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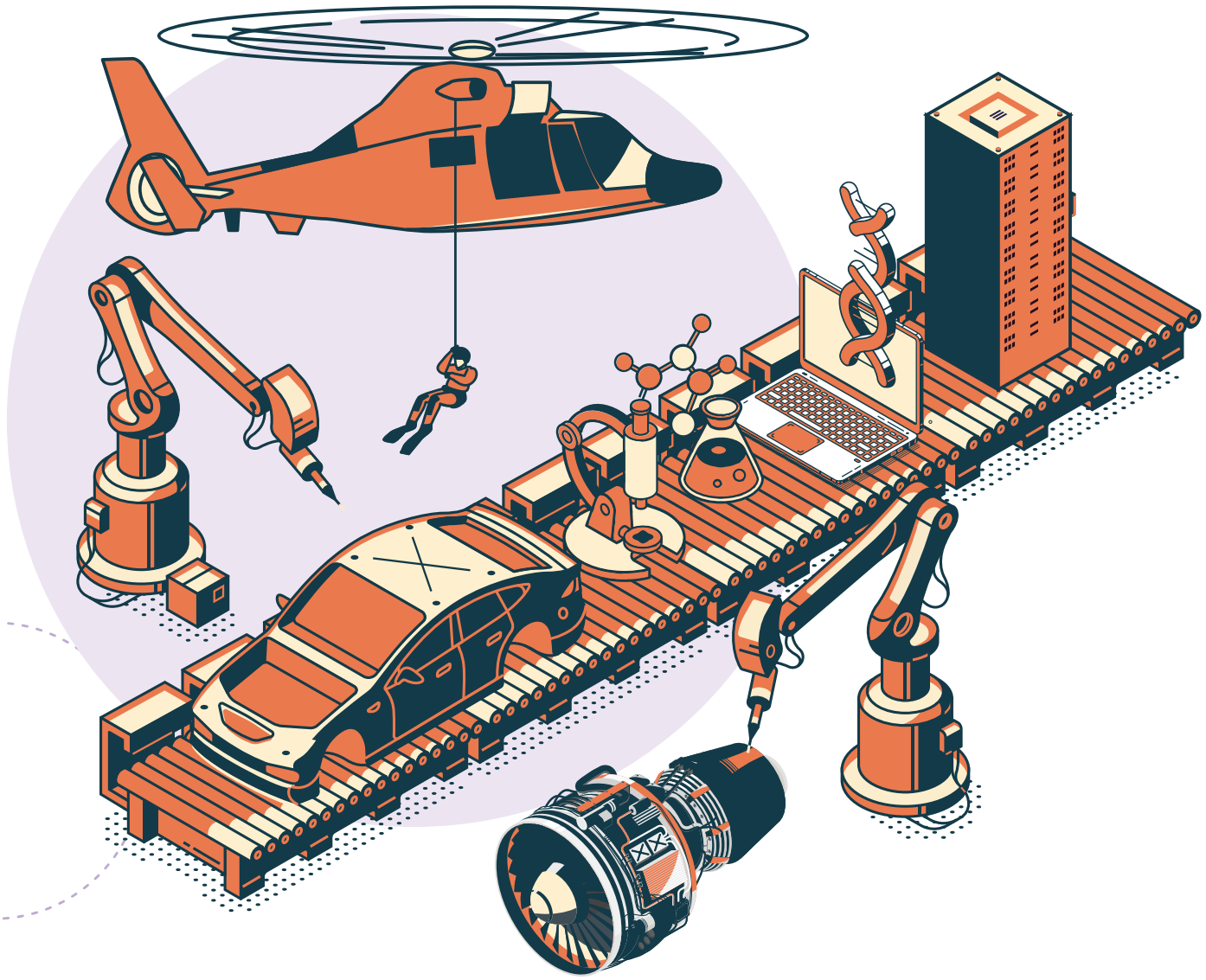
State of Industry
R&D in India

An R&D investment and disclosure analysis of
Indian and global firms in six key strategic sectors



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Foreword

"Currently, India invests about 0.7 per cent of the Gross Domestic Product (GDP) in research, I would like to see this go to about 3 per cent of the GDP. The government spends about 0.6 per cent of the GDP and I would like to see this go up to 1.5 per cent and the private sector investments must go up from 0.1 per cent to 1.5 per cent… Industry involvement in research and funding is a two-way street."

- Kris Gopalakrishnan,
Co-founder, Infosys

The Foundation for Advancing Science and Technology India (FAST India) is on a mission to catalyse India's journey to become a top 3 science and technology (S&T) nation. Exponential progress in our S&T capability, production of new knowledge and its translation to socio-economic products is imperative for the sustained economic and social development of our country.

Industry's contribution to research and development (R&D) is a pivotal part of the S&T ecosystem. Traditionally, the government funds and regulates S&T research, institutions deliver public knowledge goods, and the industry exploits this knowledge to convert it into differentiated products and services, leading to economic and social outcomes. Lately, the global industry has taken a leading role in basic research as well, either through privately owned research labs or close academic partnerships. There are several such examples such as Samsung, Microsoft, Huawei, Pfizer, Google, NVIDIA and more. Industrial R&D is indispensable for a country to move up the value chain in products/services and maintain global competitiveness.

From a macro lens, R&D investment by Indian industry is still small at 0.2% of GDP. In comparison, US industry spends 2.7% of GDP, South Korea 3.9% and the United

Kingdom 2.1%. The good news is that macroeconomic conditions have aligned for the Indian industry to push up R&D investments and reap dividends. This includes the large size of the economy (3rd largest in PPP terms), large local markets, huge startup ecosystem, a stress on building manufacturing capacity and a mature R&D institution ecosystem. This is the right time to go to the next stage of industrial evolution - creating product-led businesses, value-added manufacturing, building local technology capability to lower imports and sharply increasing high-tech exports.

At this critical juncture, FAST is pleased to bring out this report as a public good. Today, there are no objective benchmarks for the Indian industry to compare their R&D efforts with their peers in India and globally. The report provides an objective comparison of top Indian firms within themselves and global peers on R&D inputs, R&D outputs, R&D growth and R&D disclosures. The report covers firms in six important sectors- Pharmaceuticals and Biotechnology, Automobile and Components, Software and Services, Oil and Gas, Aerospace and Defence, and Chemical Sectors. Given its data-based approach, the report shall provide a great starting point for the Indian industry to discover global R&D exemplars, their relative strengths and weaknesses and potential next steps.

I see this report as a conversation starter on how the Indian industry can build powerful research programs and have substantial impact on creating shareholder value through these efforts. The report aims to open doors and create avenues for multiple threads of downstream research to answer the decades-old question of low industry R&D and how to stimulate it. The report is timely also with respect to recent government efforts to engage and promote industrial R&D through Anushandhan National Research Foundation and the INR 1 lakh crore corpus to fund research with interest-free loans.

I welcome all feedback and criticism to make this report better. I look forward to many stimulating discussions arising from this new data analysis and participate in discussions to make Indian Industrial R&D world class. FAST plans to continuously measure the state of Industry R&D in India year-on-year to track improvements and areas still lagging.

I sign off with the expectation that this report encourages discussion and leads to the identification of thrust areas for the promotion of Industry R&D. Industry is the way forward!

Varun Aggarwal

Co-founder, FAST India

Executive Summary

The Indian corporate sector has played a significant role in its economic development.[1] However, serious attention towards technology and innovation in the sector is required to transform India into a global leader.[2] India lags behind key economies in overall Gross domestic expenditure on R&D (GERD) as well as GERD by corporates. In 2022, while the overall GERD in India was 0.6%, GERD by corporates was reported to be 0.2%.[3] On the other hand, the GERD by corporates in developed countries is much higher in proportion. The gap between Global and Indian firms is also seen in outputs of Research and Development (R&D). For instance, we find that the Global firms studied for this report had **13.1x** Patents per USD Billion Dollars (patents by revenue) compared to Indian firms.

To achieve world-class industry status, it is important to understand the current state of R&D activities by the Indian industry and compare their performance with the best-in-the-class peers. This study aims to understand how Indian firms compare with leading Global firms on selected parameters for R&D inputs and outputs. Data from about 120 firms was collected and analysed for this exercise. Six sectors were chosen to allow for comparison between firms from similar industries. Data was collected between Financial Year (FY) 2016 to FY 2023.[4]

The top 10 firms by market capitalisation were chosen for selected sectors within the Indian and Global cohorts. Six sectors were identified based on national importance, frontier research areas, and economic & social importance. These sectors include Aerospace and Defence (Defence), Automobile and components (Automobiles), Chemicals, Energy[5], Pharmaceuticals, Biotechnology and Life Sciences (Pharmaceuticals), and Software and Services (Software). To be able to perform a comparative study, baseline data requirements

[1] Kniivilä 2007.
[2] Forbes 2024.
[3] World Intellectual Property Organisation 2023.
[4] Annual years 2015-2022 for firms which do not follow financial year calendar.
[5] includes firms that deal in energy, oil, gas and consumable fuels, electric utilities, independent power and renewable electricity producers

were set. Firms that did not meet these requirements were excluded from the study even when they met market capitalisation requirements. Eventually, 59 Indian and 60 Global firms were chosen for the study. Data was collected from publicly available information such as annual reports, Scopus database, Google patents data and LinkedIn. Additionally, a survey of 41 Indian firms was conducted to understand a firm's decision-making regarding R&D investments.

Input and output parameters were chosen based on literature review, consultations and availability of such data in the public domain to understand a firm's perspective on R&D activities conducted by them. R&D intensity,[6] and proportion of employees with PhD are chosen as primary input indicators, supplemented by R&D by profits and R&D growth information. R&D intensity was chosen since it allows direct comparison between firms operating in different jurisdictions, without needing currency conversions across the study period. Patents and publications by revenue were chosen as output indicators, supplemented by disclosure information.

Global vs India comparison

Table 1 provides sectoral and overall comparison between Global and Indian firms.

Table 1: Global vs India comparison: Medians

Sectors	R&D Intensity*	PhD by total Employees*	R&D by Profit*	R&D Growth	Patents by revenue	Publications by revenue
Automobiles	3.1x	3.4x	5.9x	0.7x	29.8x	1.6x
Chemicals	1.7x	1.0x	2.0x	0.8x	14.1x	3.4x
Defence	2.8x	2.5x	3.0x	0.8x	33.0x	0.4x
Energy	2.5x	4.0x	2.8x	0.6x	9.9x	0.9x
Pharmaceuticals	3.0x	7.1x	2.0x	1.2x	5.6x	8.4x
Software	32.0x	6.1x	46.3x	1.1x	12.1x	0.4x
Overall	**2.9x**	**3.7x**	**2.9x**	**0.8x**	**13.1x**	**1.3x**

Note: Information for parameters with * is shown for the latest year, while for other parameters information is shown for the study period.

Amongst these, patents by revenue had the largest gap between Global and Indian firms. Global firms had **13.1x** patents by revenue compared with Indian firms. On the other hand, Indian firms performed better in terms of R&D growth. Indian firms showed

[6] i.e. the ratio of a firm's R&D expenditure to its revenue

1.2x growth compared to Global firms during the study period. The lowest gap between Global and Indian firms after R&D growth was seen in Publications per USD Billion Dollars (publications by revenue) where Global firms had **1.3x** publications than Indian firms. Indian defence, software and energy sector firms had more publications by revenue than their Global counterparts.

R&D Inputs

Overall, Global firms consistently performed better than Indian firms for R&D inputs over the study period. The variation between Global and Indian firms for R&D intensity and R&D by profits was highest in the software, likely due to Indian software firms being service-led. Global firms reported **2.9x** R&D intensity and **3.7x** number of PhD employees as a proportion of total employees as compared with Indian firms. Indian firms showed larger R&D growth in four out of six sectors with software and pharmaceuticals firms being exceptions where Global firms' R&D growth was better. Global firms in software and pharmaceuticals outpaced Indian firms for the number of employees with PhD as a proportion of total employees by a factor of **6.1** and **7.1** respectively.

R&D Outputs

Even though they lagged behind Global firms for both output indicators studied, Indian firms performed better in publications by revenue than patents by revenue. Global firms produced **13.1x** patents per billion USD revenue and **1.3x** publications by revenue than Indian firms during the study period. In addition, we ranked firms based on the volume of R&D related information disclosed in their annual reports. Indian firms performed exceedingly well in R&D disclosures in their annual report. Out of 10, the average Indian R&D disclosure score was **6.2**, while Global firms' average score was **3.7**. This indicates that Indian firms and investors value R&D-related information.

R&D Overall sectoral rankings

The Indian and Global cohort was ranked based on the aggregate rankings of these sectors on all four parameters. Table 2 below shows rankings for Indian firms. Pharmaceutical firms performed best within the Indian cohort overall, ranking first in both input parameters. On the other hand, energy sector ranked last in all parameters except PhD employees as a proportion of total employees.

Table 2: Ranking of Indian sectors

Sectors	Overall Rank	Ranks			
		R&D Intensity	PhD by total Employees	Patents by revenue	Publications by revenue
Pharmaceuticals	**1**	1	1	2	3
Chemicals	**2**	4	2	1	5
Defence	**3**	3	4	5	1
Software	**4**	5	5	3	2
Automobiles	**5**	2	6	4	4
Energy	**6**	6	3	6	6

Table 3 below shows rankings for Global firms. Just like Indian rankings, pharmaceutical firms performed best within the Global cohort, ranking first in both input parameters and publications by revenue. Similarly, energy sector ranked last within the Global cohort on all parameters except PhD employees as a proportion of total employees.

Table 3: Ranking of Global sectors

Sectors	Overall Rank	Ranks			
		R&D Intensity	PhD by total Employees	Patents by revenue	Publications by revenue
Pharmaceuticals	**1**	1	1	3	1
Software	**2**	2	3	2	3
Defence	**3**	4	4	4	2
Chemicals	**4**	5	5	1	4
Automobiles	**5**	3	6	5	5
Energy	**6**	6	2	6	6

Conclusion and next steps

The present study provides an insight into differences between selected R&D parameters for Global and Indian firms. We find that the Indian firms are moving in the right direction by recording high R&D growth in most sectors studied and disclosing their R&D activities within annual reports. However, Indian firms are yet to catch up with Global firms in R&D intensity, number of skilled individuals, patents and publications. When compared with Global peers, even the best-performing Indian sectors pale in comparison. For instance, pharmaceuticals sector with the median average R&D intensity (5.8%) amongst the Indian cohort, lagged in comparison with Global pharmaceuticals sector, which recorded 17.3%

R&D intensity. However, there are unique market factors that impact a given firm's performance on the parameters chosen for this study. The role of the State in encouraging R&D activities through tax, intellectual property regime and Production Linked Incentives (PLIs) and Research Linked Incentives (RLIs) also need to be studied further.

We hope this study provides impetus to stakeholders to understand the reasons behind the lagging R&D performance of Indian firms and suggest ways to stimulate more R&D activities. A deep dive into firm-level R&D performance, amongst other research streams, is necessary. We will contribute towards such literature through policy briefs describing the firm-level analyses conducted for this report in the near future.

Figures

2.1 Simplified R&D Laboratory as a system (Adapted from Brown and Svenson 1988) 6

3.1 R&D Intensity 11
3.2 PhD employees as a proportion of total employees 12
3.3 Patents by USD billion revenue 13
3.4 Publications by USD billion revenue 14
3.5 Disclosure Scorecard Scores (Out of 10) 15
3.6 Sectoral Comparison: Indian firms 16
3.7 Sectoral Comparison: Global firms 17

4.1 R&D Reserves: Survey findings 21

Tables

1 Global vs India comparison: Medians vi
2 Ranking of Indian sectors viii
3 Ranking of Global sectors viii

1.1 GERD comparison of key economies 2
1.2 Corporate representation in selected Global rankings 3

3.1 Global vs India comparison: Medians 10
3.2 Overall Ranking: Indian sectors 17
3.3 Overall ranking: Global sectors 18

4.1 Indian tax incentives for R&D 22
4.2 Sectoral tax incentives in India (Indicative list) 23

Glossary

Automobiles	Automobile and components.
Defence	Aerospace and Defence.
DSIR	Department of Scientific and Industrial Research.
EDF	Electronics Development Fund.
FAME	Faster Adoption and Manufacturing of Hybrid & Electric Vehicles.
FAST India	Foundation for Advancing Science and Technology India.
FY	Financial Year.
GERD	Gross domestic expenditure on R&D.
HEI	Higher Educational Institution.
HELP	Hydrocarbon Exploration & Licensing Policy.
MEIS	Merchandise Export Incentive Scheme.
MoSPI	Ministry of Statistics and Programme Implementation.
MSME	Micro, Small and Medium Enterprise.

NaMPET	National Mission on Power Electronics Technology.
OALP	Open Acreage Licensing Policy.
P&L	Profit and Loss.
patents by revenue	Patents per USD Billion Dollars.
Pharmaceuticals	Pharmaceuticals, Biotechnology and Life Sciences.
PLI	Production Linked Incentive.
publications by revenue	Publications per USD Billion Dollars.
R&D	Research and Development.
RLI	Research Linked Incentive.
Software	Software and Services.
STPI	Software Technology Parks of India.
UNESCO	United Nations Educational, Scientific and Cultural Organisation.

Contents

Foreword iii

Executive Summary v

1 Background 1
1.1 Current status 2
1.2 The Problem of *Quantifying R&D* 2

2 Methodology 5
2.1 Selecting firms 5
2.2 Data collection 6
2.3 Limitations of the Study 7

3 India vs Sectoral Comparison 10
3.1 Overall findings: India vs Global Firms 10
3.2 Input parameters 11
3.3 Output parameters 13
3.4 Sectoral rankings 16

4 Discussion and Next steps 20
4.1 The State of Industrial R&D in India 20
4.2 State incentives for promoting R&D 21
4.3 Way forward 23

Background

There is significant empirical evidence that promoting technological change leads to the economic progress of a nation. Romer 1990 states that technological change lies at the heart of economic growth, while Mohamed, Liu, and Nie 2022 term technological innovation as the main driver for economic growth and human progress.[1] The State and industry seek to promote and facilitate technological change in a nation to pursue their objectives. While the State may be motivated to promote technological innovation to improve its international competitiveness and realise societal benefits, firms are driven by profit. Therefore, firms seek increased market share by developing innovative offerings.

Arrow 1972 proposes that a free enterprise economy is expected to under-invest in invention and R&D, given that it is a risky endeavour. He also claims that the appropriation of the product developed by R&D can only happen to a limited extent. The degree to which the returns from R&D accrue to the innovator is known as the 'appropriability problem'.

States intervene through incentives such as subsidies, tax benefits, and favourable patenting regimes to promote innovation and resolve the appropriability problem. For instance, promotion of patent protection by the State incentivises firms to disclose their innovations and receive a monopoly for a limited duration as a return. This encourages knowledge dissemination for societal welfare. However, there is a constant trade-off between firms securing monopoly rights over their innovations and the role of shared knowledge in enhancing social welfare. Many States, including India, conduct R&D alongside firms. However, the role of Industry in R&D and economic development cannot be dismissed. We discuss the status of corporate R&D in India and compare it with other nations below.

[1] As defined by Oslo Manual 2018, innovation denotes *a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).*

1.1 Current status

GERD, which includes expenditure on R&D by Business Enterprises, Higher Educational Institutions (HEIs), the Government and Not-for-Profit enterprises, is one of t he indicators used to estimate the state of R&D of a nation. In the 1980s, India spent 0.6% of its GDP on R&D and was in the league of countries such as South Korea and China.[2] However, since then the GERD of India has improved in absolute numbers but has remained the same in terms of proportion of GDP, i.e. 0.6%.[3] Table 1.1 below compares the GERD of key economies with India along with the contribution of corporates in GERD in 2022. As can be seen below, India lags behind key economies in overall GERD as well as GERD performed by corporates. Additionally, the proportion of corporate contribution to GERD in India has been constant for the past five years.

Table 1.1: GERD comparison of key economies

(%GDP)	India	USA	China	S. Korea	Japan	France	UK	Germany
Overall GERD	0.6	3.5	2.4	4.9	3.3	2.2	2.9	3.1
Corporate GERD	0.2	2.7	1.8	3.9	2.6	1.5	2.1	2.1

Source: *Global Innovation Index, 2023 Innovation in the face of uncertainty*, World Intellectual Property Organisation 2023

The low participation of corporates in Indian R&D has been identified as a key issue in the Indian innovation story. For instance, the Economic Survey of India states that India's GERD is much lower than that of the top 10 economies, *"primarily because of the disproportionately lower contribution from the business sector"*.[4] Table 1.2 provides an overview of how Indian companies fare in world rankings based on performance and innovation.

1.2 The Problem of *Quantifying R&D*

Joseph 2023 argues that there may be an underestimation of the Corporate R&D contribution as assessed by the Government of India. This is because of an inability to capture R&D data of all private firms that conduct R&D and inadequate R&D disclosures

[2] Naushad Forbes (2002). *The Struggle And The Promise: Restoring India's Potential*. Harper Collins. URL: https://harpercollins.co.in/product/the-struggle-and-the-promise/ (visited on 03/20/2024).

[3] Ministry of Finance, Government of India (2021). *Innovation: Trending Up but Needs Thrust, especially from the Private Sector*. Chap. 8. URL: https://www.indiabudget.gov.in/budget2021-22/economicsurvey/doc/vol1chapter/echap08_vol1.pdf (visited on 03/20/2024).

[4] Ministry of Finance, Government of India (2020-21). *Economic Survey of India*. Chap. Innovation: Trending Up but Needs Thrust, especially from the Private Sector. URL: https://www.indiabudget.gov.in/budget2021-22/economicsurvey/doc/vol1chapter/echap08_vol1.pdf (visited on 03/26/2024).

Table 1.2: Corporate representation in selected Global rankings

No. of Companies	India	USA	China	S. Korea	Japan	France	UK	Germany
Fortune 500	9	136	135	18	41	24	15	30
EURO 2500	24	822	678	53	233	57	95	114
BCG Innovation Report - Top 50 companies	1	25	8	1	2	1	2	5

Sourced from: *Fortune Global 500, Reaching New Heights in Uncertain Times*, and *The 2022 EU Industrial RD Investment Scoreboard*
Fortune 500 2023, Manly et al. 2023 and Grassano et al. 2022

by firms. Evidence of non-disclosure of R&D expenditures and activities by companies across the globe despite having performed R&D has been shown by Koh and Reeb 2014. In India, the *R&D Expenditure Ecosystem: Current Status and the Way Forward* by the Economic Advisory Council to the Prime Minister 2019 highlight several issues with measurement of GERD such as:

- *Non-standardised definition of Research and Development*: The report highlights different definitions used by the Ministry of Statistics and Programme Implementation (MoSPI), Department of Scientific and Industrial Research (DSIR) and United Nations Educational, Scientific and Cultural Organisation (UNESCO) causing confusion and inability to measure GERD in a standardised manner.

- *Data issues*: No official central data source for data on R&D and lack of separate heads of account for R&D were identified as critical data issues

Therefore, the fallacies of data standardisation and management may cause GERD to be underestimated in India. Having acknowledged this limitation, it is important to note that the low contribution of corporate R&D is identified as a key problem by policymakers and stakeholders.[5]

Given the above, it is essential to collate information available on the R&D activities of Indian firms as a first step to allow deeper discussions on the GERD and the contribution of the corporate sector within it. *CTIER Handbook: Technology and Innovation in India* by Centre for Technology, Innovation and Economic Research (CTIER) 2023 is one of the few reports that attempts to provide information on industry R&D indicators. However, the information on corporate R&D is usually available only at an aggregate level. We attempt to utilise public disclosures by individual firms to inform our study. To achieve this, the

[5]For instance, refer to the problem of low corporate R&D spend highlighted in Naushad Forbes (2002). *The Struggle And The Promise: Restoring India's Potential*. Harper Collins. URL: https://harpercollins.co.in/product/the-struggle-and-the-promise/ (visited on 03/20/2024).

present study focuses on two elements of corporate R&D in India,

1. Comparing top 10 Global and Indian firms in selected sectors on R&D input and output parameters, and
2. Comparison of their self-disclosed R&D activities with that of Global firms.

Methodology

We identify six relevant industry sectors based on national importance (defence), economic prosperity (automobiles, software), frontier research areas (chemicals, energy) and social importance (pharmaceuticals). The six sectors identified for this study are:

1. Aerospace and Defence
2. Automobile and Components
3. Chemicals
4. Energy[1]
5. Pharmaceuticals, Biotechnology and Life Sciences
6. Software and Services

2.1 Selecting firms

20 firms within each sector were sought to be chosen for the study, of which 10 were Indian and the other 10 were Global firms, based on market capitalisation. The sectors defined by *"Global Industry Classification Standard"* were chosen.[2] Firms that were higher in market capitalisation but did not provide information about R&D expenditure during the study period were replaced by companies next in line on market capitalisation which reported R&D expenditure. These exclusions help us in reporting the *disclosed* R&D numbers by

[1]This sector includes the firms amongst following entries in: Standard & Poor's Financial Services LLC (S&P) and MSCI 2016, Energy, Oil, Gas and Consumable Fuels, Electric Utilities, Independent Power and Renewable Electricity Producers.

[2]Standard & Poor's Financial Services LLC (S&P) and MSCI (2016). "Global Industry Classification Standard". In: URL: https://www.spglobal.com/marketintelligence/en/documents/gics-mapbook-brochure.pdf.

firms. Non-inclusion of a company in this study means that we could not source the requisite information about a firm for the duration of our study, i.e. between FY 2015-16 and FY 2022-23.

Information about R&D activities was obtained from the annual reports of the companies studied. This data was validated through databases such as SP Global Market Intelligence 2024, and Centre for Monitoring Indian Economy 2024.

2.2 Data collection

Brown and Svenson 1988 devised a method to measure R&D productivity of firms. They referred to R&D labs as a system comprising inputs, processes, outputs, receiving systems and outcomes. Given the limitations of data available for corporate R&D, we chose the two most commonly available parameters for the study – inputs and outputs. This allows us to perform a comparative study within sectors and firms. While inputs include raw materials and the stimulus of a system, outputs include patents, publications, and new products.

Figure 2.1 shows the relationship of input and output parameters as chosen by us for this study with other components of the system.

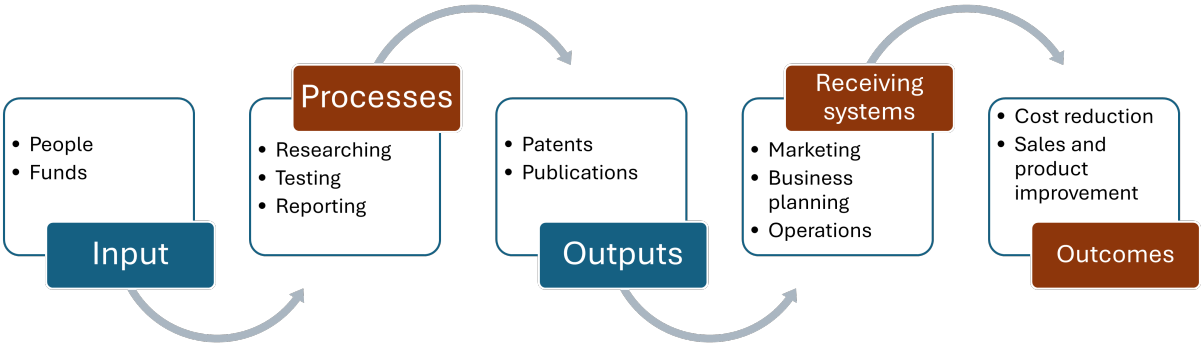

Figure 2.1: Simplified R&D Laboratory as a system (Adapted from Brown and Svenson 1988)

Input and output parameters were chosen based on literature review, consultations and availability of such data in the public domain to understand a firm's perspective on R&D activities conducted by them. These include:

1. **R&D Input parameters**
    - R&D intensity [3]
    - Number of employees with a PhD degree as a proportion of total employees
2. **R&D Output parameters**
    - Number of patents (global) assigned to the company as a proportion of revenue
    - Number of publications indexed on Scopus attributed to the company as a proportion of revenue

Information about R&D intensity was obtained from annual reports of firms. However, most of the firms studied did not provide information about the total number of scientists/researchers employed by them. Since researchers are an important input parameter for us, we obtained the total number of PhD employees from LinkedIn data. For input indicators, supplementary parameters included R&D by profits and R&D growth information, which was obtained from company disclosures. For output indicators, patent data was collected using Google Patents. Publication data was collected from Scopus. In addition, supplementary parameters included R&D disclosures within annual reports of the firms studied. For R&D disclosures, the presence/absence of 12 R&D disclosure parameters were studied for a firms' latest annual report.

2.3 Limitations of the Study

The present study sample is small in size and short in time frame. The analysis is limited to six sectors, with 10 Indian and 10 Global companies selected by market capitalisation within each sector between FY 2015-16 and FY 2022-23. Therefore, the results of the present analysis are only indicative and should not be generalised.

Furthermore, Start-ups, Micro, Small and Medium Enterprises (MSMEs) and other entities do not form a part of the sample of the companies studied since the companies within each sector are chosen according to market capitalisation. We have excluded companies that do not provide financial data regarding R&D in the public domain for the study period to allow for comparisons within our samples. In case of unclear reporting or mismatched numbers across the report, companies have been excluded from the study. Exclusion from the study does not insinuate that the excluded companies do not engage in

[3] R&D intensity is defined as the ratio of a firm's R&D expenditure to its revenue

R&D activities. Therefore, the sampling of firms is purposive and is focused on ensuring comparability within the chosen firms.

The methodology was also impacted by the variability in reporting of R&D activities. For instance, we only used standalone data for Indian firms to allow for standardisation. This is because, within India, most sampled firms report standalone financial information for R&D for the study period. Global firms tend to report information at a consolidated level, making it difficult to compare the R&D numbers of Indian and Global companies based on absolute numbers. Further, the standardisation method used by us for currency conversion may lead to variations during replicability. There are other differences in reporting by Indian and Global companies. For instance, Global companies report capital expenses as a statement of Profit and Loss (P&L) line item, unlike Indian companies. Amongst our sample size, only a limited number of firms report R&D capitalisation and amortisation. Therefore, these do not form a part of our study.

Furthermore, we have normalised the absolute number of outputs (patents and publications) by revenue of firms for Global vs. Indian comparison. While it allows us to compare the number of patents for different sizes of firms by revenue, it does not indicate the outcomes of utilising the patents. Therefore, the output parameters, i.e. patents and publications information, used in the study do not indicate their efficiency and effectiveness and are solely meant for comparison.

India vs Global Comparison

India vs Sectoral Comparison

This chapter shows the findings of our study from an overall and sectoral perspective. The first section shows a comparison between Global and Indian firms for the parameters studied. Following this, a sectoral comparison of the firms on input and output parameters is shown. Finally, the six sectors studied are ranked on the basis of their performance in Global and Indian cohorts.

3.1 Overall findings: India vs Global Firms

Table 3.1 provides sectoral and overall comparison between Global and Indian firms for the parameters studied.

Table 3.1: Global vs India comparison: Medians

Sectors	R&D Intensity*	PhD by total Employees*	R&D by Profit*	R&D Growth	Patents by revenue	Publications by revenue
Automobiles	3.1x	3.4x	5.9x	0.7x	29.8x	1.6x
Chemicals	1.7x	1.0x	2.0x	0.8x	14.1x	3.4x
Defence	2.8x	2.5x	3.0x	0.8x	33.0x	0.4x
Energy	2.5x	4.0x	2.8x	0.6x	9.9x	0.9x
Pharmaceuticals	3.0x	7.1x	2.0x	1.2x	5.6x	8.4x
Software	32.0x	6.1x	46.3x	1.1x	12.1x	0.4x
Overall	**2.9x**	**3.7x**	**2.9x**	**0.8x**	**13.1x**	**1.3x**

Note: Information for parameters with * is shown for the latest year, while for other parameters information is shown for the study period.

We find that the Indian firms lagged the most in patents by revenue parameter,

for which Global firms produced **13.1x** patents by revenue. Indian firms reported slightly (**1.2x**) better R&D growth as compared to Global firms. This is a remarkable achievement for Indian firms, given that the study period also included COVID-19 time period and regulatory changes decreasing tax deduction available to firms for R&D. For other indicators, Global firms led Indian firms by a factor of 1-4.

3.2 Input parameters

R&D intensity and number of PhD employees as a proportion of total employees are the two primary input parameters chosen for the study. While R&D intensity is a financial input parameter for R&D activities, PhD-related information indicates the number of researchers employed by a firm.

3.2.1 R&D Intensity

Figure 3.1 presents sectoral R&D intensity for FY 2023.[1]

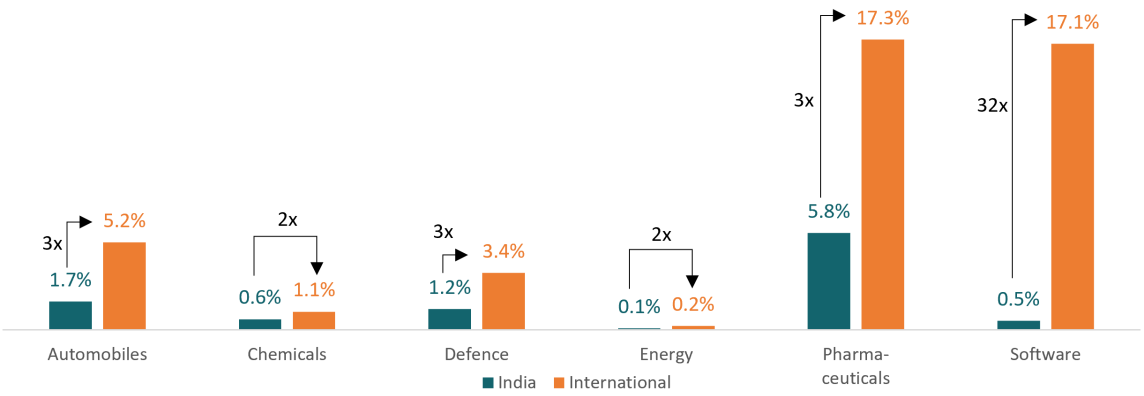

Figure 3.1: R&D Intensity

Global firms outperformed Indian firms in all sectors for R&D intensity. The R&D intensity of Global firms was **2.9x** Indian firms. The largest difference in R&D intensities is seen in the software sector. Global software firms had **32.0x** more R&D intensity than Indian firms. The smallest difference in R&D intensities was seen in the chemicals and energy sectors where Global firms outperformed Indian firms by a factor of **1.7x** and **2.5x** respectively.

[1] Annual year 2022 for firms that do not follow the FY calendar.

In addition to R&D intensity statistics, we find that Global firms spent **2.9x** proportion of their profits in R&D activities as compared to Indian firms. Software firms showcased the highest gap wherein Global firms spent **46.3x** profits by R&D than Indian firms. The smallest gap is seen in the pharmaceuticals and chemical sectors wherein Global firms spent **2.0x** more profit in R&D compared to Indian firms.

Despite lagging in R&D intensity, Indian firms documented slightly higher (**1.2x**) R&D growth as compared to Global firms for the study period. Indian firms outperformed Global firms in four sectors - defence, automobiles, chemicals and energy. Amongst these, the Indian energy sector firms grew **1.7x** Global firms. On the other hand, R&D growth of Global firms was better than Indian firms in the pharmaceutical and software sectors by **1.2x** and **1.1x** respectively.

3.2.2 PhD Employees as a proportion of total employees

Figure 3.2 shows sectoral information about PhD employees as a proportion of total employees in Global and Indian firms.[2]

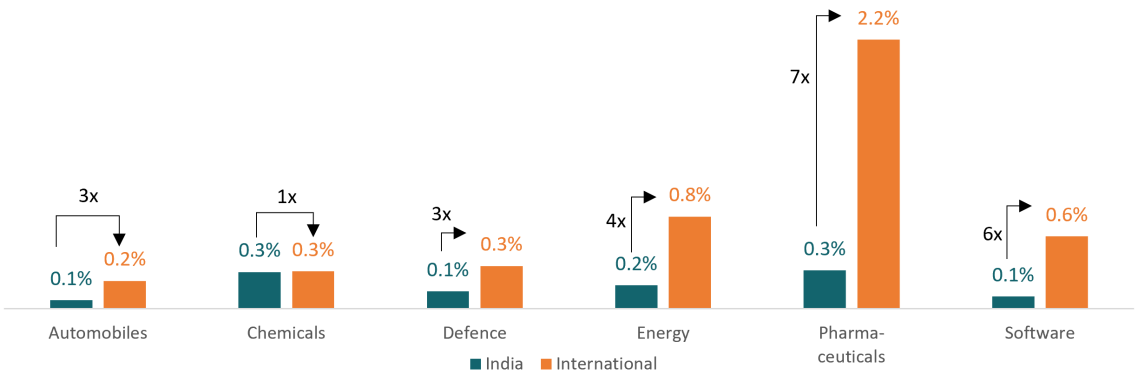

Figure 3.2: PhD employees as a proportion of total employees

On average, Global firms documented **3.7x** employees with PhD as a proportion of total employees compared to Indian firms.[3] Global pharmaceutical and software firms outperform Indian firms with the highest margin for this indicator, in line with R&D intensity-related observations. The Global pharmaceuticals and software firms have considerably higher (**7.1x** and **6.1x**, respectively) number of employees with PhD as

[2]The figures presented may not sum to the total due to rounding.
[3]Information about PhD employees was collected in December 2023.

compared to Indian firms. Indian chemical firms had an equal proportion of PhD by total employees as Global chemical firms.

3.3 Output parameters

Patents per billion USD revenue and publications per billion USD revenue were studied as primary output parameters of the study. In addition, R&D disclosure information scorecard was made to understand whether firms prefer discussion on R&D related parameters. Firms were scored on the basis of their R&D disclosure practices with respect to 12 financial and operational parameters in their annual report.

3.3.1 Patents per billion USD revenue

Figure 3.3 shows sectoral information about patents per billion USD revenue for Global and Indian firms.

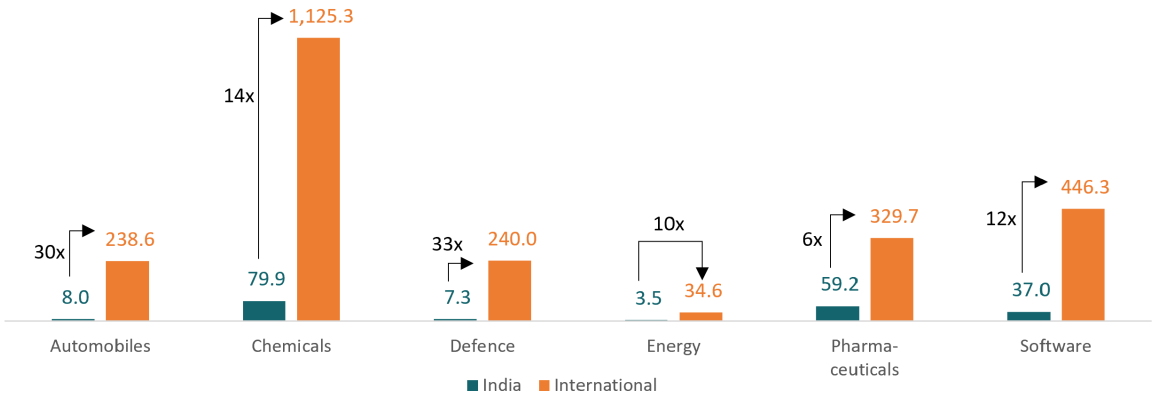

Figure 3.3: Patents by USD billion revenue

On average, the Global firms published **354.8x** more patents than Indian firms as indexed on the Google Patent database for the study period. However, when normalised by per billion USD revenue the Global firms had **13.1x** more patents than Indian firms.

The variation between Global and Indian patent data was stark in the automobiles and defence sectors. The Global firms' patents by revenue was **33.0x** for the defence sector, and **29.8x** that of Indian firms for the automobiles sector. The gap in the pharmaceutical sector was the least where Global firms had **5.6x** patents by revenue compared with Indian firms.

3.3.2 Publications per billion USD revenue

Figure 3.4 shows sectoral information about publications per billion USD revenue for Global and Indian firms.

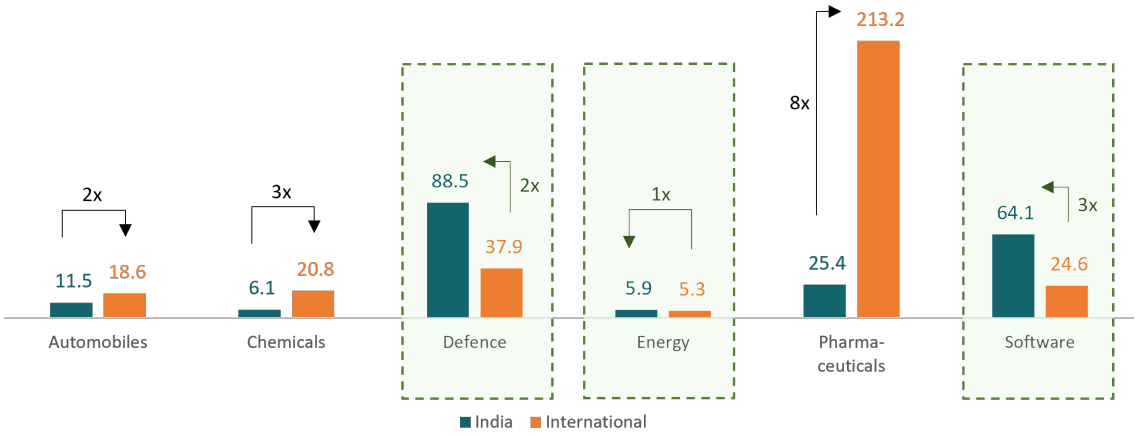

Figure 3.4: Publications by USD billion revenue

Global firms had **34.4x** articles compared to Indian firms on the Scopus database for the study period. However, when normalised by per billion USD revenue, the difference is much smaller with Global firms publishing only **1.3x** more than Indian firms.

Indian defence and software sector firms outperformed Global counterparts in publications by revenue. Indian software firms had published **2.6x**, while Indian defence firms had published **2.3x** more articles by revenue compared with their Global counterparts. Both Global and Indian energy firms had about the same number of publications by revenue.

The largest difference between the publication by revenue was seen in the pharmaceutical sector wherein the Global firms published **8.4x** more articles by revenue compared to Indian firms. Interestingly, the gap between Global and Indian pharmaceutical firms was similar for patents and publications by revenue (**5.6x** and **8.4x** respectively), but was the lowest for patents and the largest for publications by revenue parameters.

3.3.3 R&D disclosures

Figure 3.5 shows sectoral scores (out of 10) for R&D disclosures of Global and Indian firms. Indian firms consistently score higher on R&D disclosures compared with their

Global firms. Out of 10, the average Indian R&D disclosure score was **6.2**, while Global firms' average score was **3.7**. Indian pharmaceutical firms disclosed most R&D related information within our sample with an average score of **7.4** out of 10. Amongst all the firms studied, the top ten positions for R&D disclosures are held by Indian firms.

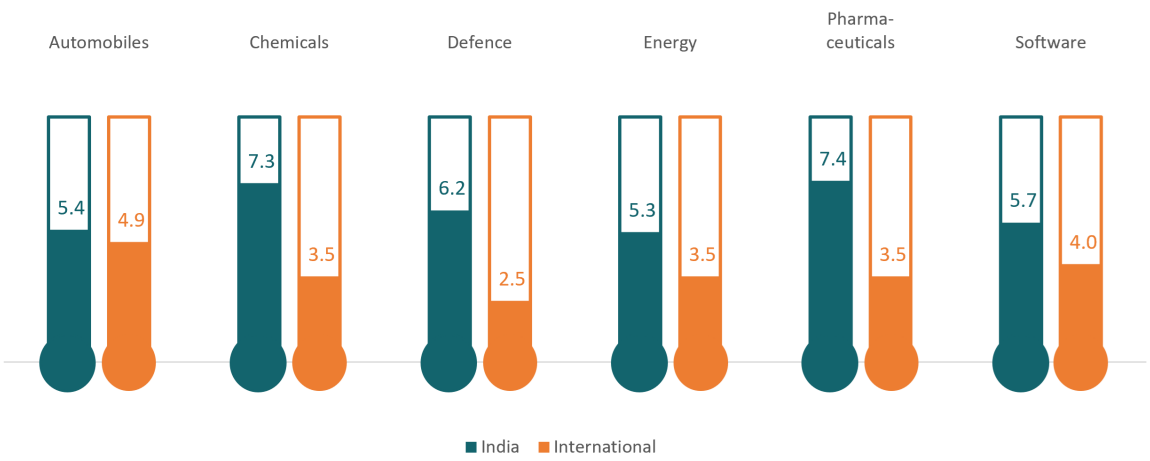

Figure 3.5: Disclosure Scorecard Scores (Out of 10)

3.4 Sectoral rankings

Figure 3.6 compares the performance of **Indian firms** sectorally on the four chosen parameters.[4] We find that the pharmaceutical sector performs well in both input parameters, and is second highest in patents by revenue but does not perform as well in publications by revenue parameter. Defence sector, with one of the largest presence of State actors, scores best in publications by revenue parameter. Chemicals sector performs best in patents by revenue and proportion of PhD employees. On the other hand, energy and automobile sectors do not perform as well as other sectors in any of these parameters.

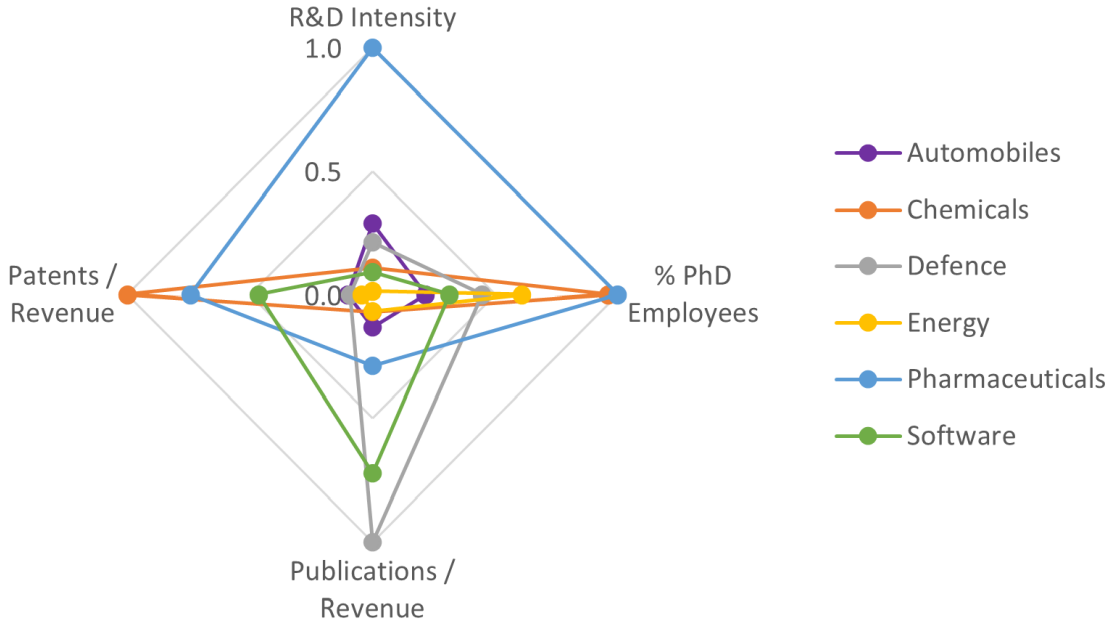

Figure 3.6: Sectoral Comparison: Indian firms

Figure 3.7 compares the performance of **Global firms** sectorally on the four chosen parameters.[5] We find that the pharmaceutical sector is best performing in R&D intensity, PhD employees as a proportion of total employees and publications by revenue. However, it lags in patents by revenue parameter. Chemicals sector performs best in patents by revenue. As seen within the Indian cohort, the energy sector lags the most in the Global cohort as well.

[4] Please note that the sector with best parameter value is given 1 score, and every other sector is scored as per its relative performance with the best performance.

[5] Please note that the sector with best parameter value is given 1 score, and every other sector is scored as per its relative performance with the best performance.

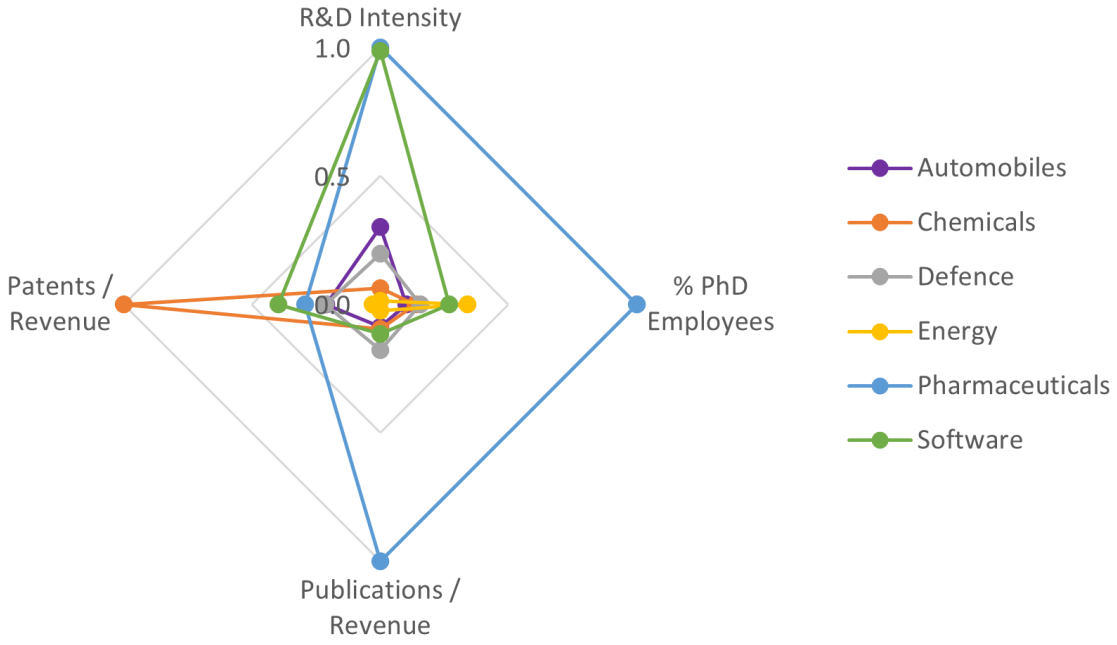

Figure 3.7: Sectoral Comparison: Global firms

Table 3.2 ranks sectoral cohorts in India based on the four primary parameters. It provides individual ranks of each sector with respect to the four parameters - R&D intensity, PhD by total employees, patens and publications by revenue. These individual rankings are used to formulate the overall rank of a sector.

Table 3.2: Overall Ranking: Indian sectors

		Ranks			
Sectors	**Overall Rank**	**R&D Intensity**	**PhD by total Employees**	**Patents by revenue**	**Publications by revenue**
Pharmaceuticals	**1**	1	1	2	3
Chemicals	**2**	4	2	1	5
Defence	**3**	3	4	5	1
Software	**4**	5	5	3	2
Automobiles	**5**	2	6	4	4
Energy	**6**	6	3	6	6

Detailed observations with respect to sectoral rankings are provided below.

1. *Pharmaceuticals:* Amongst the six sectors, the Indian pharmaceutical firms ranked 1st in both R&D intensity and PhD employees as a proportion of total employees. It

ranked 2nd for patents by revenue and third for publications by revenue.

2. *Chemicals:* Chemicals sector ranked 1st in patents by revenue. It ranked 2nd in PhD employees as a proportion of total employees. Its rank for R&D intensity was 4th, and it stood 5th in publications by revenue.

3. *Defence:* Defence ranked 1st for publications by revenue. It was 3rd in terms of R&D intensity, 4th in PhD employees by total employees and 5th in patents by revenue.

4. *Software:* Software firms did not perform well on input parameters and ranked 5th in both R&D intensity and PhD by total employees. However, it ranked 2nd for publications by revenue and 3rd for patents by revenue.

5. *Automobiles:* Automobile firms ranked 2nd for R&D intensity. However, it ranked last for PhD employees by total employees. For both output indicators, the firms ranked 4th.

6. *Energy:* The firms in the sector were ranked last in all but PhD employees by total employees where they ranked 3rd.

Table 3.3 ranks sectoral cohorts Globally based on the four primary parameters. It provides individual ranks of each sector with respect to the four parameters - R&D intensity, PhD by total employees, patens and publications by revenue. These individual rankings are used to formulate the overall rank of a sector.

Table 3.3: Overall ranking: Global sectors

		Ranks			
Sectors	**Overall Rank**	**R&D Intensity**	**PhD by total Employees**	**Patents by revenue**	**Publications by revenue**
Pharmaceuticals	**1**	1	1	3	1
Software	**2**	2	3	2	3
Defence	**3**	4	4	4	2
Chemicals	**4**	5	5	1	4
Automobiles	**5**	3	6	5	5
Energy	**6**	6	2	6	6

Detailed observations with respect to sectoral rankings are provided below.

1. *Pharmaceuticals:* Amongst the six sectors, the Global pharmaceutical firms ranked 1st in three, viz, R&D intensity, PhD employees as a proportion of total employees

and publications by revenue. It ranked 3rd for patents by revenue and third for publications by revenue.

2. *Software:* Software firms ranked 2nd in R&D intensity and patents by revenue. They ranked 3rd for the remaining parameters.

3. *Defence:* Defence ranked 2nd for publications by revenue. It was 4th in terms of R&D intensity, PhD employees by total employees and patents by revenue.

4. *Chemicals:* Chemicals sector ranked 1st in patents by revenue. It ranked 4th in publications by revenue and stood 5th for R&D intensity and PhD employees as a proportion of total employees.

5. *Automobiles:* Automobile firms ranked 3rd for R&D intensity. It ranked 5th for patents and publications by revenue and last for PhD employees as a proportion of total employees.

6. *Energy:* The firms in the energy sector were ranked last in all but PhD employees by total employees where they ranked 2nd.

Therefore, we find that Global firms outperform Indian firms in most parameters studied. However, Indian firms perform better, especially on certain aspects of R&D growth and R&D disclosures.

Discussion and Next steps

4.1 The State of Industrial R&D in India

Indian firms lag behind their Global counterparts in most input and output parameters of R&D studied. Amongst the four primary parameters studied, the gap between Global and Indian data was the most for patents per billion USD revenue, wherein Global firms had **13.1x** patents than Indian firms. On the other hand, R&D growth rate of Indian firms is more (**1.2x**) than their Global counterparts for the study period.

We also find sectoral variations in the findings. In India, firms in the pharmaceutical sector performed best in R&D intensity and PhD as a proportion of total employees as compared with other sectors. On the other hand, defence firms had the best publications and chemical firms had the best patents per billion USD revenue.

While the performance of Indian firms on the chosen indicators tells us about the 'State of Sectors', we were also interested in understanding 'how' the industry makes its decisions regarding R&D practices. To understand the 'how', 41 Indian firms were surveyed for this study to understand their perspective on R&D activities.[1] Fig 4.1 shows the response of firms on whether they have R&D reserves. R&D reserves refer to funds earmarked for R&D activities for a specified duration. As shown in the figure, only 54% respondents stated that their firms had an R&D reserve. Some respondents mentioned that while they don't maintain R&D reserves, they spend on R&D on a case-to-case basis or on an annualised basis.

[1] Most respondents were from the software sector. We normalised findings for appropriate representation of participating sectors.

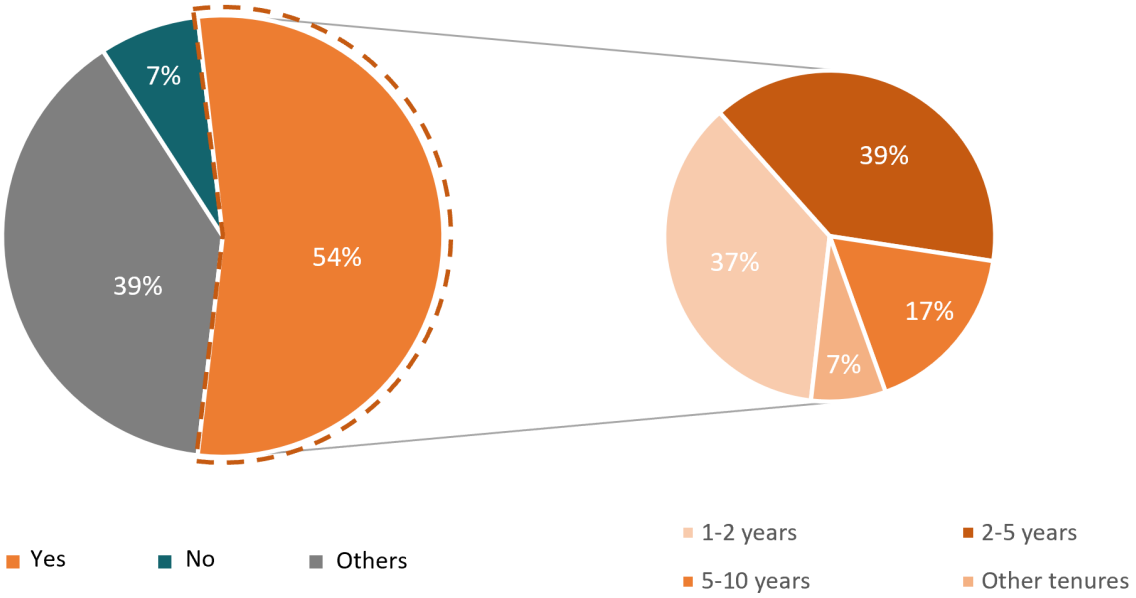

Figure 4.1: R&D Reserves: Survey findings

Of the firms with R&D reserve, the tenure for R&D reserves was 5 years or lesser for 76% respondent firms. Maintaining R&D reserves for a shorter duration by corporates signals a need for State intervention and derisking for long-term technological advancements.

4.2 State incentives for promoting R&D

With globalisation, competition across national borders has been increasing. Events such as COVID-19 highlight the need for having a robust R&D ecosystem. In such a world, the role of the State in promoting the capability of the industry cannot be overlooked. States may achieve this by providing 'space' for enterprises to master new technologies and skills without incurring enormous and unpredictable losses.[2]

Countries utilise many incentive mechanisms to encourage the corporate sector to perform R&D activities. For example, many jurisdictions prefer providing 'tax credits' for certain qualified research activities. Firms may use these tax credits to reduce their

[2]Sanjaya Lall (2003). "Reinventing industrial strategy: The role of government policy in building industrial competitiveness." In: URL: https://ora.ox.ac.uk/objects/uuid:37e1a07d-a14f-401d-bfcd-dbeb4265f702/download_file?safe_filename=qehwps111.pdf&file_format=application%2Fpdf&type_of_work=Working+paper (visited on 05/21/2024).

tax liabilities. Similarly, tax deductions are available for selected R&D expenditures in certain countries. Further, some countries promote patenting by providing incentives such as patent box regimes, i.e. tax incentives for earnings arising from patent commercialisation.

India had one of the most liberal tax incentives for R&D available to firms until recently. Table 4.1 below summarises some of these incentives available in India. As can be seen from the table, the tax incentives have been changed in the recent past by the Indian government.

Table 4.1: Indian tax incentives for R&D

Type of Tax Incentive	Indian Provision (2023)
Income tax deduction	100% tax deduction on R&D expenses on scientific research related to business
	This tax deduction was reduced from 200% to 150% in 2016 and finally to 100% in 2020.
Patent box regime	Income tax on the royalty income from patents developed and registered in India calculated at a concessional rate of 10%.
	This was introduced in 2020.
Customs and GST exemptions	No exemptions on the import of capital equipment for R&D w.e.f. 2023.
	Before this, exemptions were given for the import of more than 350 types of equipment

Sources: *The Income Tax Act, 1961*, Sections 35, 135 and Kaushik 2023

In addition to general tax incentives, various sectoral incentives (including financial and regulatory incentives) are made available to firms for conducting R&D. These include PLIs and RLIs, defence offsets, and sector-specific schemes. A State introduces such incentives to de-risk industry R&D and encourage sustainable business opportunities. A non-exhaustive list of these incentives is provided in table 4.2 below.

These incentives promote R&D activities through government derisking. For these incentives to work, the corporate sector should be aligned towards utilising the benefits offered by the States.

80.50% respondents of our survey stated that government policies on tax credits and rebates are *important* for their decisions on R&D activities, supporting the argument for appropriate government interventions.

Table 4.2: Sectoral tax incentives in India (Indicative list)

Type of Tax Incentive	Indian Provisions (2023)
Pharmaceuticals	PLIs and RLIs
Defence	Defence offset policies, Assured procurements, iDEX scheme, Open General Export License
Chemicals	Chemical Promotion Development Scheme (CPDS), PLIs for Advance Chemistry Cell Battery
Automobiles & Components	FAME and MEIS
Software and computer services	Start Up India initiative, STPI, NaMPET, EDF
Energy	HELP and OALP

Sources: Invest India 2024, Ministry of Chemicals and Fertilizers 2023, Ministry of Defence 2021, Department of Chemicals and Petro-Chemicals 2023, Ministry of Heavy Industries 2023, Heavy Industries 2023, Foreign Trade 2023, Software Technology Parks of India (STPI) 2023, Ministry of Commerce and Industry 2023, Ministry of Electronics and Information Technology 2023b, Ministry of Electronics and Information Technology 2023a, Ministry of Petroleum and Natural Gas 2023, International Energy Agency 2023

4.3 Way forward

This study is the first step by FAST India to identify and present the State of Industry R&D in India and its comparison with Global counterparts on input and output parameters. To further advance research on the state of R&D in Indian firms, several downstream research directions should be pursued.

1. A deeper sectoral analysis should be conducted to understand the specific challenges and opportunities. FAST India will release its sectoral findings with firm-level information about R&D practices of Indian firms in its upcoming publications.

2. Comparative studies between Indian firms and their Global counterparts could be expanded. This would entail a more granular analysis of R&D practices, including spending patterns, collaboration with academic and research institutions, and the role of government policies in shaping R&D strategies. Such research could identify best practices and potential areas for policy improvement.

3. Investigating the role of MSME and Startups in the R&D landscape is required to ensure coverage of the industry R&D ecosystem. MSME and Startups often face unique challenges in accessing funding and resources for R&D and can potentially be an important element of 'derisking' research in earlier stages. Research could explore the effectiveness of current support mechanisms and propose new strategies to measure and support MSME and Startup R&D activities.

4. A study mapping the journey of R&D inputs, process and outputs to outcomes would help in assessing the interlinkages between the various parameters in detail. For instance, the impact of patents and publications on revenue and profits over a specified period have the potential to provide deeper insights to behaviours of the firms.

5. Examining the long-term impact of R&D incentives on innovation performance and economic growth would be beneficial. This could involve longitudinal studies tracking firms over several years to assess how changes in tax incentives and other policies influence their R&D investments and innovation outputs.

By pursuing these research avenues, a comprehensive understanding of the R&D ecosystem in India can be developed, enabling more effective policies and practices to foster innovation and competitiveness in the Indian corporate sector.

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