the literature on firms' R&D activities in two ways. First, it provides nationally representative estimates of the distribution and trends in R&D spending, R&D propensity, and R&D intensity within the organized manufacturing sector of India, using the latest ASI (Annual Survey of Industries) data from 2015-16 to 2021-22, which has not been explored by any study so far. Second, drawing from the frameworks of Schumpeter (1942) and Arrow (1962) (discussed later), while factoring in product-subsidies, location of firm in industrial concentration areas, firm-specific characteristics, and other external factors, it examines the firm-level determinants of R&D behaviour in the organized manufacturing sector. In line with the EAC-PM (2019) report, which stresses the need for medium and large firms to allocate a minimum percentage of their turnover to R&D, the paper explore R&D trends across small, medium, and large firms. Analysis is extended for firms that have registered and unregistered with government agencies for R&D activities. Further, to gain a deeper understanding of the technological needs and innovation strategies of small and large firms, and to assess whether R&D activities vary across technology-intensive industries, firms have been categorised based on their technology intensity. This classification follows the frameworks outlined in Pavitt (1984) and Czarnitzki and Thorwarth (2012), with industries classified into low-tech, medium-low, medium-high, and high-tech categories.

The reminder of the paper is structured into following sections. Section-2 provide a detail background literature and framework used in the study. Section-3 gives detail on data sources, methodology, and empirical approach used. Section-4 offers an overview of R&D expenditure, R&D propensity and intensity across different firm segments. Section-5 discusses the results of regression analyses on the factors influencing R&D behaviour among various firms. Finally, Section-6 concludes the paper.

2. Literature and Framework: Selection of Relevant Variables for Empirical Analysis

The present study follows Schumpeterian (1942) framework while identifying the factors that influence R&D behaviour of firms. Schumpeterian view of innovation highlights firm size as a crucial factor influencing R&D behaviour (Cohen, 1995; Kumar and Siddharthan, 1994). Larger firms are often more diversified and technologically complex, with a greater

---

[5] https://www.healthcareradius.in/features/pharma/pli-scheme-industry-bats-for-rd-focus-widening-of-scope
https://pharmaceuticals.gov.in/sites/default/files/Guidelines%20for%20the%20Production%20Linked%20Incentive%20%28PLI%29%20Scheme%20for%20Promoting_1.pdf

awareness of technological opportunities. They are also better positioned to invest in R&D due to their significant market power and financial resources. This allows them to manage the risks and uncertainties associated with R&D more effectively (Lall, 1992). Consequently, firm size, which serves as a proxy for a firm's resource base, risk perception, and economies of scale, is expected to positively influence R&D behaviour (Pradhan, 2003). Therefore, a significant number of studies have explored the factors influencing R&D behaviour of firms following the Schumpeterian framework and reported that economies of scale tend to favour larger firms, which often possess substantial resources that enable them to undertake costly and risky innovation projects, while smaller firms may struggle to do the same.

Literature highlights that targeted government policies and support mechanisms, such as the product-subsidy, is important to boost firm's R&D investment, as subsidies create a significant leverage effect on R&D (Hassine and Mathieu, 2020). The impact of product subsidies on the R&D investment of new energy vehicle firms reported in Meng et.al., (2020). India also provide product-subsidy[6] to manufacturing firms especially to encourage export as well as becoming self-reliant on specified products. The subsidy extended with the purpose of export promotion and achieving self-reliance of specific products is expectedly to positively influence R&D activities by enhancing firms' financial resources and encourage them to pursue innovative projects especially to compete in the domestic as well as in global domestic market.

In India, a majority of industrial activities, in term of number of manufacturing units as well as sale generated, are concentrated in few states. Some states are more industrialised than others, as per our classification nine states. We believe that high manufacturing activity expected to positively influence R&D activities of firms located within them. Studies have highlighted that firms inside the industry clusters invest more R&D funds comparing with firms outside clusters (Hassine and Mathieu, 2020). This is because, the industrial concentration/clusters foster knowledge and technology spillover, enable collaborative research partnerships, attract skilled talent, provide shared resources, and drive market demand. To what extent industrial concentration/clustering enhance R&D activities by creating a supportive and resource-rich environment in Indian organised manufacturing sector is examined by identifying high industrialised states and rest of the states.

In addition, various studies ranging from Lall (1983) during the pre-globalization era to Kumar and Saqib (1996) and Kumar and Siddharthan (1994) in the early stages of globalization and thereafter Kumar and Aggarwal (2005), and more recently by Pradhan

---

[6] ASI, since 2015-16, started separately collecting information on 'product subsidy' (block-j) and 'other production subsidies' in block-g. 'Other production subsidies' refer to financial assistance provided by the government to producers or distributors to support the industry, prevent its decline, control prices, or encourage increased employment. While 'product subsidy' given to firms for promoting export and self-reliance of specific product. These products are classified at 7-digit NPCMS (National Product Classification of Manufacturing Sector) level. NPCMS classification is based on section 0-4 of 5-digit UN CPC (central product classification), Ver.2 that relate to the products of manufacturing sector. This study uses product-subsidy in the analysis.

(2011), Bhattacharya et. al., (2021), and Seenaiah (2023), amongst the others, have explored the factors influencing firm-level R&D behaviour. The study by Lall (1983) analysed the R&D behaviour of Indian firms, focusing on the factors affecting R&D intensity among the top 100 engineering firms in India in 1978. This study identified a positive correlation between R&D intensity and firm size. The study also found positive impact of factors such as age, technology imports, and foreign licensing agreements, while finds a negative correlation with export orientation. Kumar and Saqib (1996) investigated both R&D propensity and intensity in Indian context using data from the RBI for 291 manufacturing firms for a period of 1977 to 1981. They found that competitive pressure, export orientation, and vertical integration heightened the likelihood of engaging in R&D activities. Their analysis revealed that firm size positively influenced R&D propensity up to a certain threshold, while R&D intensity continued to increase linearly with firm size. However, they found no significant relationship between technology imports and R&D. Sasidharan and Kathuria (2011) utilized CMIE data from 1994 to 2005 and finds that foreign direct investment (FDI) positively influenced the R&D decisions of domestic firms in India. Pradhan (2011) study analysed the R&D expenditures of 4,071 SMEs in Indian manufacturing from 1991 to 2008 using CMIE Prowess data. This study identified a positive relationship between R&D intensity and factors such as age, firm size, export orientation, raw material imports, profit margins, foreign ownership and affiliation with domestic business groups. Seenaiah (2023) study empirically investigated the key drivers of R&D in high-tech manufacturing firms, using panel data from Prowess spanning for a period from 2001 through 2020 of firms ranging between 215 to 916 during the time. The findings of this study are in line with the Schumpeterian hypothesis that large sized firms are able to devote more investments on R&D. Most of Indian context studies provide a comprehensive view of the various determinants of R&D intensity and the impact of different factors on R&D behaviour in India. They highlight the significance of both firm-specific attributes and external factors in influencing R&D activities.

While using the other R&D influencing factors, studies have highlighted that older (age) firms are generally anticipated to be more experienced and to have developed greater technical skills and managerial maturity over time, which is expected to positively influence their R&D activities. The process of building technological capacity within a firm is incremental and cumulative, requiring the accumulation of knowledge, skills, and experience that foster continuous improvements in production processes, products, and procedures (Bell and Pavitt, 1992). As firms learn from their past production experiences, they leverage this accumulated knowledge to drive further technological advancements. The firm’s age, as an indicator of accumulated experience and technological learning, is hypothesized to positively impact R&D efforts in this study as well.

The firm’s foreign exposer, measured through different indicators, is another crucial factor. While highlighting the role of foreign capital, studies have reported the effect of foreign capital share on R&D activities is often unpredictable and can vary depending on the approach taken by multinational corporations (MNCs). MNCs might centralize their R&D

activities in their home countries and only transfer developed technologies to their affiliates in developing countries such as India. Alternatively, their advanced managerial skills and technological resources might lead them to adapt technologies to better suit local conditions. Consequently, the impact of foreign equity share on R&D behaviour can differ based on MNCs' strategies and operational practices. However, within the foreign orientation, the variable imported input technology reported to influence the R&D positively as R&D investment is vital for absorbing, adapting, and upgrading the imported technologies (Katrak, 1985, 1989 & 1997; Deolalikar et. al., 1989; Cohen & Levinthal, 1989; Bas & Paunov, 2018, Mo et. al., 2021). This study considered both these variables in the analysis.

With regards to the financial strength, several proxy variables of resource availability and firm capability for R&D activity have been analysed. Given the fact that R&D activity involves huge resource capability on the part of innovating firms, higher profit margins, which reflect a firm's internal resource generation, are likely to positively influence its R&D decisions (Himmelberg and Petersen, 1994; Kumar and Saqib, 1996; Kumar and Agarwal, 2005). This variable also accounts for the effects of fiscal incentives, such as tax exemptions provided to firms with recognized R&D units. All else being equal, a higher profit margin is expected to encourage firms to invest more in R&D and allocate a greater proportion of their sales towards these activities. Similarly, higher GVA indicates that a firm or sector is generating substantial economic value, which often translates into increased profitability and available capital. This surplus can then be allocated towards funding innovative projects and R&D initiatives (Griliches, 1995). That is, higher GVA expected to promote R&D by providing the financial resources and economic stability necessary for investment in innovation. It also creates an environment conducive to continuous improvement and competitive advantage, which further encourages R&D activities.

The managerial skills generally affect a firm's absorptive capacity and resource allocation towards R&D. A higher share of supervisory and managerial staff in a firm can positively influence R&D activities by improving strategic decision-making, resource allocation, and overall management of innovation processes. Firms, especially in technology and high-growth sectors, benefit from strong managerial oversight to navigate regulatory challenges, technological advancements, and competitive pressures. Therefore, share of supervisory and managerial staff in the total number of employees in a firm can indeed influence R&D activities, particularly in the Indian context, where skill levels and managerial expertise are crucial for driving innovation.

Literature highlights that high-tech industries generally exhibit higher R&D investments due to their need for continuous innovation and competitive pressures. They are also more likely to invest heavily in technology because their business activities are closely associated with science and technology. The low-medium-tech industries also engage in substantial R&D but to a lesser extent. In general, the low-tech industries have comparatively lower R&D activities, focusing more on incremental improvements. In order to assess whether technological level of an industry can significantly influence its R&D activities, a dummy for tech-level of firms is taken.

3. Data and Method

3.1. Data Sources

Studies in Indian context thoroughly examined the factors that influence R&D behaviour of firms and have also tried to present the general trends in R&D spending. Our comprehensive literature review reveals a significant gap in comparable data on industrial R&D, which has hindered their ability to identify the general trends in R&D investment and activities within organised sector industrial units. Research on the R&D activities of Indian firms has relied on various data sources (Mani 2008). Some have utilized primary data from small samples of firms, while others have relied on R&D data compiled from firm statements by CMIE-Prowess. Additionally, some studies have used databases of factories registered with the Department of Science and Technology (DST), when assesses the overall trends in R&D spending (Mani 2010). A key limitation of these datasets is that they do not fully represent the organized manufacturing sector of India, as R&D data for this sector was not available in public domain prior to 2015-16. Some earlier studies also made connotation that DST data generally fails to capture all aspects of firm R&D activities and significantly underestimates actual R&D investments (Bhattacharya and Lal 2008; Pradhan 2011). The DST dataset is limited to firms registered initially with DST (up to 1973-1984) and subsequently with the Department of Scientific and Industrial Research-DSIR, thus missing firms that do not register their R&D units or those registered with other agencies. Similarly, the CMIE-Prowess database includes only those firms that publish annual financial reports, specifically those registered under the Indian Companies Act 1956. Consequently, it excludes firms that do not disclose their annual reports. Additionally, according to the Indian Companies Act, 1956, firms are not required to report expenditure categories that constitute less than one percent of their turnover. Since, R&D expenditures are often relatively small—typically, less than one percent of turnover—this can lead to significant underestimation. Although Prowess data enables the exploration of a range of factors that could affect firms' R&D activities.

Since 2015-16, the Annual Survey of Industries (ASI) has started collecting data on R&D units and expenditures. This development enables more accurate analysis and prediction of industrial R&D activities and trends. It is important to note that ASI is the primary source of industrial statistics in India, capturing data on the entire registered manufacturing sector since 1960, commonly referred to as the organized manufacturing sector survey. This study utilizes latest ASI unit-level data from the period 2015-16 to 2021-22, which is particularly significant for several reasons. First, since 2015-16, the ASI schedule, for the first time, began collecting information on two key variables related to R&D: whether R&D unit present in the factory and the amount of R&D expenditure incurred by firms. Second, the ASI sampling design underwent notable changes starting from 2015-16, following the recommendations of Sub-Group of SCIS (Standing Committee on Industrial Statistics) approved by National Statistical Commission (GOI, 2016, p.3). This new sampling design ensures that the data is both comparable and comprehensive, including detailed information on firm-level R&D activities and other relevant variables.

The ASI data collects information on firm's R&D activities through two specific questions. The first question (in block-b) identifies whether a factory has an R&D unit, with options including: (i) yes & registered with DST/DBT (Dept. of Science and Technology / Dept. of Bio-Technology), (ii) yes & registered with another agency, or (iii) no R&D unit in the factory. The level of R&D expenditure is recorded separately in block-f, capturing expenses directly associated with R&D activities, excluding routine expenses. These two questions are used to assess the R&D activites of firms.

It is important to note that the ASI survey frame includes factories under the 'Joint Return' (JR) scheme, which permits multiple units within the same state, sector, and industry (NIC-3) that are under the same ownership to file a single consolidated return. These units may choose to file returns for each unit individually. If a factory has two units and one is exclusively engaged in R&D activities, the sales data for that R&D unit may not be reported in the ASI data. To ensure overall estimation of R&D spending, our preliminary analysis include information from all units that involved in R&D, even if sales data remain missing for some of them, however, for empirical analysis, firms with no sale data were excluded.

The ASI frame also encompasses factories categorized as 'existing with fixed assets and maintaining staff but not having production' and 'existing with fixed assets but not maintaining staff and not having production.' For the analysis purpose in present study, only operational factories are considered.

The study utilizes the multipliers provided in the data as weights to arrive at the nationally representative estimates for various indicators, like for number of manufacturing units, R&D doing firms, R&D spending, firms' turnover (i.e., sale), gross value of output, number of employees, and export and import figures, as well as for other relevant variables necessary for the analysis. One should note that ASI data might have some limitations especially in exploring various variables that could influence firm's R&D activities, such as the R&D stock, tax incentives for R&D, technological upgrades, royalties, foreign collaborations, and extent of foreign equity share in entity, among others, but ASI has an edge over other data sets as it represents the entire organised manufacturing sector of India.

3.2. Classification of Firms

To examine whether small and medium size (SMS) firms engage in R&D investments and whether their R&D behaviour aligns with that of larger firms, the analysis is conducted by categorizing firms by size as—micro, small, medium, and large. In order to classify the firm by size, study used latest definition of Indian MSMEs[7]. It is important to clarify that

---

[7] MSMEs definition: Micro: - Investment in Plant and Machinery or Equipment: Not more than Rs.1 crore and Annual Turnover; not more than Rs. 5 crore; Small: - Investment in Plant and

Contd…

the definition of MSMEs typically applies to enterprises, while ASI data focuses on factories. However, one may also note that over 90 percent of the sample factories in ASI unit-level data are single-unit operations, which can be considered enterprises. Additionally, the ASI survey permits multiple units under the same ownership in the same state, sector, and (NIC 3-digit) industry to submit a consolidated return, reinforcing their classification as enterprises. However, it is important to note that ASI only includes registered census and sample firms that meet specific employment criteria. Consequently, unregistered units and those with fewer than 10 workers—typically referred to as MSMEs—are likely to be underrepresented in ASI dataset. Therefore, caution is advised when using the term SMEs in analyses based on ASI data. However, using ASI unit-level data, one can get an insight into small and medium size (SMS) units that satisfy the turnover and investment criteria used to define MSMEs and can call them as small and medium size (SMS) firms. In this paper, we have used turnover and investment criteria just to classify small and medium size (SMS) firms and the terminology SMS firms and SMEs has been used interchangeably just to enhance readability.

In many studies, firms have also been classified based on the number of employees in their factories. In general, the firms with fewer than 20 employees had been categorized as micro-sized, those with 20 to 49 employees as small-sized, and those with 50 to 249 employees as medium-sized. In addition to following the new MSMEs definition for firm size representation in the ASI, the study also adopts a more detailed approach, using a range of employee numbers for size classification of firm. We have used the size-classification as >0 and <20, >=20 and <50, >=50 and <100, >=100 and <200, >=200 and <500, >=500 and <1000, >=1000 and <2000, >=2000 and <5000, and 5000 & above. One may refer these categories as tiny, mini, micro to small, middle, or big, large, and huge-sized firms.

Table 1: Tech-Level Classification of Industries

Tech-level Classification	*NIC-3 digit codes*
High-Tech Industries-4	210, 261, 263, 264, 265+266+267,281+262
Medium-High-Tech Industries-3	201, 202, 203, 271+273, 272, 274, 275, 279, 282, 291, 292, 293, 302, 309
Medium-Low-Tech Industries-2	192, 221, 222, 231, 239, 241, 242, 243, 251, 259, 301
Low-Tech Industries-1	101+102+103+104, 105, 106+108, 107, 110, 120, 131, 139, 141, 143, 151, 152, 161+162, 170, 181, 321+322+323+324+329

Source: Adopted from Rijesh (2016) with some modifications to align it with NIC-3 digits

Given the importance of industry classification by technology level, we have utilized tech-level classification for Indian context presented in Table-1

Machinery or Equipment: Not more than Rs.10 crore and Annual Turnover; not more than Rs. 50 crore; Medium: - Investment in Plant and Machinery or Equipment: Not more than Rs.50 crore and Annual Turnover; not more than Rs. 250 crore (https://msme.gov.in/know-about-msme).

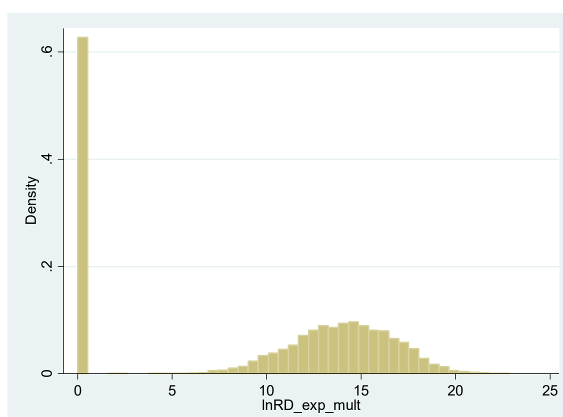
3.3. Empirical Approach

The estimation procedure followed in the study is guided by the way in which data is reported in ASI. In ASI unit-level data, firms are asked whether they are registered with DST/DBT or with other agencies for doing R&D activities. Data reported in Appendix-1 show that not all factories registered with DST/DBT for R&D are actually engaged in such activities. Similarly, not all factories registered with other agencies are involved in R&D. Additionally, some firms are actively conducting R&D without being registered with any agency. Such data reporting enforces us to categorize firms as active R&D doing firms and inactive R&D firms, and by combining these categories, we determined the total number of (active + inactive) R&D firms.

The R&D activities of firms are then conceptualized in two stages. First, firms decide whether to engage in R&D, a binary choice reflecting the likelihood of performing R&D. Second, for firms that do choose to engage in R&D, we examine how much to invest in it, which presents a truncated sample problem. Our dataset reveals a significant number of firms with zero R&D expenditure, as firms not participating in R&D naturally report zero values. This clustering at zero introduces a corner solution problem (Figure 1). To tackle the bias and inconsistency associated with this issue, the literature offers several modelling approaches, like the Tobit model (Tobin, 1958), Heckman selection (two-stage) model (Heckman 1979), and the Cragg double-hurdle model (Cragg 1971).

In dealing with the case of corner-solutions, a standard Tobit model has a limitation due to a restrictive assumption that the same parameters and hence, same underlying processes determine both the probability of a positive value of the dependent variable and the actual value, given that the observed value is non-zero (Smith and Brame, 2003; Engel and Moffatt, 2014). In simple terminology, the Tobit model assume that the factors explaining the decision to participate in R&D activity and how much a firm spend on R&D has the same effect on these two decisions. This model cannot handle the situation in which participation and amount spend on R&D may be a separate decisions, possibly influenced by different variables or by the same variables but in different ways.

Figure 1: Representation of Corner solution problem in Firm's R&D activity in ASI data



Source: Author's estimates from unit-level data of ASI

The Heckman selection model is generally viewed as a 'generalised version of the Tobit model', as it observes the decision of R&D in a two-stage process and allows the use of different sets of explanatory variables in both stages of estimations whereas the Tobit uses a one-step procedure. In

Heckman model first stage is a Probit estimation. In addition, Heckman model is generally used and suitable in case of sample selection problems due to missing values (Wooldridge, 2010).

In the Cragg model, the firms are first assumed to decide whether to participate in the R&D activity by registering themselves with an appropriate agency (as discussed in Appendix-1, firm register themselves with DST/DBT/or other agency for R&D activity), and then in the second stage they decide how much to spend on R&D. This gives scope for these effects to differ, model the decision process in two steps. It is also important to note that the Cragg two-stage model is suitable when the zeros are reported and not missing. In our case, many firms register themselves for R&D activity but are not active in doing R&D spending, so Cragg model is more suitable in this context. The Cragg double hurdle model is more flexible and suitable alternative over a standard Tobit model as it involves a Probit model estimation for the binary choice problem in the first stage and a truncated model in the second stage, thereby assuming two separate processes determining the two outcomes in the two stages (Smith and Brame, 2003; Engel and Moffatt, 2014).

Since, Cragg model is more suitable when the zero R&D values are reported, however, missing value are also there when one look at the entire data reporting. This motivates us to use Heckman two-stage model as well, to separately analyse the R&D behaviour in the first stage and R&D intensity/expenditure in the second stage along with the Cragg double-hurdle model. Heckman two-stage model is especially relevant to examine the factors for sample when one choose to spend and other have missing value. This model is easy to execute by estimating the lambda and mills ratio in the second stage. In order to correct the selectivity bias mills ratio is created using predicted probability value obtained from first stage Heckman estimation of participation in R&D activity. The mills ratio is then included as an explanatory variable in the model in the second stage Heckman model regression estimation to address selectivity bias (Cameron and Trivedi, 2005).

In case of Cragg two-step model, several authors have developed STATA command to estimate the double hurdle model like the chaggit by Burke, churdle/dbldurdle by Garcia and xtdhreg by Engel and Moffatt. To address unobserved individual heterogeneity in panel data, this paper employs the xtdhreg command developed by Engel and Moffatt (2014) for STATA. The STATA-16 has been used for empirical investigation. The xtdhreg command allows for fitting a panel-hurdle model that accommodates dependence, offering greater flexibility than the original Cragg model by enabling correlation between individual-specific error terms across the two estimation stages (Engel and Moffatt, 2014).

3.4. Estimated Equations: Double Hurdle Model

Building on the discussion of firm-level determinants of R&D activities, we specify following two stages Heckman and Cragg hurdle equations. The importance of variables used in model has already been reported in literature and framework section.

Stage-1: – Likelihood of engaging in R&D

$$RDDit = \propto 0 + \beta 1(AGEit) + \beta 2(AGE^2 it) + \beta 3(SIZEit) + \beta 4(FCSit) + \beta 5(MITit) + \beta 6(PGSit) + \beta 7(lnGVAit) + \beta 8(SKILLit) + \beta 9(TLIit) + \beta 10(HISit) + \beta 11(PSit) + \varepsilon it \quad ...(1)$$

Stage-2: – Extent of R&D spending

$$lnRDit = \propto 0 + \beta 1(AGEit) + \beta 2(AGE^2 it) + \beta 3(SIZEit) + \beta 4(FCSit) + \beta 5(MITit) + \beta 6(PGSit) + \beta 7(lnGVAit) + \beta 8(SKILLit) + \beta 9(TLIit) + \beta 10(HISit) + \beta 11(PSit) + \varepsilon it \quad ...(2)$$

where,

RDD – (R&D dummy) represents whether firm is active in doing RD, i.e. positive spending on R&D. It takes a value 1 if R&D expenditure is greater than zero, and 0 if a firm reports no R&D expenditure, for equation-1.

lnRD: (log of R&D) is the natural logarithm of R&D expenditure of the ith firm in time period t, for equation-2.

Age: Indicates the firm's age, calculated as the difference between the current year and the year of initial production.

Age2: The squared term of the Age variable.

Size: (Size of workers) is the measures of firm size based on number of employees. It represents the natural logarithm of number of employees (no of person engaged) in the firm.

FCS- (foreign capital share) represents whether the share capital of the company includes share of foreign entities, 1 for yes, 0 otherwise[8].

MIT – (imported input technology) represent whether firm do import input, measured as share of imported input in total (indigenous + imported) inputs.

PGS- (profit GVA share) represents the share of profit in GVA of the firm

lnGVA – (log of GVA) represents natural logarithm of the actual value of GVA

SKILL- represents share of supervisor & managerial staffs in total no of person engaged of the firm

TLI – (technology level of industry), represent the 0 for low-tech and low-medium tech industry and 1 for medium-high tech and high-tech industry which are classified using 3-digit NIC classification presented in Table-1.

HIS – (high industrial activity states) refers to industry concentration in states that have a higher share of sales and number of units compared to the national average, typically exceeding 5% in any one of the given study year. We identified nine states with these share criteria. The HIS variable is coded as 1 for these nine states and 0 for remaining states.

PS – (product subsidy) takes the value 1 if the firm has received a product subsidy on any of the NPCMS product item and 0 otherwise. In addition, number of product items for which a firm has received subsidies has been used for robustness checks.

In Cragg model, R&D firms are those firms that are registered with any agency for R&D activity, whereas, firms that do not spend on R&D, they are just registered themselves at government platform especially to receive schemes' benefits, are treated a non-R&D firms. The equation-1 examines likelihood of engaging in R&D while equation-2 for extent of R&D spending. We have included most of the variables of equation-1 (age, size, GVA and firm's location and other variables) as selection variables in the lognormal linear equation-

[8] The amount of foreign capital share is not available with ASI

2, especially to assess the likelihood of R&D behaviour as well as linear functional relation with R&D spending in one go in both Cragg and Heckman models. The first stage Heckman selection results (equation 1) are not presented, simply because the coefficient signs were similar as reported in the second stage estimation.

Our data spans the period from 2015-16 to 2021-22, involving cross-sectional units, which implies that panel data can be created. It is important to highlight that, according to the ASI data instruction manual, a unique Despatch Serial Number (DSL) is assigned to each selected unit for both Census and Sample schemes to track the dispatch of completed schedules. These DSL numbers are unique within each survey year but vary from year to year for the same factory, as they only denote the dispatch sequence only. As a result, DSL numbers cannot be used as a consistent identifier for units across different years. Previous research by Dubey and Roy (2022) incorrectly used the DSL number as a unique identifier for firms while using data from 2015-16 to 2017-18, assuming it was consistent across years for ASI firms. Such approaches lead to inaccuracies in creating panel data and results in inappropriate estimates. In contrast, our study employs a cohort-based approach to establish a consistent identifier for survey units across the study period, ensuring a proper panel data structure (Deaton, 1985).[9] The cohort identifier (created using NIC-5 digits, year of initial production, and location-state of the survey unit) enables tracking factories across years and facilitates us to create a strong balanced and unbalanced panel using cohort ID. An unbalanced panel (pooled) data have also been created for empirical analysis, for robustness check, for entire sample while estimating the Heckman selection model.

The appended file contains 3,12,209 observations for industries classified under NIC-2 digit codes 10 to 32 for the entire study period for firms with non-zero sale (Appendix 2). After creating the cohort identifier, the dataset is reduced to 1,71,591 observations in an unbalanced panel. There are approximately 22,719 observations in a strongly balanced panel for non-missing values. The strongly balanced panel ensures that no identifier is repeated. In the unbalanced panel, in case of repeated identifiers across years, they were addressed by readjusting the above reported cohort identifiers with sector (rural, urban) code. The empirical analysis in this paper is based on these datasets.

In order to assess the general trends in R&D activity, the study has examined R&D propensity (number of R&D doing units by total operational units) and R&D intensity (amount of R&D spending by total turnover (i.e., sale value) of units that spend on R&D)

---

[9] Panel data analysis using cohort id is not free from bias, however, bias may be negligible for reasonable cohort sizes (say over 200 units). In practice a large cohort sizes (long with enough time variation in the true cohort means of the explanatory variables) are needed to validly ignore the cohort nature of the data. If there is no time variation at all (wl - 0), the bias in the within estimator is bounded, while the errors-invariables estimator proposed by Deaton (1985) has a non-existing probability limit. A good selection criterion of cohort must have: (1) a characteristic that does not change over time on an individual basis, define a stable (sub-) population, and result from a trade-off so that (2) large enough cohorts can be formed (3) without losing too much variability.

in Indian organised manufacturing sector. A robustness of the measures of R&D intensity is done using other indicators such as share of R&D spending in ex-factor value of output, value of total output, gross value addition (GVA), net value addition (NVA) or profit.

4. Analysis of R&D Activity of Firms: An Overview

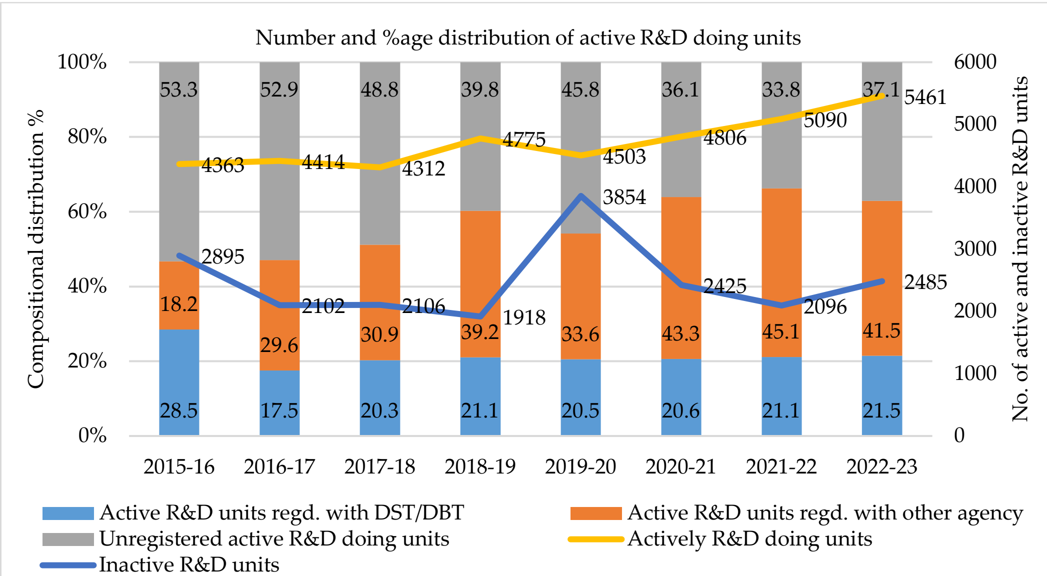
4.1. Trends in R&D Activity by Registration Status

In Indian organised manufacturing sector, around 7258 units found to be R&D units in 2015-16 which increased to 7946 units in 2022-23 (Figure 2). Of these units, around 60% units were actively doing R&D investment in 2015-16. The share of actively R&D doing units increased to 69% units in 2022-23. Thus, one can see an increase in the percentage of active R&D units among all R&D units over time, reflecting a growing emphasis on research and development in Indian manufacturing sector. The analysis by registration status shows that R&D engagement of firms registered with DST/DBT has remained relatively stable, whereas the number of factories registered with other agencies for R&D activity has nearly doubled during the study period.

We found that not all factories registered with DST/DBT for R&D are actually engaging in R&D activity. However, the share of active R&D doing units with the DST has risen over the years from 39.79% in 2015-16 to 65.87% in 2021-22. On an average around 52.5% of DST/DBT registered units were actively conducting R&D between 2015-16 to 2021-22 (Appendix 1). Similarly, not all units registered for R&D with other agencies are actively involved in R&D. The proportion of R&D units registered with other agencies and actively engaged in R&D has shown some variability, there is an upward trend in recent years. It is noteworthy that some of units that are not registered for R&D anywhere are also investing in R&D. The number of such factories however have been gradually declining, but their number still substantial, on average 2026 units between 2015-16 to 2021-22. This trend may indicate that firms are more frequently registering with various agencies to take advantage of government schemes and benefits. If one look at the share of active R&D doing units registered with DST/DBT compared to the total R&D doing units, it appears that, on average, around 78.7 percent of these units fall outside the scope of DST/DBT. This suggests that industries beyond those traditionally covered by DST/DBT (which primarily focus on science-based activities) have high participation in R&D activity. We see a rising share of active R&D doing units registered with other agency from 18% in 2015-16 to 41.5% in 2022-23 (Figure 2).

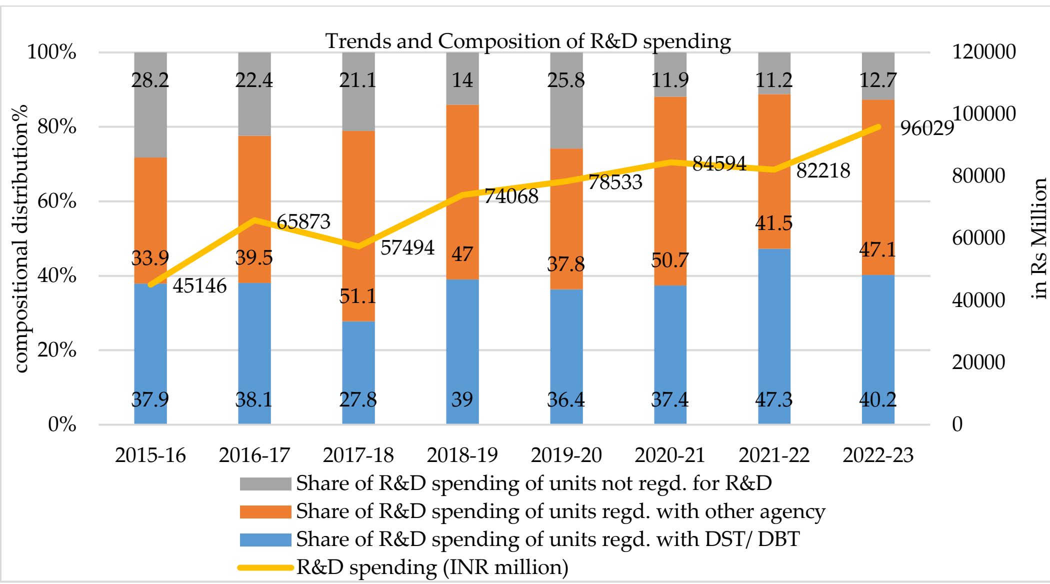
The R&D spending in Indian organised manufacturing sector see a sharp rise, more than double, during the study period, which increased from INR 45146 million in 2015-16 to INR 96029 million in 2022-23. The manufacturing units registered with DST/DBT accounted for an average 38% of R&D expenditures from 2015-16 to 2022-23 (Figure 3). The remaining 62% of R&D spending came from firms registered with other agencies (43.5%) or those not registered (18.4%) but still actively engaged in R&D. This suggests that previous studies relying solely on DST data to assess R&D landscape of organised manufacturing sector of the country have captured only 38% of total R&D expenditure of organized manufacturing sector, leading to an underestimation of overall R&D spending. We see an increasing share in R&D spending of registered units in total R&D spending during the study period, while share of R&D spending of units that are not registered for R&D activity is declining from 28.2% in 2015-16 to 12.7% in 2022-23.

Figure 2: Number and Distribution of Active R&D Doing Units in ASI sector



Source: Author's estimates from unit-level data of ASI

Figure 3: Composition of R&D spending of R&D doing units



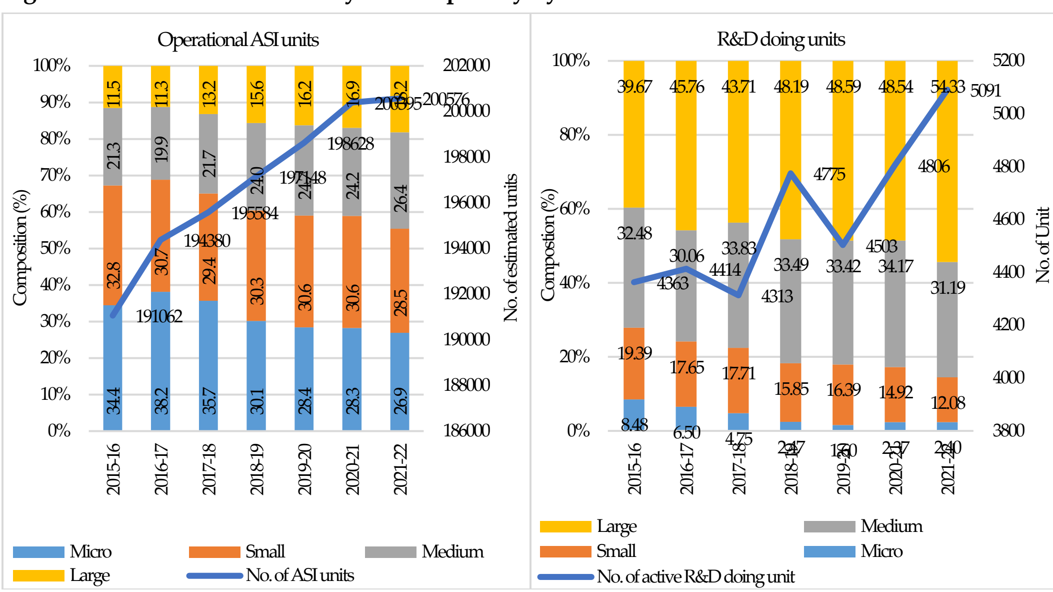
Source: Author's estimates from unit-level data of ASI

4.2. R&D Activity and Propensity by Firm-Size

The data presented in Figure-4 shows an overall increase in the number of operational factories in the ASI sector, rising from 191,062 in 2015-16 to 200,576 in 2021-22. During this period, the share of micro factories decreased from 34% to 27%, while small factories fell from 33% to 28.5%. In contrast, medium-sized factories saw their share grow from 21% to 26.4%, and large factories increased from 11.5% to 18.2%. The SMS/SMEs (the sum of small and medium categories) accounted an approximately 55% share in total operation units (Figure 4).

The status of R&D engagement revealed an increase in the number of active R&D firms, rising from 4,363 to 5,091 between 2015-16 to 2021-22. However, this growth was not uniform across all firm sizes. Micro and small firms experienced a decline in R&D engagement, while the share of medium-sized units remained relatively stable at around 33 percent. In contrast, large factories saw a significant increase in their share, growing from approximately 40% in 2015-16 to 54% in 2021-22 (Figure 4). The sudden spike in R&D doing units in 2018-19 might be because, that Prime Minister of India added a slogan Jai Annusandhan in the existing slogan of Jai Jawan, Jai Kishan, Jai Vighan and firm might have started reporting R&D data, though it became ineffective in the following year.

Figure 4: Trends in R&D Activity and Propensity by Firm-Size



Source: Author's estimates from unit-level data of ASI

The R&D propensity (the share of R&D doing unit to total operational units) slightly increased from 2.28% to 2.54% during the study period. Despite this, micro factories saw a decline in R&D propensity from 0.62% to 0.27%, small factories from 2.62% to 1.98%, medium factories from 6.04% to 5.78%, and overall SMEs from 3.48% to 3.07%. In contrast, large factories experienced an increase in R&D propensity from 13.52% to 14.65% (Table 2).

Table 2: Trends in R&D propensity

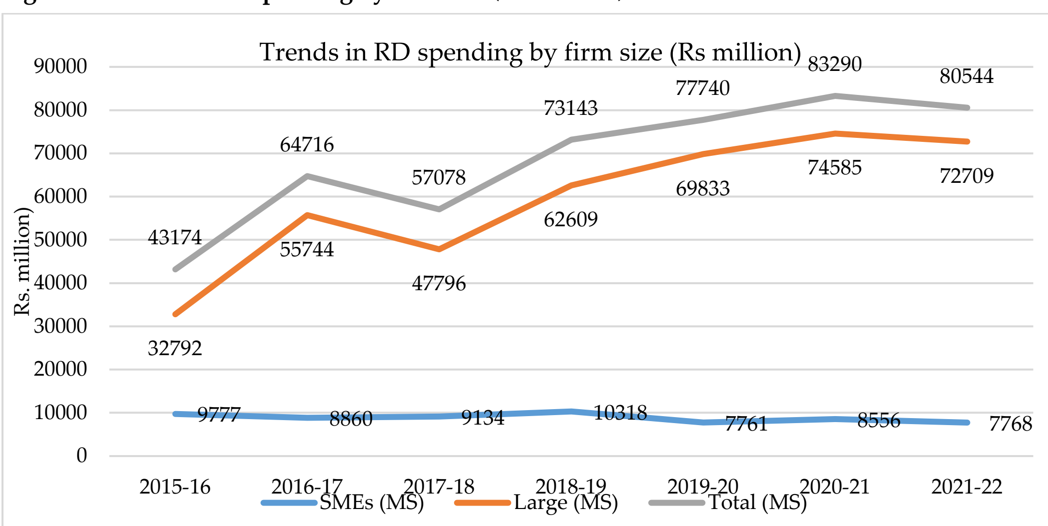
	2015-16	*2016-17*	*2017-18*	*2018-19*	*2019-20*	*2020-21*	*2021-22*
Micro	0.62	0.45	0.40	0.38	0.34	0.33	0.27
Small	2.62	2.25	2.36	2.30	2.12	2.23	1.98
Medium	6.04	6.52	5.46	6.18	5.70	5.50	5.78
Large	13.52	15.06	13.63	14.14	13.36	14.27	14.65
SMEs	3.48	3.35	3.16	3.35	3.05	3.12	3.07
Total	2.28	2.27	2.21	2.42	2.27	2.40	2.54

Note: the share of R&D doing to total operation factories is the R&D propensity
Source: Author's estimates from unit-level data of ASI

4.3. R&D Spending and Intensity by Firm-Size

For manufacturing firms (2-digit NIC2008: 10-32), We see a significant rise in R&D spending from Rs. 43,174 million to Rs. 80,544 million, nearly doubling over the study period. This increase was particularly notable among large factories whose R&D spending increased to more than double during the period. The smaller factory categories saw a reduction in their R&D expenditures, especially in recent years, starting from COVID year (Figure 5).

Figure 5: Trends in RD spending by firm size (Rs. million)



Source: Author's estimates from unit-level data of ASI; Note- MS-manufacturing sector

The compositional share of R&D spending suggest that large firms constituted a high share about 73.38% in 2015-16 which increased to 89.08% in 2021-22. The micro-size firms constitute a marginal share in R&D spending. The share of R&D spending declined for both small and medium size segments, while decline was much sharper in case of small firms. Their (SMEs) overall share in R&D declined from 25.21% to 10.82 during the study period. Despite the increase in overall spending, R&D intensity at aggregate level declined from 0.580 to 0.347 (Table 3). This decrease in R&D intensity was observed across all factory sizes, including micro, SME, and large firms, indicating a general reduction in R&D investment relative to turnover. The measures of R&D intensity using different other indicators such as share of R&D spending in ex-factor value of output, value of total output, gross value addition (GVA), net value addition (NVA) or profit, in all cases ,sees a declining trends, though intensity vary in size across these measures for both SMEs and large entities (Table 3).

Table 3: Trends in R&D Spending and intensity by Firm-size

	2015-16	*2016-17*	*2017-18*	*2018-19*	*2019-20*	*2020-21*	*2021-22*
	Composition of R&D spending						
Micro	1.41	0.29	0.30	0.29	0.19	0.18	0.10
Small	12.31	3.09	4.02	2.47	1.85	2.06	1.75
Medium	12.90	11.78	12.40	12.41	8.68	9.24	9.07
Large	73.38	84.84	83.28	84.84	89.29	88.52	89.08
SMEs	25.21	14.87	16.42	14.87	10.52	11.30	10.82
Total (Rs. Million)	45146	65873	57494	74068	78533	84594	82218
	R&D intensity: R&D spending by turnover						
Micro	6.657	2.567	2.107	2.966	1.775	2.295	2.140
Small	2.322	0.929	0.998	0.767	0.607	0.747	0.630
Medium	0.689	0.841	0.871	0.908	0.760	0.791	0.607
Large	0.495	0.674	0.524	0.546	0.659	0.546	0.330
SMEs	1.050	0.858	0.899	0.881	0.728	0.783	0.610
Total	0.580	0.698	0.564	0.580	0.667	0.566	0.347
Overall	***Measuring R&D intensity using different indicators***						
RD/ex-factory value	0.64	0.84	0.65	0.41	0.72	0.63	0.38
RD/Value of total output	0.59	0.69	0.56	0.56	0.64	0.56	0.34
RD/GVA	2.80	3.16	2.61	2.55	2.92	2.54	1.69
RD/NVA	3.29	3.72	3.08	2.95	3.46	3.02	1.95
RD/profit	6.69	7.27	6.31	5.67	6.83	5.46	3.03
SMEs							
RD/ex-factory value	1.44	0.94	0.93	0.60	0.89	0.79	0.75
RD/Value of product	1.42	0.82	0.81	1.07	0.88	0.78	0.74
RD/Total output	1.22	0.72	0.72	1.02	0.77	0.69	0.64
RD/GVA	5.24	3.06	3.00	3.91	3.28	2.65	2.63
RD/NVA	5.89	3.42	3.34	4.33	3.67	2.93	2.89
RD/profit	16.57	3.42	3.34	4.33	3.67	2.93	2.89
Large							
RD/ex-factory value	0.55	0.82	0.62	0.39	0.70	0.62	0.36
RD/Value of product	0.54	0.76	0.59	0.58	0.69	0.61	0.36
RD/Total output	0.51	0.68	0.54	0.52	0.63	0.56	0.33
RD/GVA	2.46	3.15	2.56	2.42	2.89	2.53	1.64
RD/NVA	2.91	3.72	3.03	2.82	3.44	3.02	1.89
RD/profit	5.70	7.03	6.00	5.27	6.57	5.34	2.87

Source: Author's estimates from unit-level data of ASI

4.4. R&D Propensity and Intensity by Size of Employees

An analysis of R&D propensity across firm sizes based on employee numbers reveals distinct trends from 2015-16 to 2021-22 (Table 4). Very small firms (0-20 employees), typically with fewer employees, demonstrate low R&D propensity, with their share of R&D-performing firms dropping sharply from 13.55% to 5.70%. This decline is attributed to their limited resources and infrastructure for extensive R&D activities. In case of firm-size with 20-49 employees, the R&D-performing firms comprising about 14.67% to 12.43% of the total R&D doing units. These firms see a declining R&D propensity ranges from 1.59% to 1.38%. For firms with 50-99 employees, there is a noticeable decline in the proportion of R&D-performing firms from 13.22% to 9.72% along with the decline in R&D propensity. In firms with 100-199 employees, the proportion of R&D-performing firms is higher than smaller firms and their share remained almost constant hovering around 15% and demonstrate higher R&D propensity. For firms with 200-499 employees, the proportion of R&D-performing firms is one of the highest and show rising trends from 18.66% to 21.67% along with a rise in R&D propensity 7.76% to 8.26%. Firms with 500-999 employees also show high and rising trend in R&D propensity, their share in total R&D performing units also increased from 9.88% to 13.20%. Firms with 1000-1999 employees exhibit rise in R&D propensity as well as in R&D units. Similarly, firms with 2000-4999 employees demonstrate high R&D propensity, which increased from 14.45% to 20.03%. The largest firms, with 5000 or more employees, show very high R&D propensity, rising from 32.05 to 48.09%, with an increase in the share of R&D-performing units from 4.40% to 7.17%. This analysis reflects that large firms having more than 1000 employees conduct significant R&D activities.

The analysis of R&D intensity suggests decrease in intensity from 2.13% in 2015-16 to 0.75% in 2021-22 for firms with fewer than 20 employees (Table 4). Their share of total R&D spending declined from 0.81% in 2015-16 to 0.14% in 2021-22, indicating minimal investment in R&D by these firms. For firms with 20 to 49 employees, R&D intensity has dropped from 1.96% in 2015-16 to 0.49% in 2021-22, with their share of total R&D spending declining sharply from 5.90% to 0.65% over the same period. Similarly, firms with 50 to 99 employees have seen a decrease in R&D intensity from 1.58% in 2015-16 to 0.56% in 2021-22, and their share of total R&D spending has also fallen from 5.78% to 1.55%. This trend suggests that smaller and lower-medium-sized firms face significant challenges in sustaining R&D intensity, likely due to constraints such as limited resources and infrastructure, as well as operational and competitive pressures. The firm size with 100 to 199 employees also see a slight decrease in R&D intensity from 0.79% in 2015-16 to 0.48% in 2021-22 with a consistent low share in R&D spending. Firms with 200 to 499 employees exhibit a slight increase in R&D intensity from 0.44% in 2015-16 to 0.60% in 2021-22 and have a significant share of R&D spending, ranging from 12.05% to 14.06%. The firms in these categories, we believe, start benefiting from economies of scale and more substantial resources. For firms with 500 to 999 employees, R&D intensity increased from 0.40% in 2015-16 to 0.69% in 2021-22, with their share of total R&D spending rising from 9.25% to

15.74%. This indicates their capability to sustain substantial R&D activities. Firms with 1000 to 1999 employees experienced a decline in R&D intensity from 0.51% in 2015-16 to 0.33% in 2021-22, despite maintaining a high share of R&D spending, though it decreased from 14.31% to 11.89%. This decline may be due to shifts in strategic priorities or competitive pressures. Firms with 2000 to 4999 employees have consistently high R&D spending, hovering around 21-29%. Their R&D intensity increased from 0.56% in 2015-16 to 0.60% in 2020-21, though a decline in the recent year. The firms with 5000 or more employees saw a decrease in R&D intensity from 0.59% in 2015-16 to 0.22% in 2021-22, even though their share of total R&D spending increased from 24.57% to 31.32%. This suggests that while very large firms have the resources to conduct extensive R&D, their R&D intensity relative to turnover is decreasing.

This analysis indicates that larger firms generally maintain a greater share of R&D spending and higher R&D propensity compared to smaller firms. However, even very large firms are experiencing a decline in R&D intensity, which is concerning. Smaller firms struggle with resource constraints, affecting their R&D investment, whereas medium to large firms show a trend of increased R&D engagement, reflecting their capacity to leverage significant resources for R&D activities.

Table 4: Status of R&D activities and propensity by Size of firm as per employees' engagement

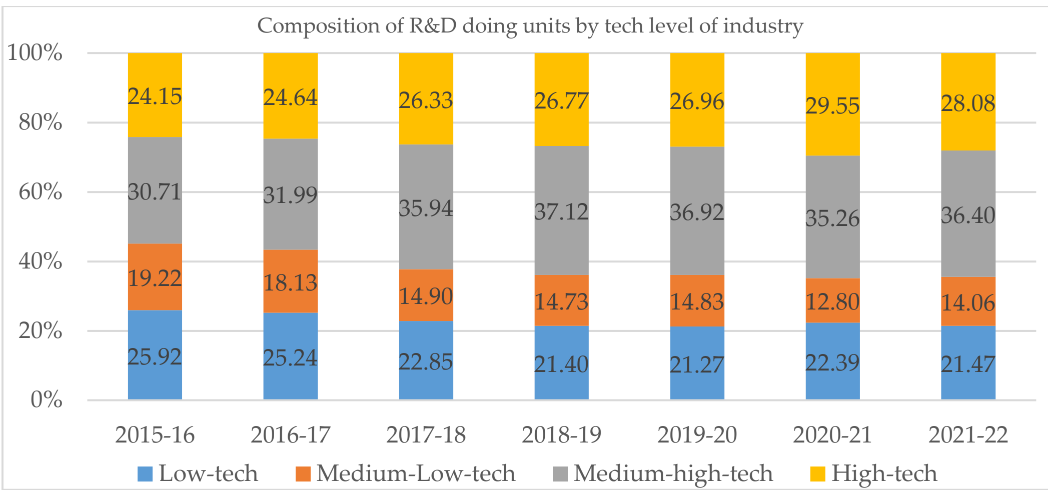
								All units		*R&D units*	
Size by No. of employees	*2015-16*	*2016-17*	*2017-18*	*2018-19*	*2019-20*	*2020-21*	*2021-22*	*2015-16*	*2021-22*	*2015-16*	*2021-22*
	R&D propensity							*Composition of total &, R&D units*			
>0&<20	0.61	0.46	0.39	0.47	0.36	0.31	0.33	50.68	44.02	13.55	5.70
>=20&<50	1.59	1.30	1.39	1.39	1.34	1.35	1.38	21.01	22.93	14.67	12.43
>=50&<100	2.74	2.47	2.96	2.78	2.48	2.43	2.01	11.02	12.27	13.22	9.72
>=100&<200	4.70	4.35	3.65	4.12	3.90	4.75	4.49	7.48	8.74	15.40	15.48
>=200&<500	7.76	7.87	6.60	7.43	7.38	7.75	8.26	5.49	6.65	18.66	21.67
>=500&<1000	10.01	10.92	9.83	11.01	10.45	12.63	12.29	2.25	2.73	9.88	13.20
>=1000&<2000	12.81	16.10	13.71	13.75	13.57	14.26	14.03	1.15	1.41	6.46	7.82
>=2000&<5000	14.45	20.64	18.06	18.38	18.66	17.96	20.03	0.59	0.87	3.76	6.84
5000&Above	32.05	35.84	36.35	39.83	28.34	38.99	48.09	0.31	0.38	4.40	7.17
	R&D intensity							*Composition share of R&D spending*			
	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2015-16	2017-18	2019-20	2021-22
>0&<20	2.13	1.70	0.50	1.67	0.43	0.19	0.75	0.81	0.17	0.15	0.14
>=20&<50	1.96	0.91	0.51	0.65	0.42	0.48	0.49	5.90	0.84	0.50	0.65
>=50&<100	1.58	0.41	0.70	0.59	0.41	0.67	0.56	5.78	2.44	0.93	1.55
>=100&<200	0.79	0.76	0.54	0.57	0.59	0.73	0.48	6.65	3.01	2.92	3.34
>=200&<500	0.44	0.68	0.64	0.52	0.62	0.85	0.60	12.05	13.98	10.21	14.06
>=500&<1000	0.40	0.73	0.48	0.59	0.55	0.44	0.69	9.25	9.99	10.77	15.74
>=1000&<2000	0.51	0.52	0.58	0.42	0.48	0.51	0.33	14.31	13.22	8.57	11.89
>=2000&<5000	0.56	0.83	0.69	0.59	0.93	0.60	0.39	20.67	26.25	29.70	21.34
5000&Above	0.59	0.70	0.48	0.64	0.66	0.53	0.22	24.57	30.10	36.24	31.30

Source: Author's estimates from unit-level data of ASI

4.5. R&D Activities and Propensity by Tech-Level

While there has been an overall increase in the number of R&D units at the aggregate level, the analysis by technology level indicates a decline in R&D-performing units among low- and medium-low tech firms during the study period. Specifically, the share of low-tech firms decreased from 25.92% to 21.47%, and medium-low tech firms saw a drop from 19.22% to 14.06% (Figure 6). Conversely, the share of R&D-performing units in the medium-high tech and high-tech segments showed upward trends, increasing from 30.7% to 36.4% and from 24.15% to 28.08%, respectively. Similar to the compositional share of R&D-performing units, propensity for R&D in low and medium-low tech sectors remained low and exhibited declining trends (Table 5). R&D propensity in medium-high and high-tech segments was not only higher but also showed an upward trend. Notably, the R&D propensity in the high-tech segment was nearly double that of medium-high segment firms (Table 5).

Figure 6: Composition of R&D doing units by tech level



Source: Author's estimates from unit-level data of ASI

Table 5: Trends in R&D propensity by tech-level

	2015-16	*2016-17*	*2017-18*	*2018-19*	*2019-20*	*2020-21*	*2021-22*
Low-tech	1.42	1.37	1.21	1.23	1.15	1.29	1.30
Medium-Low-tech	1.37	1.30	1.07	1.16	1.09	0.99	1.17
Medium-high-tech	4.64	4.79	5.18	5.90	5.45	5.44	5.89
High-tech	8.52	9.05	9.36	9.77	9.51	10.58	10.49

Source: Author's estimates from unit-level data of ASI

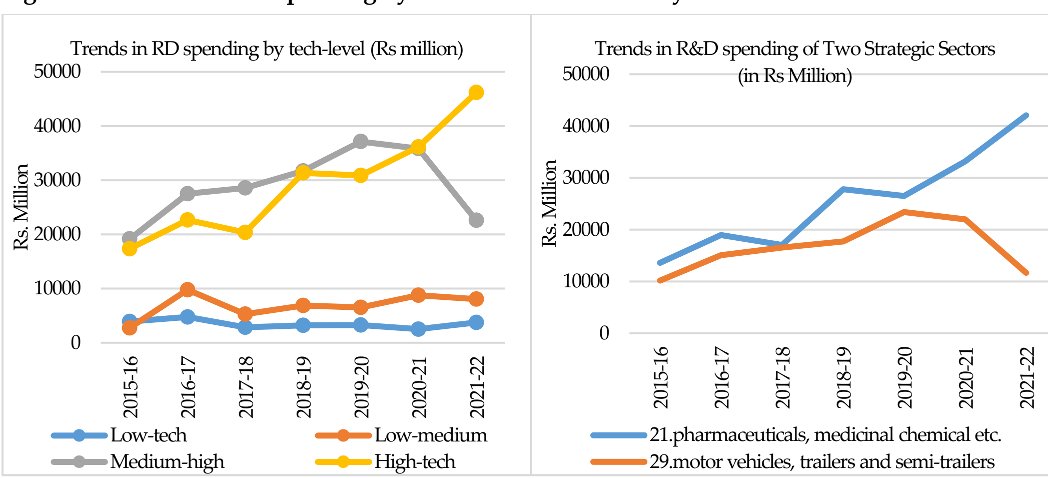
4.6. R&D Spending and Intensity by Tech-Level

Analysis of R&D spending by technology level highlights how different tech segments within the manufacturing sector allocate their research and development resources. R&D

expenditure in low-tech sector shows significant fluctuations over the years (Figure 7). The medium-low tech industries display a slight upward trend in R&D spending, although their overall share remains low. In contrast, the medium-high tech and high-tech sectors demonstrate consistent growth in R&D investment, reflecting a strong focus on innovation and technological advancement. However, medium-high tech sector experienced a sharp decline in R&D investment in recent year 2021-22, likely due to the post-pandemic impact. Meanwhile, R&D spending in high-tech industries has consistently risen.

A closer examination of R&D spending patterns reveals a significant change in two industry. The R&D spending of motor vehicle industry (NIC-29), part of the medium-high tech sector, saw a significant drop in R&D investment in 2021-22, contributing to the overall decline in R&D spending for this (medium-high) segment. In contrast, pharmaceutical industry (NIC-21), a key player in high-tech sector, experienced a substantial increase in R&D investment during the same period, driving up the overall R&D expenditure for high-tech industries (Figure 7). Data analysis suggests that over half of the total R&D spending in manufacturing sector was attributed to pharmaceutical industry in 2021-22. The detail analysis reveals that what Indian manufacturing sector was spending on R&D in 2015-16, today (in 2021-22) pharma industry alone spend almost the same amount. The rise in R&D spending in pharma sector is might be because during pandemic the demand for research was crucial to innovate new medicine and vaccines. While, the motor vehicle (NIC29) industry sees a sharp dip in overall R&D spending aftermath the COVID period (Figure 7), might be because of drop in output demand of old vehicle, as sector is transitioning towards EV based vehicles.

Figure 7: Trends in R&D Spending by tech-level of the Industry



Source: Author's estimates from unit-level data of ASI

The analysis by 2-digit industry further shows how different industries have prioritized R&D investments and how their relative importance has shifted over the years. For the purpose, we categorized two-digit industries into five segments: high focus, stable focus, moderate focus, fluctuating behaviour (Table 6). In the first segment, it is observed that pharmaceuticals (NIC21) maintained the highest R&D propensity with a significant rise from 13.40% to 19.59%. Despite a stable share of total units, its R&D investment grew substantially. The chemicals (NIC20) industry, part of first segment, also shows consistently high R&D propensity, with a slight increase from 6.40% to 6.95%. Its share in total units and R&D doing units also increased slightly. In the second sub-category that reflected stable R&D focus are computer, electronic, and optical products (NIC26), which had high R&D propensity throughout, though it slightly decreased from 9.57% to 7.96%. The industry's share of total units remained marginally stable though share in R&D doing units declined. Another industry in this segment is the electrical equipment (NIC27) also showed an increase in R&D propensity from 3.57% to 6.07%, with a rising share in R&D units. The third category is the moderate R&D investments. In this segment R&D propensity of motor vehicles (NIC29) increased from 4.35% to 6.03%, reflecting growing investment. The industry's share in total units as well as in R&D doing units saw a slight increase. The next is the machinery and equipment (NIC28) industry that had a slight rise in R&D propensity from 3.66% to 3.86%, with a stable in the share of R&D and total units. We finds a fluctuating R&D behaviour in food products (NIC10) and textiles (NIC13), beverages (NIC11) and tobacco Products (NIC12). The industry like wood products (NIC16) and furniture (NIC31) exhibited low and decreasing R&D propensities.

In terms of R&D intensity and composition of R&D spending from 2015-16 to 2021-22, the pharmaceuticals (NIC21) industry maintained a high R&D intensity, increasing from 1.71% in 2015-16 to 1.91% in 2021-22 (Table 6). Its share of total R&D spending grew significantly, from 31.47% to 52.23% during the period, indicating alone pharma industry spend over half of the R&D of the entire manufacturing sector. The chemical (NIC20) industry displayed moderate R&D intensity, with a slight decline from 0.33% to 0.19% over the years. Its share of R&D spending decreased from 7.47% to 5.03%. The industry that has stable R&D focus are the computer, electronic, and optical products (NIC26) in which R&D intensity was high initially around 1.45% in 2015-16 which declined to 0.41% in 2021-22. Their share of R&D spending also decreased significantly from 5.95% to 1.84%. The electrical equipment (NIC27) industry experienced a decrease in R&D intensity from 1.91% to 0.26%, with its share of R&D spending decreasing from 9.73% to 2.39%. The industry that shows variable R&D behaviour was motor vehicles (NIC29). Its R&D intensity increased from 0.59% to 1.14% between 2015-16 to 2020-21 which dropped to 0.45% in 2021-22. This industry also noticed a rise in the share of R&D spending from 23.54% in 2015-16 to 30.09% in 2020-21, which dropped significant to 14.51% in 2021-22. The fabricated metal products (NIC25) also showed high variability, with R&D intensity increasing from 0.66% to 0.79% and its share of R&D spending fluctuated. Some industry remained with low and decreasing R&D Intensity. For instance, the food products (NIC10) showed low R&D intensity, with a decrease from 0.34% to 0.25%. The share of R&D spending also fell from 4.16% to 2.88%. Similarly, in the textiles (NIC13) sector had low R&D intensity, with a significant fall from 0.24% to 0.05% and a minimal change in its share of R&D spending. The other industry can be put in the minor R&D investment category. For instance, the beverages (NIC11) and tobacco products (NIC12) showed very low R&D intensity and minimal changes in their shares of R&D spending.

In general, industries with high R&D propensity like pharmaceuticals and chemicals have continued to invest heavily in R&D, while sectors like food products and textiles have seen less stability in their R&D efforts. However, some sectors with initially higher R&D intensity, such as Computer and electronic products and electrical equipment, have seen a reduction in both R&D intensity and their share of total R&D spending. The fluctuating behaviour of R&D investment in various industries reflect the broader economic and industrial dynamics in India.

Table 6: Status of R&D Activities by Industry

NIC-2 digit industry	*2015-16*	*2016-17*	*2017-18*	*2018-19*	*2019-20*	*2020-21*	*2021-22*	*All units*		*R&D units*	
								2015-16	*2021-22*	*2015-16*	*2021-22*
	R&D propensity							**Composition of units**			
10.food products	1.84	1.76	1.54	1.66	1.54	1.80	1.98	17.78	17.74	13.64	13.15
11.beverages	1.97	1.91	2.05	1.76	1.32	1.58	2.04	1.12	1.03	0.92	0.79
12.tobacco products	0.66	0.41	0.25	0.52	0.95	0.35	0.45	1.71	1.32	0.47	0.22
13.textiles	0.95	0.97	0.79	0.72	0.60	0.92	0.86	7.49	7.44	2.95	2.40
14.wearing apparel	1.97	1.65	1.55	1.13	1.00	1.33	1.17	4.08	4.87	3.35	2.12
15.leather and related products	2.02	1.86	1.69	2.80	1.57	1.54	1.18	2.07	1.97	1.75	0.87
16.wood products etc.	0.44	0.40	0.33	0.10	0.87	0.05	0.15	2.18	2.16	0.40	0.12
17.paper and paper products	0.74	0.77	0.82	0.81	0.66	0.64	0.42	3.14	3.21	0.97	0.50
18.Printing and reproduction of recorded media	0.21	0.72	0.71	0.15	0.43	0.12	0.16	2.13	1.74	0.19	0.10
19.coke and refined petroleum products	1.34	3.16	1.48	2.02	2.00	2.15	3.19	0.81	0.88	0.45	1.05
20.chemicals and chemical products	6.40	6.14	6.84	7.92	7.24	7.09	6.95	5.79	6.19	15.44	16.07
21.pharmaceuticals, medicinal chemical and botanical products	13.40	14.86	16.35	17.34	17.06	20.71	19.59	2.46	2.48	13.76	18.15
22.rubber and plastics product	2.08	1.81	2.07	2.12	1.78	1.40	1.90	6.30	6.52	5.45	4.62
23.other non-metallic mineral products	1.20	0.92	0.48	0.38	0.71	0.52	0.56	13.27	12.88	6.63	2.69
24.basic metals	1.65	1.70	2.01	2.05	1.78	1.80	1.95	5.44	5.04	3.73	3.68
25.fabricated metal products	0.91	1.08	0.59	1.00	0.55	0.74	0.80	7.82	6.99	2.95	2.08
26.computer, electronic and optical products	9.57	9.28	8.17	8.48	9.80	8.30	7.96	1.06	1.09	4.23	3.25
27.electrical equipment	3.57	4.44	4.65	6.14	5.22	5.35	6.07	3.44	3.32	5.12	7.53
28. machinery and equipment	3.66	3.58	3.96	3.98	3.39	3.64	3.86	5.79	6.06	8.83	8.72
29.motor vehicles, trailers and semi-trailers	4.35	5.16	4.41	5.02	4.88	4.47	6.03	2.87	3.07	5.19	6.91
30.other transport equipment	3.56	2.23	3.53	3.32	4.04	3.70	5.30	1.05	1.08	1.56	2.14
31.furniture	1.08	0.84	0.19	0.55	0.58	0.50	0.63	0.74	1.03	0.33	0.24
32.Other manufacturing	2.74	4.11	2.80	2.78	2.87	3.38	3.69	1.47	1.87	1.68	2.58

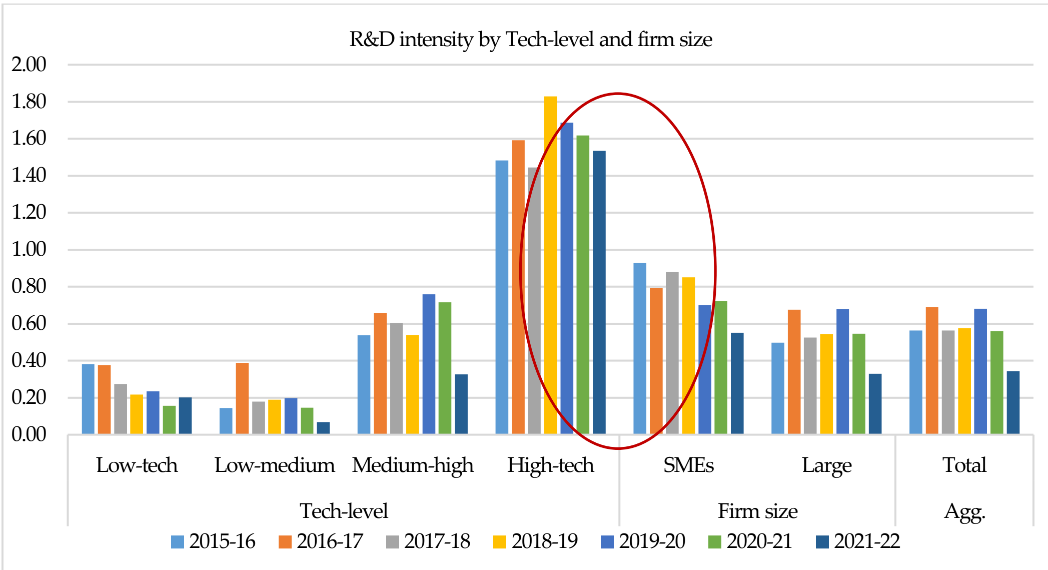
(% & No.)	2.40	2.40	2.35	2.56	2.41	2.53	2.68	176477	184939	4236	4952
	R&D intensity							**Composition of R&D spending**			
NIC-2 digit industry	*2015-16*	*2016-17*	*2017-18*	*2018-19*	*2019-20*	*2020-21*	*2021-22*	*2015-16*	*2017-18*	*2019-20*	*2021-22*
10.food products	0.34	0.30	0.18	0.13	0.20	0.12	0.25	4.16	1.79	1.76	2.88
11.beverages	0.49	0.28	0.07	0.07	0.05	0.10	0.04	0.60	0.10	0.06	0.06
12.tobacco products	0.16	0.22	0.03	0.02	0.04	0.10	0.03	0.11	0.01	0.06	0.02
13.textiles	0.24	0.37	0.09	0.21	0.07	0.10	0.05	0.87	0.23	0.22	0.24
14.wearing apparel	1.26	1.33	1.28	1.03	1.52	0.75	0.51	1.97	1.71	1.49	0.82
15.leather and related products	0.22	0.61	0.39	0.68	0.38	0.34	0.48	0.19	0.16	0.24	0.15
16.wood products etc.	0.04	0.39	0.14	0.04	0.05	0.13	0.07	0.01	0.01	0.01	0.02
17.paper and paper products	0.33	0.25	0.23	0.24	0.05	0.05	0.09	0.79	0.44	0.07	0.18
18.Printing and reproduction of recorded media	0.39	0.86	9.02	0.02	0.72	0.04	0.01	0.01	0.26	0.02	0.00
19.coke and refined petroleum products	0.33	0.06	0.10	0.07	0.06	0.01	0.01	0.58	0.88	0.44	0.66
20.chemicals and chemical products	0.33	0.54	0.29	0.20	0.24	0.32	0.19	7.47	5.97	4.35	5.03
21.pharmaceuticals, medicinal chemical and botanical products	1.71	2.02	1.81	2.30	1.97	1.92	1.91	31.47	29.80	34.11	52.23
22.rubber and plastics product	0.15	0.23	0.22	0.16	0.09	0.10	0.10	1.19	1.00	0.39	0.62
23.other non-metallic mineral products	0.19	0.43	0.53	0.47	0.48	0.47	0.52	1.08	1.83	1.86	2.23
24.basic metals	0.05	0.05	0.13	0.12	0.13	0.23	0.11	1.35	4.21	3.32	4.90
25.fabricated metal products	0.66	4.24	0.63	1.09	1.63	1.53	0.79	2.19	1.35	2.28	1.59
26.computer, electronic and optical products	1.45	0.65	0.60	0.96	0.83	0.72	0.41	5.95	1.94	2.34	1.84
27.electrical equipment	1.91	0.51	0.55	0.58	0.53	0.43	0.26	9.73	3.57	3.12	2.39
28. machinery and equipment	0.51	0.75	0.65	0.59	0.70	0.46	0.48	5.05	8.18	6.42	5.94
29.motor vehicles, trailers and semi-trailers	0.59	0.65	0.75	0.70	1.17	1.14	0.45	23.54	28.95	30.09	14.51
30.other transport equipment	0.12	1.21	0.73	0.73	0.84	0.75	0.25	1.13	7.00	6.69	2.71
31.furniture	0.03	0.16	0.41	0.50	0.24	0.13	0.13	0.00	0.02	0.01	0.01
32.Other manufacturing	0.56	1.23	1.05	1.20	1.33	0.90	0.87	0.55	0.59	0.66	0.96
(% & value in million.)	0.56	0.69	0.56	0.58	0.68	0.56	0.34	43174	57078	77740	80544

Source: Author's estimates from unit-level data of ASI

The above analysis shows a notable difference across technology levels and firm sizes, with a general trend of declining R&D intensity over the period (summarised in Figure 8). High-tech industries consistently demonstrate the highest R&D intensity, reflecting a strong commitment to R&D relative to their turnover. Medium-high tech sectors also exhibit relatively high R&D intensity, though with some fluctuation. In contrast, low-tech and low-medium tech sectors show lower and more variable R&D intensity/propensity. Regarding firm size, large firms maintain a relatively stable R&D intensity, whereas SMEs experience a noticeable decline. These trends highlight that, despite increases in overall

R&D expenditures, growth in turnover is likely outpacing the growth in R&D investments across the manufacturing sector. However, we believed that SMEs and large firms must have behaved differently in high-tech sector; analysis around this notion is presented in subsequent section.

Figure 8: R&D intensity by tech-level and firm size: A Comparative Summary



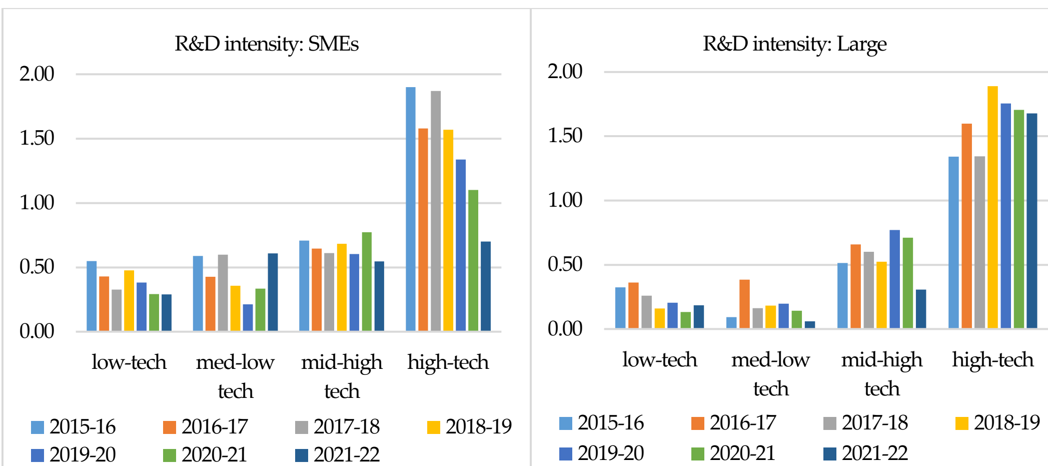
Source: Author's estimates from unit-level data of ASI

4.7. Are Tech-SMEs different

4.7.1. R&D Intensity by Firm-Size and Tech-Level

Analysis of R&D intensity across technology levels reveals a distinct behaviour between SMEs and large firms. Initially, low-tech SMEs had a higher R&D intensity of 0.55% compared to large firms, which stood at 0.32%, indicating that SMEs invested more in R&D relative to their turnover (Figure 9). Over time, SMEs experienced a significant decline in R&D intensity, dropping from 0.55% to 0.29%. The large firms also experienced a decrease in their R&D intensity from 0.32% to 0.19%. However, despite the decline in intensity, SMEs maintained a higher R&D intensity of 0.29% compared to large firms' 0.19%. When compare the R&D intensity between low-medium tech SMEs and large firms, they reveals that low-medium tech SMEs exhibit a relatively stable R&D intensity except for few years. Their R&D intensity noticed around 0.59% in 2015-16 with a slight increase to 0.61% by 2021-22. In contrast, large firms in the same sector maintain a very low R&D intensity, starting at 0.09% in 2015-16 and decreasing slightly to 0.06% by 2021-22, with a high fluctuation in between. The R&D intensity sees a consistently high level among SMEs than their large firms in this tech segment. Medium-high tech SMEs show a higher initial R&D intensity around 0.71% in 205-16 that fluctuates over time, ending at 0.55 in 2021-22. In comparison, large firms have a more stable but lower R&D intensity, decreasing from 0.51 to 0.31 between the study periods. A comparison of R&D intensity between high-tech SMEs and large firms shows that high-tech SMEs initially exhibited a high R&D intensity, starting at 1.90% in 2015-16 which declined to 0.70% by 2021-22, reflecting a significant reduction in R&D investment relative to their turnover. In contrast, high-tech large firms maintain a consistently high R&D intensity. Their intensity sees a rising trend from 1.34% to 1.68% during the period. This indicates their stable and growing commitment to R&D. That is, analysis suggest that the high-tech SMEs starts with high R&D intensity, they experience a notable decline in R&D intensity during and after the COVID-19 pandemic. The large firms show a steady increase, with their R&D intensity even rising through the pandemic. This suggests that SMEs face considerable challenges in maintaining R&D investments, whereas large firms continue to invest in R&D within the high-tech sector even during COIVD-19 period. This suggests that larger firms are more capable of maintaining high levels of R&D relative to their turnover even during pandemic, while SMEs may face challenges and are less resilient in sustaining such intensity levels during pandemic like shocks. However, R&D intensity of SMEs in low, low-medium, and medium-high tech remained higher than that of large firms across these tech segments (Figure 9).

Figure 9: Status of R&D intensity of SMEs and Large Firms by Tech-Level

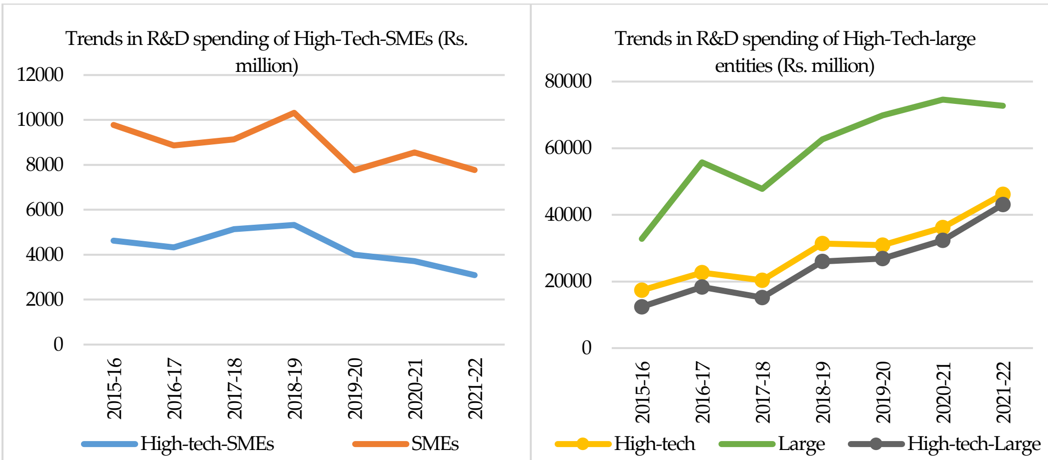


Source: Author's estimates from unit-level data of ASI

The R&D intensity of SMEs and large firms however vary depending on the sector they belong. The analysis suggests that share of R&D doing firms and their R&D spending see an increasing trends in large firm segments. Out of total R&D spending, large firms spend significantly low around less than one-third in sectors like, NIC12,13,16, 26, 25, 26, 31,32. The SMEs also dominate in R&D spending in some sector. Majority of R&D spending of SMEs goes to NIC20,21,26 and in case of large firms it goes to NIC21, 27,29. In the pharma sector SMEs emerged as an important player in R&D activity (see Appendix 3).

To understand the contradiction of rising R&D intensity among high-tech large entities while high-tech SMEs experience a decline, we analysed trends in their overall R&D spending. The analysis indicates a general decline in R&D spending among SMEs, with the high-tech segment following the same downward trend. This suggests that high-tech SMEs struggled to maintain their R&D investments during and after the COVID period, highlighting their challenges and reduced resilience in sustaining R&D intensity levels during the pandemic. However, high-tech-large entities could maintain high R&D spending (Figure 10). This suggests that larger firms are more capable of maintaining high levels of R&D relative to their turnover even during COVID period.

Figure 10: Trends in R&D spending during pandemic: Case of high-tech SMEs and Large entities



Source: Author's estimates from unit-level data of ASI

4.7.2. Spillover Effect of Firm's Location in High Industrial Activity Areas

Our next aim is to see how high industrial activities state influence the R&D propensity and intensity. Here we compared nine states R&D with the remaining states. Data shows that the nine states consistently hold approximately 67% of total manufacturing units, while the rest of the states account for around 33%, indicating a stable concentration of manufacturing activity in these nine states (Table 7). These high-concentration states also have a significantly higher share of R&D-active units, which rose from 66.88% in 2015-16 to 73.90% in 2021-22, which share of rest of the states decreased from 33.12% to 26.10%. Regarding R&D propensity, nine states data show a gradual increase in propensity from 2.28% in 2015-16 to 2.81% in 2021-22, suggesting a growing focus on R&D relative to the number of units. In contrast, rest of the states do experience a decline in R&D propensity, dropping from 2.30% to 1.99% during the same period. The share of total R&D spending in nine states cluster remains significantly high, ranging between 85-90%, reflecting a concentrated investment in R&D in these state's firms. Rest of the states left with a lower share of R&D spending, ranging between 10-15%. R&D intensity in the nine states begins at 0.67 in 2015-16, peaks at 0.82 in 2019-20, and then declines to 0.39 by 2021-22. The R&D intensity in the rest of the states has remained consistently low and declined from 0.34 in 2015-16 to 0.18 in 2021-22. This analysis reveals that nine states consistently demonstrate a higher level of R&D activity, spending, and intensity. This suggests that regional clusters or concentrations of industry create a more conducive environment for R&D investment, whereas the rest of the states reflects potential challenges in building a robust R&D

environment. The findings underscore the spillover effect of market concentration, where high industrial density and turnover in specific regions are associated with higher R&D activity and investment.

Table 7: Spillover Effect of High Industrialisation on Firm's R&D propensity and intensity

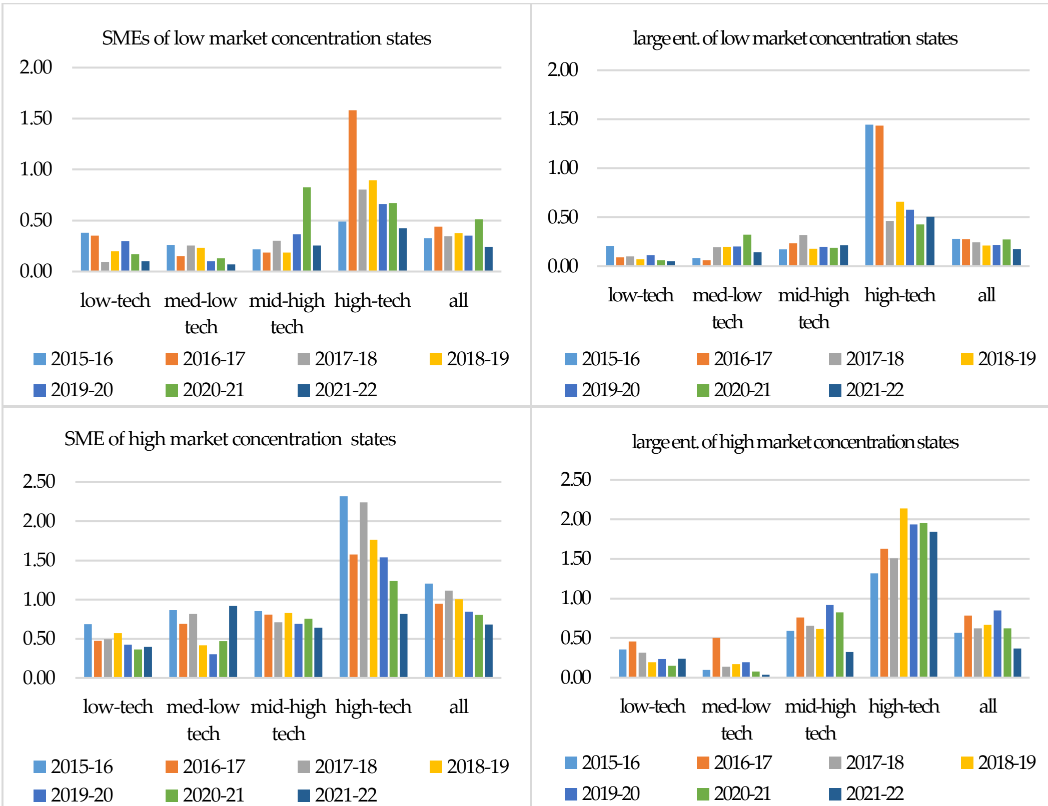
Concentration of sale and units in 9 states and rest of the state's comparison		*2015-16*	*2016-17*	*2017-18*	*2018-19*	*2019-20*	*2020-21*	*2021-22*
Composition of Total Units	9-states	67.11	67.00	67.00	66.85	66.24	66.51	66.73
	Rest of the states	32.89	33.00	33.00	33.15	33.76	33.49	33.27
Composition of R&D doing units	9-states	66.88	68.60	68.93	75.73	72.66	71.95	73.90
	Rest of the states	33.12	31.40	31.07	24.27	27.34	28.05	26.10
R&D propensity	9-states	2.28	2.33	2.27	2.74	2.49	2.59	2.81
	Rest of the states	2.30	2.16	2.08	1.77	1.84	2.01	1.99
Composition of R&D spending	9-states	85.01	89.98	88.14	89.66	90.72	87.76	88.48
	Rest of the states	14.99	10.02	11.86	10.34	9.28	12.24	11.52
R&D intensity	9-states	0.67	0.81	0.67	0.71	0.82	0.64	0.39
	Rest of the states	0.34	0.31	0.26	0.23	0.23	0.31	0.18

Source: Author's estimates from unit-level data of ASI

The SMEs, in the low industrial cluster states, reveals a consistently higher R&D intensity across all tech sectors compared to large firms, with a notably high intensity in high-tech sectors (Figure 11). Large firms exhibit lower R&D intensity across all technology sectors, with more stable but lower values in high-tech sectors when compared to SMEs. This suggests that SMEs in low concentrated states are more aggressive in their R&D investments compared to large firms, which may reflect their strategic focus or the competitive pressures they face in such markets. We see a significant change in R&D intensity of SMEs across different technology sectors. It observed that they have reduced their focus from low-tech and medium-low tech sectors while showing some increased investment in mid-high tech during the COVID-19 period. The high-tech sector remains a focal point but has seen a decline in R&D intensity over recent years.

The SMEs, in the high industrial concentration states, also exhibit higher R&D intensity across all technology sectors compared to large firms (Figure 11). This is particularly noticeable in low-tech and medium-low tech sectors where SMEs have a notable edge. In the high-tech sector, both SMEs and large firms have high R&D intensity, but SMEs lead in most of the initial years, while see a declining trends in COVID phase. The SMEs however consistently maintain higher R&D intensity in low-tech and medium-low tech sectors, while large firms show fluctuating and generally lower R&D investment. The higher R&D intensity among SMEs in high industrial concentration states might indicate a greater effort to differentiate themselves or respond to competitive pressures from larger, dominant players. The large firms, despite having potentially more resources, show lower R&D intensity in certain sectors, which might reflect strategic choices or operational focus.

Figure 11: Are SMEs different from Large across Tech-Level: Spillover Effect of High Industrialisation



Source: Author's estimates from unit-level data of ASI

4.7.3. Role of Product-Subsidy

Analysis on product-subsidy shows a decline trend in the number of factory that received product-subsidy from 1052 to 807 during the study period. The total number of items on which product subsidy received at aggregate level as well as at finest level item also see a declining trend. However, the amount of subsidy increased to almost double during the period from Rs. 2,38,725 million in 2015-16 to 6,53,384 in 2021-22 (Table 8).

The analysis on the role of product-subsidy highlights the complex role of government incentives as product-subsidy in influencing R&D behaviours. The firms receiving product subsidies show higher R&D propensity compared to those not receiving subsidies (Table 9). However, their R&D propensity declined from 7.48% in 2015-16 to 4.0% by 2021-22, while firms that did not receive product subsidies demonstrate a lower R&D propensity though with increasing trends from 2.21% in 2015-16 to 2.52% in 2021-22. However, R&D propensity of firm receiving product subsidy remains over twice the propensity of firm that did not receive such subsidy. Despite having high propensity among firm receiving product subsidies, their R&D intensity generally remains lower compared to those without subsidies. Their intensity rather decreased from 0.78% in 2015-16 to 0.08% in 2021-22. The firms that did not receive product subsidies show higher R&D intensity, but their R&D intensity also see a declining trend which decreased from 0.55% in 2015-16 to 0.35% by 2021-22.

Table 8: Status of Product-subsidy in ASI data

	No of unit/factory received product subsidy	No. of product items under subsidy at finest level	Total no of items on which product subsidy received	Amount of Subsidy received (Rs. million)
2015-16	1052	733	2356	238725
2016-17	968	678	2155	246395
2017-18	899	650	1968	219159
2018-19	830	620	1994	358169
2019-20	722	534	1795	439525
2020-21	773	570	2019	362367
2021-22	807	608	1996	653384

Source: Author's estimates from unit-level data of ASI

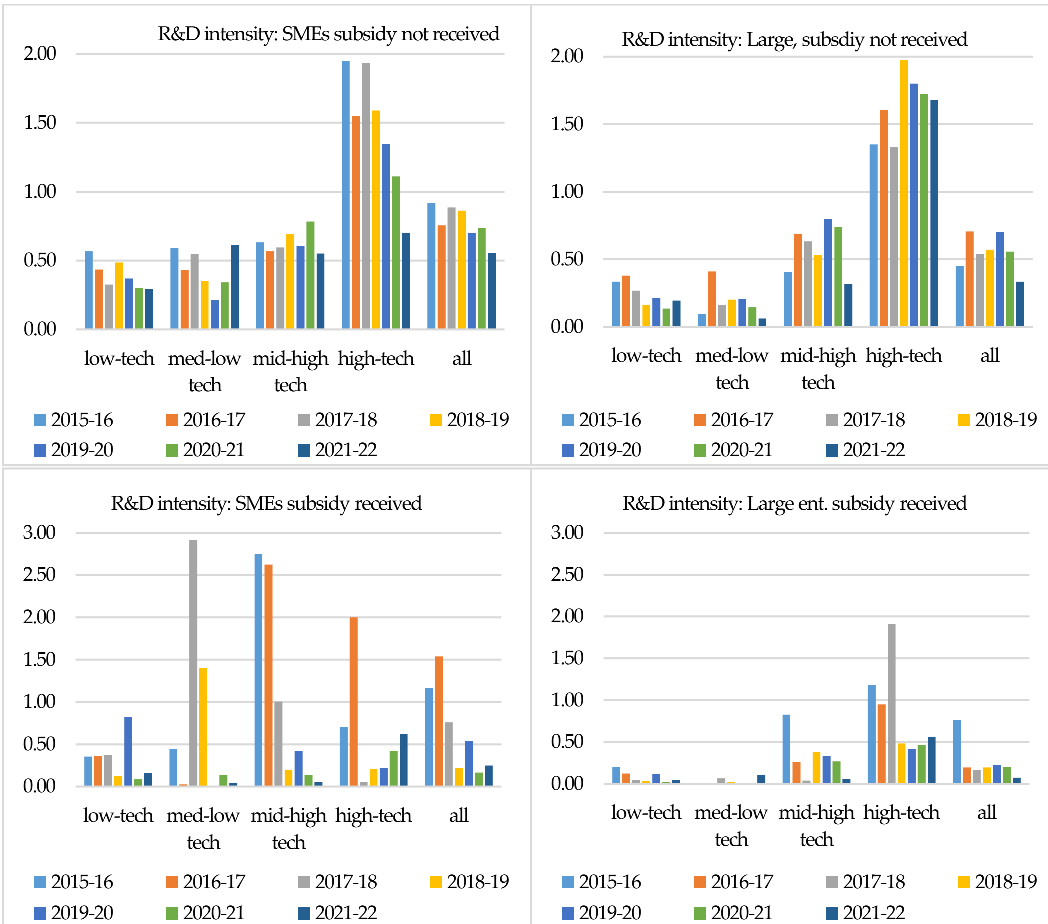
Table 9: Status of R&D activities and Government Incentives as Product Subsidy

Government incentives		*2015-16*	*2016-17*	*2017-18*	*2018-19*	*2019-20*	*2020-21*	*2021-22*	*2015-16*	*2021-22*	*2015-16*	*2021-22 (R&D units)*
									(All units)		*(R&D units)*	
		R&D propensity							Composition of units			
Whether product subsidy received	No	2.21	2.20	2.14	2.39	2.25	2.37	2.52	98.62	98.88	95.48	98.23
	Yes	7.48	8.30	8.36	5.41	4.24	5.50	4.00	1.38	1.12	4.52	1.77
		R&D intensity							Composition of R&D spending			
		2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2015-16	2017-18	2019-20	2021-22
Whether product subsidy received	No	0.55	0.72	0.58	0.61	0.69	0.58	0.35	82.17	98.57	98.37	99.54
	Yes	0.78	0.34	0.23	0.20	0.24	0.20	0.08	17.83	1.43	1.63	0.46

Source: Author's estimates from unit-level data of ASI

Product subsidies appear to boost the R&D propensity of firms, reflecting their increased engagement in R&D activities when supported by government incentives. However, the proportion of units receiving subsidies in India remained very low, starting at 1.38% in 2015-16 and decreasing to 1.12% in 2021-22 (Table 9). Their share of R&D spending is also minimal, decreasing from 4.52% to 1.77% over the period. A vast majority of units, around over 98%, do not receive subsidies. They account for a large share of R&D spending, increasing from 95.48% in 2015-16 to 98.23% in 2021-22. This suggests that firms without product subsidies dominate the composition of total R&D spending, suggesting that while subsidies may increase the number of firms involved in R&D, they contribute a smaller share of the total R&D expenditure. Overall, firms receiving product subsidies have higher R&D propensity compared to those without subsidies. However, the share of firms receiving subsidies is small, and their overall contribution to R&D spending is low. We observed that while incentives can increase R&D activity, the proportion of total R&D spending attributed to firms receiving subsidies is often low. This is because only a small percentage of firms qualify for these incentives, therefore, government subsidies often lead to an increase in R&D activities but may not always result in higher R&D intensity. This could be due to the fact that subsidies may not be sufficient to drive significant increases in R&D investment levels.

Figure 12: Are SMEs different from Large across Tech-Level: The Role of Government Incentives



Source: Author's estimates from unit-level data of ASI

The SMEs shows a high R&D intensity across all technology sectors compared to large enterprises that do not receive subsidies. This is particularly notable in the low-tech and medium-low tech sectors (Figure 12). In high-tech sector, both SMEs and large enterprises show relatively high R&D intensity, but SMEs lead in initial years while declining trends in the aftermath of COVID. However, one can say that SMEs, even without subsidies, show a more aggressive approach towards R&D, possibly driven by the need to compete and innovate independently. On the other hand, large enterprises may not utilize their resources as effectively in R&D without subsidies, leading to lower intensity levels in various technology sectors. Overall, the SMEs that do not receive subsidies demonstrate higher R&D intensity compared to large enterprises, suggesting that SMEs are more proactive or compelled to invest in R&D to maintain competitiveness. We see a high volatility across sector in both SMEs and large enterprise when they are provided with subsidy incentives and no concrete conclusion be made.

5. Empirical Analysis: Factors Influencing R&D Behaviour

5.1. Cragg Model Results

The Cragg double hurdle model results are divided into two stages: the likelihood of engaging in R&D (Stage-1) and the extent of R&D spending (Stage-2). The results suggests that older firms are not only more likely to engage in R&D but they do spend more on R&D as well (Table 10). The coefficient are statistical significant. The established/mature firms are more likely to engage in R&D activities and they are having accumulated more resources and experience therefore tend to invest more in R&D, reflecting the evolving role of firm age in shaping R&D strategies. The coefficient of age square suggest the effect of firm age on R&D likelihood increases up to a point and then diminishes, though the coefficient are not highly significant. This indicates that R&D engagement increases with age but decline as firms mature and face new challenges or become less innovative.

Larger firms are more likely to engage and doing in R&D with statistical significant coefficient value, indicating that larger firms have more resources and are better positioned to undertake R&D activity as well as higher expenditure.

Firms with foreign capital are more likely to engage in and spend more on R&D. The coefficient turn out to be significant. The foreign investments often bring advanced technologies and management practices that enhance R&D activities/spending. Firms that import inputs are more likely to engage/spend in R&D. Import of inputs might encourage firms to innovate and engage in R&D and boost R&D spending as firms integrate new technologies.

The profit margin does not significantly affect the likelihood of R&D. The GVA have a marginal impact on R&D spending. Higher GVA is associated with a higher likelihood of engaging in and doing R&D, though the effect is marginal. The firms with higher GVA often have more financial capacity for R&D, though this relationship vary here, as the impact seems to be less pronounced.

Firms in high-tech and middle-high-tech industries are more likely to engage in and spend on R&D. The high-tech sectors are generally more R&D-intensive due to their reliance on innovation. A higher share of skilled employees is marginally associated with a higher likelihood of R&D.

Firms located in states with high industrial concentration are more likely to engage in R&D. The firms in competitive, high-concentration areas often have higher R&D activities to maintain their competitive edge. Product subsidies do not significantly affect the likelihood of engaging in R&D, though the coefficient sign is positive. As reported above, while subsidies can support R&D, their direct impact on the likelihood of engaging in R&D is often limited. However, if firm receive product-subsidy on large number of product items, then the coefficient turned significant, indicating that receiving subsidy on more than one products by the firm influence the likelihood as well as extent of R&D spending positively and significantly.

The double hurdle model results are consistent with established literature, both globally and in the Indian context. The findings highlight that larger firms, those with foreign capital, and those in high-tech industries are more likely to engage in and spend more on R&D. Additionally, factors such as firm age and location in high-concentration states also play significant roles.

Table 10: Factors Influencing Firm's R&D Behaviour: Cragg's Double-Hurdle Model Estimation

Estimated double hurdle model	*Stage-1 Hurdle Equation (likelihood of doing R&D)*		*Stage-2 Hurdle Equation (Extent of R&D Spending)*	
	Coeff.	*P>z*	*Coeff.*	*P>z*
Firm's Age	0.006836***	0.000	0.0740**	0.007
Age Square	-0.000028*	0.051	-0.0003	0.130
Firm-Size (log of number of employees)	0.372923***	0.000	5.3604***	0.000
Whether Firm have foreign capital share	0.242128***	0.000	3.4587***	0.000
Whether firm do import input technology	0.275769***	0.000	3.9614***	0.000
Profit to GVA ratio	0.000040	0.144	0.0006	0.117
Log of GVA	0.007384*	0.097	0.1057*	0.091
Whether high & middle-high tech industries or otherwise	0.617933***	0.000	8.9652***	0.000
Skill (share of senior and manager in total employees)	0.002682*	0.098	0.0437*	0.054
Whether firm located in high industrial states	0.174218**	0.001	2.5610**	0.001
Whether firm received product subsidy	0.089798	0.156	1.1921	0.174
If firm received product subsidy, on how many product items subsidy received #	*0.46325**	*0.070*	*0.4469**	*0.027*
_cons	-4.272441***	0.000	-59.9617***	0.000
N	22,719		22,719	

Note: # this variable was included separately while controlling for other explanatory variables, while exclude the dummy of subsidy received. Estimates are only for balanced panel data.

Source: Author's estimates from unit-level data of ASI

5.2. Heckman Model Results

For Heckman model, we have not interpreted the coefficient of selection variables that reflects the likelihood of engaging in R&D activity, though presented in the Table-11. The impact of these variables on the likelihood turned significant in most cases as per our postulation, except for age square and firm location in high industrial activities states.

The analysis of Heckman two-stage model suggest the positive coefficients of age, indicate that older firms tend to invest more in R&D, though the coefficients turned insignificant, except for balanced panel (Table 11). The positive coefficient of age square suggests that R&D investment increases with the age but at a decreasing rate, though coefficients are insignificant except for pooled data. The results show that the larger firms invest significantly more in R&D. The high value of coefficients highlight the importance of scale in R&D investment.

The negative coefficients of foreign capital share indicate, in the pooled regression, that firms with foreign capital share tend to have lower R&D intensity. This could indicate that such firms might rely on foreign technologies rather than investing in their own R&D. The results show that firms that import inputs technology are more likely to engage in R&D. This suggests that imported technologies might complement or enhance domestic R&D efforts. The coefficients of profit margin are very small and mostly insignificant, indicating that the relationship between profitability and R&D investment is weak. The GVA has positive relationship with R&D, suggesting that firms with higher GVA tend to invest more in R&D.

The positive and significant value of the coefficients for firms in high-tech industries suggest that industry classification significantly influences R&D investment. High-tech firms are more likely to invest in R&D than others are. The positive and significant coefficients of skill indicate that a higher share of skilled employees (seniors and managers) in a firm correlates with increased R&D investment.

The firms located in high industrial concentration areas benefit them from synergies and therefore they tends to invest more in R&D. The coefficients are statistical significant and influence the R&D investment positively. The coefficients of product-subsidy are positive but are not significant in balanced panel, indicating that while subsidies may encourage some R&D investment, and the effect is not much pronounced. However, its coefficient turned positive and significant when sample size increase, both in case of pooled and unbalanced panel. Their coefficient value also turned very high in these two data set, indicating product-subsidy given for encouraging export and self-reliance is important in Indian manufacturing sector.

These results suggest that firm characteristics (age, size, and skill level), industry type, and location are significant determinants of extent of R&D spending. The variations between the unbalanced and balanced panels highlight the robustness of these findings across different firm cohorts when sample size changes.

Table 11: Factors Influencing Firm's R&D Behaviour: Heckman Selection Estimates

	Pooled data (entire sample)		*Unbalanced Panel (cohort ID)*		*Balanced Panel (cohort ID)*	
lnRD_exp	*Coeff.*	*P>z*	*Coeff.*	*P>z*	*Coeff.*	*P>z*
Firm's Age	0.0003	0.974	0.0143	0.165	0.0437*	0.046
Age Square	0.0002***	0.000	0.0000	0.523	0.0000	0.920
Firm-Size (log of number of employees)	1.2459***	0.000	1.6354***	0.000	4.1817***	0.000
Whether Firm have foreign capital share	-1.3641**	0.035	-0.7058	0.345	1.4506	0.178
Whether firm do import input technology	1.1353**	0.027	1.6314**	0.011	3.0744**	0.001
Profit to GVA ratio	0.00001	0.2740	0.00002	0.155 0	0.0009**	0.0200
Log of GVA	0.0198*	0.104	0.0379**	0.012	0.1648**	0.016
Whether high & middle-high tech industries or otherwise	2.5471**	0.001	3.0755***	0.000	6.8512**	0.001
Skill (share of senior and manager in total employees)	0.0274**	0.012	0.0393***	0.001	0.0873**	0.004
Whether firm located in high Industrial state	0.7043***	0.000	0.7386***	0.000	1.8647***	0.000
Whether firm received product subsidy	1.3850**	0.001	1.0648**	0.022	1.3573	0.203
_cons	-3.9433	0.482	-10.8843	0.125	-49.6239**	0.005
RD_unitOR_RDexp01 (selection variables)						
Firm's Age	0.0056***	0.000	0.0045***	0.000	0.0029***	0.000
Firm-Size (log of number of employees)	0.2096***	0.000	0.2286***	0.000	0.2729***	0.000
Whether Firm have foreign capital share	0.4858***	0.000	0.4358***	0.000	0.2282***	0.000
Whether firm do import input technology	0.3625***	0.000	0.3529***	0.000	0.1968***	0.000
Profit to GVA ratio	0.0000	0.365	0.0000	0.214	0.0000	0.281
Log of GVA	0.0022*	0.036	0.0005	0.710	0.0068*	0.064
Whether high & middle-high tech industries or otherwise	0.5627***	0.000	0.4843***	0.000	0.4691***	0.000
Skill (share of senior and manager in total employees)	0.0077***	0.000	0.0061***	0.000	0.0059***	0.000
Whether firm located in high Industrial state	-0.0851***	0.000	- 0.0772***	0.000	-0.0247	0.299
Whether firm received product subsidy	0.2526***	0.000	0.1915***	0.000	0.0751	0.234
_cons	-3.1448***	0.000	- 3.0721***	0.000	-3.1362***	0.000
Mills: lambda	1.7857	0.299	3.8382*	0.083	15.5691**	0.004
rho	0.2577		0.5074		1.0000	
sigma	6.9281		7.5640		15.5691	
Number of obs	312209		171591		22719	
Selected	290166		157888		2890	
Nonselected	22043		13703		19829	
Wald chi2(11)	907.52		510.77		57.20	
Prob > chi2	0.00		0.00		0.00	

Source: Author's estimates from unit-level data of ASI

We have extended this analysis for SMEs and large firms separately, presuming the firm size differ significantly across these two categories. Also, it is presumed that SMEs/SMS firms may have limited access to foreign capital and are less likely to import technological inputs, so we excluded these two variables from the outcome equation when comparing their results with those of large firms in a separate regression for them presented in Table-12[10]. The findings from the Heckman selection model comparing R&D investment outcomes between SMEs and large firms provide interesting insights. The coefficients of age fluctuate across large and SMSs firms. The coefficient of firm size turned positive and significant for both categories of firms, but impact remains slightly large in case of large firms. The impact of profit margins is almost negligible in both cases, while GVA turn positive and significant.

The coefficients for tech-level are positive and significant, with large coefficient sizes across all variables for both large and SMEs. This indicates that firms in high-tech industries invest significantly more in R&D. The positive coefficients for skill suggest that a higher share of skilled employees has a modest impact on R&D investment for both large and SMEs/SMS firms, highlighting the importance of skills in driving R&D efforts.

The coefficient for firm location in industrial concentration areas is also positive and significant for both SMS and large firms, suggesting that companies benefit from being situated in areas with high industrial concentration. This implies that external networks and collaboration can enhance R&D activities for both categories of firms.

The product subsidy coefficients were found to be positive and significant for both SMS and large firms, with SMEs/SMS firms showing higher coefficients than their larger counterparts. The coefficient for the product subsidy variable for SMEs is among the highest, second only to the tech-level of the industry, suggesting that subsidies have a greater impact on stimulating R&D in SMS firms. Regarding the factors influencing the likelihood of R&D participation, coefficients for both large and SMS firms were similar in sign and significance level, though their results are not interpreted.

Table 12: Factors Influencing R&D Behaviour of SMSs & large Firms: Heckman Selection Estimates

	Estimates for SMS Firms		*Estimates for Large Firms*	
lnRD_exp	*Pooled data (entire sample) Coeff.*	*Unbalanced Panel (cohort ID) Coeff.*	*Pooled data (entire sample) Coeff.*	*Unbalanced Panel (cohort ID) Coeff.*
Firm's Age	-0.0016	0.0020	0.0396***	0.0457***
Age Square	0.0001*	0.0001	-0.0001	-0.0001
Firm-Size (log of number of employees)	1.1182***	1.0697***	1.4385***	1.5178***
Profit to GVA ratio	0.0001	0.0002*	0.0000	0.0000
Log of GVA	0.0475**	0.0418*	0.0166	0.0706**

[10] It is worth noting that in the case of a strong balanced panel dataset, the Mills ratio was found to be insignificant for both SMS and large firms, likely due to the very small sample size. An insignificant Mills ratio suggests that the Heckman outcome equation is equivalent to OLS estimation, so we have not included results for the strongly balanced panel here.

	Estimates for SMS Firms		*Estimates for Large Firms*	
lnRD_exp	*Pooled data (entire sample) Coeff.*	*Unbalanced Panel (cohort ID) Coeff.*	*Pooled data (entire sample) Coeff.*	*Unbalanced Panel (cohort ID) Coeff.*
Whether high & middle-high tech industries or otherwise	2.3809***	2.1024***	3.5393***	3.3783***
Skill (share of senior and manager in total employees)	0.0296***	0.0310***	0.0322***	0.0372***
Whether firm located in high Industrial state	0.6255***	0.8870***	1.1481***	0.9366***
Whether firm received product subsidy	1.6064***	1.4710**	0.6039*	-0.0466
_cons	-2.2334*	-1.8756	-8.5630***	-10.6849***
RD_unitOR_RDexp01 (selection variables)				
Firm's Age	0.0046***	0.0034***	0.0093***	0.0083***
Firm-Size (log of number of employees)	0.1522***	0.1855***	0.1599***	0.1923***
Whether Firm have foreign capital share	0.5477***	0.4848***	0.3925***	0.3702***
Whether firm do import input technology	0.3457***	0.3464***	0.3116***	0.2915***
Profit to GVA ratio	0.0000	0.0000	0.0000	0.0000
Log of GVA	-0.0001	-0.0024	0.0027*	0.0036*
Whether high & middle-high tech industries or otherwise	0.5912***	0.5128***	0.5394***	0.4743***
Skill (share of senior and manager in total employees)	0.0059***	0.0047***	0.0069***	0.0057***
Whether firm located in high Industrial state	-0.1077***	-0.0845***	-0.0748***	-0.0858***
Whether firm received product subsidy	0.2485***	0.1557***	0.1784***	0.1612***
_cons	-2.775***	-2.7814***	-2.7743***	-2.8776***
Mills: lambda	1.2479***	1.1794**	3.2830***	3.7839***
rho	0.1936	0.1822	0.4169	0.4716
sigma	6.4464	6.4737	7.8755	8.0230
Number of obs	192594	104391	56328	31425
Selected	180768	7379	46967	5751
Nonselected	11826	97012	9361	25674
Wald chi2(9)	330.07	192.15	351.53	216.23
Prob > chi2	0.00	0.00	0.00	0.00

Source: Author's estimates from unit-level data of ASI

6. Conclusion and Discussion

This study makes the following notable contribution to the literature. This is the first comprehensive study on the estimates of status and trends in R&D activity of organised manufacturing sector of India. Also first study to evaluate the contribution of SMEs versus large enterprises in R&D investments across various technology levels of the Indian organized manufacturing sector. Also, first research to explore the impact of government incentives, such as product subsidies (a precursor to the Production Linked Incentive scheme -PLI), on R&D activities and intensity in organized manufacturing firms, while considering the spillover effects of state's industrial concentration and controlling for firm characteristics. Our findings suggest that there is an increase in the number of firms engaging in the R&D activities in the Indian organised manufacturing sector during the study period. However, R&D intensity sees a declining trend. The declining R&D intensity is of concern not just for the competitiveness and productivity of the manufacturing sector but also for technological progress and the long-run growth prospects. A similar type of connotation is presented some earlier studies. Studies have highlighted that despite R&D being a key driver of sustained growth, India's economy remains low R&D investment economy. India's annual R&D expenditure of approximately $17-18 billion pales in comparison to the $800 billion spent by the United States and $600 billion by China (Forbes, 2023). While India ranks fifth globally in GDP, it is only 20th in terms of overall R&D spending. This low expenditure is primarily due to inadequate R&D investment by Indian industry (Forbes, 2023). Although India has recently shown improvement in innovation performance—improvement in rank from 81st place in 2015 to 48th in 2020 on the Global Innovation Index (GOI, 2020)—its Gross Expenditure on R&D (GERD) as a percentage of GDP remains under 1%, significantly lower than other large economies such as Brazil, China, Russia, Korea (Rep.) and Thailand (data.worldbank.org)[11].

Our findings observed that SMEs are different with regards to the R&D activity. They exhibit higher R&D intensity across both low- and high-tech sectors compared to their larger counterparts. However, their R&D intensity have been dwindling in the wake of the pandemic. In the recent period, we found that despite the introduction of various initiatives, such as the product subsidy, overall R&D intensity in the manufacturing sector has not been taking off, though total R&D spending and activity levels are on the rise.

The results of double-hurdle regression finds that larger firms, those with foreign capital share, and those in high-tech industries are more likely to engage in and spend more on R&D. Additionally, factors such as firm age and location in high-industrial activity concentration states also play significant roles in the Cragg model estimation. The variable product subsidies do not significantly affect the likelihood of engaging in R&D, though the coefficient sign is positive, indicating the while subsidies can support R&D, but their direct impact on the likelihood of engaging in R&D is often limited.

The estimates of Heckman selection two-stage model suggest that SMEs are different from large firms in some cases. The results suggest that SMEs have a tendency to invest less in

---

[11] Country-wise data on Gross domestic expenditures on research and development (R&D), expressed as a per cent of GDP, is available at: https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?locations=IN-1W-XO-XT-XD-8S-Z4-XM

R&D compared to large firms, which tend to benefit more from their size and age. The size disadvantage for SMEs could reflect resource constraints or less access to capital for R&D, though, coefficients were positive. Both SMEs and large firms respond positively to being in high-tech industries, large firms appear to leverage their scale more effectively for R&D investments. The coefficients of subsidies suggests that SMEs may benefit more from subsidies, highlighting opportunities for policy intervention to support their R&D activities. Overall, the analysis indicates that SMEs and large firms differ in their R&D investment and the factors influencing it. Large firms tend to have a more favourable environment for R&D investment, while SMEs face unique challenges that may hinder their R&D capabilities, though SMEs seems strong in some cases, indicating SMEs have to play a greater role in R&D investment in Indian organised manufacturing sector.

Given the low size of R&D spending, this study recommends that industrial transformation of the country cannot occur without a substantial increase in R&D investment, innovation, and technological capacity within the industrial sector. Indian industries must significantly enhance their in-house R&D investments to ensure sustained growth and to remain competitive in the global market.

Reference

Arrow, K. J. (1962). Economic welfare and the allocation of resources for invention. In *The rate and direction of inventive activity: Economic and social factors* (pp. 609–626). Princeton University Press.

Bas, M., & Paunov, C. (2018). The unequal effect of India's industrial liberalization on firms' decision to innovate: Do business conditions matter? *The Journal of Industrial Economics, 66*(1), 205-238.

Basant, R. (1997). Technology strategies of large enterprises in Indian industry: Some explorations. *World Development, 25*(10), 1683–1700.

Baumann, J., & Kritikos, A. S. (2016). The link between R&D, innovation and productivity: Are micro firms different? *Research Policy*, *45*(6), 1263-1274.

Bell, M., & Pavitt, K. (1992). Accumulating technological capability. In *Proceedings of the World Bank Annual Conference on Development Economics, 1992* (pp. 257-581).

Bhattacharya, M., Okafor, L. E., & Pradeep, V. (2021). International firm activities, R&D, and productivity: Evidence from Indian manufacturing firms. *Economic Modelling, 97*, 1-13.

Bhattacharya, S., & Lal, K. (2008). Industrial R&D in India: Contemporary scenario. *Science and Technology*, Vol. 1. CSIR-NISTADS. https://www.nistads.res.in/all-html/india-science.html

Burke, W. J. (2009). Fitting and interpreting Cragg's tobit alternative using Stata. *The Stata Journal*, *9*(4), 584–592.

Cameron, A. C., & Trivedi, P. K. (2005). Microeconometrics: Methods and Applications (3rd eds.). Cambridge University Press.

Centre for Monitoring Indian Economy. (n.d.). *ProwessIQ database*. Mumbai: CMIE.

Coad, A., & Rao-Nicholson, R. (2008). Innovation and firm growth in high-tech sectors: A quantile regression approach. *Research Policy*, *37*(4), 633-648.

Cohen, W. M., & Levinthal, D. A. (1989). Innovation and learning: The two faces of R&D. *The Economic Journal, 99*(397), 569-596.

Cohen, W. M. (1995). Empirical studies of innovative activity. In P. Stoneman (Ed.), *Handbook of the economics of innovation and technological change* (pp. 182–264). Blackwell.

Cragg, J. (1971). Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrica, 39*(5), 829-844.

Czarnitzki, D., & Thorwarth, S. (2012). Productivity effects of basic research in low-tech and high-tech industries. *Research Policy*, *41*(9), 1555-1564.

Das, K., & Joseph, K. J. (2010). On learning, innovation and competence building in India's SMEs: Challenges ahead. *Working Paper No. 197*, Gujarat Institute of Development Research. https://gidr.ac.in/pdf/Working%20Paper%20197.pdf

Deaton, A. (1985). Panel data from time series of cross-sections. *Journal of Econometrics*, *30*, 109-126.

Deolalikar, A. B., & Evenson, R. E. (1989). Technology production and technology purchase in Indian industry: An econometric analysis. *The Review of Economics and Statistics, 71*(4), 687-697.

Desai, A. V. (1980). The origin and direction of industrial R&D in India. *Research Policy, 9*(1), 74-96.

Dubey, A., & Roy, G. K. (2022). Firm-level R&D activities in the Indian organized manufacturing: Evidence from the Annual Survey of Industries panel data. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4051729

Engel, C., & Moffatt, P. G. (2014). dhreg, xtdhreg, and bootdhreg: Commands to implement double-hurdle regression. *The Stata Journal, 14*(4), 778-797.

Etemad, H. (2004). Internationalization of small and medium-sized enterprises: A grounded theoretical framework and an overview. *Canadian Journal of Administrative Sciences, 21*(1), 1–21.

Fishman, A., & Rob, R. (1999). The size of firms and R&D investment. *International Economic Review, 40*(4), 915–931.

Forbes, N. (2023). Towards innovations-driven industrial transformation of India. *Policy Brief No 23-08*, Institute for Studies in Industrial Development, New Delhi, India.

Garcia, B. (2013). Implementation of a double-hurdle model. *The Stata Journal, 13*(4), 776-794.

Government of India. (2016). *Annual survey of industry 2015-16: Instruction manual*. Ministry of Statistics and Programme Implementation.

Government of India. (2019). EAC-PM – "Research and Development Expenditure Ecosystem: The Way Forward". A report prepared by the Office of the Principal Scientific Adviser to the Government of India, July 2019

Government of India. (2020). *Research and development statistics 2019-20 (Chapter IV)*. Department of Science & Technology, Ministry of Science & Technology. https://dst.gov.in/sites/default/files/Research%20and%20Deveopment%20Statistics%202019-20_0.pdf

Government of India. (2024). Celebrating MSMEs on National Small Industry Day 2024. Ministry of Micro, Small & Medium Enterprises. https://www.pib.gov.in/PressNoteDetails.aspx?NoteId=152063&ModuleId=3#:~:text=MSMEs%20contributed%2049.75%25%20to%20India's,recorded%20up%20to%20May%202024.

Goldar, R. N., & Renganathan, V. S. (1998). Economic reforms and R&D expenditure in industrial firms in India. *The Indian Economic Journal, 46*(2), 60–75.

Griliches, Z. (1979). Issues in assessing the contribution of R&D to productivity growth. *Bell Journal of Economics, 10*(1), 92–116.

Griliches, Z. (1995). R&D and productivity. In P. Stoneman (Ed.), *Handbook of the economics of innovation and technical change* (pp. 152-202). Blackwell.

Hasan, R. (2002). The impact of imported and domestic technologies on the productivity of firms: Panel data evidence from Indian manufacturing firms. *Journal of Development Economics, 69*(1), 23-49.

Hassinea HB, Mathieu C. R&D crowding out or R&D leverage effects: An evaluation of the French cluster-oriented technology policy. *Technological Forecasting and Social Change*. Vol.155(120025): doi.org/10.1016/j.techfore.2020.120025

Heckman, J. J. (1979). Sample selection bias as a specification error. *Econometrica, 47*(1), 153-161.

Himmelberg, C. P., & Petersen, B. C. (1994). R&D and internal finance: A panel study of small firms in high-tech industries. *The Review of Economics and Statistics, 76*(1), 38–51.

Katrak, H. (1985). Imported technology, enterprise size and R&D in a newly industrializing country: The Indian experience. *Oxford Bulletin of Economics and Statistics, 47*(3), 213–229.

Katrak, H. (1989). Imported technologies and R&D in a newly industrializing country: The experience of Indian enterprises. *Journal of Development Economics, 31*(1), 123-139.

Katrak, H. (1997). Developing countries' imports of technology, in-house technological capabilities and efforts: An analysis of the Indian experience. *Journal of Development Economics, 53*, 67-83.

Kumar, N., & Siddharthan, N. S. (1994). Technology, firm size and export behaviour in developing countries: The case of Indian enterprises. *The Journal of Development Studies, 31*(2), 289-309.

Kumar, N., & Saqib, M. (1996). Firm size, opportunities for adaptation, and in-house R&D activity in developing countries: The case of Indian manufacturing. *Research Policy, 25*(5), 712-722.

Kumar, N., & Aggarwal, A. (2005). Liberalization, outward orientation and in-house R&D activity of multinational and local firms: A quantitative exploration for Indian manufacturing. *Research Policy, 34*(4), 441–460.

Lall, S. (1983). Determinants of R&D in an LDC: The Indian engineering industry. *Economic Letters, 37*(3), 379-383.

Lall, S. (1992). Technological capabilities and industrialization. *World Development, 20*, 165-186.

Lee, C. Y. (2005). A new perspective on industry R&D and market structure. *The Journal of Industrial Economics, 53*(1), 101-122.

Mani, S. (2008). Industrial R&D in India: Broad indications. In *India, Science and Technology: 2008* (Vol. 1). CSIR-NISTADS. https://www.nistads.res.in/all-html/india-science.html

Mani, S. (2010). Financing of industrial innovations in India: how effective are tax incentives for R&D? *International Journal of Technological Learning, Innovation and Development*, Vol. 3, No. 2. Inderscience Enterprises Ltd.

Meng W, Wang Y, Li Y, Huang B. (2020). Impact of product subsidies on R&D investment for new energy vehicle firms: Considering quality preference of the early adopter group. *PLoS One*. Vol.15(7):e0236626. doi: 10.1371/journal.pone.0236626.

Mo, J., Qiu, L. D., Zhang, H., & Dong, X. (2021). What you import matters for productivity growth: Experience from Chinese manufacturing firms. *Journal of Development Economics, Vol.152*, 102677. https://doi.org/10.1016/j.jdeveco.2021.102677

Morris, S., Basant, R., Das, K., Ramachandran, K., & Koshy, A. (2001). *The growth and transformation of small firms in India*. Oxford University Press.

Nunes, P. M., Serrasqueiro, Z., & Leitao, J. (2012). Is there a linear relationship between R&D intensity and growth? Empirical evidence of non-high-tech vs. high-tech SMEs. *Research Policy, 41*(1), 36-53.

Pavitt, K. (1984). Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy, 13*(6), 343–373.

Pradhan, J. P. (2011). R&D strategy of small and medium enterprises in India. *Science, Technology and Society, 16*(3), 373-395.

Pradhan, J. P. (2003). Liberalization, firm size and R&D performance: A firm level study of Indian pharmaceutical industry (Discussion Paper No. RIS-DP # 40/2003). Research and Information System for Developing Countries (RIS).

Rijesh, R. (2016). Productivity growth in organised manufacturing sector in India: Evidence from technology intensive classification of industries. *Artha Vijnana*, 58(2), 121-148.

Sahu, P. P. (2008). Technological constraints of small scale industries in India: Some evidence from a field survey. In S. K. Bhaumik (Ed.), *Reforms in Indian agriculture for employment expansion and poverty reduction* (pp. 498–516). SAGE.

Sasidharan, S., & Kathuria, V. (2011). Foreign direct investment and R&D: Substitutes or complements? A case of Indian manufacturing after 1991 reforms. *World Development, 39*(7), 1226-1239.

Schumpeter, J. A. (1942). *Capitalism, socialism and democracy*. Harper & Brothers.

Seenaiah, K. (2023). R&D behaviour of Indian firms: A case of high-tech manufacturing (ISID-Working Paper No. 266). Institute for Studies in Industrial Development.

Siddharthan, N. S. (1988). In-house R&D, imported technology, and firm size: Lessons from Indian experience. *The Developing Economies, 26*(3), 212-221.

Smith, D. A., & Brame, R. (2003). Tobit models in social science research: Some limitations and a more general alternative. *Sociological Methods & Research, 31*(3), 364-388.

Stam, E., & Wennberg, K. (2009). The roles of R&D in new firm growth. *Small Business Economics, 33*, 77-89. https://doi.org/10.1007/s11187-009-9183-9

Tobin, J. (1958). Estimation of relationships for limited dependent variables. *Econometrica, 26*(1), 24–36.

UNCTAD. (2005). *World investment report: Transnational corporations and the internationalization of R&D*. United Nations. https://unctad.org/system/files/official-document/wir2005_en.pdf

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT Press.

Appendix 1: Status of R&D Activity in Indian Organised Manufacturing Sector

	No. of units registered with DST/ DBT for R&D activity		*No. of units registered with other agency for R&D activity*		*No. of units not registered with any agency for R&D activity*		*Total units*		*Composition of active R&D doing units*			
	Actively doing R&D units	*Not doing R&D*	*Actively doing R&D units*	*Not doing R&D*	*Actively doing R&D units*	*Not doing R&D*	*Actively doing R&D units*	*Not doing R&D*	*those regd. with DST (col2 to col8)*	*those regd. With other agency (col4 to col8)*	*un-registered units (col6 to col8)*	*% of R&D doing units beyond the scope of DST/ DBT (col11 +col12)*
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
2015-16	1245	1884	792	1011	2326	183804	4363	186699	28.5	18.2	53.3	71.5
2016-17	774	836	1306	1266	2334	187864	4414	189966	17.5	29.6	52.9	82.5
2017-18	875	732	1331	1374	2106	189166	4312	191272	20.3	30.9	48.8	79.7
2018-19	1006	649	1870	1269	1899	190455	4775	192373	21.1	39.2	39.8	78.9
2019-20	925	792	1515	3062	2063	190271	4503	194125	20.5	33.6	45.8	79.5
2020-21	988	788	2082	1637	1736	193164	4806	195589	20.6	43.3	36.1	79.4
2021-22	1073	556	2296	1540	1721	193390	5090	195486	21.1	45.1	33.8	78.9
Avg.&%	984	891	1599	1594	2026	189731	4609	192216	21.3	34.7	44	78.7

Source: Author's estimates from unit-level data of ASI

Appendix 2: Sample Size for Empirical Estimation

Year	*Total ASI sample (NIC 10-32)*	*Sample size by active R&D doing firms and remaining (appropriate for Cragg)*		*Sample size by active + inactive R&D firms and remaining (appropriate for Heckman)*	
	Firms with non-zero sale	*Active R&D doing firms*	*Remaining firms*	*Active + inactive R&D firms*	*Remaining firms*
2016	42,600	1,890	39,477	3,123	40,584
2017	44,926	1,958	41,967	2,959	43,061
2018	44,302	1,956	41,373	2,929	42,509
2019	44,164	2,143	41,146	3,018	42,293
2020	44,512	2,127	41,034	3,478	42,170
2021	45,468	2,245	42,210	3,258	43,408
2022	46,247	2,383	42,969	3,278	44,229
Total	3,12,219	14,702	2,90,176	22,043	2,98,254

Source: Author's estimates from unit-level data of ASI

Note: inactive R&D firms are those firms that are registered with any agency for reporting the R&D but actually not spending on R&D, they are just registered themselves at government platform.

Appendix 3: Status of R&D Activities for SMEs and Large Firms

	2015-16						*2021-22*					
	Composition share of R&D doing SMEs and large firms out of total firms by sector		*Sectoral share of R&D doing SMEs and Large firms*		*R&D Propensity (R&D unit by total Operational units)*		*Composition share of R&D doing SMEs and large firms out of total firms by sector*		*Sectoral share of R&D doing SMEs and Large firms*		*R&D Propensity (R&D unit by total Operational units)*	
NIC2	*Share of SMEs#*	*share of Large*	*SMEs*	*Large*	*SMEs*	*Large*	*Share of SMEs*	*share of Large*	*SMEs*	*Large*	*SMEs*	*Large*
10	59.00	28.72	14.27	13.89	2.82	14.19	52.07	40.86	12.44	13.31	2.25	13.70
11	48.72	33.33	0.80	1.09	3.44	5.88	41.03	56.41	0.59	1.10	2.61	7.83
12	20.00	25.00	0.17	0.42	0.75	9.09	18.18	81.82	0.07	0.45	0.48	13.24
13	55.20	29.60	2.89	3.10	1.21	4.36	37.82	61.34	1.65	3.65	0.70	6.68
14	51.41	35.21	3.06	4.18	1.96	12.41	41.90	56.19	1.61	2.95	0.85	9.31
15	75.68	6.76	2.34	0.42	3.13	4.72	86.05	13.95	1.36	0.30	2.01	3.61
16	23.53	5.88	0.17	0.08	0.56	5.56	66.67	33.33	0.15	0.10	0.35	11.11
17	56.10	43.90	0.96	1.51	1.23	10.34	20.00	80.00	0.18	1.00	0.18	7.66
18	25.00	62.50	0.08	0.42	0.16	4.00	0.00	100.0	0.00	0.25	0.00	5.10
19	63.16	36.84	0.50	0.59	2.13	3.89	67.31	32.69	1.28	0.85	4.60	10.24
20	62.54	21.71	17.12	11.88	9.77	20.43	60.68	34.92	17.72	13.91	7.99	24.91
21	57.46	37.56	14.02	18.33	14.69	42.69	54.95	40.93	18.13	18.41	16.58	49.93
22	57.14	25.11	5.53	4.85	2.67	17.58	67.69	30.13	5.69	3.45	2.20	9.73
23	25.98	16.73	3.06	3.93	2.09	10.59	50.38	32.33	2.46	2.15	1.43	7.11
24	31.01	62.03	2.05	8.20	0.99	10.71	31.87	68.13	2.13	6.20	1.05	8.49
25	59.20	12.00	3.10	1.26	1.55	5.88	61.17	34.95	2.31	1.80	1.00	9.70
26	65.36	13.41	4.90	2.01	13.75	19.20	70.81	22.36	4.18	1.80	9.76	15.86
27	68.66	18.43	6.24	3.35	5.01	10.78	66.49	28.95	9.10	5.40	6.69	20.22
28	65.24	26.47	10.21	8.28	5.72	22.50	47.92	46.30	7.60	10.01	3.40	28.09
29	47.73	50.91	4.40	9.37	4.02	14.93	46.78	52.92	5.87	9.05	4.89	16.64
30	60.61	36.36	1.67	2.01	4.30	14.72	45.28	42.45	1.76	2.25	4.32	18.15
31	78.57	0.00	0.46	0.00	2.56	0.00	100.0	0.00	0.44	0.00	1.22	0.00
32	67.61	14.08	2.01	0.84	3.76	5.03	69.53	25.00	3.27	1.60	4.64	9.30
All	56.40	28.21	100.0	100.0	3.58	14.05	55.03	40.37	100.0	100.0	3.16	15.49

	2015-16						*2021-22*					
	Share of R&D spending of SMEs and large firms in total R&D by sector		*Sectoral share of R&D spending of SMEs and Large firms*		*R&D intensity of SMEs and Large firms (R&D spending by turnover)*		*Share of R&D spending of SMEs and large firms in total R&D by sector*		*Sectoral share of R&D spending of SMEs and Large firms*		*R&D intensity of SMEs and Large firms (R&D spending by turnover)*	
NIC2	*Share of SMEs#*	*share of Large*	*SMEs*	*Large*	*SMEs*	*Large*	*Share of SMEs*	*share of Large*	*SMEs*	*Large*	*SMEs*	*Large*
10	29.39	68.46	5.40	3.75	0.36	0.32	24.29	75.49	7.26	2.41	0.30	0.23
11	50.09	49.87	1.33	0.39	1.48	0.29	7.43	92.51	0.04	0.06	0.16	0.04
12	95.96	3.83	0.48	0.01	6.46	0.01	18.07	81.93	0.04	0.02	0.31	0.03
13	63.33	32.65	2.43	0.37	1.22	0.09	18.18	81.82	0.46	0.22	0.18	0.05
14	15.55	84.24	1.35	2.18	0.73	1.47	3.49	96.48	0.30	0.88	0.10	0.60
15	39.63	59.91	0.34	0.15	0.12	0.52	22.16	77.84	0.34	0.13	0.16	1.19
16	89.51	0.33	0.03	0.00	0.38	0.00	22.59	77.41	0.04	0.02	0.05	0.08
17	40.14	59.86	1.39	0.62	1.73	0.22	1.30	98.70	0.02	0.19	0.06	0.09
18	40.50	45.75	0.02	0.01	0.44	0.28	0.00	100.0	0.00	0.00	0.00	0.01
19	20.60	79.40	0.52	0.60	0.81	0.28	0.61	99.39	0.04	0.73	0.04	0.01
20	48.50	50.73	15.99	4.99	0.79	0.21	26.42	73.29	13.77	4.08	0.49	0.16
21	19.66	80.24	27.32	33.25	1.95	1.66	4.39	95.61	23.76	55.32	0.61	2.12
22	16.43	81.08	0.86	1.27	0.11	0.16	19.32	80.62	1.24	0.55	0.14	0.09

23	29.01	58.63	1.39	0.84	0.51	0.13	4.73	95.12	1.09	2.35	0.39	0.53
24	8.04	91.90	0.48	1.64	0.14	0.05	1.69	98.31	0.86	5.34	0.16	0.11
25	69.48	19.92	6.72	0.57	2.63	0.16	59.01	40.86	9.74	0.72	2.99	0.38
26	56.45	31.98	14.84	2.51	4.64	0.57	45.52	54.42	8.69	1.11	1.43	0.25
27	14.48	84.83	6.22	10.87	0.95	2.29	24.34	75.59	6.04	2.00	0.37	0.24
28	34.60	65.10	7.72	4.33	0.68	0.44	14.37	85.62	8.85	5.63	0.62	0.46
29	2.33	97.66	2.42	30.27	0.35	0.60	5.90	94.10	8.87	15.12	0.65	0.44
30	19.68	79.62	0.98	1.19	0.28	0.11	5.81	92.42	1.63	2.78	0.47	0.24
31	87.48	0.00	0.01	0.00	0.03	0.00	100.0	0.00	0.10	0.00	0.13	0.00
32	71.47	28.12	1.74	0.20	1.11	0.25	68.27	31.60	6.79	0.34	1.31	0.51
All	22.65	75.95	100.0	100.0	0.93	0.50	9.64	90.27	100.0	100.0	0.55	0.33

Note: #-SMEs do not include micro firms, therefore add up, of SMEs and large firms, may not be 100.

Source: Author's estimates from unit-level data of ASI

List of ISID Working Papers

284 Towards a Resilient Steel Industry in India: Optimising Trade Competitiveness vis-à-vis China, *Beena Saraswathy*, August 2024

283 Can India Achieve Manufacturing-led Growth? Exploring Policy Strategies Using CGE Modelling Analysis, *Akhilesh Kumar Sharma*, March 2024

282 Looking Through Employment Elasticities: A Study of the Organised Manufacturing Sector in India, *Sangeeta Ghosh*, March 2024

281 Role of Clusters in the Growth of MSMEs: A Case Study of Moradabad Metal Craft Cluster, *Ajit Jha and Surya Tewari*, March 2024

280 Impact of Pandemic on Firm Performance in India across Size and Sectors: A Study Based on Formal Enterprises, *Akhilesh Kumar Sharma and Vanshika Jain*, February 2024

279 Exploring the Changing Dynamics in Indian Toy Sector: Challenges and Way Forward, *Ramaa Arun Kumar and Kanishk Rohilla*, February 2024

278 Evaluating Performance of ODOP and Its Role in Industrial Development of Uttar Pradesh, *Surya Tewari and Ajit Jha*, February 2024

277 Technological change and productivity growth in Indian electronics industry, *Sanjaya Kumar Malik*, January 2024

276 Trade Liberalisation, Export Margins, and International Competitiveness in the Indian Manufacturing Sector, *R Rijesh*, January 2024

275 Harnessing the Potential of Sustainable Industrialization in South Asia: Some Policy Lessons for Advancing SDG-9, *Nagesh Kumar & Shiladitya Chatterjee*, December 2023

274 Changing Household Consumption of Services: Redefining the Boundaries of Discretionary and Non-discretionary Expenditures, *Satyaki Roy & Veerpal Kaur*, December 2023

273 Understanding Firm's Transition, Entry, and Exit across Size, Sectors, and Age in India, *Akhilesh Kumar Sharma*, November 2023

272 Financial Liberalization and Saving in India: An Empirical Analysis, *Santosh Kumar Das*, November 2023

271 Pre-mature Servicification of Consumption Demand and India's Service-led Growth, *Satyaki Roy*, October 2023

270 Manufacturing-led Transformation for Realizing India's Development Aspirations in the Context of a Fractured Trading System: Challenges, Opportunities, and Strategic Interventions, *Nagesh Kumar*, October 2023

269 Determinants of Energy Intensity: Evidence from India's Iron and Steel Firms, *Anjali Tandon*, September 2023

268 Manufacturing Productivity in Indian States: The Role of Infrastructure, Agglomeration, and Exports, *Mahua Paul & Smruti Ranjan Sahoo*, September 2023

267 FDI, International Trade and Global Value Chains (GVCs): Trends and Patterns in India's GVC Participation, *Isha Chawla & Nagesh Kumar*, March 2023

266 R&D behaviour of Indian Firms: A Case of High-tech Manufacturing, *K Seenaiah*, March 2023

265 Impact of Import Liberalisation on Employment in Manufacturing Industries in India, *Ramaa Arun Kumar*, March 2023

* Most of the working papers are downloadable from the institute's website: https://isid.org.in/

The **Institute for Studies in Industrial Development** (ISID) is a public-funded, non-profit, autonomous institution dedicated to conducting policy research, advocacy, capacity-building, and outreach activities to foster the industrial transformation of India.

Registered on October 7, 1986, under the Indian Societies Registration Act 1860, ISID in 1988, became one of the institutions that are supported by the Indian Council of Social Science Research (ICSSR), (Government of India), through grants-in-aid. Since 2006, the Institute operates from its own well-appointed campus located in the Vasant Kunj Institutional Area in South Delhi.

The research themes and key projects are classified under following broad thematic areas:

- Industrial Structure, Performance, and Polices
- Corporate Governance and Industrial Financing
- Leveraging MSMEs and Start-ups for Industrial Transformation
- Globalization, FDI, and Trade
- Technology, Innovation and Industry 4.0
- Green Industrialization Strategy
- Employment and Labour Markets
- Spatial Dimensions of Industrial Development and Industrial Infrastructure
- Sectoral Studies on Competitiveness of Indian Manufacturing

ISID is recognized as a Scientific and Industrial Research Organization (SIRO) by the Government of India. It is also listed on DARPAN portal of NITI Aayog (India's Planning Agency) as a recognized think-tank. It is also a member of the Asia-Pacific Research Network on Trade (ARTNet) and the South Asia Network on SDGs (SANS) of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). ISID's Databases and e-resources are accessed by the academic community across the country through the Information and Library Network (INFLIBNET) Centre of the University Grant Commission (UGC).

ISID Institute for Studies in Industrial Development
An institution of Indian Council of Social Science Research (Ministry of Education)
Policy Research to Foster India's Industrial Transformation
4 Vasant Kunj Institutional Area, New Delhi - 110070, India
Phone: +91 11 3510 4511 | E-mail: info@isid.org.in | Website: https://isid.org.in