Linking R&D Activities and Firm Performance: A Study of Indian Manufacturing Sector

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(Dr. Khushdeep Dharni)
Principal Investigator

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Executive Summary

In the fast changing business environment and with fast paced technological development, R&D has emerged as crucial factor for the survival of business organizations. R&D has become a major decision area in the contemporary organizations. In the current competitive environment, R&D activities are considered as the source of competitive advantage to excel in the marketplace so as to ensure long run success. This research project is aimed at exploring the trends in R&D landscape in Indian Manufacturing Sector. An attempt has also been made to link R&D activities and output with firm performance. Results of the study are based on both secondary and primary data. For secondary data, 243 manufacturing companies, from CNX 500 of National Stock Exchange, across seven sectors were included in the study. These seven sectors were Automobile, Consumer Goods, Industrial Manufacturing, Metals, Pharmaceuticals, and Textile. Period of analysis, for secondary data, was ten years, i.e., from 2004-05 to 2013-14. For collection of primary data 51 manufacturing companies were included in the survey with representation from all the seven sectors. Using Content Analysis, trends related to Qualitative Intellectual Capital have been explored. R&D activities were measured on basis of R&D Expenditure and R&D Intensity. R&D Output has been measured on basis of Patent Applications, Patents Granted, Backward Citations and Forward Citations. Value relevance of different methods was measured by taking different kinds of returns and Tobin's q as the measure of firm performance.

Major findings and issues have been listed as follows:

- Positive trend coefficients were found across all the sectors for different types of intellectual capital disclosures with the exception of Pharmaceutical and Textile sectors.
- There was a significant difference across various sectors in terms of Relational Capital disclosures, Structural Capital disclosures, and Human Capital disclosures.
- For R&D expenditure, positive trend coefficients were observed for all the sectors. This phenomenon indicates that there has been an increase in spending on R&D activities by all

the sectors over the period of study. While for R&D intensity, positive trend coefficients were found in all the sectors with the exception of Energy, Metal and Textile sector.

- Significant positive growth trends has been witnessed for patent applications across various sectors with the exception of Consumer Goods, Metals and Pharmaceutical sectors.
- For grant of patents, significant positive growth trends can be seen for Automobile sector, Industrial Manufacturing, Metals and Pharmaceuticals sectors.
- Pharmaceutical sector was having highest R&D intensity across all the sectors over the period of study. This sector is also the leader in terms of Patent Applications and Patent Grant.
- Value relevance in context of firm performance was found for Intellectual Capital Based methodologies as well as Patent Applications. On the other hand, no value relevance was found for patents granted as well as citations. This indicates that currently Indian Manufacturing Sector is having 'Quantitative Orientation' towards R&D output rather than having 'Qualitative Orientation'.
- Major focus of R&D activities was found to be on product development and relatively less focus was observed for basic research and applied research. Lack of focus on basic research is quite evident from the results of the study.
- For technology acquisition, major focus of companies was to conduct In-house R&D followed by setting up Joint Ventures. Other sources such as contracting out, licensing in and cross licensing were considered less important.
- R&D outputs are exploited by Indian manufacturing companies largely by embedding the outputs in their own products and production processes . Activities such as licensing out and cross licensing were found to be negligible.
- Companies reported considerable research partnerships/associations with Universities and academic institutes both with in India and Abroad. More participation in International Research consortia was seen as compared to national research consortia.
- Sector specificity has been observed from the results of the study. Significant variations across the sectors have been observed for R&D activities, R&D output and linkage between

R&D activities and firm performance. Pharmaceutical sector stands apart from other sectors on the above-mentioned basis.

- Tendency on part of Indian manufacturing companies to go alone is quite evident from results. It has been seen that right from acquisition of technology to exploitation of technology Indian manufacturing companies tend to work in 'isolation'.
- For the majority of sectors, Licensing In and Cross Licensing options scored very low on importance scale both for technology acquisition and commercialization.
- Quality manpower availability and attrition of R&D manpower have emerged as the major hurdles in R&D landscape. There is a need for putting initiatives in place so that Indian manufacturing companies get quality manpower with basic skills related to the respective domains.
- Companies covered under the survey agreed that formal techniques to assess R&D returns were not used. Lack of formal techniques to assess R&D returns can lead to inefficient R&D investment with lower levels of productivity. This phenomenon can potentially undermine the investment in R&D initiatives.
- From the primary data based survey, it was revealed that one third of companies were not having any R&D policy in the organizations. R&D policy is considered vital for aligning R&D with the strategic goals of the organization and also provides a uniform directional framework for the organization as a whole.
- 'Technology Management' is a popular domain in the western countries. But this subject is sparingly taught in India either as part of engineering education or management education curriculum. Improved R&D management on account of better technology management skills can provide a boost to productivity of R&D and related investment in Indian scenario.

Chapter 1
Introduction

1.1 Background of the Study

Intensified business competition and technological advancements have transformed the major value drivers of the business. In the era of knowledge based economies physical and financial assets are fast transforming into commodities. Intangible assets such as Research and Development (R&D) activities and output are the drivers of abnormal profits, strong competitive positions and growth. There has been a shift in the sources of wealth creation and increasingly the focus is shifting from material assets to intangible assets (Goldfinger, 1997). In the fast changing business environment and with fast paced technological development, product and process R&D have emerged as crucial factors for the survival of business organizations. Careful selection of R&D activities by the managers is the key to the success of the business in the long-run. R&D has become a major decision area in the contemporary organizations. Higher market-to-book values are highlighting the importance of R&D activities and related output. Macroeconomic implications of R&D activities and output for national growth and welfare are beyond debate. Knowledge has become the basic economic resource in the Knowledge Economy. Knowledge economy refers to a system of consumption and production that is based on intellectual capital. Intellectual Capital is considered as one of the pillars of Knowledge Economy. Intellectual Capital has been gaining more importance as compared to the physical assets held by the organizations. For prospering in the new Knowledge Economy, it has become vital to create, acquire and exploit the intellectual capital continuously. Dynamic approach to Intellectual Capital argues that it covers the activities that are undertaken by firms in order to leverage the stock of knowledge resources, create value and protect new knowledge. Such activities encompass e.g. conducting R&D activities, managing knowledge, imparting skill to staff, so as to create new stocks of intellectual capital (Kianto, 2007; Meritum, 2002). Innovations are created primarily by investments in Intellectual Capital (Lev, 2001). There are three components of Intellectual Capital (Mention 2004, Starovic and Marr (2004), i.e., Relational Capital (Business Collaboration, Licensing Agreements, Brands, Science Based Cooperation etc.), Structural Capital (Intellectual Property, Technological

Infrastructure, R&D efforts etc.) and Human Capital (Competencies, Skills, Know how, Individual Networks etc.). The three components of Intellectual Capital are not independent of each other. There is a large degree of interaction among them (Angelopoulos et al., 2012).

Research and Development may vary from company to company based on nature of business, competitive landscape and managerial policies. In the current competitive environment R&D activities may provide the competitive advantage to excel in the market as well as ensure long run success.

Intellectual Capital management has been acknowledged as a critical domain for sustained innovative initiatives in the organization by means right kind of technology acquisition and exploitation efforts with considerable amount of investment being committed to R&D activities, it becomes paramount to assess their utility and functionality for firm performance. Since the seminal work of Schumpeter (1942), there have been numerous attempts to link R&D and firm performance. Measurement of R&D activities is not a simple task given the complexity of the domain in terms of accounting treatment and disclosure practices. Further, R&D activities can not contribute to firm performance alone and their contribution to performance is affected by presence of collateral assets such as complementary technologies, product development, brand and company reputation.

R&D and Knowledge initiatives also vary in their nature and mechanism to contribute to firm performance. For example, Product R&D is undertaken with the aim of developing altogether new products and improving the existing ones. These types of activities are expected to add to sales revenue of the firm. Process R&D activities are undertaken with the aim of increasing the efficiency of existing products by plugging leakages or improving productivity levels as well as devising new ways of accomplishing the existing tasks. Process R&D activities are expected to cut the cost and enhance the margins.

Patenting activities are on the rise worldwide. Under the legal framework companies seek to protect the output of their R&D activities through patenting. Patenting has been used for claiming exclusive production and marketing rights over new products and processes. At the same time patenting has also been employed as a tool for blocking the competition from the emerging opportunities in a given domain. Patent citation analysis has emerged as a patent tool for measuring the quality of patent. Numerous studies are available from the developed nations, attempting to link patent citations with firm performance. In developing countries like India the studies linking citations and firm performance are rare as a majority of studies focus on R&D expenditure alone as the measure of R&D activities.

While R&D activities and output are acquiring greater significance and attention from the managers, investors are the ultimate evaluators of managerial efforts. Investors' judgment on proficiency of management activities is signalled by changes in the share prices in capital markets. Ability of the investors to correctly signal the future performance of the companies can be considered as an indicator of market efficiency and maturity. Instances of putting value on R&D activities can be the key to stimulation of R&D investments in the business organizations. Companies cannot afford to ignore the investors' sentiments. A positive link between R&D activities and firm performance can be the harbinger of sustenance and strengthening of R&D efforts. Therefore, there is a need to investigate the relationship between R&D activities and firm performance.

1.2 Objectives of the Study

This research project is aimed at achieving the following specific objectives:

- To study the trends in acquisition and commercialization activities of R&D based assets reported by Indian manufacturing companies
- To measure the R&D activities and R&D output using alternative methodologies
- To investigate the relationship of R&D activities and R&D output with firm performance in Indian context
- To explore the organization level variables affecting R&D output in India.
- To generate a model to be adopted in Indian conditions using the data generated under the study

1.3 Brief Review of Literature

This section has been divided into two parts. First part deals with the literature review in Indian context and the second part deals with the relevant literature from the domain in general.

1.3.1 Literature Review: Indian Context

There are numerous factors affecting R&D activities at firm level. Studies have reported a positive effect of firm size on R&D (Lall 1987, Kartak, 1985). Post liberalization R&D activities in India have picked up. Aggarwal (2000) concluded that earlier technology imports were weakly related with past R&D efforts, but in post liberalization period the impact of R&D efforts on technology imports have increased significantly. Kumar and Aggrawal (2005) have offered evidence to suggest that increased competition has pushed local firms to rationalize their R&D activities. Further, it was suggested that R&D activities of the local firms are primarily directed towards assimilating imported technology. Ghosh (2009) examined the factors influencing R&D in manufacturing entities from the period 1995 to 2007. It was concluded that large companies have a higher probability of pursuing R&D; however, R&D intensity is lower. It was estimated that a 10 percent increase in firm size raises R&D intensity by approximately 0.6 percent.

Creating Intellectual Capital involves huge resource commitments in terms of time and money. Intellectual capital is expected to affect the organization in a variety of ways including enhancing internal efficiency of an organisation, market performance of an organisation and the profitability of an organisation.

Fewer studies exploring the relationship between R&D activities and firm performance are available in Indian context. A number of studies have advocated positive relationship between R&D activities and firm performance. Private return on R&D stock for Indian pharmaceutical sector was examined by Chatterjee (2007) using Tobin's Q estimation of market value. Results indicate that market positively valued R&D activities of Indian pharmaceutical firms. An increase in depreciation rates of R&D implying higher obsolescence of R&D activities was also reported. Chadha and Oriani (2009) investigated the stock market valuation of R&D investment in India. It was reported that stock market positively values the firms' R&D

investment. A positive and significant coefficient of R&D capital adjusted with total tangible assets was also reported. It was argued that investment on R&D has a higher market value than investment on tangible assets. Based on the study of 20 Indian pharmaceutical firms for the period 1996 to 2006, Kavida and Sivakoumar (2009) reported that R&D capital is significantly and positively related to the market value of the firm.

Murale and Ashrafali (2010) suggested a significant positive relationship between market to book value and corporate intellectual capital. Kumar et al. (2012) reported a significant curvilinear relationship between R&D intensity and firm value, indicating the diminishing marginal return of R&D expenditure. It was suggested that the firms should treat R&D expenditure as asset to the firm as long as the expenditure is moderate; otherwise, it incurs cost to the firm. Sharma (2012) examined the impact of R&D activities on firms' performance for Indian pharmaceutical industry from 1994 to 2006. Results indicate that R&D intensity has a positive and significant effect on total factor productivity. Further, production function approach indicated that output elasticity to R&D capital varies from 10 percent to 13 percent.

On the other hand, literature presents contrary findings as well. Sarkar and Sarkar (2005) used R&D expenditure as an explanatory variable in examining firm value. It was reported that R&D expenditure is not related to performance measures such as market to book ratio, Tobin'Q, Return to assets, and net value added to assets. Need for exploring the issue to greater extent has also been advocated. Kamath (2007) has pointed out the need to extend the research on intellectual capital to alternate settings and also to alternate industries in both manufacturing and service sector.

There are a number of benefits associated with reporting intellectual capital. Intellectual capital reporting truly reflects the actual worth of the company and provides insight into the drivers of sustainable performance (Kamath, 2007). It supports a corporate goal of enhancing the shareholder value and it provides more useful information to existing and potential investors. Birari (2015) has examined the disclosure of information on intellectual capital by top 20 Indian firms by market capitalization. It was found that the reporting of information on intellectual capital was meagre and information technology firms report maximum information on intellectual capital. It was also found that there was lack of uniformity and standardization while disclosing information on intellectual capital.

Ragini (2012) examined the type and extent of information on intangibles being disclosed with the help of a disclosure Index and also compared the various disclosure practices of intangibles of the top one hundred Indian, US, and Japanese companies. It was reported that the countries had shown a significant improvement in their overall disclosure scores over the five year period. The Japanese companies have shown the maximum improvement in the overall disclosure scores over five year period, followed by US and Indian companies.

Sen and Sharma (2013) has studied voluntary Intellectual Capital disclosures made by Indian pharmaceutical and software companies in their annual report. Results reveal that the Intellectual Capital disclosure made by the sample companies did not fulfil the informational needs of stakeholders and companies need to disclose more meaningful information in their annual reports. Mehrotra and Malhotra (2015) examined the developments in the area of management and reporting of Intellectual Capital by firms and reported that there was a lack of consistency in reporting practices across the sectors and there is a need of uniform and consistent framework for the reporting of intellectual capital items. Kumar (2005) has also studied the current disclosure practices of the firm which would lead to the decision making of the market players and valuation of the intangible assets. The study suggested that information on intangibles would be disclosed when fair values of intangibles would be determined and fair values of intangibles would be determined with dynamic production structure with both tangible and intangible inputs.

1.3.2 Literature Review: General Context

Research & Development expenses significantly affect the performance of the firm (Gleason and Klock 2006, Black et al 2006, Guo et al 2002, Chavuin and Hirschey 1993, Gelb 2002, Lu et al 2010, Hall et al. 2013, Sveiby 1995, Sougiannis 1994, Gu 1990, Kavida and Sivakoumar 2010 and Gao et al 2012). Only few research studies support that fact that negative relation was also found between the Research and Development expenses and the performance of the firm (Heiens et al 2007, Godfrey and Kon 2001). Effect of Intellectual Capital on firm performance varies across different sectors. A significant relation was found between the Intangible Assets and firm performance in Biotechnology, Pharmaceuticals, IT, R&D intensive and Knowledge management firms.

Ghosh and Wu (2007) reported a positive relationship between intellectual capital and firm performance and have recommended research on investors' evaluation of intellectual capital of the firm. Juma and Payne (2004) also reported a relationship between intellectual capital and firm performance in new ventures of high tech industries. It also revealed that the use of knowledge assets would increase the economic value added of the firm. Barros *et al.* (2010) investigated the relationship between intellectual capital and value creation in the textile manufacturing sector and reported that the stock and flow of intellectual capital positively affects the value creation of an organization.

Guo *et al.* (2012) has also reported the positive association between patents and R&D expenditure in biotech firms and concluded that the quality of human capital plays a positive role in technology innovations and financial performance. Youndt and Snell (2004) examined the impact of intellectual capital on Human Resource configurations and organizational performance. Results indicate that these activities do not directly increase organizational-level performance; rather they help increase employees' knowledge and skills, facilitate group interaction, knowledge sharing, and enable organizations to store knowledge in systems, routines, processes, and cultures which would drive organizational performance. It was also found that Human Resource system is fundamental in the development of intellectual capital.

Few studies have also studied the relationship of intellectual capital with stock returns and other financial factors. Li *et al.* (2012) has examined the relationship between a firm's stock return and its intangible investment and reported that investment in intangible assets positively affects the stock returns and helps in sustaining competitive advantage. It was also found that there exists a negative relationship between the R&D intensity and the stock returns. The role of intellectual assets in moderating company financial health toward company market value and the role of intangible asset in moderating policy in corporate governance toward market value have been examined by Widiantoro (2012). Results reveal that intellectual capital plays a positive role in moderating company financial health and policy in corporate governance toward market value. Neuhausler et al. (2011) analyzed patents and the financial performance of firm based on stock market data regarding the results of R&D and its protection and the technology base of a firm’s influence on its market value and profits. To assess the value of a firm's patent portfolio, different value measures like the number of received patent citations, opposed patents, number of inventors were used. The results of the study suggested that at the firm level, forward citations and size positively influence market value. Chang (2011) examined the relationship between the patent performance and corporation performance in the pharmaceuticals companies using panel regression model to explore the relationship measured from patent H index, current impact index (CII) and essential patent index (EPI). The results demonstrated that patent H index and EPI have positive influences upon corporate performance. Medrano (2011) examined relationship between quality patents and firm performance on innovation effort and survival in the German laser source Industry . The aim of the study was to analyse relationship between relevant innovation effort and firm survival for the population of German laser source producers. Results reveal that quality patents was positive associated with firm survival.

Chen (2014) examined that whether firms' reliance on intellectual capital is an important determinant of financing constraints and concluded that the firms which have a higher intangible component in the total assets grow faster as compared to other firms. Results also reveal that apart from firm age and size, the nature of assets also helps in predicting firm dynamics.

Raquel and Rosina (2009) have provided evidence on the role of ownership structure on firm’s innovative performance. The study took into account innovative output that depends upon a set of factors related to the firm internal characteristics and environment. The study also assessed the impact of number of patents on firm’s performance. The results of the study revealed that patenting activity was positively favoured by being located in an environment with a high innovative activity.

Chen et al (2013) investigated the relationship between R&D investment, patent filings and financial success among a sample of Taiwanese high tech companies from 2000 to 2011 and reported that firms with a high level of innovative energy had better stock returns and net sales, but such firms did not had an advantage in terms of operating income.

Kehelwalatenna and Premaratne (2013) have reported negative to neutral association between intellectual capital and firm productivity and emphasized on the need for using intellectual capital assets more efficiently.

Ibadin (2016) has investigated the relationship between the level of disclosure (structural and relational) and specific characteristics, namely, company size, leverage, audit firm size, national differences of companies, age of company, profitability, ownership concentration, type of industry, foreign activity of company, and ratio of market to book value of assets in Nigerian companies. The results of study indicate that foreign activities of company and size of auditing firm were positively related and statistically significant to disclosures of relational intellectual capital assets. Size of audit firm was statistically significant with a positive relationship to disclosure of structural intellectual capital assets and age of company was found to be statistically significant and positively related to disclosure of structural intellectual capital assets and disclosures of relational intellectual capital assets.

Measurement of Intellectual Capital can be termed as the most challenging aspect of the domain. Broadly there are two research streams for the measurement of Intellectual Capital i.e. IC1 - ostensive and IC2-performative (Mouritsen et al, 2006).

Research studies based on IC2- Performative stream used methodology of content analysis (Sonnier et al, 2004, Finch 2006, Holmen 2011, Anuradha 2008, Kang and Gray 2011,Li et al 2008, Lenciu et al 2011, and Abeysekera 2006,), Survey method (Khalique et al 2013, Ahmadi et al 2012, Yang and Lin 2009, Chen et al 2006, Lenciu et al 2011, Shin et al 2011, Chiucchi 2008, Srinivasan 2006, Suraj and Ajferuke 2013, and Lee and Lee 2007) and event study method (Collins et al 1997).

Apart from investors such information may also be useful for other stakeholders. These benefits are to retain and attract quality employees, to retain and attract customers of company products, to lobby for more synergetic collaborations with partners, for the society and to manage the perceptions of the capital market (Saleh, 2010). Information on various dimensions of intellectual capital such as human resources can increase the quality of decision making on part of stakeholders. Qualitative disclosure is important because it helps market participants to bridge the gap between the financial statements and the economic reality of firms' operations (Glassman 2003). Increased disclosure may also lead to lower information asymmetry and an increase in market liquidity (Leuz and Verracchia, 2000).

A peep into previous literature suggests that that the disclosure practices are basically of two types Quantitative and Qualitative. In literature these have also been termed as hard and soft information (Petersen 2004; Engelberg 2008; Demers and Vega 2010; Minnis 2010). The information related to the qualitative disclosures includes the human resource information, brand equity, employee related information, and customer related information, stakeholders' information, policies and strategies of the organisation. The information related to the quantitative disclosures includes the information related to goodwill, patents, intellectual property and other intangible assets which are acquired by the organisations. The majority of companies disclose quantitative information, with both financial and nonfinancial components, rather than qualitative (Kang and Gray, 2011).

Basic purpose of reporting information is to enable the organisations to communicate important information to the stakeholders of the organisation. When the wealth of the organization is based more on R&D based assets, that are usually intangible in nature, it becomes important to communicate the efforts for creation of such assets to various stakeholders as well as communicating the existing stock of such assets. Organisations provide qualitative disclosure to improve investors' understanding of firms, fundamental business activities as well as influence investors' interpretations of changes in financial performance and their assessment of future prospects.

Intellectual Capital disclosures are expected to attract more investments by the investors (Barth et al 2001, Gelb 2002, Wyatt and Abernetny 2008). Higher disclosures by the organisations can also be indicative of more earnings of the organisation (Roulbtone 2011, Ling 2013, Doukas and Padmanabhan 2002, Carmeli and Azeroual 2009, Su and Well 2014, Ritter and Wells 2006, Barth and Kasznik 1999). Reporting of information related to Intellectual Capital also signifies the sensitivity of firms towards the financial valuation (Bosworth and Rogers 1998, Godfrey and Kon2001, and Hwang and Basu 1996). Disclosures on Intellectual Capital have also been described as the indicators of the market value and stock prices of the firms (Riedel 2011, Ritter and wells 2006, Behname et al 2012, Diviera et al 2006, Bouleune et al 2011, Svieby 1995 and Khedri 2012).

Meca *et al.* (2005) assessed the information dealing with intellectual capital that firms disclose in presentations to sell-side analysts and the factors that influenced the information to be disclosed. Results reveal that the information on strategy, customers, and processes was revealed and the information on research, development and innovation were least reported because of fear of competitive disadvantage. It was also concluded that more profitable firms disclose more detailed information on intangibles and less profitable firms disclose less information on intangibles and the factors responsible for the level of information disclosure were agency costs, political costs, external financing needs, analyst coverage, firm's reputation and market-to-book ratio levels. Anuradha (2008) examined the effectiveness of annual reports in reporting information related to intellectual capital and the Intellectual Capital reporting practices of business firms. Results reveal that annual reports of academic institutions can be used as an instrument in inquiring intellectual capital reporting because these institutions commonly signal what they perceive as important through the reporting mechanism. It was also suggested that content analysis can be used as a research method in capturing the data but to get better results this method has to be combined with other data capture methods such as interview and survey methods.

The effect of intangible assets on various factors related to enterprises has been advocated. Hierman and Clarysse (2007) analyzed which tangible and intangible assets affect the research based start-ups and reported that the effect of tangible and intangible assets on research based start-ups differs between software and other companies. Oliver and Fumas (2007) have also examined the effect of intellectual capital on the economic value of an enterprise and the costs at which these are accumulated. Results reveal that investment in intangible assets positively affects the market value of an enterprise. It was also concluded that intellectual capital build up from adjustment costs of investments in IT and rents from market power split evenly the economic value of the bank above the replacement cost of material and immaterial assets. Miyagawa *et al.* (2014) examined the effects of intangible assets on the value of the firm and stock market of Japanese firms. It was found that intangible assets increase the value of the firm. It was also found that not all intangible assets are valued in stock market, the investment in innovative property and economic competencies are valued but the investment in R&D and human resource is not valued by Japanese firms.

From the available literature, it can be seen that R&D activities are expected play an important role in enhancing firm performance. There are number of studies conducted in the domain in the developed countries but in India context, there is a noticeable scarcity. Outcome of the study will help to understand the linkage of R&D activities and R&D output with firm performance leading to better insight into the issue and effective policy interventions. This study will help to understand whether investors regard R&D as a significant value-increasing activity in context of Indian Manufacturing sector. Identification of such phenomenon may be instrumental in enhancing the R&D investment in Indian Manufacturing sector both quantitatively and qualitatively.

Chapter 2
Research Methodology

This chapter describes the methodology that has been adopted for conducting the research work. This chapter has been divided into five sections. First section of the chapter gives an outline of the broad research and sampling design followed for conducting the study. There are five objectives of the study (Section 1.2) and based on the objectives of the study different sections have been framed. Conceptual framework and research methodology followed for achieving first two objectives have been given in second section. Methodology followed for achieving the third objectives has been discussed in the third section. Fourth section of the chapter has been carved for presenting the methodology adopted for fulfilment of last two objectives. Fifth section deals with the various data analysis techniques used for analysis. Nomenclature used for these five sections is as follows:

Section 2.1 : Research Framework and Sampling

Section 2.2 : Methodology for Trend Analysis of Qualitative Disclosures, R&D Activities and R&D Output

Section 2.3 : Methodologies for Linking R&D Efforts and Firm Performance

Section 2.4 : Methodology for Regression Models

Section 2.5 : Data Analysis Techniques and Limitations of the Study

At the end of this chapter, limitations of the study have also been presented.

2.1 Research Framework and Sampling

The present study has been conceptualised to explore trends in acquisition and commercialization activities of R&D based assets reported by Indian manufacturing companies. An attempt has been made to measure the R&D activities and R&D output using alternate methodologies. Relationship between R&D activities as well as R&D output with firm performance has also been investigated. Regression models have been employed to capture the dynamics related to linkage between R&D operations and firm performance.

The research design for this study is exploratory and conclusive in approach. It explores the trends of disclosures related to R&D activities and R&D output. Further an attempt has been made to conclusively relate R&D to firm performance.

2.1.1 Sampling Design

The study makes use of both secondary data and primary data. Description of the companies selected for both secondary data and primary data has been given in the following text.

For the purpose of collecting secondary data, all manufacturing companies of CNX 500 Index of National Stock Exchange of India Limited (as on 01.01.2014) will be included in the study. The CNX 500 is India's first broad based benchmark of the Indian capital market with strength of 500 companies. The CNX 500 Index represents about 97.30% of the free float market capitalization of the stocks listed on NSE as on September 30, 2013. For the purpose of this study, 243 manufacturing firms, from seven major sectors have been considered. List of the companies included in the study has been presented in Annexure- I. Given the fact that study focused on manufacturing sector alone, non-manufacturing firms were excluded from the analysis. Further, the few manufacturing sectors such as Cement and Chemical were excluded for the want of sufficient number of firms and data availability as required by the methodology

Table 1: Sector wise Distribution of Companies for Secondary Data

Sector	Number of Firms
Automobile	30 (12.34)
Consumer Goods	60 (24.69)
Energy	34 (13.99)
Industrial Manufacturing	47 (19.34)
Metals	26 (10.70)
Pharmaceuticals	31 (12.76)
Textile	15 (6.17)
Total	243 (100)

Figures in parentheses are percentages

used for analysis. In all, 257 firms did not qualify for the study on account of the reasons mentioned above, therefore, leaving a set of 243 firms for the analysis purpose. For these 243 companies, average value of Sales was Rs. 132005.50 million, average net worth was Rs.

64886.30, and average level of employment was 7894.62 employees. Further, out of total 243 companies, 207 companies were Indian companies, while 36 companies were having foreign ownership. Period of analysis , for secondary data, was ten years, i.e., from 2004-05 to 2013-14. Sector wise distribution of the manufacturing firm included in the sample is given in the table 1.

For studying the technology acquisition and commercialization aspects, firm level primary data was collected through a structured questionnaire. Sample size for collecting primary data was 51 firms. These firms were spread across the seven sectors and were selected on the basis of their willingness to participate. These 51 firms were a subsample of 243 companies for which secondary data was collected. Sector wise distribution of firms for which primary data was collected is given in table 2.

Table 2: Sector wise Distribution of Companies for Primary Data

Sector	Number of Companies
Automobile	10 (19.61)
Pharmaceuticals	10 (19.61)
Industrial Manufacturing	10 (19.61)
Metals	6 (11.76)
Energy	5 (9.80)
Textile	5 (9.80)
Consumer Goods	5 (9.80)
Total	51 (100)

Figures in parentheses are percentages

2.2 Methodology for Trend Analysis of Qualitative Disclosures, R&D Activities and R&D Output

Both secondary and primary sources were used for fulfilling the first objective of the study. Methodology used by Kang (2006) and Merkley (2010) was adapted to explore Qualitative disclosures related to Intellectual Capital. There are three categories of Intellectual Capital i.e. Relational Capital, Human Capital and Structural Capital. A list of keywords was prepared with an extensive list of 40 items with 8 items in Human Capital, 18

Items in Relational Capital and 14 Items in Structural Capital. The list of keywords has been presented in Annexure II. Using content analysis, data was collected from the annual reports of the companies. Content analysis is one of the best known and the most appropriate research methods in investigating the level and content of disclosures in corporate annual reports (Marston and Shrives, 1991). For conducting content analysis every keyword was searched in the annual reports and the number of times the keyword appeared in the annual report was noted. Thus, all the keywords in three categories were searched in the similar way and the data on three categories of qualitative disclosures i.e. relational capital, structural capital and human capital was collected. The data was used to calculate the Relational Capital disclosures, Structural Capital disclosures and Human Capital disclosures. Annual reports of the companies were downloaded from the website of the companies. For the companies whose annual reports were not available on their website were downloaded from the database reportjunction. Steps of carrying out content analysis have been presented in Annexure IV.

For fulfilling the second objective R&D activities and R&D output have been measured using different methodologies. For measuring R&D activities, both quantitative as well as qualitative approach were used. R&D activities were assessed quantitatively by recording R&D intensity (ratio of R&D expenditure to sales). Values of R&D expenditure and sales were obtained from CMIE-Prowess Database. R&D output was measured using patent applications, patent count, , and patent citations. Patent count is the number of patents granted to a firm in the given year. Patent citations included forward citations and backward citations. Forward citations are the number of citations to a firm's patents included in the subsequent patent applications. Backward citations are number of citations in a firm's patent. Patent applications and patent granted were measured with the help of 'Indian Patent Advanced Search System' made available by Patent Office of India . Backward and Forward citations were obtained from Espacenet Patent Search, a service provided by European Patent Office.

2.2.1 Trend Analysis

Trend means the smooth and regular movements of a series over a long period of time. These movements are the result of those forces which change very gradually over a long period of time. Trend analysis has been used to find out to the trend of disclosures related to intangible assets as well as trends pertaining to R&D outputs, i.e., Patent Applications, Patents Granted, Backward Citations and Forward Citations. Trend analysis was run by using time as the independent variable and the qualitative disclosures of Human Capital, Relational Capital, and Structural Capital were considered as dependent variables separately. The same procedure was also adopted for the measures of R&D output.

Following trend equation was used for estimation.

$$\mathrm{Ln}\,(Y_i) = \beta_1 + \beta_2 T_i + \varepsilon_i$$

Where,

$$\mathrm{Ln}\,(Y_i) = \text{Dependent Variable}$$

$$T_i = \text{Time Period}$$

$$\varepsilon_i = \text{Error term}$$

Growth of various qualitative disclosures has been calculated using LOG-LIN growth model (Gujarati, 2007). For this first of all a trend equation was fitted with natural log of respective disclosures or measures of R&D output as dependent variables and time as independent variable. Further growth rate for particular series was calculated by taking antilog of the trend coefficient and subtracting one from the obtained value.

Difference between trend coefficients of various sectors was tested by introducing the dummies for various sectors coupled with their interaction effects with the time in the original trend equation, the regression equation was estimated by pooling the data for all the sectors. Significant *F*- statistics indicate that there is a significant difference in trend coefficients of various sectors. Six dummy variables were introduced and the interaction effects were observed for human capital, relational capital and structural capital disclosures. Similar procedure was also used for the measures of R&D output.

2.2.2 Questionnaire used for Primary Data Collection

Pre structured non-disguised questionnaire (attached as Annexure-III) was used for the purpose of primary data collection. Questionnaire contained a number of queries inform of dichotomous and rating scale questions. Major issues of inquiry included in the questionnaire were type of R&D activities, channels of technology acquisition and commercialization, R&D networking, Orientation towards R&D, R&D Policy, Hindrances related to R&D activities. Five point Likert scale was used for obtaining the responses with '5' designated as 'Most Important' and '1' designated as 'Not Important at all'. Respondents for filing the questionnaire were largely the persons heading R&D department in the respective organizations. Responses obtained by the questionnaires were tabulated so as to facilitate the analysis of data. Data analysis was done using JMP software of SAS Inc.

2.3 Methodologies for Linking R&D Efforts and Firm Performance

Alternative methodologies were used for linking R&D efforts with firm performance using secondary data. Details of these methodologies have been presented as follows:

- Intellectual Capital Score based Methodology 1 and Methodology 2
- Methodology based on R&D Intensity and measures of R&D Output

As presented in Table 3, various input measures were linked to different measures of firm performance. Based on input measures different portfolios were created and further performance of these portfolios were assessed on basis of various measures of firm performance. In case of Intellectual Capital Score based Methodology 1 and Methodology 2, the companies were divided into four portfolios for each methodology. For the remaining input measures, i.e., Patent Applications, Patents Granted, Total Citations (Sum of Backward Citations and Forward Citations), and R&D intensity, the companies were divided into two portfolios each.

Table 3: Measures for Linking R&D with Firm Performance

Input (Measure of R&D)	Output (Measure of Firm Performance)
• Intellectual Capital Score Methodology 1 • Intellectual Capital Score Methodology 2 • Patent Applications • Patents Granted • Backward Citations • Forward Citations • Total Citations • R&D Intensity	• Monthly Returns • Tobin's Q • Return on Total Assets (ROTA) • Return on Capital Employed (ROCE) • Return on Net Worth (RONW)

Details of creation of these portfolios as well the description of measures of firm performance have been provided in the following text.

2.3.1 Intellectual Capital Score based Methodology 1 and Methodology 2

For linking Intellectual Capital Score with firm performance, methodology used by Angelopoulos et al (2012) was adapted. As per this methodology Intellectual capital is divided into three components: Relational Capital (RC), Structural Capital (SC) and Human Capital (HC). For measurement of these components different indices were developed. These indices were used to calculate the Relational Capital score, Structural Capital score and Human Capital score. Using specific methodology as suggested by Angelopoulos et al (2012) indices for different categories of intellectual capital were developed. Further, median value for individual index was calculated. Indices of various companies, in a given sector, were compared with the median value of index for the respective sector. Companies with index value greater than median of all indices within the sector were assigned the value of 1 for respective index, otherwise value of 0 was assigned. All the companies thus received the value of either 1 or 0 on the basis of three indices. Intellectual capital score was calculated by adding Relational Capital score, Structural Capital score and

Human Capital score. On account of this addition Intellectual capital score could assume the possible values of 0,1,2,and 3.

On the basis of intellectual capital score the companies were divided into four categories. These four categories were treated as four portfolios and performance of these portfolios on the basis of various measures of firm performance, given in table 3, were compared. Methodology for calculating various scores i.e. Relational capital score, Human capital score and Structural capital score is presented in the following section.

Difference between Methodology 1 and Methodology 2

For calculation of Intellectual Capital Score, two methodologies with a minute difference have been used. This difference is in terms of calculation of Structural Capital Score. For Methodology 1, R&D expenses have been amortised at a rate of 20%, while for Methodology 2, R&D expenses have been amortised at a rate of 33%. For details, subsequent section on Structural Capital score calculation may be seen. This variation has been inculcated so as to observe the impact of lagged R&D expenditure (with different time lags) on firm performance.

Relational Capital scores based on Methodology 1 and Methodology 2

Relational capital represents the ability of an organisation to develop and maintain relations with the customers and stakeholders that serve long term interest of both the organisation and customers and stakeholders. Relational capital index was calculated based on the total assets and sales of an organisation. Values of total assets and sales were obtained from CMIE-Prowess database. The measure of Relational Capital is defined as follows:

$$RC\_INDEX_{i,t}^{j} = \frac{\Delta\{\frac{S_{i,t}^{j}}{TA_{i,t}^{j}}\}}{\frac{S_{i,t}^{j}}{TA_{i,t}^{j}}}$$

where, $S^j_{i,t}$ denotes the sales, $TA^j_{i,t}$ denotes total assets, $\left((S^j_{i,t})\middle|TA^j_{i,t}\right)$ is the total assets turnover ratio of firm i in sector j in year t. $\Delta\{\frac{S^j_{i,t}}{TA^j_{i,t}}\}$ represents the change in total assets turnover ratio of firm i in sector j between years t and t-1.

After calculating the RC_INDEX, RC_SCORES were calculated on the basis of these values. Median Value was calculated for RC_INDEX and RC_SCORE of 1 or 0 was allotted on the basis of comparison between RC_Index of sector and RC_Index of a firm within a sector.

$$RC\_SCORE^j_{i,t} = \begin{cases} 1 \; if \; RC\_INDEX^j_{i,t} - RC\_INDEX^j_t > 0 \\ 0 \; if \; RC\_INDEX^j_{i,t} - RC\_INDEX^j_t \leq 0 \end{cases}$$

Structural Capital scores based on Methodology 1 and Methodology 2

Structural capital is divided into technological capital and organisational capital. Structural capital includes the organisational culture, values, attitudes, information, structure, R&D expenses, intellectual property, product development, and licensing and technology initiative. A component of Structural Capital is calculated on the basis of R&D expenses. It has been assumed that R&D expenses are amortised at a rate of 20% to compute a firm's R&D capital (Lev and Sougiannis, 1996, Eberhart et al., 2004) for Intellectual Capital Score based Methodology 1. The technological capital of a firm i belonging to sector j in year t is calculated as follows:

$$RDC^j_{i,t} = RD^j_{i,t} + 0.8RD^j_{i,t-1} + 0.6RD^j_{i,t-2} + 0.4RD^j_{i,t-3} + 0.2RD^j_{i,t-4}$$

Where, $RD^j_{i,t}$ denotes the unamortised R&D expenditure of firm i belonging to the sector j in year t.

For Intellectual Score based Methodology 2, R&D expenses are amortised at a rate of 33 % to compute a firm's R&D capital. For Intellectual Score based Methodology 2, the technological capital of a firm i belonging to sector j in year t is calculated as follows:

$$RDC^j_{i,t} = RD^j_{i,t} + 0.67RD^j_{i,t-1} + 0.33RD^j_{i,t-2}$$

But for the calculation of R&D capital, there is no difference between Intellectual Capital Score based Methodology 1 and Methodology 2.

Previous studies have used selling, general and administrative expenses as a proxy for measuring another structural capital (Edvinsson and Malone, 1997, Roos and Roos, 1997, Lev et al., 2009). Selling, general and administrative expenses comprise some components of Relational Capital and to eliminate the impact of SGA expenses which are attributed to Relational Capital the following regression equation was fitted:

$$SGA_{i,t}^{j} = p_{0,t}^{j} + p_{i,t}^{j} RC\_INDEX_{i,t}^{j} + u\_sga_{i,t}^{j}$$

where, $SGA_{i,t}^{j}$ are SGA expenses for firm i in time period t, $p_{0,t}^{j}$ is a constant term for inelastic SGA expenses required in normal course of business, and $p_{i,t}^{j}$ is the coefficient associating the annual average SGA expenses with the level of Relational Capital of a firm i in sector j in year t. Using the residuals ($u\_sga_{i,t}^{j}$) of the above mentioned equation, Organisational Capital for a given firm was calculated. Three year amortisation period has been assumed to estimate the Organisational Capital for a firm i belonging to the sector j in year t using the corresponding error terms in the following equation:

$$OC_{i,t}^{j} = pu\_sga_{i,t}^{j} + 0.67\, pu\_sga_{i,t-1}^{j} + 0.33\, pu\_sga_{i,t-2}^{j}$$

Where, $pu\_sga_{i,t}^{j}$ denotes positive estimation errors of above equation of firm i belonging to sector j in year t. The positive values of $u\_sga_{i,t}^{j}$ were considered, the negative values were treated as zero.

Using the $RDC_{i,t}^{j}$ and $OC_{i,t}^{j}$ the measure of structural capital $SC\_INDEX_{i,t}^{j}$ is calculated by using following equation:

$$SC\_INDEX_{i,t}^{j} = \frac{RDC_{i,t}^{j} + OC_{i,t}^{j}}{TA_{i,t}^{j}}$$

After calculating the SC_INDEX, SC_SCORES were calculated on the basis of these values. Median was calculated for SC_INDEX, and SC_SCORE of 1 or 0 was allotted on the basis of comparison between median of SC_Index of industry and SC_Index of a firm within a sector.

$$SC\_SCORE_{i,t}^{j} = \begin{cases} 1 \; if \; SC\_INDEX_{i,t}^{j} - SC\_INDEX_{t}^{j} > 0 \\ 0 \; if \; SC\_INDEX_{i,t}^{j} - SC\_INDEX_{t}^{j} \leq 0 \end{cases}$$

Human Capital scores based on Methodology 1 and Methodology 2

Human Capital includes the knowledge, skills, abilities, and strengths of human resource working in an organisation. Human capital is measured on the basis of sales and employee wages in an industry. To measure the Human Capital, output of firm i belonging to sector j in year t is calculated by using following equation:

$$Q_{i,t}^{j} = \frac{S_{i,t}^{j}}{w_{i.t}^{j}}$$

where, $Q_{i,t}^{j}$ is the output of a firm i belonging to sector j in year t, $S_{i,t}^{j}$ is the sales of firm i belonging to sector j in year t, and $w_{i.t}^{j}$ is the average annual per employee wage of firm i in sector j in year t. In order to calculate the firm's conditional normal output of a given year t the following cross – sectional model was fitted:

$$log(Q_{i,t}^{j}) = log(a_{0,t}^{j}) + a_{1,t}^{j} RC\_SCORE_{i,t}^{j} + a_{2,t}^{j} SC\_SCORE_{i,t}^{j} + a_{3,t}^{j} log(TA_{i,t}^{j}) + a_{4,t}^{j} log(N_{i,t}^{j}) + e_{i,t}^{j}$$

Where, $TA_{i,t}^{j}$ denotes the total assets of firm i belonging to sector j in year t, $N_{i,t}^{j}$ denotes the number of employees, and $e_{i,t}^{j}$ is the error term.

After getting the $e_{i,t}^{j}$ error term, HC_INDEX is calculated by using the following equation:

$$HC\_INDEX_{i,t}^{j} = \frac{e_{i,t}^{j}}{N_{i,t}^{j}}$$

After calculating the HC_INDEX, HC_SCORES were calculated on the basis of these values. Median Value was calculated for HC_INDEX of all the firms in the given sector and HC_SCORE of 1 or 0 was allotted on the basis of difference between HC_Index of industry and HC_Index of a firm within a sector.

$$HC\_SCORE_{i,t}^{j} = \begin{cases} 1 \; if \; HC\_INDEX_{i,t}^{j} - HC\_INDEX_{t}^{j} > 0 \\ 0 \; if \; HC\_INDEX_{i,t}^{j} - HC\_INDEX_{t}^{j} \leq 0 \end{cases}$$

Where, $HC\_INDEX_{t}^{j}$ is the median value of Human Capital index in the sector j.

Intellectual Capital score based on Methodology 1 and Methodology 2

Intellectual capital score is the total of Relational Capital score, Structural Capital score and Human Capital score. The intellectual capital score is calculated by adding the

RC_SCORE, SC_SCORE and HC_SCORE. The IC_SCORE ranges from 0 to 3. All these scores were having a value of either 1 or 0.

$$IC_{SCORE}{}^{j}_{i,t} = RC_{SCORE}{}^{j}_{i,t} + SC_{SCORE}{}^{j}_{i,t} + HC_{SCORE}{}^{j}_{i,t}$$

2.3.2 Methodology based on R&D Intensity and measures of R&D Output

Two portfolios each were created for these methodologies. Median values for all the firms within a given sector were calculated for the given input measure. For example, sector wise median value was calculated for R&D Intensity for each time period. R&D Intensity of individual firm was compared against the calculated median value. If R&D intensity of a given firm was more than the median value for the sector, then score of 1 was assigned, otherwise the particular firm was assigned 0. Based on this procedure, all the firms were having value of 1 or . All the firms with the same value were placed in the same portfolio so as to create two portfolios. The same procedure was adopted for making portfolios on basis of Patent Applications, Patents Granted, and Total Citations.

2.3.3 Measures of Firm Performance

This sub sections deals with the description and calculation of various measures of firm performance used in the study.

Calculation of Monthly Returns

The portfolios were constructed to compare the performance of alternate methodologies. For calculation of monthly returns, the data on closing prices for different firms was collected from website nseindia.com for the period of analysis. Firm-specific returns were calculated on monthly frequency. The firm-specific monthly returns were calculated by taking month end to month end change in closing prices of securities in a portfolio.

$$Monthly\ \ Return = \frac{P_t - P_{t-1}}{P_{t-1}}$$

where

$P_t = Current\ Period\ Price\ ,\ P_{t-1} = \ Previous\ Period\ Price$

Monthly portfolio return was calculated by taking average of returns of all the securities (stocks of companies) in a given portfolio. Dividend adjustments were made by re-investing the dividends at the month end. The relation between intellectual capital and monthly was examined to check whether the portfolios with different intellectual capital provide significantly different returns. For this purpose, portfolio returns related in time were compared using related sample t-test. A significant difference in the returns would indicate that intellectual capital carries predictability value or is having value relevance for monthly returns.

Tobin's Q

Tobin's Q has been used as one of the measures of firm performance. Tobin's q is defined as the ratio of a firm's market value to its book value. The book value of the firm is the equal the total value of its assets reported on the balance sheet. The market value is the stock market value of the firm at the end of the year plus the market value of its debt. The market value of a firm's debt is difficult to obtain and therefore following the previous literature and the normal value of long term and short term debt has been used instead (Hall et al. 2007). If value of Tobin's Q is greater than one, it signifies that the firm has been able to command more market value as compared to its book value. A value of Tobin's Q being less than one is indicative of poor performance of the firm. Higher value of Tobin's Q indicates better firm performance. Values of different variables used for the calculation of Tobin's Q have been taken from CMIE-Prowess database.

Returns

Returns have been widely used as the measure of firm performance. For the purpose of this study three different types of returns, i.e., Return on Capital Employed (ROCE), Return on Net Worth (RONW), and Return on Total Assets (ROTA) have been used. Values for these returns have been calculate from CMIE-Prowess database. Return on Capital Employed (ROCE) is calculated as the ratio of Net Income to Capital Employed. Capital Employed is sum of long term debt and shareholders' equity. Net Income is the bottom line of income statement. It is the measure of net profit of the company after providing for all expenses including taxes. RONW is calculated as the ratio of net income to net worth. Net worth is the amount that belongs to the shareholders. ROTA is calculated as ratio of net income to average total assets. Total assets includes current assets as well as non-current assets. It is important to note that RONW is based only on shareholders' funds. ROCE takes into consideration both equity and debt. ROTA is a widely used profitability measure in innovation studies (Roberts and Amit, 2003) and captures the ability of a firm to develop profits from its asset or investment base (no matter whether the source of the investment was equity or debt).

Comparison of Various Measures of Firm Performance

Broad measures of firm performance included in the study are monthly returns, Tobin's Q, and various returns i.e. Return on Capital Employed (ROCE), Return on Net Worth (RONW), and Return on Total Assets. Monthly Returns and Tobin's Q are based on market performance of the firm. Tobin's Q is annual basis and considers the market capitalization of the firm at the end of the year. On the other hand, monthly returns take into consideration closing stock prices at the end of each month. Various return such as ROCE, RONW and ROTA are the intrinsic measures of firm performance and are not based on the market value of the firm. These return measures have been calculated on annual basis.

2.4 Methodology for Regression Models

Effect of various organizational level variables on R&D output was also investigated using regression analysis. Organization level variables included are R&D Expenditure, Export Intensity (Ratio of Exports to Sales), firm size (measured by total assets), firm age, financial leverage (Ratio of Debt to Equity), type of ownership (whether the given firm is having foreign/domestic ownership), and nature of business (sector). Pooled regression was run by using various measures of R&D output (Patent Applications, Patents Granted, Total Citations). For the purpose of generating a model from the data obtained from the study, regression models were estimated by using Tobin's Q as the measure of firm performance. Various explanatory variables, used for this purpose, included R&D Expenditure, patent Applications, Patents Granted, Total Citations, Export Intensity (Ratio of Exports to Sales), firm size (measured by total assets), firm age, leverage (Ratio of Debt to Equity), type of ownership (whether the given firm is having foreign/domestic ownership), and nature of business (sector). Year dummies for different time periods were also introduced at the time of estimation of the regression models. Brief description of various explanatory variables is as follows:

- R&D Expenditure: Annual R&D Expenditure incurred by a firm (Rs. millions)
- Export Intensity: Ratio of Total Exports to Sales, Maximum value can be 1
- Firm Age: Age of the firm measured in Years
- Financial Leverage: Measured as the ratio of Debt to Equity
- Type of Ownership: Dummy variable, Value: 1 if the firm is having foreign ownership otherwise 0.
- Nature of Business: Dummy variable based on the sector to which a firm belongs.

Data pertaining to all these variables was extracted from CMIE-Prowess database.

2.5 Data Analysis Techniques

Apart from the techniques discussed in the previous sections statistical techniques such as Paired t test, Analysis of Variance, and one sample t-test: assuming equal variance were used to for data analysis . These statistical techniques have been discussed in the following text.

One Sample t-test

One sample t-test is a statistical procedure used to examine the mean difference between the sample and the known value of the population mean. We draw a random sample from the population and then compare the sample mean with the population mean and make a statistical decision as to whether or not the sample mean is different from the population mean. The formula for one sample t-test is as follows:

$$t = \frac{\bar{x} - \mu}{S} \sqrt{n}$$

Where, μ is the assumed population mean, $\bar{x}$ is the mean of the sample, n is the number of observations in a sample.

The hypothesis used for one sample t-test is as follows:

$H_0 : \mu_1 = \mu_2$

$H_1 : \mu_1 \neq \mu_2$

Null hypothesis means there is no difference between population mean and assumed mean and alternate hypothesis states that two means are different. One sample t-test was applied to find out whether the responses obtained on rating scale, in case of primary data, were significantly different from the assumed mean (mid-point of the scale).

Paired t- test

In case the observations are paired at the time of comparison, then the test procedure is known as 'paired t-test'. In this test of significance two samples are related. We test the null hypothesis that the mean difference of the population is zero. Where null hypothesis specifies that mean difference is same for all the groups and alternate hypothesis states that difference is significantly different for groups. Paired t-test was used to find the significant difference in the returns of various portfolios based on Intellectual Capital Score Methodology 1 and Methodology 2 as well as measures of R&D output and R&D Intensity.

Analysis of Variance

Analysis of Variance (*ANOVA*) is used to test for the significance of the differences among more than two sample means. Using *ANOVA,* inferences can be made about whether the different samples have been drawn from the populations having the same mean. *ANOVA* involves determining one estimate of the population variance from the variance among the sample means and second estimate of the population variance from the variance with in the sample. Further, both the estimates are compared. If both the estimates are approximately equal in value, then the null hypothesis, *i.e.,* sample means do not vary significantly, is accepted. These two estimates of the population variance are compared by computing their ratio, called *F* statistics.

One-Way Analysis of Variance is a way to test the equality of three or more means at one time by using variances. The null hypothesis will be that all population means are equal, the alternative hypothesis is that at least one mean is different. When samples are not drawn from the populations having the same mean, between-column variance tends to be large than with-in column variance and the value of *F*-statistics tends to be large. This leads to the rejection of null hypothesis.

The hypothesis used for one way *ANOVA* is as follows:

$$H_0 : \mu_1 = \mu_2 = \mu_3 = \dots\dots\dots \mu_k$$

$$H_1 : \mu_1 \neq \mu_2 \neq \mu_3 \neq \dots\dots\dots \mu_k$$

The *ANOVA* test procedure produces an F-statistic, which is used to calculate the p-value. If $p < .05$, the null hypothesis will be rejected at 5% level of significance. It can be concluded that the means are not the same for all groups. If $p > 0.05$, we fail to reject null hypothesis. It can be concluded that the means are not different for all the groups. Analysis of Variance (*ANOVA*) was used to find the differences across the sectors in terms of various measures such as R&D Expenditure, R&D Intensity, different types of disclosures, measures of R&D output, as well as the issues probed on basis of primary data . Further, Post-hoc analysis was undertaken for the instances with significant F-statistics. Post-hoc analysis involves comparison of individual means in pairs. In case no significant difference was found between two means then this phenomenon is presented by superscripting the means with the same letter.

2.6 Limitations of the Study

The study is subject to certain constraints and limitations. These are listed below so that the findings of the study could be understood in their perspective.

1. Major portion of the study is based on secondary data. Accuracy of secondary data is limited to the accuracy of the data source from where data have been obtained.

2. Primary data have been collected using survey method. Therefore, the results obtained from primary data carry the limitations of survey methodology. For example, primary data collected from the respondents may include the personal bias of the respondents.
3. Various variables representing the sector estimates are the averages of all the firms in a given sector. This procedure may conceal the top performing and underperforming firms behind the average.
4. Factors such the organizational culture, compensation policies, organizational loyalty and presence of collateral assets are expected to impact R&D activities and R&D output as well as their relation with the firm performance. It is important to note that such factors have not been explicitly included in the analysis.

Chapter 3
Results

This chapter deals with the analysis of data collected in the study. Present chapter has been structured into the following sections :

Section 3.1 : Trend Analysis of Qualitative Disclosures, R&D Activities and R&D Output

Section 3.2 : Results of Field Survey

Section 3.3 : Linking R&D Activities and Output with Firm Performance

Section 3.4 : Regression Models

3.1 Trend Analysis of Qualitative Disclosures, R&D Activities and R&D Output

This section deals with the measurement of qualitative disclosures related to Intellectual Capital, R&D activities and R&D output. Results of trend analysis (explained in section 2.2.1) have also been presented.

3.1.1 Intellectual Capital Disclosures across various sectors

In this section the sector wise qualitative disclosures, results of trend analysis, category wise comparison of disclosures across sectors and comparison of relational capital disclosures, human capital disclosures, and structural capital disclosures have been discussed.

3.1.1.1 Sector Wise Intellectual Capital Disclosures

Sector wise Relational Capital disclosures, Structural Capital disclosures and Human Capital disclosures for various sectors have been discussed below.

Automobile Sector

In this section year wise disclosures related to Relational Capital, Structural Capital and Human Capital pertaining to automobile sector have been presented.

It can be seen from table 4 that Relational Capital related disclosures increased from 30.69 in 2004-2005 to 44 in 2013-2014. Results of trend analysis indicate that there was a significant positive trend in case of Relational Capital related disclosures for automobile sector. A compound annual growth rate of 5.55 percent was observed for Relational Capital disclosures in automobile sector. Also, average number of Structural Capital related disclosures was 12.93 in year 2004-2005 and this number gradually increased to 21.86 in 2013-2014. Trend equation of Structural Capital disclosures indicates that there was a significant positive trend during the period of study. Compound annual growth rate for Structural Capital disclosures was found to be 6.82 during this period. Further, it can be seen from table 4 that Human Capital related disclosures stood at 12.73 in year 2004-2005 and increased to 17.24 in 2013-2014. Linear trend equation for Human Capital disclosures indicates that there was significant positive trend. It can also be seen from table that compound annual growth rate of 3.77 percent was observed for Human Capital disclosures in the case of automobile sector. Maximum compound annual growth rate was observed in the case of Structural Capital disclosure i.e. 6.82 percent.

Table 4: Average Qualitative Disclosures for Automobile Sector

Year	Relational Capital Disclosures	Structural Capital Disclosures	Human Capital Disclosures
2004-05	30.69	12.93	12.73
2005-06	27.38	12.93	11.63
2006-07	29.03	13.70	11.37
2007-08	28.83	13.63	12.97
2008-09	30.47	15.27	15.53
2009-10	40.13	17.33	11.77
2010-11	36.07	18.63	14.17
2011-12	40.10	20.07	14.27
2012-13	42.80	20.37	16.03
2013-14	44.00	21.86	17.24
Trend Equation	**3.241+0.054T**	**2.432+0.066T**	**2.410+0.037T**
R^2	0.81	0.96	0.60
t-value	5.88	13.57	3.43
p-value	0.0004	0.0001	0.0089
CAGR (%)	5.55	6.82	3.77

Source: Author's Calculations based on data extracted from Annual Reports of Companies
(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

Consumer Goods Sector

In this section year wise disclosures related to Relational Capital, Structural Capital and Human Capital pertaining to consumer goods sector have been presented. Results of trend analysis of various disclosure categories have also been presented.

Table 5: Average Qualitative Disclosures for Consumer Sector

Year	Relational Capital Disclosures	Structural Capital Disclosures	Human Capital Disclosures
2004-05	33.71	11.47	7.92
2005-06	38.33	14.88	9.98
2006-07	53.25	16.15	9.98
2007-08	47.88	16.68	10.83
2008-09	47.47	17.85	10.98
2009-10	50.60	16.48	10.85
2010-11	50.85	15.70	11.55
2011-12	66.68	16.13	13.33
2012-13	61.53	18.58	14.67
2013-14	60.71	18.03	14.83
Trend Equation	**3.582+0.060T**	**2.598+0.032T**	**2.093+0.060T**
R^2	0.76	0.52	0.91
t-value	4.99	2.94	8.93
p-value	0.0011	0.0188	0.0001
CAGR(%)	6.18	3.25	6.18

Source: Author's Calculations based on data extracted from Annual Reports of Companies
(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

A glance on Table 5 reveals that Relational Capital related disclosures increased from 33.71 in 2004-2005 to 60.71 in 2013-2014. Results of trend analysis indicate that there was a positive and significant trend in the case of Relational Capital related disclosures for consumer goods sector. A compound annual growth rate of 6.18 percent was observed for Relational Capital disclosures in consumer goods sector. It can also be seen from table 5 that average number of Structural Capital related disclosures were 11.47 in year 2004-2005 and this number increased to 18.03 in 2013-2014. Trend equation of Structural Capital disclosures indicates that there was a significant positive trend during the period of study. Compound annual growth rate for Structural Capital disclosures was found to be 3.25 during this period. Further, it can be seen from table that Human Capital related disclosures stood at 7.92 in year 2004-2005 and increased to 14.83 in year 2013-2014. Linear trend equation for indicates that there was a significant positive trend for Human Capital disclosures. It can also be seen from table that compound annual growth rate of 6.18 percent was observed for Human Capital disclosures in case of consumer goods sector.

Energy sector

In this section year wise disclosures related to Relational Capital, Structural Capital and Human Capital pertaining to energy sector have been presented. Results of trend analysis of various disclosure categories have also been provided.

It can be seen from table 6 that Relational Capital related disclosures increased from 32.55 in 2004-2005 to 54.30 in year 2013-14. Results of trend analysis indicate that there was a positive and significant trend in the case of Relational Capital related disclosures for basic energy sector.

Table 6: Average Qualitative Disclosures for Energy Sector

Year	**Relational Capital Disclosures**	**Structural Capital Disclosures**	**Human Capital Disclosures**
2004-05	32.55	11.30	15.74
2005-06	40.47	10.08	16.08
2006-07	36.26	12.41	14.32
2007-08	51.26	15.70	20.46
2008-09	40.19	12.24	18.54
2009-10	46.69	13.49	18.97
2010-11	50.19	15.95	21.30
2011-12	44.89	12.81	20.11
2012-13	46.32	14.22	21.00
2013-14	54.30	15.31	26.41
Trend Equation	**3.556+0.041T**	**2.400+0.033T**	**2.667+0.051T**
R^2	0.58	0.45	0.75
t-value	3.33	2.54	4.86
p-value	0.0104	0.0346	0.0013
CAGR (%)	4.18	3.36	5.23

Source: Author's Calculations based on data extracted from Annual Reports of Companies

(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

A compound annual growth rate of 4.18 percent was observed for Relational Capital disclosures. It can also be seen from table 6 that average number of Structural Capital related disclosures were 11.30 in year 2004-2005 and this number increased to 15.31 in 2013-14. Trend equation of Structural Capital disclosures indicates that there was a significant positive trend during the period of study. Compound annual growth rate for Structural Capital disclosures was estimated to be 3.36 during this period. Further, it can be seen from table that Human Capital related disclosures stood 15.74 in year 2004-2005 and increased to 26.41 in 2013-2014. Linear trend equation for Human Capital disclosures indicates that there was a positive and significant trend as trend coefficient for Human Capital disclosures was significantly different from zero. Compound annual growth rate of 5.23 percent was estimated for Human Capital disclosures in the case of energy sector.

Industrial Manufacturing

In this section year wise disclosures related to Relational Capital, Structural Capital and Human Capital pertaining to industrial manufacturing sector have been presented. Results of trend analysis of various intangible disclosure categories have also been presented.

Table 7 : Average Qualitative Disclosures for Industrial Manufacturing Sector

Year	Relational Capital Disclosures	Structural Capital Disclosures	Human Capital Disclosures
2004-05	16.39	13.45	9.07
2005-06	14.65	11.91	9.23
2006-07	14.86	13.32	9.81
2007-08	21.21	13.66	10.84
2008-09	22.22	13.81	11.22
2009-10	25.80	17.45	12.35
2010-11	20.87	17.30	12.66
2011-12	25.60	16.77	13.70
2012-13	28.23	17.23	14.15
2013-14	26.15	16.02	13.36
Trend Equation	**2.660+0.070T**	**2.497+0.038T**	**2.152+0.053T**
R^2	0.77	0.68	0.94
t-value	5.17	4.14	11.21
p-value	0.0008	0.0033	0.0001
CAGR (%)	7.25	3.87	5.44

Source: Author's Calculations based on data extracted from Annual Reports of Companies

(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

A glance on Table 7 reveals that Relational Capital related disclosures increased from 16.39 in 2004-2005 to 26.15 in 2013-2014. Results of trend analysis indicate that there was a positive and significant trend in case of Relational Capital related disclosures for industrial manufacturing sector. A compound annual growth rate of 7.25 percent was observed for Relational Capital disclosures in industrial manufacturing sector. It can also be seen from table 7 that average number of Structural Capital related disclosures were 13.45 in year 2004-2005 and this number increased to 16.02 in 2013-2014. Trend equation of Structural Capital disclosures indicates that there was a significant positive trend during the period of study. Compound annual growth rate for Structural Capital disclosures was estimated to be 3.87 during this period. Further, it can be seen from table 7 that Human Capital related disclosures stood at 9.07 in year 2004-2005 and increased to 14.15 in 2012-2013, after that it decreased to 13.36 in year 2013-2014. Linear trend equation for Human Capital disclosures indicates that there was positive and significant trend as trend coefficient for Human Capital disclosures was significantly different from zero. It can also be seen from table that compound annual growth rate of 5.44 percent was observed for Human Capital disclosures in case of industrial manufacturing sector.

Metal Sector

In this section year wise disclosures related Relational Capital, Structural Capital and Human Capital pertaining to metal sector have been presented. Results of trend analysis of various intangible disclosure categories have also been provided. It can be seen from table 8 that Relational Capital related disclosures increased from 13.44 in 2004-2005 to 30.00 in year 2009-2010. Then it dipped to 26.89 in 2010-11 before increasing to 35.67 in 2013-2014. Results of trend analysis indicate that there was a positive and significant trend in case of Relational Capital related disclosures for metal sector. A compound annual growth rate of 10.74 percent was observed for Relational Capital disclosures in basic metals sector. It can also be seen from table 8 that average number of Structural Capital related disclosures were 8.36 in year 2004-2005 and this number reached to a high of 16.64 in 2013-2014. Trend equation of Structural Capital disclosures indicates that there was a significant positive trend during the period of study. Compound annual growth rate for Structural Capital disclosures was estimated to be 8.98 during this period.

Table 8: Average Qualitative Disclosures for Metals Sector

Year	Relational Capital Disclosures	Structural Capital Disclosures	Human Capital Disclosures
2004-05	13.44	8.36	11.68
2005-06	14.92	7.93	12.52
2006-07	17.76	7.82	13.24
2007-08	22.72	10.00	17.92
2008-09	24.36	9.86	15.48
2009-10	30.00	12.39	17.58
2010-11	26.89	12.54	17.78
2011-12	27.00	12.75	21.56
2012-13	31.74	15.32	26.07
2013-14	35.67	16.64	23.81
Trend Equation	**2.589+0.102T**	**1.925+0.086T**	**2.374+0.085T**
R^2	0.90	0.93	0.91
t-value	8.41	10.20	8.81
p-value	0.0001	0.0001	0.0001
CAGR (%)	10.74	8.98	8.87

Source: Author's Calculations based on data extracted from Annual Reports of Companies
(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

Further, it can be seen from table 8 that Human Capital related disclosures stood at 11.68 in year 2004-2005 and increased to 23.81 in 2013-14. Linear trend equation for Human Capital disclosures indicates that there was a positive and significant trend as trend coefficient for Human Capital disclosures was significantly different from zero. Compound annual growth rate of 8.87 percent was estimated for Human Capital disclosures in case of metal sector.

Pharmaceutical Sector

In this section year wise disclosures related to Relational Capital, Structural Capital and Human Capital pertaining to pharmaceutical sector have been presented. Results of trend analysis of various intangible disclosure categories have also been provided. It can be seen from table 9 that Relational Capital related disclosures decreased from 42.97 in 2004-2005 to 41.97 in 2013-2014. Results of trend analysis indicate that there was neither a positive nor a negative trend as trend coefficient for Relational Capital disclosures was not significantly different from zero. It can also be seen from table 6 that average number of Structural Capital related disclosures were 64.75 in year 2004-2005 and this number dipped to 57.13 in 2013-14. Trend equation of Structural Capital disclosures indicates that there was a significant negative trend during the period of study.

Table 9: Average Qualitative Disclosures for Pharmaceutical Sector

Year	Relational Capital Disclosures	Structural Capital Disclosures	Human Capital Disclosures
2004-05	42.97	64.75	19.97
2005-06	47.31	60.00	17.16
2006-07	49.41	58.63	18.97
2007-08	40.25	54.56	19.13
2008-09	45.34	56.63	21.34
2009-10	44.19	53.28	18.78
2010-11	43.56	49.34	20.25
2011-12	42.78	53.25	25.88
2012-13	34.59	46.56	21.59
2013-14	41.97	57.13	25.19
Trend Equation	3.860-0.017T	**4.136-0.023T**	**2.852+0.032T**
R^2	0.30,	0.52	0.56
t-value	-1.87	-2.93	3.20
p-value	0.0983	0.0189	0.0126
CAGR (%)	-	-2.33	3.25

Source: Author's Calculations based on data extracted from Annual Reports of Companies
(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

Compound annual growth rate for Structural Capital disclosures was estimated to be -2.33 percent during this period. Further, it can be seen from table 9 that Human Capital related disclosures stood at 19.97 in year 2004-2005 and increased to 25.91 in 2013-2014. Linear trend equation for Human Capital disclosures indicates that there was significant positive trend as trend coefficient for Human Capital disclosures was not significantly different from zero. It can also be seen from table that compound annual growth rate of 3.25 percent was observed for Human Capital disclosures in the case of pharmaceutical sector.

Textile Sector

In this section year wise disclosures related to Relational Capital, Structural Capital and Human Capital pertaining to pharmaceutical sector have been presented. Results of trend analysis of various intangible disclosure categories have also been provided.

Table 10: Average Qualitative Disclosures for Textile Sector

Year	**Relational Capital Disclosures**	**Structural Capital Disclosures**	**Human Capital Disclosures**
2004-05	18.46	8.19	8.77
2005-06	27.07	8.44	8.71
2006-07	45.87	11.63	11.13
2007-08	32.67	9.06	8.20
2008-09	37.00	11.13	10.73
2009-10	34.31	11.94	8.75
2010-11	54.88	11.00	11.63
2011-12	41.56	15.19	19.38
2012-13	48.19	11.63	10.25
2013-14	46.00	7.81	7.88
Trend Equation	**3.170+0.080T**	2.214+0.023T	2.194+0.023T
R^2	0.57	0.11	0.07
t-value	3.25	1.00	0.77
p-value	0.0118	0.3471	0.4622
CAGR (%)	8.33	-	-

Source: Author's Calculations based on data extracted from Annual Reports of Companies
(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

It can be seen from table 10 that Relational Capital related disclosures increased from 18.46 in 2004-2005 to 46.00 in 2013-2014. Results of trend analysis indicate that there was significant positive trend. Compound annual growth rate of 8.33 percent was estimated for

Relational Capital disclosures in the case of textile sector. It can also be seen from table 7 that average number of Structural Capital related disclosures were 8.19 in year 2004-2005 and this number increased to 15.19 in 2011-12 before decreasing to a low of 7.81 in 2013-14. Trend equation of Structural Capital disclosures indicates that there was a positive and non significant trend during the period of study as trend coefficient for disclosures was not significantly different from zero. Further, it can be seen from table 10 that Human Capital related disclosures stood at 8.77 in year 2004-2005 and increased to 19.38 in 2012-2013 before decreasing to 7.88 in 2013-14. Linear trend equation for Human Capital disclosures indicates that there was a positive and non significant trend as trend coefficient for Structural Capital disclosures was not significantly different from zero.

By introducing the dummies for various sectors coupled with their interaction effects with the trend variable in the original trend equations, the regression equation was estimated by pooling the data for all the sectors for the three types of Intellectual Capital disclosures. This methodology was used for testing the difference between the regression coefficients for different groups for the given component of Intellectual Capital. In this methodology, significant *F*-statistics indicate that there is a significant difference in the regression coefficients (trend coefficients) of various sectors. Significant *F*-statistics were found for disclosures of all the three types of Intellectual Capital, *i.e.*, Relational Capital ($F=41.43$, $p<0.0001$), Structural Capital ($F=124.65$, $p<0.0001$), and Human Capital ($F= 30.05$, $p<0.0001$).

3.1.1.2 Category Wise Disclosures

Category wise Relational Capital, Human Capital, and Structural Capital disclosures across various sectors have been discussed below. Analysis of Variance (ANOVA) was used to find the differences across the sectors for different categories of disclosures. Results of Analysis of Variance (ANOVA) have been presented in the following text.

Relational Capital Disclosures

In this section result of Analysis of Variance (ANOVA) for Relational Capital disclosures have been discussed. Analysis of Variance (ANOVA) was used to find the variation across different sectors in case of Relational Capital disclosures. The results have been presented in Table 11.

It can be seen from table 11 that the mean value of Relational Capital disclosures was highest for consumer sector i.e. 51.10 followed by energy and pharmaceutical sector with mean values of 44.31 and 43.24 respectively. The mean value of Relational Capital disclosures was least for industrial manufacturing i.e. 21.60. It can be said that consumer sector was disclosing highest information about Relational Capital. The calculated F-value came out to be 19.94, with p-value less than 0.0001 which indicates that there was significant variation across different sectors for disclosing Relational Capital disclosures.

Table 11: Comparison for Relational Capital Disclosures across sectors

Sectors	Mean	Std Dev	F-value (p-value)
Consumer	51.10[a]	6.38	19.94(<.0001*)
Energy	44.31[ab]	6.89	
Pharmaceutical	43.24 [b]	4.02	
Textile	38.60[bc]	10.89	
Automobile	34.95[c]	6.38	
Metals	24.45[d]	7.32	
Industrial Manufacturing	21.60[d]	4.95	

(Levels not connected by same letter are significantly different)

Structural Capital Disclosures

In this section, results of Analysis of Variance (ANOVA) for Structural Capital disclosures have been discussed. Analysis of Variance (ANOVA) was used to find variation across different sectors in case of Structural Capital Disclosures. The results have been presented in Table 12.

Table 12: Comparison for Structural Capital Disclosures across sectors

Sectors	Mean	Std Dev	F-value (p-value)
Pharmaceutical	55.41^{a}	5.25	267.56 (<.0001*)
Auto	16.67^{b}	3.41	
Consumer	16.20^{b}	2.01	
Industrial Manufacturing	15.09^{bc}	2.06	
Energy	13.35^{cd}	1.95	
Metals	11.36^{de}	3.08	
Textile	10.60^{e}	2.26	

(Levels not connected by same letter are significantly different)

It can be seen from table 12 that the mean value of Structural Capital disclosures was highest for pharmaceutical sector i.e. 55.41 followed by automobile and consumer goods sector with mean values of 16.67 and 16.20 respectively. The mean value of Structural Capital disclosures was least for textile sector i.e. 10.60. It can be concluded that pharmaceutical sector was disclosing highest information about Structural Capital. The *F*-value was estimated to be 267.56, with p-value less than 0.0001 which indicates that there was significant variation across different sectors in case of Structural Capital Disclosures across the sectors.

Human Capital Disclosures

In this section, results of Analysis of Variance (ANOVA) for Human Capital disclosures have been discussed. Analysis of Variance (ANOVA) was used to find variation across different sectors in the case of disclosing Human Capital information. The results have been presented in Table 13.

Table 13: Comparison for Human Capital Disclosures across sectors

Sectors	Mean	Std Dev	F-value (p-value)
Pharmaceutical	20.83^{a}	2.79	18.31 (<.0001*)
Energy	19.29^{ab}	3.46	
Metals	17.76^{b}	4.83	
Automobile	13.77^{c}	2.02	
Industrial Manufacturing	11.64^{cd}	1.87	
Consumer	11.49^{cd}	2.19	
Textile	10.54^{d}	3.37	

(Levels not connected by same letter are significantly different)

It can be seen from table 13 that the mean value of Human Capital disclosures was highest for pharmaceutical sector i.e. 20.83 followed by energy and metal sectors with mean values of 19.29 and 17.76 respectively. The mean value of Human Capital disclosures was least for textile sector i.e. 10.54. It can be stated that pharmaceutical sector was disclosing highest information about Human Capital. The calculated *F*-value came out to be 18.31, with p-value less than 0.0001 which indicates that there was a significant variation across different sectors in case of Human Capital disclosures.

3.1.2 R&D Activities across various sectors

In this section the sector wise results related to R&D activities have been presented. Extent of R&D activities has been measured quantitatively using R&D Expenditure and R&D Intensity. Further, the results of trend analysis on basis of these two variables have also been presented.

Automobile Sector

In this section year wise results pertaining to R&D expenditure and R&D intensity pertaining to automobile sector have been presented.

Table 14: Average R&D Expenditure and Intensity of Automobile sector

Year	R&D Expenditure (Rs. Million)	R&D Intensity (%)
2004-05	224.53	0.52
2005-06	251.71	0.49
2006-07	308.73	0.44
2007-08	347.46	0.55
2008-09	352.00	0.61
2009-10	389.78	0.57
2010-11	896.51	0.66
2011-12	1149.22	0.63
2012-13	1635.80	1.10
2013-14	1562.35	0.82
Trend Equation	**4.959+0.243T**	**-0.884+0.073T**
R^2	0.91	0.70
t-value	9.14	4.28
p-value	0.0001	0.0027
CAGR (%)	27.51	7.57

Source: Author's Calculations based on data extracted from CMIE-Prowess and Annual Reports of Companies

It can be seen from table 12 that R&D expenditure of automobile sector increased from Rs. 224.53 million in 2004-2005 to Rs. 1635.80 million in 2012-2013. Then it decreased to Rs. 1562.35 million in 2013-14. Results of trend analysis indicate that there is a significant positive trend of R&D Expenditure for automobile sector. Compound annual growth rate of 27.51 percent has been observed for R&D expenditure in automobile sector. Also, R&D intensity increased from 0.52 percent in 2004-05 to 1.10 percent in 2012-13. But, it decreased to 0.82 percent in 2013-14. A significant positive trend has been observed for R&D Intensity in case of Automobile sector and compound annual growth rate of 7.57 percent has been estimated.

Consumer Goods Sector

In this section year wise measurement of R&D expenditure and R&D intensity pertaining to consumer goods sector have been presented.

Table 15: Average R&D Expenditure and Intensity of Consumer Goods Sector

Year	**R&D Expenditure (Rs. Million)**	**R&D Intensity (%)**
2004-05	35.01	0.27
2005-06	41.19	0.27
2006-07	39.79	0.23
2007-08	53.79	0.37
2008-09	75.58	0.49
2009-10	92.62	0.58
2010-11	117.56	0.53
2011-12	136.75	0.45
2012-13	132.80	0.34
2013-14	144.17	0.51
Trend Equation	**3.346+0.180T**	**-1.344+0.071T**
R^2	0.95	0.44
t-value	12.12	2.50
p-value	0.0001	0.0371
CAGR (%)	19.72	7.36

Source: Author's Calculations based on data extracted from CMIE-Prowess and Annual Reports of Companies (Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

Table 15 reveals that R&D expenditure of consumer goods sector increased from Rs. 35.01 million in 2004-2005 to Rs. 144.17 million in 2013-2014. Trend equation of R&D expenditure indicates that there is a significant positive trend during the period of study.

Compound annual growth rate is found to be 19.72 percent during this period. It can be seen from table that R&D intensity increased from 0.27 percent in 2004-05 to 0.51 percent in 2013-14. A significant positive trend has been observed for R&D Intensity and compound annual growth rate of 7.36 percent has been estimated for consumer goods sector.

Energy

In this section year wise results related to R&D expenditure and R&D intensity pertaining to energy sector have been presented. It can be seen from table 16 that R&D expenditure of energy sector increased from Rs. 168.93 million in 2004-2005 to Rs. 600.69 million in 2013-2014. Results of trend analysis indicate that there is a significant positive trend for energy sector. Compound annual growth rate of 17.35 percent is observed for R&D expenditure in energy sector. Also, R&D intensity increased marginally from 0.11 percent in 2004-05 to 0.12 percent in 2013-14. Positive but non-significant trend has been observed for R&D Intensity in case of Energy sector.

Table 16: Average R&D Expenditure and Intensity of Energy Sector

Year	R&D Expenditure (Rs. Million)	R&D Intensity (%)
2004-05	168.93	0.11
2005-06	176.02	0.09
2006-07	203.67	0.08
2007-08	245.53	0.08
2008-09	293.91	0.08
2009-10	323.74	0.08
2010-11	494.42	0.09
2011-12	428.89	0.09
2012-13	600.69	0.10
2013-14	627.70	0.12
Trend Equation	**4.891+0.160T**	-2.494+0.019T
R^2	0.97	0.18
t-value	15.22	1.33
p-value	0.0001	0.2210
CAGR (%)	17.35	-

Source: Author's Calculations based on data extracted from CMIE-Prowess and Annual Reports of Companies (Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

Industrial Manufacturing Sector

In this section year wise measurements of R&D expenditure and R&D intensity pertaining to industrial manufacturing sector have been presented.

Table 17: Average R&D Expenditure and Intensity of Industrial Manufacturing Sector

Year	R&D Expenditure (Rs. Million)	R&D Intensity (%)
2004-05	116.31	0.59
2005-06	93.85	0.44
2006-07	140.84	0.45
2007-08	263.17	0.47
2008-09	375.79	0.58
2009-10	474.48	0.83
2010-11	550.24	0.80
2011-12	678.77	0.89
2012-13	720.10	1.06
2013-14	624.55	1.06
Trend Equation	**4.452+0.241T**	**-0.953+0.103T**
R^2	0.89	0.80
t-value	7.92	5.63
p-value	0.0001	0.0005
CAGR (%)	27.20	10.84

Source: Author's Calculations based on data extracted from CMIE-Prowess and Annual Reports of Companies (Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

It can be seen from table 17 that R&D expenditure of industrial manufacturing sector increased from Rs. 116.31 in 2004-2005 to Rs. 720.10 in 2012-2013. Then it decreased to Rs. 624.55 million in 2013-14. Results of trend analysis indicate that there is a significant positive trend of R&D expenditure for industrial manufacturing sector. A compound annual growth rate of 27.2 percent is observed for R&D expenditure in industrial manufacturing sector. Also, R&D intensity increased from 0.59 percent in 2004-05 to 1.06 percent in 2013-14. A significant positive trend has been observed for R&D Intensity and compound annual growth rate of 10.84 percent has been estimated.

Metals

In this section year wise values of average R&D expenditure and R&D intensity pertaining to metals sector have been presented.

Table 18: Average R&D Expenditure and Intensity of Metals Sector

Year	R&D Expenditure (Rs. Million)	R&D Intensity (%)
2004-05	113.64	0.10
2005-06	103.81	0.08
2006-07	134.80	0.14
2007-08	140.92	0.07
2008-09	165.40	0.08
2009-10	153.69	0.07
2010-11	201.12	0.07
2011-12	193.95	0.09
2012-13	201.41	0.08
2013-14	197.33	0.10
Trend Equation	**4.639+0.075T**	-2.359-0.016T
R^2	0.88	0.05
t-value	7.49	-0.67
p-value	0.0001	0.5195
CAGR (%)	7.79	-

Source: Author's Calculations based on data extracted from CMIE-Prowess and Annual Reports of Companies (Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

It can be seen from table 18 that R&D expenditure of metals sector stood at Rs. 113.64 million in year 2004-2005 and increased to Rs. 197.33 million in 2013-2014. Trend equation R&D expenditure yielded a significant positive trend during the period of study as trend coefficient is significantly different from zero. Compound annual growth rate of 7.79 percent is estimated for R&D expenditure in the case of metals sector. Further, R&D intensity of metals sector did not show any increase from 2004-05 to 2013-14. Results of trend analysis indicate that there is neither a positive nor a negative trend as trend coefficient is not significantly different from zero.

Pharmaceutical Sector

In this section year wise measurement of average R&D expenditure and R&D intensity pertaining to pharmaceutical sector have been presented. It can be seen from table 19 that average R&D expenditure of pharmaceutical sector increased from Rs. 435.48 million in 2004-2005 to Rs. 1881.68 million in 2013-2014. Trend equation of R&D expenditure indicates that there is a significant positive trend during the period of study.

Table 19: Average R&D Expenditure and Intensity of Pharmaceutical Sector

Year	R&D Expenditure (Rs. Million)	R&D Intensity (%)
2004-05	435.48	3.49
2005-06	576.09	3.95
2006-07	653.23	3.93
2007-08	685.97	3.48
2008-09	780.95	8.07
2009-10	884.75	9.04
2010-11	1014.15	7.37
2011-12	1195.00	15.06
2012-13	1443.81	8.47
2013-14	1881.68	7.52
Trend Equation	**5.974+0.145T**	**1.128+0.129T**
R^2	0.98	0.62
t-value	18.31	3.59
p-value	0.0001	0.0071
CAGR (%)	15.60	13.77

Source: Author's Calculations based on data extracted from CMIE-Prowess and Annual Reports of Companies (Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

Compound annual growth rate is found to be 15.60 percent during this period. Further, it can be seen from table that R&D intensity increased from 3.49 percent in 2004-05 to 7.52 percent in 2013-14. A significant positive trend has been observed for R&D Intensity and compound annual growth rate of 13.77 percent has been estimated for this sector.

Textile

In this section year wise values of average R&D expenditure and R&D intensity pertaining to textile sector have been presented. It can be seen from table 20 that average R&D expenditure of textile sector stood at Rs. 7.61 million in year 2004-2005 and increased to Rs. 106.22 million in 2013-2014. Trend equation for R&D expenditure indicates that there is a significant positive trend during the period of study as trend coefficient is significantly different from zero. Compound annual growth rate of 33.91 percent has been estimated for R&D expenditure in the case of textiles sector.

Table 20 : Average R&D Expenditure and Intensity of Textile Sector

Year	R&D Expenditure (Rs. Million)	R&D Intensity (%)
2004-05	7.61	0.20
2005-06	8.13	0.20
2006-07	14.18	0.27
2007-08	29.60	0.33
2008-09	31.82	0.29
2009-10	35.88	0.26
2010-11	46.90	0.24
2011-12	51.18	0.20
2012-13	86.92	0.32
2013-14	106.22	0.34
Trend Equation	**1.805+0.292T**	-1.541+0.035T
R^2	0.95	0.25
t-value	12.72	1.65
p-value	0.0001	0.1383
CAGR (%)	33.91	-

Source: Author's Calculations based on data extracted from CMIE-Prowess and Annual Reports of Companies
(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

Further, R&D intensity of textiles sector increased from 0.20 percent in 2004-05 to 0.34 percent in 2013-14. Positive but non-significant trend has been observed for R&D Intensity in textiles sector.

Comparison of Average R&D Expenditure across sectors

In this section result of Analysis of Variance (ANOVA) for R&D expenditure across the sectors have been discussed.

Table 21: Variation of R&D Expenditure (Rs. Million) across Sectors

Sector	Mean	Std Dev	F-value (p-value)
Automobile	711.809[ab]	555.79	13.477(<0.0001)
Consumer	86.926[c]	43.55	
Energy	356.349[bc]	171.86	
Industrial Manufacturing	403.810[bc]	240.19	
Metal	160.606[c]	37.00	
Pharmaceutical	955.110[a]	443.58	
Textile	41. 845 [c]	32.74	

Levels not connected by same letter are significantly different

Results of ANOVA have been presented in Table 21. It can be seen from Table 21 that the mean value of R&D expenditure is highest for pharmaceutical sector i.e. Rs. 955.110 million followed by automobile and industrial manufacturing sector with mean values of Rs. 711.809 million and Rs. 403.810 million respectively. The mean value of R&D expenditure was least for textile i.e. Rs. 41.845 million. The calculated *F*-value came out to be 13.477, with p-value less than 0.0001 which indicates that there is significant variation across different sectors for R&D expenditure.

Comparison of R&D Intensity across Sectors

In this section, the results of Analysis of Variance (ANOVA) for R&D Intensity has been discussed. Analysis of Variance (ANOVA) was used to find the variation across different sectors in terms of R&D intensity. The results have been presented in Table 32.

Table 22: Variation of R&D Intensity (%) across Sectors

Sector	Mean	Std Dev	F-value (p-value)
Automobile	0.639[b]	0.192	34.47(<0.0001)
Consumer	0.405[b]	0.123	
Energy	0.089[b]	0.013	
Industrial Manufacturing	0.716[b]	0.243	
Metal	0.088[b]	0.020	
Pharmaceutical	7.038[a]	3.593	
Textile	0.265[b]	0.054	

Sectors not connected by same letter are significantly different

It can be seen from Table 22 that the mean value of R&D intensity is highest for pharmaceutical sector i.e. 7.038 percent followed by industrial manufacturing and automobile sector with mean values of 0.716 percent and 0.639 percent respectively. The mean value of R&D intensity is least for metals sector i.e. 0.088. The calculated *F*-value came out to be 17.664, with p-value less than 0.0001 which indicates that there is significant variation across different sectors in terms of R&D Intensity.

3.1.3 R&D Output across various sectors

In this section the sector wise results related to R&D output have been presented. R&D output has been measured on basis of patent applications, patents granted, backward citations, forward citations, and total citations. Further, the results of trend analysis related to various measures of R&D output have also been presented.

Automobile sector

In this section year wise values related to patent applications, patents granted, backward citations, forward citations and total citations pertaining to automobile sector have been presented.

Table 23: Patent Output of Automobile Sector

Year	Patent Applications	Patents Granted	Backward Citations	Forward Citations	Total Citations
2004-05	0.37	0.13	0.10	0.13	0.23
2005-06	1.20	0.16	0.00	0.00	0.00
2006-07	1.17	0.39	0.65	0.06	0.71
2007-08	3.97	0.87	0.58	0.26	0.84
2008-09	4.90	1.23	0.10	0.81	0.90
2009-10	2.77	0.81	0.13	1.71	1.84
2010-11	6.50	0.42	0.00	0.81	0.81
2011-12	5.43	0.74	0.26	2.00	2.26
2012-13	10.63	0.71	0.52	1.35	1.87
2013-14	13.57	1.48	0.55	1.48	2.03
Trend Equation	**-0.694+0.342T**	**-1.708+0.200T**	-6.682+0.399T	-8.119+1.057T	-6.347+0.869T
R^2	0.86	0.56	0.03	0.31	0.26
t-value	6.94	3.16	0.51	1.88	1.68
p-value	0.0001	0.0134	0.6231	0.0969	0.1321
CAGR (%)	40.77	22.14	-	-	-

Source: Author's Calculations based on data extracted from Patent Databases
(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

It can be seen from table 23 that average number of patent applications increased from 0.37 in 2004-2005 to 13.57 in year 2013-14. Results of trend analysis indicate that there is a positive and significant trend in the case of patent applications for automobile sector. Compound annual growth rate of 40.77 percent is observed for average number of patent applications. It can also be seen from table 23 that average number of patents granted are 0.13 in year 2004-05 and this number increased to 1.48 in 2013-14. Trend equation of patents granted indicates that there is a significant positive trend during the period of study. Compound annual growth rate for patents granted is estimated to be 22.14 percent during this period. Further, it can be seen from the table that average number of backward citations stood at 0.10 in year 2004-05 and increased to 0.55 in 2013-2014. Linear trend equation for backward citations indicates that there is a positive and non significant trend. Further, average number of forward citations is 0.13 in year 2004-05 and the same increased to 1.48 in 2013-2014. Linear trend equation for forward citations indicates that there is a positive but non-significant trend. Average number of total citations is 0.23 in 2004-05 which increased to 2.03 in 2013-14. Result of trend analysis indicates that there is a positive but non-significant trend for total citations in Automobile sector.

Consumer Goods Sector

In this section year wise results related to patent applications, patents granted, backward citations, forward citations and total citations pertaining to consumer goods sector have been presented. It can be seen from table 24 that average number of patent applications increased from 0.90 in 2004-05 to 2.41 in year 2013-14. Trend equation of patent applications indicates that there is a positive and non significant trend during the period of study as trend coefficient is not significantly different from zero. It can also be seen from table 24 that average number of patents granted were 0.27 in year 2004-05 and this number decreased to 0.20 in 2013-14. Trend equation of patents granted indicates that there is a non-significant trend during the period of study. Further, it can be seen from table that average number of backward citations stood at 0.29 in year 2004-05 and increased to 5.08 in 2013-2014. Linear trend equation for backward citations indicates that there is a non significant trend. Also, average number of forward citations is 0.19 in year 2004-05 and increased to 0.58 in 2013-2014.

Table 24: Patent Output of Consumer Goods Sector

Year	Patent Applications	Patents Granted	Backward Citations	Forward Citations	Total Citations
2004-05	0.90	0.27	0.29	0.19	0.47
2005-06	2.93	0.12	0.00	0.00	0.00
2006-07	1.83	0.92	0.10	4.12	4.22
2007-08	2.98	3.39	0.19	17.22	17.41
2008-09	3.10	3.71	0.00	18.66	18.66
2009-10	2.69	3.86	9.00	18.49	27.49
2010-11	2.83	2.86	15.88	12.69	28.58
2011-12	3.95	4.78	48.97	45.95	94.92
2012-13	2.66	3.44	18.47	11.97	30.44
2013-14	2.41	0.20	5.08	0.58	5.66
Trend Equation	0.513+0.071T	-0.697+0.174T	-10.099+1.357T	-5.757+1.016T	-5.978+1.1167T
R2	0.28	1.13	0.26	0.21	0.27
t-value	1.77	0.14	1.69	1.48	1.73
p-value	0.1139	0.2910	0.1297	0.1775	0.1226
CAGR (%)	-	-	-	-	-

Source: Author's Calculations based on data extracted from Patent Databases
(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

Linear trend equation for forward citations indicates that there is a positive and non significant trend. Average number of total citations is 0.47 in 2004-05 which increased to 5.66 in 2013-14. Result of trend analysis indicates that there is a positive and non-significant trend.

Energy Sector

In this section year wise values related to patent applications, patents granted, backward citations, forward citations and total citations pertaining to energy sector have been presented. Table 25 reveals that average number of patent applications increased from 0.18 in 2004-05 to 1.30 in year 2013-14. Result of trend equation of patent applications indicate that there is a positive and significant trend during the period of study. Compound annual growth rate of 16.07 percent is observed for average number of patent applications. It can also be seen from table 25 that average number of patents granted are 0.35 in year 2004-05 and this number increased to 0.53 in 2013-14.

Table 25: Patent Output of Energy Sector

Year	Patent Applications	Patents Granted	Backward Citations	Forward Citations	Total Citations
2004-05	0.18	0.35	0.71	0.09	0.79
2005-06	0.58	0.24	0.82	0.56	1.38
2006-07	0.39	0.47	1.85	0.21	2.06
2007-08	0.55	0.15	0.44	0.00	0.44
2008-09	0.27	0.09	0.12	0.00	0.12
2009-10	0.73	0.21	0.97	0.00	0.97
2010-11	0.48	0.26	2.50	0.88	3.38
2011-12	0.52	0.12	0.24	0.32	0.56
2012-13	1.15	0.47	1.18	0.29	1.47
2013-14	1.30	0.53	1.74	0.71	2.44
Trend Equation	**-1.458+0.149T**	-1.542+0.025T	-0.526+0.0460T	-7.726+0.391T	-0.434+0.074T
R^2	0.57	0.02	0.02	0.03	0.05
t-value	3.26	0.35	0.41	0.46	0.66
p-value	0.0116	0.7334	0.6896	0.6548	0.5253
CAGR (%)	16.07	-	-	-	-

Source: Author's Calculations based on data extracted from Patent Databases
(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

Trend equation of patents granted indicates that there is a non significant positive trend during the period of study. Further, it can be seen from the table that average number of backward citations stood at 0.71 in year 2004-05 and increased to 1.74 in 2013-2014. Linear trend equation for backward citations indicates that there is a positive but non-significant trend as trend coefficient is not significantly different from zero. Also, average number of forward citations is 0.09 in year 2004-05 and increased to 0.71 in 2013-2014. Linear trend equation for forward citations indicates that there is a positive and non significant trend. Average number of total citations is 0.79 in 2004-05 which increased to 2.44 in 2013-14. Results of trend analysis indicate that there is a positive and non-significant trend for total citations in case of Energy sector.

Industrial Manufacturing sector

In this section year wise values related to patent applications, patents granted, backward citations, forward citations and total citations pertaining to industrial manufacturing sector have been presented.

Table26: Patent Output of Industrial Manufacturing Sector

Year	Patent Applications	Patents Granted	Backward Citations	Forward Citations	Total Citations
2004-05	0.21	0.15	0.02	0.00	0.02
2005-06	1.80	0.09	0.00	0.00	0.00
2006-07	1.67	0.09	0.34	0.00	0.34
2007-08	2.67	0.15	0.00	0.09	0.09
2008-09	3.48	0.17	0.04	0.06	0.11
2009-10	5.38	0.23	0.06	0.55	0.62
2010-11	4.24	0.45	0.36	0.45	0.81
2011-12	6.24	0.28	0.13	0.62	0.74
2012-13	7.67	0.47	0.13	0.98	1.11
2013-14	6.76	0.40	0.00	0.13	0.13
Trend Equation	**-0.585+0.301T**	**-2.586+0.184T**	-7.393+0.175T	**-16.570+1.967T**	-8.373+0.959T
R^2	0.74	0.77	0.01	0.68	0.28
t-value	4.73	5.19	0.22	4.15	1.75
p-value	0.0015	0.0008	0.829	0.0032	0.1190
CAGR (%)	35.12	20.20	-	614.91	-

Source: Author's Calculations based on data extracted from Patent Databases

(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

Table 26 reveals that average number of patent applications increased from 0.21 in 2004-05 to 6.76 in year 2013-14. Result of trend equation of patent applications indicates that there is a positive and significant trend during the period of study. Compound annual growth rate of 35.12 percent has been observed for average number of patent applications. It can also be seen from table 26 that average number of patents granted were 0.15 in year 2004-05 and this number increased to 0.40 in 2013-14. Trend equation of patents granted indicates that there is a significant positive trend over the period of study. Compound annual growth rate for patents granted is estimated to be 20.20 percent during this period. Further, it can be seen from table that average number of backward citations stood at 0.02 in year 2004-05 which diminished to zero in 2013-2014. Linear trend equation for backward citations indicates that there is a positive but non significant trend as trend coefficient is not significantly different from zero. Also, value of average number of forward citations is nil in 2004-05 which increased to 0.13 in 2013-2014. Linear trend equation for forward citations indicates that there is a significant positive trend. Compound annual growth rate of 614.91 percent is estimated for forward citations. Average number of total citations was 0.02 in 2004-05 which increased to 0.13 in 2013-14. Result of trend analysis indicates that there is a positive but non-significant trend for total citations in case of industrial manufacturing sector.

Metals Sector

In this section year wise values related to patent applications, patents granted, backward citations, forward citations and total citations pertaining to metals sector have been presented.

Table 27: Patent Output of Metals Sector

Year	Patent Applications	Patents Granted	Backward Citations	Forward Citations	Total Citations
2004-05	0.33	0.35	0.04	0.27	0.44
2005-06	1.92	0.12	0.00	0.00	0.00
2006-07	0.42	0.08	0.12	0.00	0.12
2007-08	2.71	0.04	0.12	0.00	0.12
2008-09	3.25	0.27	0.12	0.27	0.38
2009-10	5.13	0.35	0.12	0.19	0.31
2010-11	2.13	0.54	0.19	0.12	0.31
2011-12	0.71	0.81	0.54	1.27	1.81
2012-13	5.13	0.92	0.50	2.04	2.54
2013-14	3.54	0.69	0.31	1.42	1.73
Trend Equation	-0.438+0.185T	**-2.627+0.247T**	-7.746+0.824T	-14.960+1.664T	-7.952+0.995T
R^2	0.31	0.49	0.29	0.37	0.28
t-value	1.91	2.77	1.82	2.18	1.76
p-value	0.0932	0.0245	0.1056	0.0608	0.1168
CAGR (%)	-	28.02	-	-	-

Source: Author's Calculations based on data extracted from Patent Databases
(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

Table 27 reveals that average number of patent applications increased from 0.33 in 2004-05 to 3.54 in year 2013-14. Result of trend equation of patent applications indicates that there is a positive but non significant trend during the period of study. It can also be seen from table 27 that average number of patents granted are 0.35 in year 2004-05 and this number increased to 0.69 in 2013-14. Trend equation of patents granted indicates that there is a significant positive trend during the period of study. Compound annual growth rate for patents granted is estimated to be 28.02 percent during this period. Further, it can be seen from table 27 that average number of backward citations stood at 0.04 in year 2004-05 and increase to 0.31 in 2013-2014. Linear trend equation for backward citations indicates that there is a positive and non significant trend as trend coefficient is not significantly different from zero. Also, average number of forward citations is 0.27 in year 2004-05 and increased to 1.42 in 2013-2014. Linear trend equation for forward citations indicates that there is a positive and non significant trend. Average number of total citations is 0.44 in 2004-05 which increased to 1.73 in 2013-14. Result of trend analysis indicates that there is a positive and non-significant trend for total citations in case of metal sector.

Pharmaceutical Sector

In this section year wise values related to patent applications, patents granted, backward citations, forward citations and total citations pertaining to pharmaceutical sector.

Table 28: Patent Output of Pharmaceutical sector

Year	Patent Applications	Patents Granted	Backward Citations	Forward Citations	Total Citations
2004-05	5.28	5.03	11.77	8.94	20.71
2005-06	5.48	4.10	4.13	5.61	9.74
2006-07	7.03	4.84	10.00	5.45	15.45
2007-08	34.59	5.52	2.29	10.48	12.77
2008-09	21.62	6.26	6.42	7.97	14.39
2009-10	21.97	5.13	14.23	10.58	24.81
2010-11	12.24	5.97	15.65	10.87	26.52
2011-12	11.83	4.77	17.19	10.94	28.13
2012-13	12.07	5.87	17.00	10.06	27.06
2013-14	16.34	7.35	10.26	12.52	22.77
Trend Equation	2.022+0.092T	**1.493+0.036T**	1.631+0.109T	**1.834+0.067T**	**2.493+0.083T**
R^2	0.20	0.43	0.24	0.50	0.47
t-value	1.42	2.46	1.60	2.82	2.65
p-value	0.1939	0.0395	0.1484	0.0223	0.0294
CAGR (%)	-	3.67	-	6.93	8.65

Source: Author's Calculations based on data extracted from Patent Databases
(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

It can be seen from table 28 that average number of patent applications increased from 5.28 in 2004-05 to 16.34 in year 2013-14. Trend equation of patent applications indicates that there is a positive and non significant trend during the period of study as trend coefficient is not significantly different from zero. It can also be seen from table 28 that average number of patents granted were 5.03 in year 2004-05 and this number increased to 7.35 in 2013-14. Trend equation of patents granted indicates that there is a significant positive trend during the period of study. Compound annual growth rate for patents granted is estimated to be 3.67 percent during this period. Further, it can be seen from table 28 that average number of backward citations stood at 11.77 in year 2004-05 and decreased to 10.26 in 2013-2014. Linear trend equation for backward citations indicates that there is a positive and non significant trend. Also, average number of forward citations is 8.94 in year 2004-05 and increased to 12.52 in 2013-2014. Significant positive trend is observed in linear trend equation for forward citations. Compound annual growth rate of 6.93 percent is estimated for forward citations.

Average number of total citations is 20.71 in 2004-05 which increased to 22.77 in 2013-14. Result of trend analysis indicates that there is a positive and significant trend for total citations in case of Pharmaceutical sector and compound annual growth rate of 8.65 percent has been observed.

Textiles Sector

In this section year wise results related to patent applications, patents granted, backward citations, forward citations and total citations pertaining to textile sector have been presented. It can be seen from table 29 that in 2004-05, average number of patent applications is nil which increased to 0.47 in year 2013-14. Trend equation of patent applications indicates that there is a positive and significant trend during the period of the study. Compound annual growth rate of 253.95 percent has been observed for average number of patent applications. It can also be seen from table25 that average number of patents granted are 1.00 in year 2004-05 and this number decreased to 0.53 in 2013-14. Trend equation of patents granted indicates that there is a non-significant trend during the period of study. Further, it can be seen that average number of backward citations were nil in year 2004-05 and increased to 0.40 in 2013-

2014. Linear trend equation for backward citations indicates that there is a positive and significant trend. Compound annual growth rate of 238.72 percent is estimated for backward citations. Also, average number of forward citations is 2.27 in year 2004-05 and decreased to 0.80 in 2013-2014. Results of trend analysis indicate that there is neither a positive nor a negative trend as trend coefficient is not significantly different from zero.

Table 29: Patent Output of Textile Sector

Year	Patent Applications	Patents Granted	Backward Citations	Forward Citations	Total Citations
2004-05	0.00	1.00	0.00	2.27	2.27
2005-06	0.00	0.33	0.60	1.33	1.93
2006-07	0.20	0.67	0.00	1.00	1.00
2007-08	0.07	0.27	0.07	0.67	0.73
2008-09	0.40	0.87	1.73	1.13	2.87
2009-10	0.20	0.87	2.27	2.67	4.93
2010-11	0.33	0.60	1.27	1.73	3.00
2011-12	0.27	1.53	3.47	2.40	5.87
2012-13	0.20	1.13	0.67	0.47	1.13
2013-14	0.47	0.53	0.40	0.80	1.20
Trend Equation	**-10.877+1.264T**	-0.687+0.058T	**-9.640+1.220T**	0.512-0.052T	0.561+0.025T
R^2	0.53	0.10	0.40	0.07	0.01
t-value	3.02	0.96	2.31	-0.79	0.31
p-value	0.0165	0.3647	0.0498	0.4505	0.7632
CAGR (%)	253.95	-	238.72	-	-

Source: Author's Calculations based on data extracted from Patent Databases
(Trend equations in bold represent significant trend coefficients, Growth Rate has been calculated only for significant trend coefficients)

Average number of total citations is 2.27 in 2004-05 which decreased to 1.20 in 2013-14. Result of trend analysis indicates that there is a positive and non-significant trend for total citations in case of Textile sector.

Comparison of Patent Applications across Sectors

In this section, result of Analysis of Variance (ANOVA) for average number of patent applications has been discussed. Analysis of Variance (ANOVA) was used to find the variation across different sectors in case of patent applications. The results have been presented in Table 30. It can be seen from table 30 that the mean value of patent applications is highest for pharmaceutical sector i.e. 14.845 followed by automobile and industrial manufacturing sector with mean values of 5.050 and 4.011 respectively. The mean value of patent applications is least for textile i.e. 0.213. The calculated *F*-value came out to be 15.442, with p-value less than 0.0001 which indicates that there is significant variation across different sectors for patent applications.

Table 30: Patent Applications variation across Sectors

Sector	Mean	Std Dev	F-value (p-value)
Automobile	5.050^{b}	4.271	15.442(<0.0001)
Consumer	2.628^{b}	0.810	
Energy	0.615^{b}	0.359	
Industrial Manufacturing	4.011^{b}	2.465	
Metal	2.525^{b}	1.769	
Pharmaceutical	14.845^{a}	9.143	
Textile	0.213^{b}	0.159	

Sectors not connected by same letter are significantly different

Comparison of Patents Granted across Sectors

In this section, result of Analysis of Variance (ANOVA) for average number of patents granted has been discussed. Analysis of Variance (ANOVA) was used to find the variation across different sectors in case of patent applications. The results have been presented in Table 31. It can be seen from table 31 that the mean value of patents granted is highest for pharmaceutical sector i.e. 5.484 followed by consumer and textile sectors with mean values of 2.356 and 0.780 respectively. The mean value of patent applications is least for industrial manufacturing i.e. 0.247. The calculated *F*-value came out to be 56.895, with p-value less than 0.0001 which indicates that there is significant variation across different sectors for patents granted.

Table 31: Patents Granted variation across Sectors

Sector	Mean	Std Dev	F-value (p-value)
Automobile	0.694^{ab}	0.437	56.895(<0.0001)
Consumer	2.356^{b}	1.781	
Energy	0.288^{c}	0.159	
Industrial Manufacturing	0.247^{c}	0.146	
Metal	0.415^{c}	0.312	
Pharmaceutical	5.484^{a}	0.922	
Textile	0.780^{c}	0.384	

Sectors not connected by same letter are significantly different

Comparison of Backward Citations across Sectors

In this section, results of Analysis of Variance (ANOVA) for average number of backward citations have been discussed. Analysis of Variance (ANOVA) was used to find the variation across different sectors in case of backward citations. The results have been presented in Table 29.

It can be seen from Table 32 that the mean value of backward citations is highest for pharmaceutical sector i.e. 10.894 followed by consumer and energy sectors with mean values of 9.798 and 1.056 respectively. The mean value of backward citations is least for industrial manufacturing i.e. 0.109. The calculated F-value came out to be 6.052, with p-value less than 0.0001 which indicates that there is significant variation across different sectors for backward citations.

Table 32: Backward Citations variation across Sectors

Sector	Mean	Std Dev	F-value (p-value)
Automobile	0.287[b]	0.257	6.052(<0.0001)
Consumer	9.798[a]	15.41	
Energy	1.056[b]	0.768	
Industrial Manufacturing	0.109[b]	0.136	
Metal	0.204[b]	0.185	
Pharmaceutical	10.894[a]	5.296	
Textile	1.047[b]	1.143	

Sectors not connected by same letter are significantly different

Comparison of Forward Citations across Sectors

In this section, result of Analysis of Variance (ANOVA) for average number of forward citations has been discussed. Analysis of Variance (ANOVA) was used to find the variation across different sectors in case of forward citations. The results have been presented in Table 30.

It can be seen from Table 33 that the mean value of forward citations is highest for consumer goods sector i.e. 12.986 followed by pharmaceutical and textile sectors with mean values of 9.342 and 1.447 respectively. The mean value of forward citations is least for industrial manufacturing i.e. 0.287. The calculated F-value came out to be 9.582, with p-value less than 0.0001 which indicates that there is significant variation across different sectors for forward citations.

Table 33: Forward Citations variation across Sectors

Sector	Mean	Std Dev	F-value (p-value)
Automobile	0.861[b]	0.740	9.582(<0.0001)
Consumer	12.986[a]	13.87	
Energy	0.306[b]	0.315	
Industrial Manufacturing	0.287[b]	0.341	
Metal	0.558[b]	0.736	
Pharmaceutical	9.342[a]	2.343	
Textile	1.447[c]	0.778	

Sectors not connected by same letter are significantly different

Comparison of Total Citations across Sectors

In this section, result of Analysis of Variance (ANOVA) for average number of total citations has been discussed. Analysis of Variance (ANOVA) was used to find the variation across different sectors in case of total citations. The results have been presented in Table 31.

It can be seen from Table 31 that the mean value of total citations is highest for consumer goods sector i.e. 22.785 followed by pharmaceutical and textile sectors with mean values of 20.236 and 2.493 respectively. The mean value of forward citations is least for industrial manufacturing i.e. 0.396. The calculated *F*-value came out to be 8.3391, with p-value less than 0.0001 which indicates that there is significant variation across different sectors for total citations.

Table 34: Total Citations variation across Sectors

Sector	Mean	Std Dev	F-value (p-value)
Automobile	1.148[b]	0.792	8.3391(<0.0001)
Consumer	22.785[a]	27.92	
Energy	1.362[b]	1.014	
Industrial Manufacturing	0.396[b]	0.394	
Metal	0.775[b]	0.898	
Pharmaceutical	20.236[a]	6.656	
Textile	2.493[b]	1.730	

Sectors not connected by same letter are significantly different

Results of trend analysis for all the variables have been summarized in table 35.

Summarized Results of Trend Analysis

	Automobile	Consumer	Energy	Industrial Manufacturing	Metal	Pharmaceutical	Textile
s	*Positive*	*Positive*	*Positive*	*Positive*	*Positive*	*NS*	*Po*
s	*Positive*	*Positive*	*Positive*	*Positive*	*Positive*	*Negative*	
s	*Positive*	*Positive*	*Positive*	*Positive*	*Positive*	*Positive*	
re n)	*Positive*	*Positive*	*Positive*	*Positive*	*Positive*	*Positive*	*Po*
(%)	*Positive*	*Positive*	*NS*	*Positive*	*NS*	*Positive*	
ns	*Positive*	*NS*	*Positive*	*Positive*	*NS*	*NS*	*Po*
	Positive	*NS*	*NS*	*Positive*	*Positive*	*Positive*	
	NS	*NS*	*NS*	*NS*	*NS*	*NS*	*Po*
	NS	*NS*	*NS*	*Positive*	*NS*	*Positive*	
	NS	*NS*	*NS*	*NS*	*NS*	*Positive*	

gnificant Positive Trend Coefficient, Negative: Significant Negative Trend Coefficient, NS: Non significant Trend Coefficient

3.1.4 Correlation of Qualitative Disclosures with Selected Variables

Results of correlation analysis of Qualitative Disclosures with indicators of R&D, such as R&D Expenditure, R&D Intensity, Patent Applications, Patents Granted have been presented in table 36. This table also shows the results of correlation analysis of Qualitative Disclosures with various measures of firm performance such as Tobin' s Q, Return on Capital Employed (ROCE), Return on Net Worth (RONW), and Return on Total Assets (ROTA).

Table 36: Correlation of Qualitative Disclosures with and Indicators of R&D and Firm Performance

Variables		Correlation Coefficient	p-value
SC Disclosures	R&D Expenditure	**0.280****	<.0001
	R&D Intensity	**0.109****	<.0001
	Patent Applications	**0.293****	<.0001
	Patents Granted	**0.243****	<.0001
	Tobin's Q	**0.128****	<.0001
	ROCE	0.025	0.2204
	RONW	**0.054****	0.0090
	ROTA	**0.068****	0.0009
RC Disclosures	R&D Expenditure	**0.120****	<.0001
	R&D Intensity	-0.024	0.3552
	Patent Applications	**0.203****	<.0001
	Patents Granted	**0.340****	<.0001
	Tobin's Q	**0.108****	<.0001
	ROCE	0.003	0.8514
	RONW	**0.045***	0.0313
	ROTA	-0.009	0.6599
HC Disclosures	R&D Expenditure	**0.164****	<.0001
	R&D Intensity	**0.058***	0.0242
	Patent Applications	**0.126****	<.0001
	Patents Granted	**0.061****	0.0028
	Tobin's Q	**0.069****	0.0014
	ROCE	-0.007	0.7048
	RONW	**0.074****	0.0004
	ROTA	0.035	0.0877

It can be seen from the table that there is a significant positive correlation between Relational Capital Disclosures and R&D Expenditure. On the other hand, there was no significant correlation between Relational Capital Disclosures and R&D Intensity. Further, it can be seen from the table that both patent applications and patents granted were having significant positive correlation with Relational Capital Disclosures. Significant positive correlation was also observed between Relational Capital Disclosures and RONW. Correlation results also indicate a significant positive correlation of Structural Capital Disclosures with various R&D indicators such as R&D Expenditure, R&D Intensity, patent applications and patents granted. Structural Capital Disclosures were also having significant positive correlation with both RONW and ROTA. Human Capital Disclosures were found to have significant positive correlation with R&D Expenditure, R&D Intensity, patent applications and patents granted. RONW and Human Capital Disclosures were also positively correlated. It can also be seen from the table that all three dimensions of qualitative disclosures were having significant positive correlation with Tobin's Q.

3.2 Results of Field Survey

This section presents the results obtained from the analysis of primary data collected from the field survey of 51 manufacturing firms. Various issues such as type of R&D activities undertaken, sources of technology acquisition, commercialization of R&D output, R&D networking, orientation of firms towards R&D activities, and hurdles in R&D landscape have been discussed

Respondent organizations were enquired about having a separate R&D unit in the organization. It can be seen from table 37 that the majority of the organizations covered under the study: i.e. about 84 percent were having separate R&D unit in the organization.

Table 37: Existence of R&D Unit in the Organization *(n=51)*

R&D Unit in the Organization	Frequency (%)
Yes	43 (84.3)
No	8 (15.7)

Further, a query pertaining to R&D manpower in the organization was included in the questionnaire. Mean R&D manpower was found to be 407.23 with standard deviation of 721.19.

3.2.1 Type of R&D Efforts

This section deals with the issues pertaining to distribution of R&D effort and type of R&D activities undertaken by manufacturing firms.

Table 38: Distribution of R&D efforts *(n=51)*

Activity	**Mean**	**Standard Deviation**	***t*-Value**	***p*-Value**
Development	56.67	21.15	2.25	0.029
Applied Research	30.45	14.7	-9.49	<0.001
Basic Research	12.88	12.34	-21.48	<0.001

*Tested Against assumed mean=50 (Mid Point of the scale)

Table 38 presents the distribution of R&D efforts across different type of R&D activities. Broadly R&D activities can be divided into three categories, i.e. Basic Research, Applied Research and Development. It can be seen from table 36 that major focus of R&D effort was on development. About 57 percent of total R&D efforts for the respondent organizations focused on development aspect. Very less efforts, i.e., 12.88 percent were in the category of Basic Research. Mean of R&D efforts for Applied Research came out to be 30.45 percent. Calculated means for various R&D activities were compared with assumed mean of 50 percent (mid-point of the scale). It can be seen from Table 38 that calculated t-value was found to be 2.25 (p= 0.029) for development efforts. Value of t-statistic for Applied Research (t=-9.49, p<0.0001) and Basic Research (t=-21.48, p<0.0001) indicate that for the mentioned categories the R&D efforts were significantly different from the assumed mean. From the available results, it can be interpreted that Indian Manufacturing Sector is largely focusing on development and relatively less focused on Basic Research Activities. This may be on account of the fact that Basic Research activities demand high level of investment, involve larger gestation period and are relatively more prone to failure. On the other hand, developmental efforts are quick in terms of providing commercial benefits and involve relatively lesser effort. Basic research efforts are required for technology leadership and demand long term investments and sustained efforts.

Table 39: Comparison of R&D Efforts across Sectors

Sector	Automobile	Consumer	Energy	Ind Mfg	Metals	Pharma	Textile	F-value (p-value)
Basic Research	16.2[ab]	8.0[abc]	19.0[a]	7.5[bc]	14.17[abc]	19.5[a]	1.0[c]	2.548 (0.033)
Applied Research	27.8	29.0	36.0	26.0	34.17	36.0	25.0	1.435 (0.223)
Development	56.0	63.0	45.0	66.5	51.67	44.5	74.0	2.101 (0.072)

Analysis of variance (ANOVA) was used to find out differences in various types of R&D efforts in the organization across various sectors. Results of ANOVA have been presented in table 39. It can be seen from the table that there was significant difference in terms of basic research efforts across various sectors at 5 percent level of significance. No significant difference was found across applied research effort and development efforts across various sectors. It can be seen that pharmaceutical and Automobile sectors were having relatively higher percentage of basic research efforts with mean score of 19.5 percent and 16.2 percent respectively. Mean values of Basic Research efforts were found relatively low for consumer (8 percent) and for textile sector (one percent).

Respondents were also enquired about the type of R&D activities undertaken. Broadly organizations undertake Product R&D and Process R&D. It can be seen from table 40 that mean score for Product R&D was found to be 58.33 percent while for Process R&D, the means score was 41.67 percent. Both the means were found to be significantly different from the assumed mean of 50 percent.

Table 40 : Type of R&D Undertaken *(n=51)*

Type of R&D	Mean	Standard Deviation	*t*-Value	*p*-Value
Product	58.33	21.74	2.73	0.009
Process	41.67	21.74	-2.73	0.009

*Tested Against assumed mean=3 (Mid Point of the scale)

Results indicate that manufacturing firms in India concentrate more on Product R&D as compared to Process R&D. Product R&D activities provide revenue side benefits by churning out new products and improving the existing products. Process R&D activities are usually focused on improving the productivity for driving down the costs.

Table 41: Comparison of Type of R&D Undertaken across Sectors

Sector	Automobile	Consumer	Energy	Ind Mfg	Metals	Pharma	Textile	F-value (p-value)
Product R&D	63.50	71.00	36.00	58.50	54.17	64.50	50.00	1.675 (0.149)
Process R&D	36.50	29.00	64.00	41.50	45.83	35.50	50.00	0.772 (0.592)

ANOVA was used to find out the variations in terms of type of R&D activities across sectors and results have been presented in table 41 . It can be seen that there was no significant difference across various sectors in terms of type of R&D activities.

3.2.2 Technology Acquisition and Commercialisation of R&D Output

Results regarding various sources of technology acquisition used by Indian manufacturing firms. The respondents were asked to rate various sources of technology acquisition on scale 1-5.

Table 42: Importance of Sources for Technology Acquisition *(n=51)*

Source	Mean	Standard Deviation	*t*-Value	p-Value
In-house R&D	4.59	0.60	18.72	<0.001
Joint Venture	3.06	1.06	0.39	0.69
Contracting Out	2.31	0.99	-4.95	<0.001
Licensing in	2.22	1.04	-5.35	<0.001
Non Acquisition (Buying Final Product)	1.90	1.13	-6.90	<0.001
Cross Licensing	1.61	0.94	-10.57	<0.001

In this scale '5' represented 'Most Important' and '1' represented 'not important at all'. Results based on responses to the just mentioned scale have been presented in Table 42. It can be seen from table that In-house R&D was considered the most important source of technology acquisition with a mean value of 4.59 out of maximum of 5. This indicates that Indian manufacturing companies largely rely on In-house R&D. This mean value was tested against assumed mean of 3 (mid-point) of the scale. Results indicate that mean value for In-house R&D was found to be highly significant ($t=18.72$, $p<0.0001$).

As per the results, next important source of technology acquisition came out to be Joint Ventures with a mean value of 3.06. This value was found not significantly different from midpoint of the scale. Contracting out R&D and Licensing in the technology were termed relatively less important with mean score of 2.31 and 2.22 respectively. Buying technology embedded in the final product (non-acquisition) and cross licensing were at the bottom in terms of technology acquisition with mean scores of 1.90 and 1.61 respectively. It can also be seen from Table 42 that mean values of Contracting Out, Licensing In, Non acquisition and Cross Licensing were less than mean value of 3 and were significantly different from the assumed mean.

ANOVA results regarding sources of technology acquisition have been presented in table 43. It can be seen from table 43 that there was no significant difference for mean importance assigned to in-house R&D across various sectors at 5 percent level of significance. A significant difference at 5 percent level of significance was determined across sectors for mean importance assigned to non- acquisition route. For the remaining sources i.e. , contracting out , Joint venture, Licensing In, and Cross Licensing, there was significant difference across all sectors at 1 percent level of significance. Respondent organizations were enquired about various channels of technology flow in the organization. Responses pertaining to this query have been shown inn Table 44. It can be seen that the most important channel of technology flow was "Customer Induced". This means that customers were demanding newer technology based products to which the manufacturing firms under the survey were responding. Customer induced option got a mean score of 4.41 out of maximum of 5.

Table 43: Comparison of Importance of Sources for Technology Acquisition across Sectors

Sector	Automobile	Consumer	Energy	Ind Mfg	Metals	Pharma	Textile	F-value (p-value)
In-house	4.9	4.6	4.0	4.5	4.33	4.8	4.6	1.802 (0.121)
Contracting out	2.2[bc]	1.8[bc]	2.8[ab]	2.0[bc]	1.83[bc]	3.4[a]	1.6[c]	4.788 (0.0008)
Joint Venture	3.4[a]	2.0[b]	3.6[a]	2.8[ab]	2.17[b]	3.4[a]	3.8[a]	3.288 (0.0093)
Licensing In	2.5[ab]	1.8[bc]	2.6[ab]	1.6[c]	1.67[bc]	3.2[a]	1.6[bc]	4.102 (0.0024)
Cross Licensing	1.3[b]	1.4[b]	1.4[b]	1.4[b]	1.33[b]	2.8[a]	1.0[b]	5.202 (0.0004)
Non Acquisition	2.3[ab]	1.6[b]	1.2[b]	1.6[b]	1.5[b]	1.8[b]	3.4[a]	2.775 (0.0224)

Mean value of 4.41 was found to be significantly different from the assumed mean of 3 (t=12.53, p<0.0001). When the technological activities are driven by the customers such a phenomenon is termed as "Market Pull". Further, it can be seen from

Table 44: Channels of Technology flow in the organization *(n=51)*

Channels	Mean	Standard Deviation	*t*-Value	*p*-Value
Customer Induced	4.41	0.8	12.53	<0.001
Planned Channels	3.76	1.05	5.19	<0.001
Reverse Engineering Channel	3.57	0.98	4.12	<0.001

*Tested Against assumed mean=3 (Mid Point of the scale)

Table 44 that 'Planned Channels' such as Joint Ventures, Licensing Agreements etc were also considered important with mean value of 3.76 (t=5.19, p<0.0001). Indian manufacturing firms were also employing 'Reverse Engineering' for inflow of technology. This option got a mean score of 3.57 (t=4.12, p<0.0001) and was different from the assumed mean of 3 (midpoint of the scale). From the available results, it can be stated that "Customer Induced" technology was considered the most important channel by Indian manufacturing organizations but Planned Channels and Reverse Engineering were also being put to use.

Table 45: Comparison of Channels of Technology flow across Sectors

Sector	Automobile	Consumer	Energy	Ind Mfg	Metals	Pharma	Textile	F-value (p-value)
Reverse Engineering	3.4^{bc}	3.2^{bc}	3.0^{bc}	3.7^{abc}	2.83^{c}	4.3^{a}	4.0^{ab}	2.485 (0.0371)
Planned Channels	3.8	3.4	4.4	3.6	3.17	3.9	4.2	0.936 (0.479)
Customers	4.5^{ab}	4.8^{ab}	4.0^{bc}	4.4^{ab}	3.5^{c}	4.6^{ab}	5.0^{a}	2.719 (0.025)

Comparisons across various sectors on basis of channels of technology flow have been shown in table 45. It can be seen from the table that there was no significant variation across the sectors in case of planned channels. ANOVA results reveal that significant variation at 5 percent level was found in case of 'Reverse Engineering'. Maximum importance to this channel was found in case of pharmaceutical companies followed by Textile firms. Least importance to 'Reverse Engineering' was accorded by Energy sector and Metals. Maximum importance to 'Customer Induced' technologies was given by Textile sector and Pharmaceuticals. Relatively lesser importance was given to this channel by Metals.

Exploiting and commercializing R&D output is a critical dimension in R&D management. With increased competition in the outside world and pressure to justify R&D expenditure in house, commercialization of R&D output is expected to assume higher significance in the future. Respondent organizations were enquired about importance of various options used for exploiting/ commercializing R&D output. Results related to this query have been presented in Table 46. It can be seen from table 46 that the most important option in this context was employing the gains of R&D output in own products with a mean score of 4.51. This score was found to be significantly different ($t=14.22$, $p<0.0001$) from the midpoint of the scale. Formation of Joint Ventures and Contracting out R&D output was considered relatively less important with mean score of 2.84 and 2.61 respectively. Both the mean values were found to be statistically not different from the assumed mean of 3.

Table 46: Options for Commercializing R&D output *(n=51)*

Options	Mean	Standard Deviation	*t*-Value	*p*-Value
Employ in own Production/Products	4.51	0.75	14.22	<0.001
Joint Venture	2.84	0.96	-1.15	0.25
Contract out Manufacture/Marketing	2.61	1.09	-2.55	0.14
Licensing Out	2.04	1.07	-6.37	<0.001
Cross Licensing	1.63	0.89	-10.97	<0.001

*Tested Against assumed mean=3 (Mid Point of the scale)

Licensing out and cross licensing were considered least important for commercialization of R&D output with mean values of 2.04 and 1.63 respectively. These mean scores were less than the assumed mean of 3 and also were significantly different from the assumed mean.

Table 47 presents use of various options by the firms for exploitation of R&D output. It can be seen from the table that except for 'Contracting out' there was significant variation across various sectors for different options for exploitation of R&D output.

Table 47: Comparison of Options for Commercializing R&D output across Sectors

Sector	Automobile	Consumer	Energy	Ind Mfg	Metals	Pharma	Textile	F-value (p-value)
Own Product	4.1^{bc}	5.0^{a}	3.8^{c}	4.2^{bc}	4.67^{ab}	5.0^{a}	5.0^{a}	3.979 (0.0029)
Contracting out	2.4	2.2	3.0	2.2	3.17	3.3	1.8	2.147 (0.0647)
Joint Venture	2.9^{ab}	2.4^{bc}	3.0^{ab}	2.7^{bc}	1.83^{c}	3.5^{a}	3.2^{ab}	2.651 (0.0278)
Licensing Out	2.3^{ab}	1.4^{bc}	1.8^{bc}	2.2^{ab}	1.5^{bc}	2.9^{a}	1.0^{c}	3.259 (0.0097)
Cross Licensing	1.8^{ab}	1.4^{b}	1.0^{b}	1.5^{b}	1.33^{b}	2.5^{a}	1.0^{b}	3.456 (0.0070)

In case of 'Joint Venture' , there was significant variation at 5 percent level with Energy and Automobile companies according relatively more important to the option. A significant variation across the sectors was found in case of 'Embedding R&D output in own product' , Licensing out, and Cross Licensing.

3.2.3 R&D Networking

R&D is considered a creative activity and this activity is expected to augment by means of partnerships and networking. Respondent organizations were enquired about their research collaborations and networking at National/ International levels. Organizations can enhance their R&D programs by associating with National and International research consortia, Universities/ Academic Institutes and Government Research Labs. Responses to this query have been analyzed and presented in table 48.

Table 48: Research partnership/Associations of the organization* *(n=51)*

Partnership Avenue	Frequency
University/Academic Institute	36 (70.6)
International Research Consortia	30 (58.8)
National Research Consortia	16 (31.4)
Government Research Lab	12 (23.5)

(*Multiple responses were allowed)

It can be seen from table 48 that the majority of the firms are having research collaborations with University/Academic Institutes (both in India and abroad). About 71 percent of the organizations were having collaborations with such institutes. Organizations were also participating in International Research consortia in their respective domains with about 59 percent affirmative responses to the option. Relatively lesser partnership was seen in case of National Research consortia and Government Research Labs with affirmative responses to the tune 31.4 percent and 23.5 percent. From the results, it can be stated that relatively lesser reliance/partnership was seen in case of private and public research opportunities with an exception of Universities and Academic Institutes.

3.2.4 R&D Orientation of the Organizations

Respondent organizations were also enquired about various issues related to R&D. Such issues included primacy of R&D in the organization, direct/indirect contribution of R&D to profits, R&D evaluation techniques adopted etc. All these issues were presented in form of statements and the respondents were requested to express their level of agreement with respect to various statements.

Table 49: View point regarding R&D of the organization ***(n=51)***

Statement	Mean	Standard Deviation	*t*-Value	*p*-Value
R&D activities support the organization to sustain in the competitive landscape **(S6)**	4.63	0.48	23.8	<0.001
Spending/Place of R&D activities has increased over the past decade in the organization **(S5)**	4.35	0.52	18.49	<0.001
R&D activities directly add to profitability of the firm **(S2)**	3.84	0.78	7.67	<0.001
R&D is a Primary function of the organization **(S1)**	3.8	0.74	7.66	<0.001
R&D activities indirectly add to profitability to the firm **(S3)**	3.29	0.94	2.22	0.03
Formal techniques to assess the returns of R&D are employed in the organization (S4)	2.63	1.05	-2.51	0.01

Results pertaining to this dimension have been presented in table 49. It can be seen from table 49 there was an overwhelming agreement to the statement that R&D activities support in sustenance of competitive advantage with a mean score of 4.63 out of maximum of 5. A considerable level of agreement was also observed regarding increased pace of spending on R&D activities in last decade. This statement got a mean score of 4.35. Probing into the issue of manner of contribution of R&D activities to profit revealed that the respondents agreed on the issue of R&D activities directly adding to profit (mean score= 3.84) as compared to indirect contribution (3.29). Given the fact that more efforts are made by Indian firms for product development, these mean scores are on the expected lines. Mean score for 3.8 was obtained for R&D being a primary function in the organization. Respondents did not agree to the statement that formal techniques for assessing returns on R&D are employed in India. This statement was having mean score of 2.63 that was found to be significantly different from the mid- point of the scale, i.e., 3 (t= 2.63, p = 0.015).

From the available results, it can stated that Indian manufacturing firm acknowledge the importance of R&D activities in sustaining competitive advantage and agree that R&D spending pace has picked over the last 10 years. But not using formal techniques for assessing the performance of R&D expenditure is a matter of concern. Non-use of evaluation techniques can be result in inefficiency in garnering returns from the existing R&D efforts. At the same time, this phenomenon can also lead to under investing in R&D. Therefore, there is a need on part of manufacturing firms to adopt formal assessment techniques for R&D returns so that right kind of R&D projects can be selected and R&D efficiency may be enhanced.

Table 50 presents ANOVA results related to rating of various statements concerning R&D orientation of the manufacturing firms across sectors. It can be seen from the table that there was no significant variation across the sectors on the given issues except in case of considering

Table 50: Comparison of View point regarding R&D of across Sectors

Sector	Automobile	Consumer	Energy	Ind Mfg	Metals	Pharma	Textile	F-value (p-value)
S1	4.0^{ab}	3.6^{abc}	3.6^{abc}	3.9^{ab}	3.5^{bc}	4.3^{a}	3.0^{c}	2.505 (0.036)
S2	3.7	3.6	3.8	4.1	3.33	4.4	3.4	2.087 (0.074)
S3	3.7	3.0	3.0	3.4	2.83	3.2	3.6	0.814 (0.565)
S4	2.9	2.6	3.0	2.5	1.83	3.2	1.8	2.022 (0.084)
S5	4.5	4.4	4.4	4.1	4.17	4.6	4.2	1.124 (0.364)
S6	4.6	4.6	4.8	4.6	4.5	4.8	4.4	0.543 (0.773)

R&D as primary function of the organization and the respondents from Pharmaceuticals and Automobile sectors were having relatively higher level of agreement with the statement (S1).

On the other hand, relatively lower level of agreement, on the issue, was recorded in case of Metals and Textile.

3.2.5 Hurdles in Undertaking R&D Activities

R&D activities may face a number of hurdles. These hurdles may be related to availability and continuity of quality R&D manpower and inadequate infrastructure for smooth running of R&D operations. Respondents were asked to rate various problems related to R&D on a five point scale, where '5' represented 'Most prevalent' and '1' represented 'Not prevalent at all'. Responses from such queries were analyzed and have been presented in Table 51. It can be seen from Table 51 that there was problem, of non-availability and quality of R&D manpower, prevalent to a considerable extent. This problem got a mean score of 3.53 and was significantly different (t= 4.41, p< 0.0001) from the mid-point of the scale. Respondents also rated the problem of attrition of R&D manpower as prevalent to some extent as the mean score was found to be 3.33 (t= 2.75, p<0.0001).

Table 51: Hindrance to R&D Activities in the organization *(n=51)*

Hindrance	Mean	Standard Deviation	*t*-Value	*p*-Value
Adequate and quality R&D Manpower is not available (H1)	3.53	0.85	4.41	<0.001
Rate of attrition among R&D manpower is high (H2)	3.33	0.86	2.75	<0.001
Adequate R&D infrastructure is not available (H3)	2.35	0.89	-5.18	<0.001

Problem of adequate R&D infrastructure was prevalent to relatively a lesser extent. Mean score for this problem was pegged at 2.53 and this value was found to be significantly different from mid-point of the scale (t= -5.18, p<0.0001). During the discussions with the respondents, it was observed that students graduating from academic institutes across India are not trained for carrying out R&D operations and organizations have to put in considerable effort for training and skilling the recruits for the intended R&D operations. Further, the gap between business requirements and academic training in terms of depth and relevance of the domains was also a cause of concern. Large scale R&D efforts demand skilled management executives to overlook the R&D operations. It was observed that the majority of R&D managers was technical hands and not formally trained in management. Technology management is relatively less explored domain in India both in fields of academia and research. Superior R&D efforts can be achieved by an optimum combination of human skills and physical resources. Available results indicate that more efforts are required on the side of R&D manpower to get better R&D efficiency in Indian manufacturing section.

Table 52 presents results related to R&D manpower and infrastructure for various sectors. It can be seen from the table that significant variation across sector was found in terms of attrition of R&D manpower. This variation was significant at one percent level of significance.

Table 52: Comparison of Hindrance to R&D Activities across Sectors

Sector	Automobile	Consumer	Energy	Ind Mfg	Metals	Pharma	Textile	F-value (p-value)
H1	3.6	3.6	3.6	3.6	3.33	3.1	4.2	1.018 (0.427)
H2	3.7^{ab}	2.8^{c}	2.8^{c}	3.7^{ab}	3.0^{bc}	2.9^{c}	4.2^{a}	3.403 (0.0076)
H3	2.2	2.6	2.0	2.5	2.5	2.3	2.4	0.298 (0.935)

A look at the table reveals that relatively higher attrition problem was reported by Textile sector and Automobile sector. On the other hand, relatively lesser attrition was observed in case of Pharmaceuticals, Energy and Consumer Goods.

3.2.6 R&D Policy in the Organization

Respondents organizations were enquired about having R&D policy in the organization as well as whether the policy is in written form. Having an R&D policy can be broadly taken as proxy for basic R&D orientation of the organization.

Table 53: R&D Policy in the organization *(n=51)*

Existence of R&D Policy	Response
Yes	34 (66.7)
No	17 (33.3)

It can be seen from Table 53 that only two third of the surveyed organizations were having R&D policy in place. Further only 60.8 percent of the organizations were having R&D policy in written form. It is pertinent to mention that written R&D policy can be easily communicated to the employees in the organization. Respondent organizations were also enquired about sharing of benefits arising from patent output, with the inventors/scientists working on the corresponding projects. Only 12 percent of the organizations reported that monetary and non-monetary benefits are shared with inventors. Even these organizations did not reveal the sharing mechanism.

3.3 Linking R&D Activities and Output with Firm Performance

In this section the results of value relevance of R&D Activities and R&D Output have been discussed. An attempt has been made to related various measures of R&D Activities and R&D Output with Firm Performance. Using the methodology as discussed in section 2.3 various portfolios were created and their performance was compared. If a given input measure is able to discriminate various portfolios on basis of measures of the firm performance then it is having the value relevance or it carries an element of predictability with respect to future firm performance. Value relevance of different input measures has been inferred by using various measures of firm performance (section 2.3, Table 3). Results pertaining to alternate methodologies adopted for linking R&D efforts with firm performance have been presented in the following text.

3.3.1 Value Relevance of Intellectual Capital Score Based Portfolio Returns Methodology 1

Four portfolios were created on basis of Intellectual Capital (IC) Score Based Methodology 1 as discussed in section 2.3.1.

Table 54: Returns of Portfolios based on IC Score (Methodology 1)

Portfolio	Monthly Return
IC_SCORE 3	0.022
IC_SCORE 2	0.018
IC_SCORE 1	0.018
IC_SCORE 0	0.011

Table 54 presents returns of various portfolios based on Intellectual Capital Score Methodology 1. It can be seen from table that highest mean return was observed for IC_SCORE 3 portfolio (Portfolio with Intellectual Capital score equal to 3) with 0.022 percent monthly return. Portfolios IC_SCORE 2 and IC_SCORE 1 were having second highest monthly returns with value of 0.018 percent. Monthly returns for portfolio IC_SCORE 0 was found to be 0.011 percent.

Portfolio means were compared to find out any significant difference between different portfolios. Results thus obtained have been presented in Table 55.

Table 55: Comparison of Portfolios based on IC Score (Methodology 1) on basis of Monthly Returns

Portfolio	Mean Difference	t (p-value)
SCORE 3 - SCORE 2	0.003	1.286 (0.1010)
SCORE 3 - SCORE 1	0.003	0.944 (0.1738)
SCORE 3 - SCORE 0	0.010	2.090 (0.0198)*
SCORE 2 - SCORE 1	0.00013	0.051 (0.4796)
SCORE 2 – SCORE 0	0.007	1.823 (0.0359)*
SCORE 1 – SCORE 0	0.006	2.321 (0.0114)*

*Significant at 5% level of significance

It can be seen from the table 55 that there was a mean difference of 0.003 percent between monthly returns of portfolio IC_SCORE 3 and IC_SCORE 2. This difference was not found to be significant at 5 percent level of significance. Mean difference between monthly returns of portfolio IC_SCORE 3 and portfolio IC_SCORE 1 was found to be 0.003 percent. This difference was also not found to be significant at 5 percent level of significance. Mean difference between IC_SCORE 3 and IC_SCORE 0 was observed to be 0.010. This difference was found to be significant at 5 percent level of significance. Therefore, it can be stated that IC_SCORE 3 portfolio yielded higher returns as compared to IC_SCORE 0 portfolio.

While comparing the mean difference of portfolio IC_SCORE 2 with IC_SCORE 1, it was found that there was a mean difference of 0.00013 percent between monthly returns of portfolio IC_SCORE 2 and IC_SCORE 1. This difference was not found to be significant at 5 percent level of significance. It can be seen from the table that mean difference between monthly returns of portfolio IC_SCORE 2 and portfolio IC_SCORE 0 was found to be 0.007 percent. This difference was found to be significant at 5 percent level of significance. Therefore, it can be stated that IC_SCORE 2 portfolio yielded higher returns as compared to IC_SCORE 0 portfolios. There was a mean difference of 0.007 percent between monthly returns of portfolio IC_SCORE 1 and IC_SCORE 0. This difference was found to be significant at 5 percent level of significance. It can be stated that IC_SCORE 1 portfolio yielded higher returns as compared to IC_SCORE 0 portfolios. From the available results, it can be stated that there was value relevance of Intellectual Capital Score Methodology 1 on basis of monthly returns of securities of the companies.

Mean value of Tobin's Q for Intellectual Capital Score Based Methodology 1 has been shown in table 56.

Table 56: Tobin's Q of IC Score (Methodology 1) Based Portfolios

Portfolio	Tobin's Q
IC_SCORE 3	1.728
IC_SCORE 2	1.570
IC_SCORE 1	1.353
IC_SCORE 0	1.145

It can be seen from table that highest mean return was observed for IC_SCORE 3 portfolio i.e., 1.728. Portfolio IC_SCORE 2 was having second highest mean value of 1.57 followed by Portfolio IC_SCORE 1 having mean value of 1.353. Lowest value of mean score of 1.145 was found to be in case of portfolio IC_SCORE 0 .

Various portfolios were compared using related sample t-test and results have been shown in table 57. It can be seen from the table 57 that there was a mean difference of 0.158 between monthly returns of portfolio IC_SCORE 3 and IC_SCORE 2. This difference was not found to be significant at 5 percent level of significance. Mean difference between monthly returns of portfolio IC_SCORE 3 and portfolio IC_SCORE 1 was found to be 0.374. This difference was found to be significant at 5 percent level of significance. The mean difference between

IC_SCORE 3 and IC_SCORE 0 was observed to be 0.582. This difference was found to be significant at 5percent level of significance. Therefore, it can be stated that IC_SCORE 3 portfolio yielded higher returns as compared to IC_SCORE 1 portfolio and IC_SCORE 0 portfolio.

Table 57: Comparison of IC Score (Methodology1) Based Portfolios on basis of Tobin's Q

Portfolio	MEAN DIFFERENCE	t-value (p-value)
SCORE 3 – SCORE 2	0.158	0.968 (0.1826)
SCORE 3 – SCORE 1	0.374	2.980 (0.0103)*
SCORE 3 – SCORE 0	0.582	2.989 (0.0101)*
SCORE 2 – SCORE 1	0.216	1.836 (0.0544)
SCORE 2 – SCORE 0	0.424	4.109 (0.0023)**
SCORE 1 – SCORE 0	0.207	1.557 (0.0817)

*Significant at 5% level of significance,**Significant at 1% level of significance

While comparing the mean difference of portfolio IC_SCORE 2 with portfolio IC_SCORE 1 it was found that there was a mean difference of 0.216. Mean difference between portfolio IC_SCORE 2 and portfolio IC_SCORE 0 on basis of Tobin's Q was found to be 0.424. This difference was found to be significant at 1 percent level of significance. Therefore, it can be stated that IC_SCORE 2 portfolio performed better than IC_SCORE 0 portfolios on basis of Tobin's Q. There was a mean difference of 0.207 between portfolio IC_SCORE 1 and IC_SCORE 0 on basis of Tobin's Q. This difference was not found to be significant at 5percent level of significance. From the overall results, it can be inferred that there was some value relevance of Intellectual Capital Score Methodology 1 for predicting the firm performance on basis of Tobin's Q.

Table 58 presents mean Return on Capital Employed (ROCE) for various portfolios created on basis of Intellectual Capital Score Methodology 1.

Table 58: ROCE of IC Score (Methodology 1) Based Portfolios

Portfolio	**Mean ROCE**
IC_Score 3	20.268
IC_Score 2	11.287
IC_Score 1	13.827
IC_Score 0	11.204

It can be seen from table that highest mean ROCE was observed for IC_Score 3 portfolios with value of 20.268 percent. Portfolio IC_Score 2 was found to have mean ROCE of 11.287 percent.

Mean ROCE for portfolio IC_Score 1 was found to 13.827 percent. Least mean ROCE was found to be 11.204 percent for IC_SCORE 0 portfolio.

Various portfolios were compared using related sample t-test and results have been shown in table 59. It can be seen from the table 57 that there was a mean difference of 8.980 percent between returns of portfolio IC_SCORE 3 and IC_SCORE 2. This difference was found to be significant at 5 percent level of significance. Mean difference between returns of portfolio IC_SCORE 3 and IC_SCORE 1 was found to be 6.440 percent. This difference was found to be significant at 1percent level of significance. The mean difference between ROCE 3 and ROCE 0 was observed to be 9.244 percent.

Table 59: Comparison of IC Score (Methodology 1) Based Portfolios on basis of ROCE

Portfolio	MEAN DIFFERENCE	STANDARD ERROR	t (p-value)
SCORE 3 – SCORE 2	8.980	4.306	2.085 (0.0377)*
SCORE 3 – SCORE 1	6.440	1.721	3.741 (0.0036)**
SCORE 3 – SCORE 0	9.244	1.598	5.783(0.0003)**
SCORE 2 – SCORE 1	-2.540	4.322	-0.587 (0.7124)
SCORE 2 – SCORE 0	0.263	4.433	0.059 (0.4772)
SCORE 1 – SCORE 0	2.803	0.870	3.219 (0.0073)**

*Significant at 5% level of significance,**Significant at 1% level of significance

This difference was found to be significant at 1 percent level of significance. Therefore, it can be stated that IC_SCORE 3 portfolio returned significantly higher mean ROCE as compared to other portfolios. No significant difference was observed between IC_SCORE 2 portfolio and IC_SCORE 1 portfolio as well as IC_SCORE 2 portfolio and IC_SCORE 0 portfolio . Further, it can be seen that there was a significant difference between IC_SCORE 1 portfolio and IC_SCORE 0 portfolio .

Table 60 presents mean Return on Net Worth (RONW) for various portfolios created on basis of Intellectual Capital Score Methodology 1.

Table 60: RONW of IC Score (Methodology 1) Based Portfolios

Portfolio	**Mean RONW**
IC_Score 3	27.508
IC_Score 2	21.177
IC_Score 1	18.543
IC_Score 0	16.095

It can be seen from table that highest mean return was observed for IC_Score 3 portfolios, i.e., 27.508 percent . Portfolio IC_Score 2 was found to have value of 21.177percent. Mean RONW for portfolio IC_Score 1 was found to 18.543 percent while IC_Score 0 portfolio was having mean RONW of 16.095 percent. Mean RONW of various portfolios were compared and results have been presented in table 61.

Table 61: Comparison of IC Score (Methodology 1) Based Portfolios on basis of RONW

Portfolio	Mean Difference	t-value (p-value)
SCORE 3 – SCORE 2	6.331	2.479 (0.0211)*
SCORE 3 – SCORE 1	8.964	4.743 (0.0010)**
SCORE 3 – SCORE 0	11.413	3.897 (0.0030)**
SCORE 2 – SCORE 1	2.633	1.837 (0.0544)
SCORE 2 – SCORE 0	5.082	2.545 (0.0192)*
SCORE 1 – SCORE 0	2.448	1.807 (0.0568)

*Significant at 5% level of significance,**Significant at 1% level of significance

It can be seen from the table 61 that there was a mean difference of 6.331 percent between RONW of portfolio IC_Score 3 and IC_Score 2 . This difference was found to be significant at 5 percent level of significance. It can be seen from the table that mean difference between RONW of portfolio IC_Score 3 and portfolio IC_SCORE 1 was found to be 8.964 percent. This difference was found to be significant at 1 percent level of significance. Mean difference between portfolio IC_Score 3 and portfolio IC_SCORE 0 was observed to be 11.413. This difference was found to be significant at 1 percent level of significance. Therefore, it can be stated that IC_Score 3 portfolio yielded higher RONW as compared to the remaining portfolios. There was a significant difference between RONW of IC_Score 2 portfolio and IC_Score 0 portfolio. Available results indicate value relevance of Intellectual Capital Score Methodology 1 for RONW.

Mean ROTA for various portfolios created on basis for Intellectual Capital Score Methodology 1 have been shown in table 62.

Table 62: ROTA of IC Score (Methodology 1) Based Portfolios

Portfolio	Mean ROTA
IC_Score 3	11.450
IC_Score 2	8.516
IC_Score 1	8.882
IC_Score 0	7.277

It can be seen from table that highest mean ROTA was observed for IC_Score 3 portfolio ,i.e., 11.450 percent return while the lowest ROTA was found in case of IC_Score 0 portfolio (7.277 percent). Mean ROTA values for portfolio IC_Score 2 and IC_Score 1 were found to be 8.516 percent and 8.882 percent respectively. Mean ROTA of various portfolios were compared and results have been presented in table 63.

Table 63: Comparison of IC Score (Methodology 1) Based Portfolios on basis of ROTA

Portfolio	Mean Difference	t-value (p-value)
SCORE 3 – SCORE 2	2.934	2.593 (0.0179)*
SCORE 3 – SCORE 1	2.568	5.145 (0.0007)**
SCORE 3 – SCORE 0	4.172	4.722 (0.0011)**
SCORE 2 – SCORE 1	-0.366	-0.399 (0.6491)
SCORE 2 – SCORE 0	1.238	2.066 (0.0388)*
SCORE 1 – SCORE 0	1.604	2.868 (0.0120)*

*Significant at 5% level of significance,**Significant at 1% level of significance

It can be seen from the table 63 that there was a mean difference of 2.934 percent between ROTA of IC_Score 3 portfolio and IC_Score 2 portfolio . This difference was found to be significant at 5 percent level of significance. Mean difference between returns of IC_Score 3 portfolio and IC_Score 31 portfolio was found to be 2.568 percent. This difference was found to be significant at 1 percent level of significance. The mean difference between IC_Score 3 portfolio and IC_Score 0 portfolio was observed to be 4.172. This difference was also found to be significant at 1 percent level of significance. Therefore, it can be stated that IC_Score 3 portfolio yielded higher ROTA as compared to the remaining portfolios.

3.3.2 Value Relevance of Intellectual Score Based Portfolio Returns Methodology 2

Four portfolios were created on basis of Intellectual Score Based Portfolio Returns Methodology 1 as discussed in Section

Average monthly returns of these portfolios have been presented in Table 64.

Table 64 : Monthly Returns of Portfolios based on IC Score (Methodology 2)

Portfolio	Mean Returns
IC_SCORE 3	0.020
IC_SCORE 2	0.019
IC_SCORE 1	0.019
IC_SCORE 0	0.009

It can be seen from table that highest mean return was observed for IC_SCORE 3 portfolio with value of 0.020 percent. Portfolios IC_SCORE 2 and IC_SCORE 1 were having second highest monthly return with value of 0.019 percent. Least monthly return for portfolio IC_SCORE 0 was found to be 0.009 percent. Various portfolios were compared on basis of monthly returns and results this obtained have been presented in table 65.

Table 65: Comparison of Portfolios based on IC Score (Methodology 2) on basis of Monthly Returns

Portfolio	Mean Difference	t-value (p-value)
SCORE 3 – SCORE 2	0.001	0.506 (0.3070)
SCORE 3 – SCORE 1	0.001	0.546 (0.2932)
SCORE 3 – SCORE 0	0.011	2.606 (0.0054)**
SCORE 2 – SCORE 1	0.00052	0.216 (0.4144)
SCORE 2 – SCORE 0	0.010	2.837 (0.0029)**
SCORE 1 – SCORE 0	0.009	3.090 (0.0014)**

**Significant at 1% level of significance

It can be seen from the table 65 that there was a mean difference of 0.001 percent between monthly returns of portfolio IC_SCORE 3 and IC_SCORE 2. This difference was not found to be significant at 5 percent level of significance. Mean difference between monthly returns of portfolio IC_SCORE 3 and portfolio IC_SCORE 1 was found to be 0.001 percent. This difference was also not found to be significant at 5 percent level of significance. Mean difference between IC_SCORE 3 and IC_SCORE 0 was observed to be 0.011. This difference was found to be significant at 1 percent level of significance. Therefore, it can be stated that IC_SCORE 3 portfolio yielded higher returns as compared to IC_SCORE 0 portfolios. There was significant difference between monthly returns of portfolio IC_SCORE 2 and portfolio IC_SCORE 0 as well as between monthly returns of portfolio IC_SCORE 1 and portfolio IC_SCORE 0 at 1 percent level of significance. From the available results, it can be stated that IC_Score 0 portfolio was having significantly lower returns as compared to the remaining portfolios.

Mean values of Tobin's Q for various portfolios created on basis of Intellectual Capital Score Methodology 2 have been presented in tables 66.

Table 66: Tobin's Q of IC Score (Methodology 2) Based Portfolios

Portfolio	Tobin's Q
IC_SCORE 3	1.824
IC_SCORE 2	1.560
IC_SCORE 1	1.297
IC_SCORE 0	1.253

It can be seen from table that highest mean value of Tobin's Q (1.824) was observed for IC_SCORE 3 portfolio. Portfolio IC_SCORE 2 was having second highest mean value of 1.560 followed by Portfolio IC_SCORE 1 having mean value of 1.297. Mean value of Tobin's Q for portfolio IC_SCORE 0 was found to be least (1.253). Various portfolios were compared on basis of Tobin's Q and results obtained from the analysis have been presented in Table 67.

Table 67: Comparison of IC Score (Methodology 2) Based Portfolios on basis of Tobin's Q

Portfolio	Mean Difference	t-value (p-value)
SCORE 3 – SCORE 2	0.264	1.433 (0.0974)
SCORE 3 – SCORE 1	0.527	3.178 (0.0078)**
SCORE 3 – SCORE 0	0.571	2.465 (0.0215)*
SCORE 2 – SCORE 1	0.262	2.256 (0.0293)*
SCORE 2 – SCORE 0	0.306	3.226 (0.0073)**
SCORE 1 – SCORE 0	0.043	0.276 (0.3951)

*Significant at 5% level of significance,**Significant at 1% level of significance

It can be seen from the table 67 that there was a mean difference of 0.264 between portfolio IC_SCORE 3 and IC_SCORE 2. This difference was not found to be significant at 5 percent level of significance. Mean difference between portfolio IC_SCORE 3 and portfolio IC_SCORE 1 was found to be 0.527. This difference was found to be significant at 1 percent level of significance. The mean difference between IC_SCORE 3 and IC_SCORE 0 was observed to be 0.571. This difference was found to be significant at 5 percent level of significance. Therefore, it can be stated that IC_SCORE 3 portfolio yielded higher Tobin's Q as compared to IC_SCORE 1 and IC_SCORE 0 portfolios.

While comparing the mean difference of portfolio IC_SCORE 2 with portfolio IC_SCORE 1, it was found that there was a mean difference of 0.262 and this difference was found to be significant at 5 percent level of significance. Mean difference between monthly raw returns of portfolio IC_SCORE 2 and portfolio IC_SCORE 0 was found to be 0.306. This difference was found to be significant at 1 percent level of significance. Therefore, it can be stated that IC_SCORE 2 portfolio yielded higher Tobin's Q as compared to IC_SCORE 1 and IC_SCORE 0 portfolios.

Mean ROCE values for various portfolios created on basis of Intellectual Capital Score Methodology 2 have been presented in table 68.

Table 68: ROCE of IC Score (Methodology 2) Based Portfolios

Portfolio	Mean ROCE
IC_SCORE 3	19.955
IC_SCORE 2	11.596
IC_SCORE 1	13.403
IC_SCORE 0	11.281

It can be seen from table that highest mean ROCE was observed for IC_SCORE 3 portfolio with value of 19.955. Portfolio IC_SCORE 2 was having mean ROCE value of 11.596. Mean ROCE for portfolio IC_SCORE 1 was found to 13.403. Least mean ROCE of 11.281 was found in case of IC_Score 0 portfolio. Various portfolios were compared on basis of ROCE and results have been presented in table 69.

Table 69: Comparison of IC Score (Methodology 2) Based Portfolios on basis of ROCE

Portfolio	Mean Difference	t-value (p-value)
SCORE 3 – SCORE 2	8.359	1.847 (0.0535)
SCORE 3 – SCORE 1	6.552	3.760 (0.0035)**
SCORE 3 – SCORE 0	8.673	4.930(0.0008)**
SCORE 2 – SCORE 1	-1.807	-0.399 (0.6491)
SCORE 2 – SCORE 0	0.314	0.070(0.4730)
SCORE 1 – SCORE 0	2.121	2.302 (0.0274)*

*Significant at 5% level of significance,**Significant at 1% level of significance

It can be seen from the table 69 that there was a mean difference of 8.359 between ROCE of portfolio IC_SCORE 3 and IC_SCORE 2. This difference was not found to be significant at 5 percent level of significance. Mean difference between ROCE of portfolio IC_SCORE 3 and portfolio IC_SCORE 1 was found to be 6.552 and this difference was significant at 1 percent level of significance. The mean difference between IC_SCORE 3 portfolio and IC_SCORE 0 portfolio was observed to be 8.673. This difference was found to be significant at 1 percent level of significance. Therefore, it can be stated that IC_SCORE 3 portfolio yielded higher ROCE as compared to IC_SCORE 1 portfolio and IC_SCORE 0 portfolio.

Mean RONW values for various portfolios created on basis of Intellectual Capital Score Methodology 2 have been presented in table 70.

Table 70: RONW of IC Score (Methodology 2) Based Portfolios

Portfolio	Mean RONW
IC_SCORE 3	26.932
IC_SCORE 2	21.731
IC_SCORE 1	18.039
IC_SCORE 0	16.201

It can be seen from table that highest RONW was observed for IC_SCORE 3 portfolio with value of 26.932. Portfolio IC_SCORE 2 was having second highest value of RONW (21.731). Mean RONW for IC_SCORE 1 was found to 18.039percent. Least mean RONW was observed for IC_SCORE 0 with value of 16.201.

Table 71: Comparison of IC Score (Methodology 2) Based Portfolios on basis of RONW

Portfolio	Mean Difference	t-value (p-value)
SCORE 3 – SCORE 2	5.200	2.292 (0.0278)*
SCORE 3 – SCORE 1	8.892	4.713 (0.0011)**
SCORE 3 – SCORE 0	10.730	3.403 (0.0057)**
SCORE 2 – SCORE 1	3.692	2.564 (0.0187)*
SCORE 2 – SCORE 0	5.530	2.464 (0.0216)*
SCORE 1 – SCORE 0	1.838	1.161 (0.1418)

*Significant at 5% level of significance,**Significant at 1% level of significance

It can be seen from the table 71 that there was a mean difference of 5.20 between returns of portfolio IC_SCORE 3 and portfolio IC_SCORE 2. This difference was found to be significant at 5 percent level of significance. Mean difference between RONW of IC_SCORE 3 portfolio and IC_SCORE 1 portfolio was found to be 8.892. This difference was found to be significant at 1 percent level of significance. The mean difference between IC_SCORE 3 portfolio and IC_SCORE 0 portfolio was observed to be 10.730. This difference was found to be significant at 1 percent level of significance. Therefore, it can be stated that IC_SCORE 3 portfolio yielded higher RONW as compared to all other portfolios.

Mean ROTA values for various portfolios created on basis of Intellectual Capital Score Methodology 2 have been presented in table 72.

Table 72: ROTA of IC Score (Methodology 2) Based Portfolios

Portfolio	Mean ROTA
IC_SCORE 3	11.063
IC_SCORE 2	8.670
IC_SCORE 1	8.752
IC_SCORE 0	7.476

It can be seen from table that highest mean ROTA value of 11.063 was observed for portfolio IC_SCORE 3. Mean ROTA of portfolio IC_SCORE 2 was found to be 8.670. Portfolio IC_SCORE 1 was found to have mean ROTA of 8.752. Mean ROTA for portfolio IC_SCORE 0 was found to be 7.476. Various portfolios were compared on basis of ROTA and results thus obtained have been presented in table 73.

Table 73: Comparison of IC Score (Methodology 2) Based Portfolios on basis of ROTA

Portfolio	Mean Difference	t-value (p-value)
SCORE 3 – SCORE 2	2.392	2.290 (0.0279)*
SCORE 3 – SCORE 1	2.311	3.992 (0.0026)**
SCORE 3 – SCORE 0	3.587	3.536 (0.0048)**
SCORE 2 – SCORE 1	-0.081	-0.087 (0.5335)
SCORE 2 – SCORE 0	1.194	1.849 (0.0534)
SCORE 1 – SCORE 0	1.275	2.036 (0.0405)*

*Significant at 5% level of significance,**Significant at 1% level of significance

It can be seen from the table 73 that there was a mean difference of 2.392 between ROTA of portfolio IC_SCORE 3 and portfolio IC_SCORE 2. This difference was found to be significant at 5 percent level of significance. Further, mean difference between ROTA of portfolio IC_SCORE 3 and portfolio IC_SCORE 1 was found to be 2.311 percent. This difference was found to be significant at 1 percent level of significance. The mean difference between ROTA of portfolio IC_SCORE 3 and portfolio IC_SCORE 1 was observed to be 3.587. This difference was found to be significant at 1 percent level of significance. Therefore, it can be stated that portfolio IC_SCORE 3 yielded higher RTOTA as compared to the remaining portfolios.

3.3.3 Value Relevance of R&D Intensity for Firm Performance

Using the methodology given in Section two portfolios were created . Portfolio RDI 1 was having the companies with relatively higher R&D intensity and portfolio RDI 0 was having companies with relatively lower R&D intensity. Performance of these portfolios have been compared on basis of monthly returns, Tobin's Q, Return on Capital Employed (ROCE), Return on Net Worth (RONW), and Return on Total Assets (ROTA).

Average monthly returns of portfolios RDI 1 and RDI 0 have been presented in Table 74.

Table 74: Monthly Returns of R&D Intensity Based Portfolios

Portfolio	Mean Returns	Difference	t- value (p-value)
RDI 1	0.022	0.001	0.505 (0.3070)
RDI 0	0.021		

Table 74 reveals that higher mean monthly return was observed for RDI 1 portfolio with value of 0.022 percent. On the other hand, mean value for Portfolio RDI 0 was found to be 0.021. It can be seen from the table 74 that there was a mean difference of 0.001 percent between monthly returns of portfolio RDI 1 and RDI 0. This difference was not found to be significant at 5 percent level of significance.

Mean Tobin's Q of portfolios RDI 1 and RDI 0 have been presented in Table 75. It can be seen from table that higher mean Tobin's Q was observed for RDI 1 portfolio with value of 1.682.

Table 75: Tobin's Q of R&D Intensity Based Portfolios

Portfolio	Mean Tobin's Q	Mean Difference	t- value (p-value)
RDI 1	1.682	0.435	6.318 (<0.0001)**
RDI 0	1.247		

**Significant at 1% level of significance

Further, mean value for Portfolio RDI 0 was found to be 1.247. It can be seen from the table 75 that there was a mean difference of 0.435 between Tobin's Q of portfolio RDI 1 and RDI 0. This difference was found to be significant at 1 percent level of significance.

Mean ROCE of portfolios RDI 1 and RDI 0 have been presented in Table 76. It can be seen from table that higher mean ROCE was observed for RDI 1 portfolio with value of 17.39 percent. On the other hand, mean value for Portfolio RDI 0 was found to be 11.233.

Table 76: ROCE of R&D Intensity Based Portfolios

Portfolio	Mean ROCE	Mean Difference	t- value (p-value)
RDI 1	17.390	6.157	6.443(<0.0001)**
RDI 0	11.233		

**Significant at 1% level of significance

It can be seen from the table 76 that there was a mean difference of 6.157 percent between ROCE of portfolio RDI 1 and RDI 0. This difference was found to be significant at 1 percent level of significance.

Mean RONW of portfolios RDI 1 and RDI 0 have been presented in Table 77. It can be seen from table that higher mean RONW was observed for RDI 1 portfolio with value of 23.415 percent. Further, mean value for Portfolio RDI 0 was found to be 19.777.

Table 77: RONW of R&D Intensity Based Portfolios

Portfolio	Mean RONW	Mean Difference	t- value (p-value)
RDI 1	23.415	3.638	6.295 (<0.0001)**
RDI 0	19.777		

It can be seen from the table 77 that there was a mean difference of 3.638 percent between RONW of portfolio RDI 1 and RDI 0. This difference was found to be significant at 1 percent level of significance.

Mean ROTA of portfolios RDI 1 and RDI 0 have been presented in Table 78. It can be seen from table that higher mean ROTA was observed for RDI 1 portfolio with value of 10.776 percent.

Table 78: ROTA of R&D Intensity Based Portfolios

Portfolio	Mean ROTA	Difference	t- value (p-value)
RDI 1	10.776	2.805	9.543 (<0.0001)**
RDI 0	7.971		

**Significant at 1% level of significance

On the other hand, mean value for Portfolio RDI 0 was found to be 2.805 percent . It can be seen from the table 78 that there was a mean difference of 3.638 percent between ROTA of portfolio RDI 1 and RDI 0. This difference was found to be significant at 1 percent level of significance.

3.3.4 Value Relevance of Patent Applications for Firm Performance

Using the methodology given in Section two portfolios were created . Portfolio APP 1 was having the companies with relatively higher Patent Applications and portfolio APP 0 was having companies with relatively lower Patent Applications. Performance of these portfolios have been compared on basis of monthly returns, Tobin's Q, Return on Capital Employed (ROCE), Return on Net Worth (RONW), and Return on Total Assets (ROTA).

Average monthly returns of portfolios APP 1 and APP 0 have been presented in Table 79. It can be seen from table that higher mean monthly return was observed for APP 1 portfolio with value of 0.027 percent. Mean value of monthly return for Portfolio APP 0 was found to be 0.021.

Table 79: Monthly Returns of Patent Applications Based Portfolios

Portfolio	Mean Returns	Difference	t- value (p-value)
APP 1	0.027	0.006	2.111 (0.0185)*
APP 0	0.021		

It can be seen from the table 79 that there was a mean difference of 0.006 percent between monthly returns of portfolio APP 1 and APP 0. This difference was found to be significant at 5 percent level of significance.

Average Tobin's Q of portfolios APP 1 and APP 0 have been presented in Table 80. It can be seen from table that higher Tobin's Q was observed for APP 1 portfolio with value of 1.644. On the other hand, mean value for Tobin's Q for Portfolio APP 0 was found to be 1.413.

Table 80: Tobin's Q of Patent Applications Based Portfolios

Portfolio	Mean Tobin's Q	Difference	t- value (p-value)
APP 1	1.644	0.231	2.452 (0.0183)*
APP 0	1.413		

*Significant at 5% level of significance

It can be seen from the table 80 that there was a mean difference of 0.231 percent between Tobin's Q of portfolio APP 1 and APP 0. This difference was found to be significant at 5 percent level of significance.

Average ROCE of portfolios APP 1 and APP 0 have been presented in Table 81. It can be seen from table that higher ROCE was observed for APP 1 portfolio with value of 19.53 percent. Further, mean ROCE for Portfolio APP 0 was found to be 12.673.

Table 81: ROCE of Patent Applications Based Portfolios

Portfolio	Mean ROCE	Difference	t- value (p-value)
APP 1	19.563	6.89	4.118 (0.0013)**
APP 0	12.673		

It can be seen from the table 81 that there was a mean difference of 6.89 percent between ROCE of portfolio APP 1 and APP 0. This difference was found to be significant at 1 percent level of significance.

Average RONW of portfolios APP 1 and APP 0 have been presented in Table 82. It can be seen from table that higher mean RONW was observed for APP 1 portfolio with value of 24.605 percent.

Table 82: RONW of Patent Applications Based Portfolios

Portfolio	Mean RONW	Difference	t- value (p-value)
APP 1	24.605	3.966	3.620 (0.0028)**
APP 0	20.639		

**Significant at 1% level of significance

On the other hand, mean value for Portfolio APP 0 was found to be 20.639 percent. It can be seen from the table 82 that there was a mean difference of 3.966 percent between RONW of portfolio APP 1 and APP 0. This difference was found to be significant at 1 percent level of significance.

Average ROTA of portfolios APP 1 and APP 0 have been presented in Table 83 . It can be seen from table that higher ROTA was observed for APP 1 portfolio with value of 10.859 percent. Further, mean value for Portfolio APP 0 was found to be 8.859 percent.

Table 83: ROTA of Patent Applications Based Portfolios

Portfolio	Mean ROTA	Difference	t- value (p-value)
APP 1	10.859	2.000	7.528 (<0.0001)**
APP 0	8.859		

**Significant at 1% level of significance

It can be seen from the table 83 that there was a mean difference of 2.000 percent between ROTA of portfolio APP 1 and APP 0. This difference was found to be significant at 1 percent level of significance.

3.3.5 Value Relevance of Patent Grants for Firm Performance

Using the methodology given in Section two portfolios were created . Portfolio GRANT 1 was having the companies with relatively higher Patent Grants and portfolio GRANT 0 was having companies with relatively lower Patent Grants. Performance of these portfolios have been compared on basis of monthly returns, Tobin's Q, Return on Capital Employed (ROCE), Return on Net Worth (RONW), and Return on Total Assets (ROTA).

Average monthly returns of portfolios GRANT 1 and GRANT 0 have been presented in Table 84. It can be seen from table that lower mean monthly return was observed for GRANT 1 portfolio with value of 0.017 percent. Further, mean value of monthly returns for Portfolio GRANT 0 was found to be 0.022.

Table 84: Monthly Returns of Patent Grants Based Portfolios

Portfolio	Mean Returns	Difference	t- value (p-value)
GRANT 1	0.017	-0.005	-1.710 (0.9541)
GRANT 0	0.022		

It can be seen from the table 84 that there was a mean difference of -0.005 percent between monthly returns of portfolio GRANT 1 and GRANT 0. This difference was not found to be significant at 5 percent level of significance.

Average Tobin's Q of portfolios GRANT 1 and GRANT 0 have been presented in Table 85. It can be seen from table that higher Tobin's Q was observed for GRANT 1 portfolio with value of 1.702 . On the other hand, mean value for Portfolio GRANT 0 was found to be 1.420.

Table 85: Tobin's Q of Patent Grants Based Portfolios

Portfolio	Mean Tobin's Q	Difference	t- value (p-value)
GRANT 1	1.702	0.282	2.808 (0.0102)*
GRANT 0	1.420		

*Significant at 5% level of significance

It can be seen from the table 85 that there was a mean difference of 0.282 percent between Tobin's Q of portfolio GRANT 1 and GRANT 0. This difference was found to be significant at 5 percent level of significance.

Average ROCE of portfolios GRANT 1 and GRANT 0 have been presented in Table 86 . It can be seen from table that lower ROCE was observed for GRANT 1 portfolio with value of 12.554 percent. Further, mean value of ROCE for Portfolio GRANT 0 was found to be 14.411.

Table 86: ROCE of Patent Grants Based Portfolios

Portfolio	Mean ROCE	Difference	t- value (p-value)
GRANT 1	12.554	-1.857	-0.8164 (0.7823)
GRANT 0	14.411		

It can be seen from the table 86 that there was a mean difference of -1.857 percent between ROCE of portfolio GRANT 1 and GRANT 0. This difference was not found to be significant at 5 percent level of significance.

Average RONW of portfolios GRANT 1 and GRANT 0 have been presented in Table 87. It can be seen from table that higher mean RONW was observed for GRANT 1 portfolio with value of 22.753 percent. Further, mean value for Portfolio GRANT 0 was found to be 21.306 percent.

Table 87: RONW of Patent Grants Based Portfolios

Portfolio	Mean RONW	Difference	t- value (p-value)
GRANT 1	22.753	1.447	0.452 (0.3308)
GRANT 0	21.306		

Table 87 reveals that there was a mean difference of 1.447 percent between RONW of portfolio GRANT 1 and GRANT 0. This difference was not found to be significant at 5 percent level of significance.

Average ROTA of portfolios GRANT 1 and GRANT 0 have been presented in Table 88. It can be seen from table that higher ROTA was observed for GRANT 1 portfolio with value of 9.487 percent. Further, mean value for Portfolio GRANT 0 was found to be 9.254 percent.

Table 88: ROTA of Patent Grants Based Portfolios

Portfolio	Mean ROTA	Difference	t- value (p-value)
GRANT 1	9.487	0.233	0.432 (0.3376)
GRANT 0	9.254		

It can be seen from the table 88 that there was a mean difference of 0.233 percent between ROTA of portfolio GRANT 1 and GRANT 0. This difference was not found to be significant at 5 percent level of significance.

3.3.6 Value Relevance of Patent Citations for Firm Performance

Using the methodology given in Section two portfolios were created . Portfolio CIT 1 was having the companies with relatively higher Patent Citations and portfolio CIT 0 was having companies with relatively lower Patent Citations. Performance of these portfolios have been compared on basis of monthly returns, Tobin's Q, Return on Capital Employed (ROCE), Return on Net Worth (RONW), and Return on Total Assets (ROTA).

Average monthly returns of portfolios CIT 1 and CIT 0 have been presented in Table 89 . It can be seen from table that lower mean monthly return was observed for CIT 1 portfolio with value of 0.020 percent. On the other hand, mean value for Portfolio CIT 0 was found to be 0.022.

Table 89: Monthly Returns of Patent Citations Based Portfolios

Portfolio	Mean Returns	Difference	t- value (p-value)
CIT 1	0.020	- 0.002	-0.820 (0.793)
CIT 0	0.022		

It can be seen from the table 89 that there was a mean difference of -0.002 percent between monthly returns of portfolio CIT 1 and CIT 0. This difference was not found to be significant at 5 percent level of significance.

Average Tobin's Q of portfolios CIT 1 and CIT 0 have been presented in Table 90. It can be seen from table that higher Tobin's Q was observed for CIT 1 portfolio with value of 1.699 .

Table 90: Tobin's Q of Patent Citations Based Portfolios

Portfolio	Mean Tobin's Q	Difference	t- value (p-value)
CIT 1	1.699	0.267	1.581 (0.0741)
CIT 0	1.432		

Further, mean value of Tobin's Q for Portfolio CIT 0 was found to be 1.432. It can be seen from the table 90 that there was a mean difference of 0.267 between Tobin's Q of portfolio CIT 1 and CIT 0. This difference was found to be significant at 5 percent level of significance.

Average ROCE of portfolios CIT 1 and CIT 0 have been presented in Table 91. It can be seen from table that higher ROCE was observed for CIT 1 portfolio with value of 15.438 percent. Further, mean value of ROCE for Portfolio CIT 0 was found to be 13.941.

Table 91: ROCE of Patent Citations Based Portfolios

Portfolio	Mean ROCE	Difference	t- value (p-value)
CIT 1	15.438	1.497	0.698 (0.2511)
CIT 0	13.941		

It can be seen from the table 91 that there was a mean difference of 1.497 percent between ROCE of portfolio CIT 1 and CIT 0. This difference was not found to be significant at 5 percent level of significance.

Average RONW of portfolios CIT 1 and CIT 0 have been presented in Table 92. It can be seen from table that higher mean RONW was observed for CIT 1 portfolio with value of 22.479 percent.

Table 92: RONW of Patent Citations Based Portfolios

Portfolio	Mean RONW	Difference	t- value (p-value)
CIT 1	22.479	1.143	0.309 (0.3821)
CIT 0	21.336		

On the other hand, mean value of RONW for Portfolio CIT 0 was found to be 21.336 percent. It can be seen from the table 92 that there was a mean difference of 1.143 percent between RONW of portfolio CIT 1 and CIT 0. This difference was not found to be significant at 5 percent level of significance.

Average ROTA of portfolios CIT 1 and CIT 0 have been presented in Table 93. It can be seen from table that higher ROTA was observed for CIT 1 portfolio with value of 9.634 percent. On the other hand, mean value for Portfolio CIT 0 was found to be 9.238 percent.

Table 93: ROTA of Patent Citations Based Portfolios

Portfolio	Mean ROTA	Difference	t- value (p-value)
CIT 1	9.634	0.396	
CIT 0	9.238		

Table 93 reveals that there was a mean difference of 0.396 percent between ROTA of portfolio CIT 1 and CIT 0. This difference was not found to be significant at 5 percent level of significance.

3.4 Regression Models

This section contains the results of data analysis for Objective 4 and Objective 5 of the research. Using regression models an attempt has been made to identify the organizational level variables affecting R&D output in Indian Manufacturing sector. Using the data generated in the study, an attempt has been made to build a model for linkage between both R&D activities and R&D output with firm performance. Discussion on these issues has been presented in the following text.

3.4.1 Organizational Level Variables affecting R&D Output

A regression model has been fitted to find out the organizational level variables affecting R&D output in case of Indian Manufacturing sector. R&D output, for the purpose of this research, has been measured on basis of patent applications, patent granted and total citations of patents of a given firm. Total citations included both backward citations and forward citations. Explanatory variables used for estimating the regression equation included R&D expenditure, Size of firm, Age of firm, Export intensity, Leverage, and type of ownership. For estimating the models both current as well as lagged R&D expenditure have been considered. Because lagged values of R&D expenditure are also expected to impact the R&D output of a firm. For capturing the sector specific effects dummy variables for various sectors were also included in the estimation process. There are seven sectors included in the study,

Table 94: Regression Model (Dependent Variable: Patent Applications)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
R&D	0.007117 **	-	-	-	-	-
R&D (Lag 1)	-	0.008938**	-	-	-	-
R&D (Lag 2)	-	-	0.010982**	-	-	-
R&D (Lag 3)	-	-	-	0.012308**	-	-
R&D (Lag 4)	-	-	-	-	0.013321**	-
R&D (Lag 5)	-	-	-	-	-	0.017180**
Export Intensity	-5.382888**	-5.005784**	-5.096984**	-5.244677**	-5.464410**	-5.560063**
Total Assets	8.82E-07	3.50E-07	8.19E-07	2.50E-06	4.54E-06	4.97E-06
Age	0.017698	0.022431	0.025643	0.031496	0.042628	0.059141
Leverage	-0.078417	-0.161677	-0.069130	-0.072093	-0.065582	-0.065414
Foreign_DUMMY	3.564182	3.512165	3.513571	2.971671	2.060219	3.236555
INDMFGDUMMY	2.684763	2.592059	2.655971	2.610518	3.166298	5.365160
ENERGYDUMMY	-2.180528	-2.133037	-2.524746*	-4.101783*	-5.470825*	-4.849115*
METALDUMMY	5.533609**	5.811426**	5.700367**	4.831038*	4.161427	5.992954*
PHARMADUMMY	5.333966**	5.168211**	5.102083**	5.245407**	5.934260*	7.481225**
TEXTILEDUMMY	0.766173	0.773262	0.688534	0.000538	-0.336173	1.003135
CONSUMER DUMMY	1.415781	1.472601	1.446156	0.718794	0.220736	1.824546
YD2	0.217654	-0.094136	-0.118928	0.109596	-1.215169	-2.043705
YD3	-0.964933	-1.117609	-1.462605	-0.969423	-1.180879	-3.938173*
YD4	2.485158	1.787154	1.962189	1.884508	1.965907*	-0.320298
YD5	2.420452	2.209081	1.450318	2.176430	1.613882	-0.504122
YD6	1.671799	1.246151	1.010540	1.316320	1.468945	-1.306659
YD7	-1.370521	-0.924771	-1.401861	-0.997170	-2.052884	-4.258910**
YD8	-1.812528	-2.266807	-1.553895	-1.488615	-1.539186	-3.919957
YD9	-0.291177	-0.721885	-1.079554	0.338522	-0.067956	-2.466549
YD10	0.013867	-0.659858	-1.151751	-0.735987	0.291478	-2.733925
R-squared	0.345148	0.363547	0.359866	0.291824	0.246638	0.246874
Adjusted R-squared	0.334670	0.353207	0.349286	0.279872	0.233604	0.232122

*Significant at 5% level of significance,**Significant at 1% level of significance

therefore, six dummy variables for various sectors have been included. Automobile sector has been taken as the reference for introducing sectoral dummies in the model. Data used for estimation of regression equation spanned over a period of ten years i.e. from 2004-05 to 2013-14. To capture the effect of different time periods, year dummies have also been included in the model. Nine year dummies were introduced in the regression equation with the first time period (Year 2004-05) acting as the reference point. Different models were estimated using the secondary data and these models have been presented in Tables 94, 95, and 96. Results of regression model with patent applications as the dependent variable have been presented in Table 94.

It can be seen from the table that current as well as lagged R&D expenditure were having significant positive impact on patent applications. Further, it can be seen from table 94 that best model fit was found with lagged R&D expenditure with a lag of one year. Model 2 reveals better performance of pharmaceutical sector with respect to patent applications. Export intensity was having significantly negative relation with patent applications. This phenomenon may be on account of domestically operating firm going for large number of patent applications. Majority of year dummies introduced in the regression equation were not significant at 5 percent level of significance. Other explanatory variables such as size, age, leverage and ownership were not having significant impact on patent applications.

Results of various regression models with 'Patents Granted' as dependent variable have been presented in Table 95. It can be seen from table that current as well as lagged R&D expenditures were significant positive relation with 'Patents Granted'. It can also be seen from the table that model fits improved with the higher lags. This indicates that R&D expenditures are having significantly positive and lagged influence on patent grant. Time taken for conversion of R&D into patent application and subsequently into award of patent can be used as justification of the lag between R&D expenditure and patent grant. Three sectoral dummies for pharmaceutical, Metals and consumer goods were found to have significant and positive coefficients. This phenomenon is on account of better performance of these sectors vis a vis other sectors in terms of grant of patents. Export intensity was having positive and significant

Table 95 : Regression Model (Dependent Variable: Patents Granted)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
R&D	0.001554**					
R&D (Lag 1)		0.001882**				
R&D (Lag 2)			0.002476**			
R&D (Lag 3)				0.003436**		
R&D (Lag 4)					0.004769**	
R&D (Lag 5)						0.005855**
Export Intensity	2.841276**	2.841805**	3.072004**	3.251580**	3.444224**	3.662406**
Total Assets	-1.93E-07	-1.75E-07	-2.79E-07	-4.56E-07	-5.85E-07	-5.98E-07
Age	-0.002089	-0.000919	0.000315	0.001615	0.002605	0.006654
Foreign_DUMMY	1.359807	1.360625	1.418977	1.497524	1.566858	1.599092
INDMFGDUMMY	-0.636230	-0.636147	-0.566637	-0.584054	-0.636991	-0.105195
ENERGYDUMMY	0.560049	0.510061	0.699066	0.774546	0.735180	1.205840
METALDUMMY	1.146178*	1.159366*	1.362140**	1.466092**	1.462406**	1.935300**
PHARMADUMMY	4.673132**	4.698860**	4.720941**	4.595703**	4.341107**	4.632137**
TEXTILEDUMMY	0.163191	-0.077220	-0.134849	-0.153983	-0.158742	0.303348
CONSUMER DUMMY	0.995802*	1.025737*	1.189600*	1.225843*	1.199870*	1.612802
Leverage	-0.025128	-0.022877	-0.020442	-0.019423	-0.019998	-0.012348
YD2	-0.831106	-0.948939*	-1.121197*	-1.110295*	-1.137028*	-1.814050
YD3	-0.349476	-0.420677	-0.739748	-0.819055	-0.722302	-1.710511
YD4	0.815055	0.674305	0.634174	0.300311	0.303226	-0.029883
YD5	-0.368168	-0.391769	-0.801348	-0.942631	-1.175940	-1.684134
YD6	-0.894923	-0.972832	-1.132319*	-1.361201*	-1.454610*	-2.165410*
YD7	-0.925458	-0.840872	-1.130153	-1.314504*	-1.484025*	-1.927528
YD8	-1.312785*	-1.505523**	-1.610460*	-1.906374**	-2.075805**	-2.713109*
YD9	-1.083956*	-1.141478*	-1.528935**	-1.641860*	-1.933994**	-2.553162*
YD10	-0.829415	-0.944982	-1.280269*	-1.645087*	-1.617118*	-2.360111*
R-squared	0.153940	0.153549	0.161895	0.169567	0.172751	0.175167
Adjusted R-squared	0.140903	0.140313	0.148560	0.156086	0.158964	0.159589

*Significant at 5% level of significance,**Significant at 1% level of significance

Table 96: Regression Model (Dependent Variable: Citations)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
R&D	0.005115**					
R&D (Lag 1)		0.005871**				
R&D (Lag 2)			0.007498*			
R&D (Lag 3)				0.009995*		
R&D (Lag 4)					0.015184**	
R&D (Lag 5)						0.017087**
Export Intensity	7.183048**	7.289351**	7.865360**	8.673206**	9.084357**	8.599046**
Total Assets	-6.24E-07	-3.26E-07	-4.74E-07	-6.93E-07	-1.91E-06	-1.48E-06
Age	-0.024928	-0.022141	-0.017823	-0.012529	-0.012648	-0.012391
Foreign_DUMMY	2.048726	2.056003	2.000224	2.079376	2.182594	0.723025
INDMFGDUMMY	-0.602203	-0.873510	-0.981557	-1.089518	-1.225207	-0.226988
ENERGYDUMMY	4.035266	3.697656	3.898695	3.860743	4.306002	4.779521
METALDUMMY	3.426833*	2.983214	3.164874	3.109445	3.600526	3.349765
PHARMADUMMY	16.49706**	16.49151**	16.34592**	16.12473**	14.99238**	15.42483**
TEXTILEDUMMY	2.673179	0.873746	0.853152	0.513439	0.799452	1.172301
CONSUMER DUMMY	3.285491**	3.051792**	3.112057**	3.124502*	3.331932*	3.017180*
Leverage	-0.030905	0.025382	-0.024472	-0.017674	-0.011536	0.018703
YD2	-2.976776*	-3.114773*	-3.336436**	-3.314297**	-3.411485*	-3.609463*
YD3	0.205736	0.511890	-0.170688	-0.420611	-0.060337	-1.889332
YD4	-4.554331**	-4.513837**	-4.624613**	-5.322200**	-5.493850**	-4.983494**
YD5	-2.623835	-2.448118	-2.906184	-3.062141	-3.782897*	-3.385803
YD6	-2.961963	-2.870294	-3.237246*	-3.776435*	-3.850690*	-4.035419*
YD7	-0.678908	-0.115930	-0.523258	-0.949765	-1.568959	-0.534129
YD8	-2.662493*	-3.171848	-3.091680	-3.826418	-4.573062*	-4.170728
YD9	-2.642424	-2.423993	-2.891461	-3.194199	-4.193552	-3.899025
YD10	-2.987923	-2.836468	-3.394600	-4.361454*	-4.665077*	-4.639144
R-squared	0.199573	0.192845	0.195887	0.200839	0.216643	0.221003
Adjusted R-squared	0.187220	0.180204	0.183072	0.187845	0.203554	0.206292

*Significant at 5% level of significance,**Significant at 1% level of significance

coefficient. This indicates that companies with fair share of export in their sales were having relatively higher grants of patents. Few year dummies were found to be significant. Remaining explanatory variables such as size, age, leverage and ownership were not having significant impact on Patent grants.

Using the same set of explanatory variables alternative models were built with citations as the dependent variable. These results have been presented in table 96. It can be seen from the table that current and lagged R&D expenditures were having positive and significant coefficients. This indicates positive relation between R&D expenditure and citations. Further better model fitting was found with lagged R&D expenditures. This phenomenon is similar to granted patents. Sector dummies for pharmaceutical and consumer goods sector were found to have positive and significant coefficients. This indicates better performance of these sectors vis a vis other sectors on the basis of patent citations. Export intensity was having positive and significant impact on citations. While the remaining variables such as size, age, ownership and leverage were not having significant impact on citations.

3.4.2 Models Linking R&D Activities and Output with Firm Performance

Regression models with firm performance as dependent variable are discussed in the following text. Tobin's Q has been taken as the proxy for firm performance. There are number of studies that have used Tobin's Q as measure of firm performance. Explanatory variables used for the estimation included current and lagged R&D expenditures, Export intensity, Age, Selling and General Administrative expenses, ownership and leverage. To deal with the issues of Autocorrelation and Heteroscedasticity, HAC (Heteroscedasticity and Autocorrelation Consistent) standard errors were used by employing Newey - West method. This estimation procedure taken care of problems related to Heteroscedasticity and Autocorrelation (Gujarati, 2007). Fitted models were also checked for multicollinearity and these models were meeting the assumption of multicollinearity.

Estimated regression models have been presented in table 97. It can be seen from table 97 that current and lagged R&D expenditure variables were having positive and significant impact on firm performance. Further, it can be seen that value of coefficients of determination

Table 97: Regression Models- I (Dependent Variable: Tobin's Q)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
R&D	6.97E-05**					
R&D (Lag 1)		6.38E-05**				
R&D (Lag 2)			9.21E-05*			
R&D (Lag 3)				0.000135*		
R&D (Lag 4)					0.000202*	
R&D (Lag 5)						0.000307*
Export Intensity	0.217675	0.355576	-0.002055	-0.029620	-0.174188	-0.473331
SGA Expenses	3.71E-06	4.66E-06	4.64E-06	4.12E-06	3.36E-06	2.81E-06
Age	0.000700	0.001325	-0.000569	-0.000972	-0.001942	-0.004886**
Foreign_DUMMY	1.689430**	1.649163**	1.670584**	1.693084**	1.712990**	1.845962**
INDMFGDUMMY	0.211147	0.181417	0.237979*	0.268151*	0.290595*	0.188390
ENERGYDUMMY	-0.044575	-0.077379	-0.043400	-0.000256	0.020098	-0.088707
METALDUMMY	0.236097	0.055983	0.089796	0.142468	0.161888	0.089519
PHARMADUMMY	1.257295**	1.261112**	1.284052**	1.268326**	1.277506**	1.126629**
TEXTILEDUMMY	-0.211190	-0.253432	-0.127638	-0.092873	-0.066177	-0.089956
CONSUMER DUMMY	1.413582**	1.389591**	1.433293**	1.456440**	1.450695**	1.365547**
Leverage	-0.109980	-0.106818	-0.099964	-0.101249	-0.094942	-0.093379
YD2	1.120621**	1.038610**	1.179896**	1.158890**	1.255695**	1.419170**
YD3	0.646132**	0.683611**	0.753957**	0.785163**	0.809495**	1.093181**
YD4	0.592182	0.716774**	0.694518**	0.666532**	0.747039**	0.988216**
YD5	0.077967	-0.036220	0.145424	0.072091	0.113548	0.398600*
YD6	0.850489**	0.825270**	0.789879**	0.909458**	0.874676**	1.066627**
YD7	0.872063**	0.760775**	0.870317**	0.777024**	0.895871**	1.098026**
YD8	0.636999**	0.612364**	0.741042**	0.744826**	0.770275**	1.015178**
YD9	0.611723**	0.591521**	0.705702**	0.720936**	0.769821**	0.957862**
YD10	0.839396**	0.779535**	0.894105**	0.899412**	0.948246**	1.216322**
R-squared	0.244049	0.231839	0.262261	0.256867	0.276560	0.310170
Adjusted R-squared	0.231827	0.219287	0.250026	0.244293	0.264011	0.296710

*Significant at 5% level of significance,**Significant at 1% level of significance

Table 98 : Regression Models- II (Dependent Variable: Tobin's Q)

Variable	Model 7	Model 8	Model 9	Model 10
Applications	0.007031*			
R&D Intensity		0.067056**		
Grant			0.006249	
Total Citations				-0.000248
Export Intensity	-0.280263	-0.355931	-0.204270	-0.194702
SGA Expenses	4.72E-06*	7.17E-06*	5.45E-06*	6.11E-06*
Age	0.002156	-0.000422	0.002136	0.002104
Foreign_DUMMY	1.501368**	1.679479**	1.491238**	1.495979**
INDMFGDUMMY	0.248882*	0.296214	0.260391**	0.254197*
ENERGYDUMMY	-0.097690	-0.134533	-0.080760	-0.091591
METALDUMMY	0.378648	0.302207	0.322508	0.306254
PHARMADUMMY	1.535403**	1.110999**	1.530075**	1.567954**
TEXTILEDUMMY	0.224024	-0.050639	0.199994	0.199375
CONSUMER DUMMY	1.060868**	1.433269**	1.082631**	1.079473**
Leverage	-0.147496	-0.102050	-0.150706	-0.150995
YD2	0.987950**	1.215067**	0.989852**	0.993313**
YD3	0.656880**	0.749777**	0.677679**	0.684539**
YD4	0.742883**	0.704183**	0.772664**	0.783471**
YD5	0.129913	0.131908	0.129520	0.136517
YD6	0.963149**	0.882101**	0.962455**	0.967511**
YD7	0.896821**	0.837131**	0.881554**	0.887617**
YD8	0.726517**	0.762882**	0.732010**	0.736385**
YD9	0.678952**	0.663968**	0.677043**	0.683101**
YD10	0.804417**	0.939026**	0.806901**	0.814442**
R-squared	0.172905	0.353804	0.182412	0.181542
Adjusted R-squared	0.163430	0.343271	0.173471	0.172562

*Significant at 5% level of significance,**Significant at 1% level of significance

increased with higher lags of R&D expenditure. This indicates presence of lagged effect of R&D expenditure with firm performance. Sector dummies for consumer goods and pharmaceutical sector were found to be positive and significant. This indicates better performance of these sectors in terms of translating R&D inputs into firm performance. Significant and positive coefficient of foreign ownership dummy indicates the superiority of firms with foreign ownership over domestic firms. Majority of year dummies were found to statistically significant. The remaining variables such as export intensity, leverage and selling & general administrative expenses were not having significant impact on the measure of firm performance. Table 98 presents the results of regression models using various measures of patent output such as patent applications, patent granted and citations as explanatory variables of firm performance. It can be seen from the table that patent applications were having significant and positive relation with Tobin's Q. R&D intensity was also having significant and positive relation with firm performance. Numbers of patents granted as well as citations were not having any significant impact on firm performance. Sectoral dummies for Pharmaceutical and Consumer goods were having significant and positive coefficients. Majority of year dummies were also found to be significant. It can be seen from the table that foreign dummy was having significant and positive relationship with the firm performance. This indicates that the firms with foreign ownership were doing better than their Indian counterparts in terms of translating R&D efforts into firm performance. Better R&D management and presence of collateral assets could be the reason for this phenomenon.

Chapter 4

MAJOR FINDINGS & SUGGESTIONS

Major findings of the research project have been summarized in this chapter. Based on the results of the research, an attempt has also been made to identify the prominent issues and make suggestions with respect to such issues.

4.1 Major Findings

Major findings of the research project have been summarized as follows:

1. Positive trend coefficients were found across all the sectors for different types of intellectual capital disclosures with the exception of Pharmaceuticals and Textiles. In case of Pharmaceuticals sector, negative trend coefficient was observed for structural capital. This may be attributed to the fact that qualitative intellectual capital disclosures have already hit a peak in case of Pharmaceutical sector. In case of relational capital disclosures no significant trend was found for pharmaceutical sector. For textile sector, no significant trend coefficient was observed for Structural Capital and Human Capital disclosures. Overall increasing trends in Qualitative Disclosures have also been advocated by Abeysekara and Guthrie (2005). Qualitative disclosures are important because these help the companies to bridge the gap between the financial statements and the economic reality of firms' operations (Glassman 2003). Increased disclosure may also lead to lower information asymmetry and an increase in market liquidity (Leuz and Verracchia, 2000).

2. There was a significant difference across various sectors in terms of relational capital disclosures. Highest relational capital disclosures were found in case of Consumer Goods sector. Relatively lesser Relational Capital disclosures were observed in case of Industrial Manufacturing and Metals. This phenomenon may be attributed to the nature of business. It is common for Consumer Goods companies to emphasize more on Relational Capital disclosures as these companies deal with retailers and individual

consumers. On the other hand, Industrial Manufacturing and Metal companies largely deal with business consumers.

3. Significant variations, across the sectors were found in terms of Structural Capital disclosures. Pharmaceutical sector was the leader in such disclosures while relatively lesser Structural Capital disclosures were observed in case of Textile sector. Structural capital is considered as a critical dimension in the Pharmaceutical sector. Therefore, highest structural capital disclosures have been observed for this sector.
4. Various sectors were also having significantly different human capital disclosures. Highest human capital disclosures were observed in case of Pharmaceutical sector while lowest human capital disclosures were observed in case of Textile sector. Significant differences have been observed across various sectors and these results are consistent with the evidence available in literature (Guthrie et al 2006 and Razak and Tosiagi 2016). The difference in the disclosures across the sectors may be there on account of nature of business, size of organisations and management policies regarding disclosures.
5. Generally, a significant positive correlation between Qualitative Disclosures and various measures of firm performance has been observed. These results are supported by the findings of Andreeva and Garanina (2016), Cleary (2015), and Felicio et al (2014).

6. For R&D Expenditure, positive trend coefficients were observed for all the sectors. While for R&D Intensity, positive trend coefficients were found in all the sectors with the exception of Energy, Metal, and Textile sectors . This means for these three sectors although R&D expenditure has increased but R&D expenditure has not been able to keep pace with sales of the company. This phenomenon indicates that R&D activities do not assume much significance for these sectors.
7. A significant variation, across the sectors was observed for R&D expenditure. Pharmaceutical sector was found to be leading on this front followed by Automobile sector and Industrial manufacturing sector. Least R&D expenditure was found in case of Textile and Consumer goods sector.

8. Pharmaceutical sector was having highest R&D intensity across all the sectors over the period of study. R&D intensity for pharmaceutical sector was found to be around 7 percent. For the rest of the sector R&D intensity was found to be less than one percent. Lowest R&D intensity was observed for Energy and Textile sectors.
9. A positive growth trend was witnessed for patent applications across various sectors with the exception of Consumer Goods, Metals and Pharmaceutical sectors.
10. Maximum patent application activity was found in case of Pharmaceutical sector followed by Automobile and Industrial manufacturing sector. On the other hand least patent applications were found in case of Textile and Energy sector.
11. In terms of grant of patents, a positive growth trend can be seen for Automobile, Industrial Manufacturing, Metals and Pharmaceuticals sectors.
12. On an average maximum number of patents were granted to Pharmaceutical Sector followed by Consumer Goods sector. Least number grant of patents was found for Energy sector and Metal sector.
13. As far as citations are concerned, positive growth trend was found for forward citations in case of Industrial Manufacturing; forward citations and total citations in case of pharmaceutical sector; and backward citations in case of Textile sector.
14. Pharmaceutical sector and consumer goods sector were leading in terms of backward citations while other sectors scored quite low on this count. Various sectors had significant variations on the basis of backward citations.
15. Consumer goods and Pharmaceutical sectors were leading in forward citations. Significant variation was found on the basis of this dimension across various sectors. Similar results were obtained for total citations as well.
16. Implications of intellectual capital score based methodologies for various measures of firm performance are significant. It can be seen that there is significant predictability of firm performance in terms of monthly returns, Tobin's Q, ROCE, ROTA and RONW for these methodologies. Intellectual capital has been considered value relevant for the organisations on account of their impact on the relationships with investors (Barth et al 2001, Gelb 2002, and Wyatt and Abernetny 2008).

17. Patent applications were also having significant implications for all measures of firm performance such as monthly returns, Tobin's Q, ROCE, ROTA and RONW. This indicates the value relevance of patent applications in context of firm performance. These results are consistent with the previous evidence regarding the relation between patenting activity and firm performance and supported by various studies such as Bosworth and Roger (2001), Shane (2001), Chen and Chang (2010), Hall et al (2013), Koen (2013), and Rakho (2014).
18. Patent grant was not having significant implication for any measure of firm performance except Tobin's Q.
19. Patent citations were not having significant implication for any of the firm performance measures. This indicates no value relevance of patent quality in context of firm performance.
20. R&D intensity was having significant implications for firm performance for all measures except monthly returns. This means R&D intensity is having significant predictability of firm performance.
21. Majority of the companies covered under survey were having separate R&D unity in the organization and on an average 407 persons were working in R&D departments of Indian manufacturing firms.
22. Major focus of R&D activities was found to be on product development and relatively lesser focus was observed for basic research and applied research. Lack of focus on basic research is quite evident from the results of the study.
23. Significant variation, across sectors, was observed regarding the focus on basic research. Pharmaceutical, Energy, and Automobile sectors were having relatively higher focus as compared to other sectors. On the other hand, least focus on basic research was observed in case of Textile sector.
24. Indian manufacturing companies were found to focus more on product R&D as compare to process R&D.
25. For technology acquisition, major focus of companies was to conduct In-house R&D. Setting up Joint Ventures came as a distant second option. Other sources such as

contracting out, licensing in and cross licensing were low in terms of importance assigned.

26. Significant variation was found across the sectors for all sources of technology acquisition except for in-house R&D.
27. Customer induced channel was the main channel for flow of technology in the companies followed by Planned Channels and Reverse Engineering.
28. Significantly higher importance was accorded to 'Reverse Engineering' in case of Pharmaceuticals and Textile sectors.
29. R&D outputs were being exploited by Indian manufacturing companies largely by embedding the outputs in their own products and production processes . Activities such as licensing out and cross licensing were found to be lowly rated.
30. Companies reported considerable research partnerships/associations with Universities and academic institutes both with in India and Abroad. More participation in International Research consortia was seen as compared to national research consortia. Least number of partnerships were reported with Government Research Labs.
31. Companies largely view R&D activities in supporting role to sustain in the competitive environment.
32. There was a lack of use of formal assessment techniques for the evaluation of R&D investments in Indian Manufacturing sector.
33. Inadequate availability of skilled manpower was the major hurdle prevalent in R&D arena.
34. One third of the companies were not having any R&D policy in place.

4.2 Major Issues and Suggestions

Major issues identified from the results of the study have been listed in the following section. An attempt has also been made to suggest measures for tackling the identified issues.

1. In general, positive growth trends have been witnessed in case of R&D expenditure, R&D intensity and patent applications for Indian Manufacturing sector. This is

encouraging to find that Indian manufacturing companies are paying more attention to R&D related activities. But comparison with global averages of top 2500 companies indicates that a lot needs to be done on this front. Table 99 presents the comparison of R&D intensities of various sectors for Indian and global benchmarks for the period 2005-2014 . It can be seen from table 99 that average R&D intensity for Indian pharmaceutical sector is almost half of average global R&D intensity.

Table 99 : Comparison of R&D Intensity (in percent) : 2005-2014

Sector	Global Average	Indian Average
Pharmaceuticals	14.13	7.04
Automobile	5.58	0.64
Industrial Manufacturing	4.76	0.72
Oil and Gas	2.79	0.09
Metal	2.51	0.09

Author's Calculations, Global Average is calculated on basis of top 2500 companies worldwide as per EU Industrial R&D Scoreboards

The gap becomes more pronounced in case of other sectors such as Automobile, Industrial Manufacturing, Oil and Gas, and Metals. Therefore there is pertinent need to step up pace in R&D domain on part of Indian manufacturing firms. Vigorous efforts are required on this front as Indian companies will have to go a long way to wipe out the gap between domestic scenario and global benchmarks.

2. For exploiting the fruits of R&D investment a multi phase mechanism needs to be put in place. R&D investments are converted into R&D outputs and further these R&D outputs are commercialized to the advantage of the investing firm. Results of the study indicate that patent applications were having value relevance for firm performance but patent grant and patent citations (taken as proxy for patent quality) were not having significant implications for firm performance. This phenomenon indicates information asymmetry and lack of knowledge on part of investors, financial analysts and other stakeholders. Patent application is merely a preliminary step in the process of innovation and related appropriation. It seems that in Indian scenario predictability value of firm performance is limited only to filing patent application and not much attention is paid to patent grant, the quality

of patent and commercial exploitation. There is need to undertake urgent measures so as to transform ‘Quantitative Orientation’ towards 'Qualitative Orientation'. Qualitative orientation will ensure that value relevance is in place not only for patent applications but for more significant and vital downstream activities such as patent grant, patent quality and commercial exploitation of innovation.

3. Tendency on part of Indian manufacturing companies to go alone is quite evident from the results. It has been seen that right from 'acquisition of technology' to 'exploitation of technology' Indian manufacturing companies tend to work in isolation. Given the global competitive scenario, it is important to ensure that there is reasonable extent of networking among Indian manufacturing companies in the domain of R&D. Collaborative efforts within the national boundaries were found to be less compared to international collaborations. Therefore, there is an urgent need of a policy intervention that can provide the suitable platforms and forums for networking among Indian manufacturing companies in the domain of creation, acquisition and commercial exploitation of technology.
4. Results of Primary data based survey also point towards the immaturity of technology markets in India. For the majority of the sectors, 'Licensing in' and 'Cross Licensing' options scored very low on importance scale, both for technology acquisition and commercialization. Low activity in these dimensions points that Indian technology markets lack growth and maturity. PATLICE Survey 2013 of European Committee also points to this issue. As per the survey, Asian Countries fall back considerably as licensees of European Technology and India ranks low on this count (Radauer and Dudenbostel, 2013). Suitable policy measures may be put in place for boosting up the activities pertaining to licensing of technologies in Indian market.
5. Sector specificity has been observed from the results of the study. Significant variations across the sectors have been observed for R&D activities, R&D output and linkage between R&D activities and firm performance. The differences should be taken into account at the time of policy formulation. Sectors specify policies will be

more useful rather than blanket policy for the whole of the manufacturing sector. R&D is a critical dimension for this sector, therefore, a separate/distinct R&D policy initiatives are desirable for pharmaceutical sector. Existing sectoral policies should be reinforced with more focus on distinct R&D policy interventions.

6. Quality manpower availability and attrition of R&D manpower have emerged as the major hurdles in R&D landscape. There is a need for suitable initiatives so that Indian manufacturing companies get quality manpower with basic skills related to the respective domains. Another noticeable point is the fact that the majority of R&D operations are handled by technical hands that lack capacity in management skills.
7. Regression models suggest that foreign companies are not having much advantage over their Indian counterparts at the stage of patent applications. But these companies perform much better at the time of converting R&D efforts into firm performance. This phenomenon may be on account of presence of better collateral assets and superior technology management processes. There is a large scope of improvement on part of Indian companies when it comes to converting R&D efforts to firm performance vis a vis their foreign counterparts.
8. Companies covered under the survey agreed that formal techniques to assess R&D returns were not used. Lack of formal techniques to assess R&D returns can lead to inefficient R&D investment with lower levels of productivity. This phenomenon can potentially undermine the investment in R&D initiatives. Formal assessment of R&D investment is expected to improve the selection of R&D projects and enhance the R&D returns. Enhanced R&D returns may provide a boost to more investment in R&D activities. There is a need for undertaking capacity building initiatives in this context.
9. From the primary data based survey, it was revealed that one third of companies were not having any R&D policy in the organizations. R&D policy is considered vital for aligning R&D with the strategic goals of the organization and also provides a uniform directional framework for the organization as a whole. There is a need to

spread awareness and undertake capacity building among Indian manufacturing companies so that effective R&D management processes are put in place.

10. Improved Technology Management can be a potent tool for the aforementioned issues. 'Technology Management' is a popular domain in the western countries. But this subject is sparingly taught in India either as part of engineering education or management education curriculum. Improved R&D management on account of better technology management skills can provide a boost to productivity of R&D and related investment in Indian scenario. There is a need to ensure that technology management is taught in higher education institutes across the country.

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Annexure-I

Keywords for Qualitative Disclosures

Relational Capital	**Structural Capital**	**Human Capital**
Alliance	R&D	Training
Joint Venture	Product Development	Industrial Relation
Customer Integration	Know how	Human Resource
Supplier Integration	Technology Initiative	Productivity
Collaboration	Licensing	Employee Satisfaction
Regulatory Approach	Innovation Revenues	Sales per Employee
Brand	Patent	Human Capital
Online sale	Trademark	Employee Turnover
Capital Market	Copyright	
Customer Relationship	Intellectual Property	
Customer Service	First Move	
Customer Acquisition	Goodwill	
Supplier	Royalty	
New Customer	Commercialisation	
Customer Turnover		
Major Customer		

Annexure-II
List of Companies included in the Study

Company	Sector
A B B India Ltd.	Industrial Manufacturing
A B G Shipyard Ltd.	Industrial Manufacturing
A I A Engineering Ltd.	Industrial Manufacturing
Aban Offshore Ltd.	Energy
Advanta Ltd.	Consumer Goods
Agro Tech Foods Ltd.	Consumer Goods
Ajanta Pharma Ltd.	Pharmaceutical
Akzo Nobel India Ltd.	Consumer Goods
Alembic Pharmaceuticals Ltd.	Pharmaceutical
Alok Industries Ltd.	Textiles
Alstom India Ltd.	Industrial Manufacturing
Alstom T & D India Ltd.	Industrial Manufacturing
Amara Raja Batteries Ltd.	Automobile
Amtek Auto Ltd.	Automobile
Amtek India Ltd.	Automobile
Apar Industries Ltd.	Industrial Manufacturing
Apollo Tyres Ltd.	Automobile
Arvind Ltd.	Textiles
Asahi India Glass Ltd.	Automobile
Ashok Leyland Ltd.	Automobile
Asian Paints Ltd.	Consumer Goods
Astral Poly Technik Ltd.	Industrial Manufacturing
Astrazeneca Pharma India Ltd.	Pharmaceutical
Aurobindo Pharma Ltd.	Pharmaceutical
Automotive Axles Ltd.	Automobile
B E M L Ltd.	Industrial Manufacturing
Bajaj Auto Ltd.	Automobile
Bajaj Corp Ltd.	Consumer Goods
Bajaj Electricals Ltd.	Consumer Goods
Bajaj Hindusthan Ltd.	Consumer Goods
Balkrishna Industries Ltd.	Automobile
Balrampur Chini Mills Ltd.	Consumer Goods
Bata India Ltd.	Consumer Goods
Berger Paints India Ltd.	Consumer Goods

Bharat Electronics Ltd.	Industrial Manufacturing
Bharat Forge Ltd.	Industrial Manufacturing
Bharat Heavy Electricals Ltd.	Industrial Manufacturing
Bharat Petroleum Corpn. Ltd.	Energy
Biocon Ltd.	Pharmaceutical
Blue Star Ltd.	Consumer Goods
Bombay Burmah Trdg. Corpn. Ltd.	Consumer Goods
Bombay Dyeing & Mfg. Co. Ltd.	Textiles
Bosch Ltd.	Automobile
Britannia Industries Ltd.	Consumer Goods
C E S C Ltd.	Energy
Cadila Healthcare Ltd.	Pharmaceutical
Cairn India Ltd.	Energy
Carborundum Universal Ltd.	Industrial Manufacturing
Castrol India Ltd.	Energy
Century Enka Ltd.	Textiles
Century Plyboards (India) Ltd.	Consumer Goods
Chennai Petroleum Corpn. Ltd.	Energy
Cipla Ltd.	Pharmaceutical
Coal India Ltd.	Metals
Colgate-Palmolive (India) Ltd.	Consumer Goods
Crompton Greaves Ltd.	Industrial Manufacturing
Cummins India Ltd.	Industrial Manufacturing
D C M Shriram Inds. Ltd.	Consumer Goods
Dabur India Ltd.	Consumer Goods
Dishman Pharmaceuticals & Chemicals Ltd.	Pharmaceutical
Divi'S Laboratories Ltd.	Pharmaceutical
Dr. Reddy'S Laboratories Ltd.	Pharmaceutical
Eicher Motors Ltd.	Automobile
Elder Pharmaceuticals Ltd.	Pharmaceutical
Electrosteel Castings Ltd.	Industrial Manufacturing
Elgi Equipments Ltd.	Industrial Manufacturing
Emami Ltd.	Consumer Goods
Esab India Ltd.	Industrial Manufacturing
Escorts Ltd.	Automobile
Ess Dee Aluminium Ltd.	Industrial Manufacturing
Essel Propack Ltd.	Industrial Manufacturing

Exide Industries Ltd.	Automobile
F A G Bearings India Ltd.	Industrial Manufacturing
F D C Ltd.	Pharmaceutical
Federal-Mogul Goetze (India) Ltd.	Automobile
Finolex Cables Ltd.	Industrial Manufacturing
Finolex Industries Ltd.	Industrial Manufacturing
Flexituff International Ltd.	Industrial Manufacturing
Future Retail Ltd.	Consumer Goods
G A I L (India) Ltd.	Energy
Gabriel India Ltd.	Automobile
Gillette India Ltd.	Consumer Goods
Gitanjali Gems Ltd.	Consumer Goods
Glaxosmithkline Consumer Healthcare Ltd.	Consumer Goods
Glaxosmithkline Pharmaceuticals Ltd.	Pharmaceutical
Glenmark Pharmaceuticals Ltd.	Pharmaceutical
Godfrey Phillips India Ltd.	Consumer Goods
Godrej Consumer Products Ltd.	Consumer Goods
Godrej Industries Ltd.	Consumer Goods
Graphite India Ltd.	Industrial Manufacturing
Greaves Cotton Ltd.	Industrial Manufacturing
Gujarat Industries Power Co. Ltd.	Energy
Gujarat Mineral Devp. Corpn. Ltd.	Metals
Gujarat N R E Coke Ltd.	Metals
Gujarat State Petronet Ltd.	Energy
H E G Ltd.	Industrial Manufacturing
H S I L Ltd.	Consumer Goods
Havells India Ltd.	Consumer Goods
Heritage Foods Ltd.	Consumer Goods
Hero Motocorp Ltd.	Automobile
Himatsingka Seide Ltd.	Textiles
Hindalco Industries Ltd.	Metals
Hindustan Copper Ltd.	Metals
Hindustan Oil Exploration Co. Ltd.	Energy
Hindustan Petroleum Corpn. Ltd.	Energy
Hindustan Unilever Ltd.	Consumer Goods
Hindustan Zinc Ltd.	Metals
Honeywell Automation India Ltd.	Industrial Manufacturing

I T C Ltd.	Consumer Goods
Indian Metals & Ferro Alloys Ltd.	Metals
Indian Oil Corpn. Ltd.	Energy
Indraprastha Gas Ltd.	Energy
Ingersoll-Rand (India) Ltd.	Industrial Manufacturing
Ipca Laboratories Ltd.	Pharmaceutical
J B Chemicals & Pharmaceuticals Ltd.	Industrial Manufacturing
J K Tyre & Inds. Ltd.	Automobile
J S W Energy Ltd.	Energy
J S W Steel Ltd.	Metals
Jai Corp Ltd.	Industrial Manufacturing
Jain Irrigation Systems Ltd.	Industrial Manufacturing
Jaiprakash Power Ventures Ltd.	Energy
Jindal Saw Ltd.	Metals
Jindal Stainless Ltd.	Metals
Jindal Steel & Power Ltd.	Metals
Jubilant Foodworks Ltd.	Consumer Goods
Jubilant Life Sciences Ltd.	Pharmaceutical
Jyothy Laboratories Ltd.	Consumer Goods
Jyoti Structures Ltd.	Energy
K S B Pumps Ltd.	Industrial Manufacturing
K S K Energy Ventures Ltd.	Energy
Kalpataru Power Transmission Ltd.	Energy
Kansai Nerolac Paints Ltd.	Consumer Goods
Kaveri Seed Co. Ltd.	Consumer Goods
Kesoram Industries Ltd.	Automobile
Kewal Kiran Clothing Ltd.	Textiles
Kitex Garments Ltd.	Textiles
Lakshmi Machine Works Ltd.	Industrial Manufacturing
Lovable Lingerie Ltd.	Textiles
Lupin Ltd.	Pharmaceutical
M R F Ltd.	Automobile
Maharashtra Scooters Ltd.	Automobile
Maharashtra Seamless Ltd.	Metals
Mahindra & Mahindra Ltd.	Automobile
Mandhana Industries Ltd.	Textiles
Mangalore Refinery & Petrochemicals Ltd.	Energy

Marico Ltd.	Consumer Goods
Maruti Suzuki India Ltd.	Automobile
Mcleod Russel India Ltd.	Consumer Goods
Mercator Ltd.	Metals
Merck Ltd.	Pharmaceutical
Monnet Ispat & Energy Ltd.	Metals
Motherson Sumi Systems Ltd.	Automobile
N H P C Ltd.	Energy
N M D C Ltd.	Metals
N T P C Ltd.	Energy
National Aluminium Co. Ltd.	Metals
Nava Bharat Ventures Ltd.	Energy
Neyveli Lignite Corpn. Ltd.	Energy
Nitin Fire Protection Inds. Ltd.	Industrial Manufacturing
Odisha Mining Corpn. Ltd.	Metals
Oil & Natural Gas Corpn. Ltd.	Energy
Oil India Ltd.	Energy
Opto Circuits (India) Ltd.	Pharmaceutical
Orchid Chemicals & Pharmaceuticals Ltd.	Pharmaceutical
P T C India Ltd.	Energy
Page Industries Ltd.	Textiles
Petronet L N G Ltd.	Energy
Pfizer Ltd.	Pharmaceutical
Pipavav Defence & Offshore Engg. Co. Ltd.	Industrial Manufacturing
Piramal Enterprises Ltd.	Pharmaceutical
Power Grid Corpn. Of India Ltd.	Energy
Praj Industries Ltd.	Industrial Manufacturing
Prakash Industries Ltd.	Metals
Procter & Gamble Hygiene & Health Care Ltd.	Consumer Goods
Radico Khaitan Ltd.	Consumer Goods
Rajesh Exports Ltd.	Consumer Goods
Ranbaxy Laboratories Ltd.	Pharmaceutical
Rasoya Proteins Ltd.	Consumer Goods
Ratnamani Metals & Tubes Ltd.	Metals
Raymond Ltd.	Textiles
Rei Agro Ltd.	Consumer Goods
Reliance Industrial Infrastructure Ltd.	Industrial Manufacturing

Reliance Industries Ltd.	Energy
Reliance Infrastructure Ltd.	Energy
Reliance Power Ltd.	Energy
Ruchi Soya Inds. Ltd.	Consumer Goods
S K F India Ltd.	Industrial Manufacturing
S R F Ltd.	Textiles
Sanofi India Ltd.	Pharmaceutical
Sesa Sterlite Ltd.	Metals
Shanthi Gears Ltd.	Automobile
Shasun Pharmaceuticals Ltd.	Pharmaceutical
Shoppers Stop Ltd.	Consumer Goods
Shree Renuka Sugars Ltd.	Consumer Goods
Shrenuj & Co. Ltd.	Consumer Goods
Siemens Ltd.	Industrial Manufacturing
Sintex Industries Ltd.	Industrial Manufacturing
Sona Koyo Steering Systems Ltd.	Automobile
Steel Authority Of India Ltd.	Metals
Sterlite Technologies Ltd.	Energy
Strides Arcolab Ltd.	Pharmaceutical
Sun Pharma Advanced Research Co. Ltd.	Pharmaceutical
Sun Pharmaceutical Inds. Ltd.	Pharmaceutical
Sundram Fasteners Ltd.	Automobile
Supreme Industries Ltd.	Industrial Manufacturing
Suzlon Energy Ltd.	Industrial Manufacturing
Swaraj Engines Ltd.	Industrial Manufacturing
T D Power Systems Ltd.	Industrial Manufacturing
T T K Prestige Ltd.	Consumer Goods
T V S Motor Co. Ltd.	Automobile
Tata Coffee Ltd.	Consumer Goods
Tata Global Beverages Ltd.	Consumer Goods
Tata Motors Ltd.	Automobile
Tata Power Co. Ltd.	Energy
Tata Sponge Iron Ltd.	Metals
Tata Steel Ltd.	Metals
Thermax Ltd.	Industrial Manufacturing
Titan Company Ltd.	Consumer Goods
Torrent Pharmaceuticals Ltd.	Pharmaceutical

Torrent Power Ltd.	Energy
Trent Ltd.	Consumer Goods
Tribhovandas Bhimji Zaveri Ltd.	Consumer Goods
Trident Ltd.	Textiles
Tube Investments Of India Ltd.	Consumer Goods
Uflex Ltd.	Industrial Manufacturing
Unichem Laboratories Ltd.	Pharmaceutical
United Breweries Ltd.	Consumer Goods
Usha Martin Ltd.	Metals
Uttam Galva Steels Ltd.	Metals
V I P Industries Ltd.	Consumer Goods
V S T Industries Ltd.	Consumer Goods
Vaibhav Global Ltd.	Consumer Goods
Vardhman Textiles Ltd.	Textiles
Venky'S (India) Ltd.	Consumer Goods
Vesuvius India Ltd.	Industrial Manufacturing
Videocon Industries Ltd.	Consumer Goods
Wabco India Ltd.	Automobile
Welspun Corp Ltd.	Metals
Welspun India Ltd.	Textiles
Wheels India Ltd.	Automobile
Whirlpool Of India Ltd.	Consumer Goods
Wockhardt Ltd.	Pharmaceutical
Zydus Wellness Ltd.	Consumer Goods

Annexure-III
Questionnaire for Primary Data Collection

Name of the Organization:
Year of Establishment:
Major Business Activity:
Q. 1 Do you have an R&D unit in the organization?

☐ Yes ☐ No

Q. 2(a) Please mention the name and designation of the person heading R&D activities in the organization.

Q. 2(b) Please mention the strength/number of persons engaging in R&D in your organization.

Q. 3 Please indicate the distribution of R&D efforts in the organization in the table given below.

Activity	**Percentage**
Basic Research	
Applied Research	
Development	
Sum Total	100%

Q. 4 Please indicate the emphasis on type of innovation/R&D in your organization:-

Type	**Share**
Product R&D	
Process R&D	
Sum Total	100 %

Q.5 Please indicate the importance of the following sources for technology acquisition on a scale of 1 to 5 (5: Most important, 1: Not important at all) in context of your organization.

Source	**5**	**4**	**3**	**2**	**1**
In- house R&D					
Contracting Out					
Joint Venture					
Licensing in					
Cross Licensing					
Non acquisition (Buying Final Product)					
Any other (Please specify….)					

Q. 6 Please indicate the importance of the following channels of technology flow, in context of your organization, on a scale of 1 to 5 (5: Most important, 1: Not important at all)

Channels	**5**	**4**	**3**	**2**	**1**
Reverse Engineering channel					
Planned channels (Licensing, JVs , Franchise, Technical consortium)					
Customer Induced					
Any other (please specify…………………………………………………….)					

Q. 7 Please indicate the importance of the following options for exploiting / commercializing R&D output, in context of your organization, on a scale of 1 to 5 (5: Most important, 1: Not important at all)

Options	**5**	**4**	**3**	**2**	**1**
Employ in own production/ products					
Contract out manufacture/ marketing					
Joint venture					
License out					
Cross licensing					
Any other (Please specify….)					

Q. 8 Please indicate research partnerships/ associations of your organization, during the last 7-10 years, in the table given below.

Entity	**Response**	**Name of Partners / Association (if any)**
National Research consortia	Yes ☐ No ☐	1. 2. 3.
International research consortia	Yes ☐ No ☐	1. 2. 3.
University / Academic institute	Yes ☐ No ☐	1. 2. 3.
Government Research Labs	Yes ☐ No ☐	1. 2. 3.

Q. 9 Please indicate your opinion about the following statements, in context of your organization on a scale of 1 to 5 (5: Strongly agree, 1: Strongly Disagree)

Statement	5	4	3	2	1
R&D is a primary function of the organization.					
R&D activities directly add to profitability of the firm.					
R&D activities indirectly add to profitability of the firm.					
Formal techniques to assess the returns of R&D are employed in the organization.					
Spending/Pace of R&D activities has increased over the past decade in the organization.					
R&D activities support the organization to sustain in the competitive landscape.					

Q. 10 Please rate the following hindrances to R&D in the organization on a scale of 1 to 5 (5: Most prevalent, 1: not prevalent at all)

Hindrance	5	4	3	2	1
Adequate and quality R & D manpower is not available					
Rate of attrition among R & D manpower is high					
Adequate R & D infrastructure is not available					
Any other(Please specify)..					

Q. 11 (a) Do you have an R&D policy in the organization?

☐ Yes ☐ No

(b) If yes , is R&D policy written and communicated .

☐ Yes ☐ No

Q. 12 (a) Do benefits of R&D outcome (such as patents) are shared with the inventors in the organization?

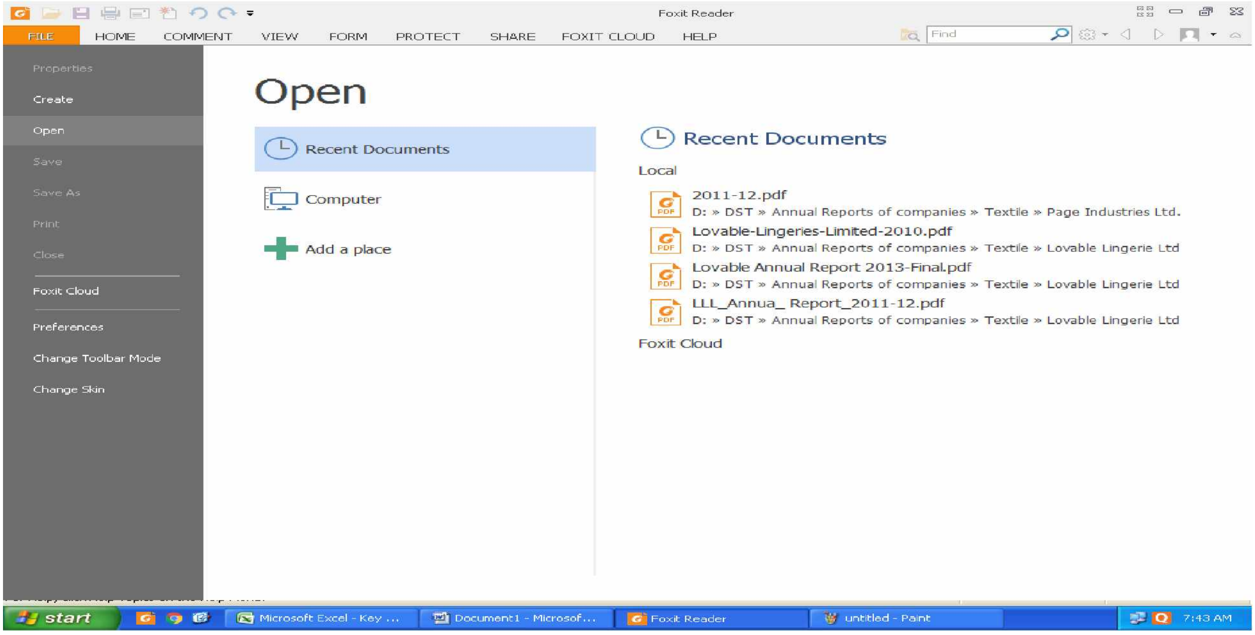
☐ Yes ☐ No

(b) If yes, please detail out the sharing mechanism.

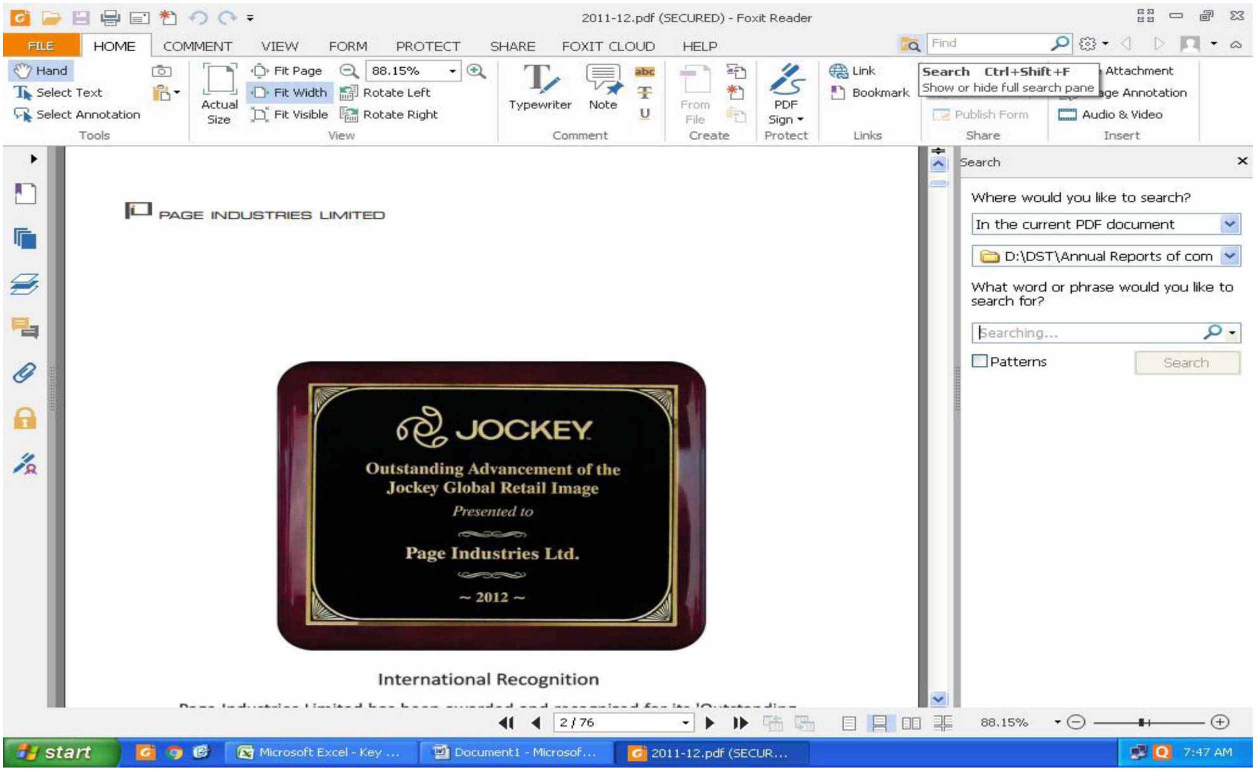
____

Annexure IV (Finding Keywords)

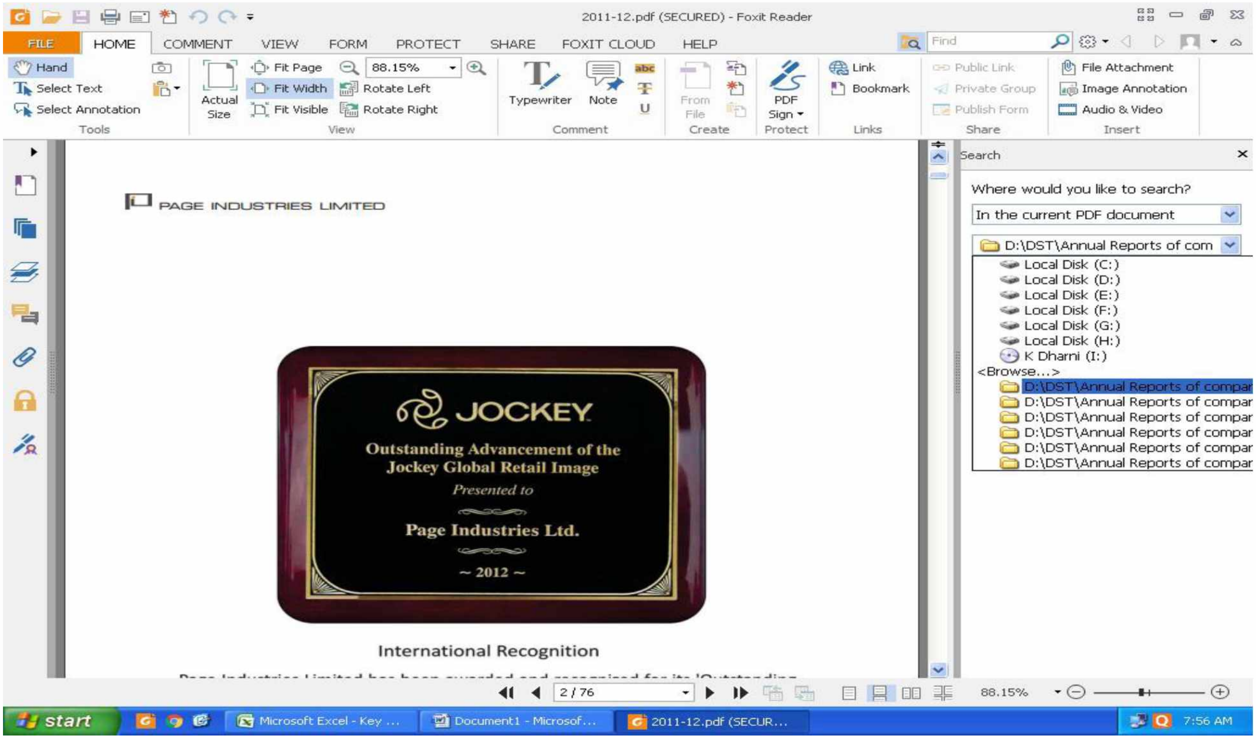
Step 1: Run Foxit Reader and open any file you want to search.



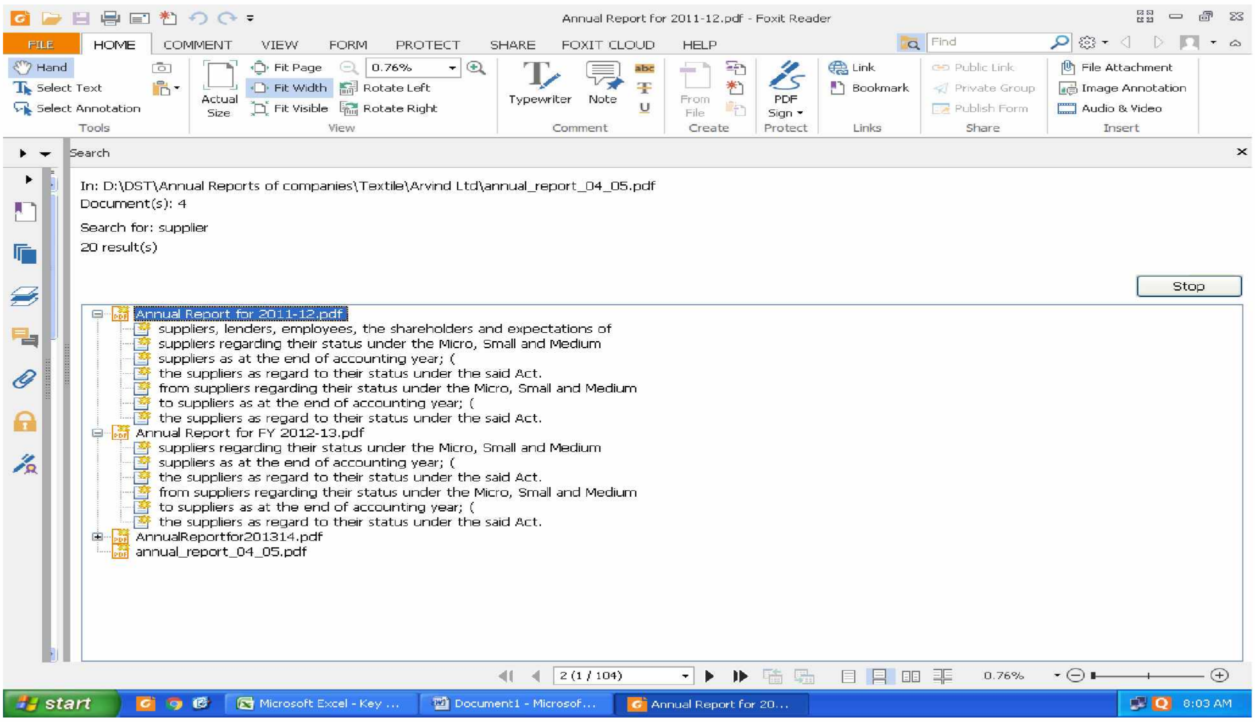
Step 2: Go to search button on right upper side and click it then advanced search option tab will pop out.



Step 3: Browse the folder or file you want search



Step 4: Enter keyword then click search button and count your results manually.



Annexure- V
Glossary of Key Terms Used

Acquisition of R&D Assets

Acquisition of R&D assets means acquiring the R&D assets either by creating these in-house or procuring these from outside sources. Major options for acquiring R&D assets include: In-house R&D, Joint Ventures, Contracting Out, Licensing In, Cross Licensing, Non-acquisition (Buying the final technology embedded product instead of acquiring technology).

Applied Research

Applied research is a methodology used to solve a specific, practical problem of an individual or group.

Backward Citations

Backward citations are number of citations in a firm's patent.

Basic Research

Basic research, also called pure research or fundamental research, is scientific research aimed to improve scientific theories for improved understanding or prediction of natural or other phenomena.

CMIE Prowess

Prowess is a database of the financial performance of over 27,000 companies. It includes all companies traded on the National Stock Exchange and the Bombay Stock Exchange. The Prowess database is built from Annual Reports, quarterly financial statements, Stock Exchange feeds and other reliable sources.

Commercialization of R&D Assets

Commercialization means appropriating the R&D assets for organizational gains. Major commercialization options include embedding R&D based technology in own production processes and products, Joint Ventures, Contract Out Manufacture/Marketing, Licensing Out, Cross Licensing etc.

Content Analysis

Content analysis is a research technique used to make replicable and valid inferences by interpreting and coding textual material. By systematically evaluating texts (annual reports of the companies), qualitative data can be converted into quantitative data. In context of the present research, annual reports of the companies have been evaluated with respect to presence and repetition of certain keywords.

Contracting Out

Contracting out is a type of outsourcing activity where R&D process, in whole or in part, is outsourced from an external organization.

Cross Licensing

Cross Licensing involves reciprocity among different organization with respect to Intellectual Property such as patents. Cross licensing is undertaken to increase cooperation and for avoiding litigation.

Export Intensity

It is the ratio of export earnings to sales in context of a firm.

Forward Citations

Forward citations are the number of citations to a firm's patents included in the subsequent patent applications.

Human Capital

It is a component of Intellectual Capital . Human Capital includes the knowledge, skills, abilities, and strengths of human resource working in an organisation.

Intellectual Capital

Intellectual Capital argues that it covers the activities that are undertaken by firms in order to leverage the stock of knowledge resources, create value and protect new knowledge. Such activities encompass e.g. conducting R&D activities, managing knowledge, imparting skill to staff, so as to create new stocks of intellectual capital. There are three components of Intellectual Capital , i.e., Relational Capital, Structural Capital, and Human Capital.

Joint Venture

A Joint Venture (JV) is a business arrangement in which two or more parties agree to pool their resources for the purpose of accomplishing a specific task. This task can be a new project (such as an R&D initiative) or any other business activity.

Leverage

Leverage is referred as the amount of debt used to finance assets by a company.

Licensing Out

Licensing out is the process of commercialisation of patents through receipt of royalties from some other party in the market.

Monthly Returns

Monthly returns are calculated by taking month end to month end change in closing prices of a security /securities in a portfolio.

$$Monthly\ \ Return = \frac{P_t - P_{t-1}}{P_{t-1}}$$

where

$P_t = Current\ Period\ Price$, $P_{t-1} = \ Previous\ Period\ Price$

Non-acquisition

Non-acquisition of technology means final the final product (with technology embedded in it) instead of acquiring the technology itself.

Portfolio

A portfolio is a grouping of financial assets such as stocks of different companies.

Product R&D

R&D activities primarily focused at creating new products and improving the existing products are called 'Product R&D'.

Process R&D

R&D activities primarily focused at creating new processes and improving the existing ones are called 'Process R&D'.

Rate of Attrition

It is a measure of number of employees leaving a particular organization over a period of time.

R&D Activities

Research and Development refers to the creation of know-how and know-why of new products and processes that eventually translate into commercial development. For purpose of research R&D activities include the processes involved right from acquisition of new technologies to commercialization of the same in the market place.

R&D Intensity

It is the ratio of R&D Expenditure to Sales in context of a firm.

R&D Policy

An IP policy is basically a set of guidelines that deals with the issues such as ownership, protection, commercialization and benefit sharing with respect to IP created in an organization.

Relational Capital

It is a component of Intellectual Capital . Relational capital represents the ability of an organisation to develop and maintain relations with the customers and stakeholders that serve long term interest of both the organisation and customers and stakeholders.

Reportjunction

It is a comprehensive database of company financial accounting reports. Annual reports of the companies can be downloaded from this database.

ROCE

Return on Capital Employed (ROCE) is calculated as the ratio of Net Income to Capital Employed. Capital Employed is sum of long term debt and shareholders' equity.

RONW

RONW is calculated as the ratio of net income to net worth. Net worth is the amount that belongs to the shareholders.

ROTA

ROTA is calculated as ratio of net income to average total assets. Total assets includes current assets as well as non-current assets.

Structural Capital

It is a component of Intellectual Capital . Structural capital includes the organisational culture, values, attitudes, information, structure, R&D expenses, intellectual property, product development, and licensing and technology initiative.

Tobin's Q

Tobin's q is defined as the ratio of a firm's market value to its book value. The book value of the firm is the equal the total value of its assets reported on the balance sheet. The market value is the stock market value of the firm at the end of the year plus the market value of its debt.

Value Relevance

Value relevance is defined as the ability of information disclosed by financial statements and other sources to capture and summarize firm value. Value relevance can be measured through the statistical relations between information presented and stock returns.