IMPACT OF EXCHANGE RATE RISK ON PERFORMANCE AND GROWTH OF IT COMPANIES IN INDIA

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DECLARATION

I hereby declare that this thesis "IMPACT OF EXCHANGE RATE RISK ON PERFORMANCE AND GROWTH OF IT COMPANIES IN INDIA" is an original work done by me for the award of Degree of Philosophy in Management. I also declare that this thesis or any other part of it has not been submitted by me for the award of any degree, diploma, title, or recognition before.

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Date: 06/01/2022

CERTIFICATE

Certified that the thesis entitled, "IMPACT OF EXCHANGE RATE RISK ON PERFORMANCE AND GROWTH OF IT COMPANIES IN INDIA" which is being submitted by Er. Sumit Goyal in fulfillment of the requirements for the award of Degree of Doctor of Philosophy, Thapar Institute of Engineering and Technology (TIET) - Deemed to be University, Patiala is a record of candidate's work, carried out by him under my supervision and guidance. The matter embodied in this thesis has not been submitted in part or full to any other University or Institute for the award of any degree. I also certify that he complied with the Plagiarism Guidelines of the University.

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ABSTRACT

The Information Technology (IT) industry of India has proved its capabilities in delivering both on and offshore services to clients globally over the years. However, the technological advances and innovations taking place at the global level not only present a whole new range of growth prospects, but also challenges for this highly competitive industry. Moreover, the IT sector of India also witnessed the economic recession in 2008, which had an adverse impact on the prospects of this industry. In this scenario, it is imperative for Indian IT companies not only to maintain their focus on increasing their technical efficiencies, but also to deal with the increased competition emanating from the Asia Pacific region. The importance of Indian IT sector demands efficiency usage of resources to compete at global level and provide efficient solutions in the service business.

The main objective of this study includes the estimation of relative efficiency of the top 18 selected Indian IT software service companies in order to determine benchmarks, output slacks and target settings for the duration 2010 to 2017 using Data Envelopment Analysis. This study also investigates the factors influencing the performance of IT companies in India and explores the relationship between sales with respect to employee's compensation and total assets of 37 selected IT companies in India. Furthermore, this study examines the long-term as well as short-term dynamic relationship between IT growth and economic growth of India using quarterly Gross Domestic Product (GDP), aggregate quarterly IT sector Net Sales and aggregate quarterly IT sector Net Profit from 2010Q1 to 2017Q4. Also, since IT companies in India get 90 percent of their revenue from foreign countries, it is imperative to examine the impact of exchange rate volatility on stock prices and profitability of IT firms of India for the duration 2010Q1 to 2017Q4.

Data were collected from the Prowess Database provided by the Centre for Monitoring Indian Economy (CMIE), the Bombay Stock Exchange of India and from the Handbook of Statistics on Indian Economy published by the Reserve Bank of India. The analysis was done using Data Envelopment Analysis, Multi-Component Data Envelopment Analysis, Tobit Regression, Cobb-Douglas production function, Co-integration, and Error Correction Model.

The results of the study obtained through analysis of DEA revealed mixed trends in efficiency. The top five IT companies exhibited higher efficiency as compared to the rest of the selected IT companies. Tata Consultancy Services, HCL Technologies Ltd. and Tech Mahindra Ltd. is more

efficient while Infosys Ltd. and Mphasis Ltd. have lower efficiency. The inefficient companies have to increase their workers' productivity to become more efficient, have to catch-up and follow the best practices of the benchmark company HCL.

The thesis developed a Cobb Douglas Production function which established that compensation to employees and total assets are statistically significant variables explaining productivity of the selected IT companies in India. It also established that IT industry in India exhibits decreasing returns to scale. The results further indicated that output for Indian IT companies is more dependent on labor as compared to capital of the company. The results of the pre-recession period are very similar to our aggregate analysis. However, it was found that during post-recession IT companies became more labor intensive. Subsequently, we estimated panel data with varying intercepts and varying slope. The results indicated that sales turnover function of all IT companies is unique. This study can suggest the policy makers to determine the optimum level of inputs that shall be provided to the sales production function of the company to attain maximum benefits.

The results of IT-led growth hypothesis show that there exists no long-run relationship between the quarterly GDP of India and the aggregate quarterly IT sector net sales. However, the quarterly GDP of India and the aggregate quarterly IT sector net profit are co-integrated. In short-run, changes in aggregate quarterly IT sector net profit have a positive impact on short-run changes in the quarterly GDP of India.

Further the results of the study also show that Rupee-Dollar exchange rate is a major variable impacting the net profit of IT companies in India. However, the net profit of Infosys and Tech Mahindra are not influenced by the rupee-euro exchange rates. Further, the results also depict that rupee-dollar exchange rate is a major variable impacting the stock prices of all the IT companies in India. The stock prices of Wipro are not influenced by the rupee-euro exchange rates. However, the other IT firms have to hedge its exchange rate exposure not only in rupee-dollar but also in rupee-Euro.

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LIST OF ABBREVIATIONS

ACN/ACCN/Accenture	Accenture PLC
A.D.	After Death of Christ
ADF	Augmented Dicky-Fuller
Adobe	Adobe Inc.
ADR	Applied Data Research Company
Amazon	Amazon.com, Inc.
Americas	North America and Canada
AOTE	Average Overall Technical Efficiency
AOTIE	Average Overall Technical Inefficiency
APAC	Asia Pacific
APTE	Average Pure Technical Efficiency
APTIE	Average Pure Technical Inefficiency
ASE	Average Scale Efficiency
ASIE	Average Scale Inefficiency
AWS	Amazon Web Services
B.C.	Before the death of Christ
BCC	Banker Charnes Cooper
BPM	Business Process Management
BRICS	Brazil, Russia, India, China and South Africa
BSE	Bombay Stock Exchange
CA/Computer Associates	Computer Associates Technologies
CCR	Charnes Cooper Rhodes
CD	Compact Disc
CMC	Computer Maintenance Corporation Ltd.
CME	Communication, Media, Entertainment
CMIE	Centre for Monitoring Indian Economy
COBOL	Common Business-Oriented Language
COFORGE	Coforge Ltd.
CoV	Coefficient of Variation

COVID-19	Corona Virus Disease 2019
CRM	Customer Relationship Management
CRS	Constant Returns toScale
CSC	Computer Sciences Corporation
CTS	Cognizant
CUC	Computer Usage Company/Computer Usage Corporation
CYENT	Cyient
DEA	Data Envelopment Analysis
DF	Dickey- Fuller
DMU	Decision Making Unit
DMSU	Decision Making Sub-Unit
DRS	Decreasing Returns to Scale
DVD	Digital Versatile Disc
ECM	Error Correction Mechanism
EDVAC	Electronic Discrete Variable Automatic Computer
E-Governance/e-health/e-education/e-agriculture	Electronic Governance/Electronic health/Electronic education/Electronic agriculture
Engg.	Engineering
ENIAC	Electronic Numerical Integrator and Calculator
ERNET	Education and Research in Computer Networking
ERP	Enterprise Resource Planning
ERU	Energy, Utilities and Resources
EUR	Europe
FDI	Foreign Direct Investment
Forex	Foreign Exchange
FORTRAN	Formula Translation/Formula Translator Language
FSI	Banking, Financial, Security, Insurance
FY	Financial Year
GDM	Global Delivery Model
GDP	Gross Domestic Product
GEOMR	Geometric

GUI	Graphical User Interface
HCL/HCL Tech	HCL Technologies
HNDG	Hinduja Global Solutions Ltd.
HNDV	Hinduja Ventures Ltd.
HP	Hewlett-Packard Company
HRM	Human Resource Management
HXWR	Hexaware Technologies
I(1)	Integrated of order 1
IBM	International Business Machines Ltd.
IBRD	International Bank for Reconstruction and Development
ICs	Integrated Circuits
IMF	International Monetary Fund
Informatics	Informatics General Corporation/Informatics, Inc.
INFY/INF	Infosys Ltd.
iOS	iPhone Operating System
IOT	Internet of Things
IP	Intellectual Property, including Patents
IRP	Interest rate Parity
IRS	Increasing Returns toScale
IT	Information Technology
ITAA	Information Technology Association of America
IT-BPM	Information Technology and Business Process Management
ITeS	IT enabled Services
L&T Infotech	Larson and Tubro Infotech Ltd.
LSH	Life Sciences and Health Care Services
K-economy	Knowledge Economy
MC-DEA	Multi-Component DEA
MFG	Manufacturing
Microsoft/MS	Microsoft Corporation
MNC	Multinational Corporations
MNDTR/MINDTREE	Mindtree Ltd.

MPHSI	Mphasis Ltd.
MPI	Malmquist Productivity Index
NA	North America
NASSCOM	National association of software and services companies
NIC	National Informatics Centre
NIIT	National Institute of Information Technology
OECD	Organization of Economic Cooperation and Development
OIC	Organization of Islamic Cooperation
OLS regression	Ordinary least squares (OLS) regression
OPEC	Oil and Petroleum Exporting Countries
Oracle	Oracle Corporation
ORCLF	Oracle Financial Services Software Ltd.
OTE	Overall Technical Efficiency
OTIE	Overall Technical Inefficiency
POLRS	Polaris Consulting and Services Ltd.
PRSTN	Persistent Systems
PS4	Play Station 4
PTE	Pure Technical Efficiency
PTIE	Pure Technical Inefficiency
R&D	Research & Development
RAND Corporation	Research and Development Corporation
RCL	Retail, Transport and Logistics
REER	Real Effective Exchange Rate
ROW/RoW	Rest of World
SAGE	Semi-Automatic Ground Environment
SAP	Systems Applications and Products in Data Processing
SDC	System Development Corporation
SE	Scale Efficiency
SEZ	Special Economic Zone
SIE	Scale Inefficiency

Siebel	Siebel Systems
SOA	Service Oriented Architecture
SRM	Student Relationship Management
Std. Error	Standard Error
STP	Software Technology Park
TCS	Tata Consultancy Services/ Tata Consultancy Services Ltd.
TECHM/Tech Mahindra	Tech Mahindra
TFP	Total Factor Productivity
TLXI	Tata Elxsi
UK/U.K.	United Kingdom
U.S./US/USA	United States of America
USD	United States of America Dollar
USD Bn	USD Billion
USD Mn	USD Million
VLSI	Very Large Scale Integrated
WIPRO/WPRO	Wipro Ltd.
Y2K	Year 2000
ZNSR	Zensar Technologies Ltd.

CHAPTER I

INTRODUCTION

1.1 Background

The World War II was still going on, however in July 1944, delegates from 44 countries met in Bretton Woods, New Hampshire, USA to decide the new international monetary system. This meeting popularly called the Bretton Woods Agreements that resulted in three new institutions – the Bretton Woods system of pegged exchange rate regime, the International Monetary Fund (IMF) and the International Bank for Reconstruction and Development (IBRD), also called the World Bank.

The Bretton Woods System found an international monetary system, which aimed at promoting trade in goods and services and stabilization of exchange rate in the foreign exchange (FOREX) market internationally. It was a system of payments based on the USD (United States of America Dollar), in which all the currencies were defined in terms of USD and the USD was itself convertible in gold.

In the early 1970s, when the speculative attacks began against the USD in the FOREX market along with inadequate supply of the U.S. gold, which no longer supported the large number of dollars in the circulation in the World. With the President Richard Nixon's announcement that the U.S. would no longer exchange gold for the USD led to the ultimate collapse of the Bretton Woods System of somewhat fixed exchange rate regime. With its collapse, a new free float exchange rate system came into existence, which was characterized by higher amount of risk and uncertainty in the international FOREX markets. Firms engaged in export-import activities found that the new regime is adversely impacting their operations. To mitigate the risk and uncertainty, a new breed of financial instruments called derivatives instruments also came in a big way in the markets. Now the current international financial system is characterized by a very big forward, futures, options, swaps and other hybrid sophisticated financial instruments markets, which may sometimes seems to be self-

destructing, occasionally gets reflected in the forms of various financial crises in recent times. IT industry of not only India but also the global IT industry is exposed to a large extent to exchange rate risk.

IT industry has made an indelible imprint on the life of every individual in today's world. It is not only the enterprises that are impacted by IT, but it has also influenced the life of every individual whether at home or at office. IT has expanded and touched every aspect of business, from the area of communication and media sector including mobile phones, smart phones; tourism & hospitality sector; education – online education, networked classrooms; e-commerce; e-governance; energy, natural resources and utilities; transportation to food industry; housing sector; retail and wholesale industry, e-retail; manufacturing industry; financial and banking sector, rural development; marketing - brand positioning, usage of social media for marketing, understanding customer behaviour; environment management, and so on and so forth (Bhati et al., 2017; Bodla & Saini, 2017; Bhati et al., 2019; Carter et al., 2019; Baishya & Samalia, 2020; Kumar et al., 2020).IT has helped to reduce time to market, reduce total cost of ownership and make the day to day life of human beings more comfortable than before. According to Khan (2002), IT has brought in automation of lot of processes and functions that were performed manually hitherto, thus increasing the productivity. IT has developed and implemented automated solutions around Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Human Resource Management (HRM) and now Students Relationship Management (SRM) software systems to increase the productivity of most of the organisations and educational institutes (Sternad et al., 2009; Sternad & Bobek, 2013; Bezzina et al., 2017). The increase of Information technology by the organizations can have severe negative impact on the environment footprint. Green IT and Green Information system solutions address the environment sustainability problem to a good extent. Organisations are launching new green products to achieve their goals towards environment sustainability. Most of the large IT companies are working aggressively towards reducing the environmental impact because of Information technology industry (Dangelico & Pujari, 2010; Jenkin et al., 2010).

Information technology thrives on knowledge, technology, and human capital. The backbone of IT industry is human capital, organizational capital, and relational knowledge. All these can be summed up by the term known as Knowledge based economy. The human capital is the key ingredient for the productivity of the IT industry forms and is one of the three pillars for the growth of K-economy. Organizational assets include knowledge assets, databases, and historical information, documents that can be reused by the human intellectuals to generate more knowledge, innovate, and execute research for future development. Relational capital refers to the social collaboration between all the stakeholders. These stakeholders make use of the explicit knowledge available to them and use their intellect and knowledge to develop human and organizational assets.

The knowledge-based economy refers to an economic system in which knowledge is created, acquired, transmitted, and applied effectively by economic agents including enterprises, organizations, and individuals for the greater economic, social development and for the betterment of life and performance. K-economy is the outcome of a greater recognition of the role of knowledge and information technology in the process of economic growth. Traditionally, the output or production function of any firm was defined as the function of land, labour, capital, and entrepreneurship. Land includes all the physical assets and the resources, whereas labour refers to all the skilled and un-skilled labour working in any enterprise. Capital relates to both fixed capital and operational capital while entrepreneurship refers to the manager and senior leadership. These four parameters used to determine the output of any company. However, in knowledge-based economy there are other parameters that are included in the function to determine the output. It is knowledge and IT. So, output now is defined as a function of land, labour, capital, entrepreneur and knowledge. Knowledge includes innovation and skilled human labour. IT industry and knowledge economy have a strong correlation between them. In fact, Information technology and knowledge are synonym of each other. The knowledge is brick and mortar for the IT industry while at the same time it is the advancements in the IT industry namely mobile communication, internet and computer industry which has provided ways and means to increase knowledge dissemination and has provided better means for

innovation thus building a knowledge economy, Cowan & Paal (2000). In the knowledge economy, the traditional factors of production function become secondary while knowledge takes over the key role in influencing the output of the society. Knowledge, the intellectual capital asset is said to be governed by law of increasing returns on the production function whereas the traditional factors are subject to the law of diminishing returns, Mithani (2010).

Knowledge application and knowledge management are integral parts of the knowledge economy. IT helps a great deal in knowledge accumulation, storage, dissemination and knowledge growth through innovation, transmission, and easier access to knowledge. IT gives a technological base on which knowledge-based economies can grow for the betterment of the society.

The framework on which a knowledge-based economy thrives on is based on following:

1. Knowledge - Human Capital, Organizational Capital, and Relational Capital
2. Infrastructure
    a. Internet, Communication media provided by IT that helps in Knowledge dissemination, knowledge sharing, information storage and development of more knowledge assets.
    b. Platform and Products – Hardware components, IT Software Products and Applications (e-Commerce viz. Business-to-Business, Business-to-Consumer) developed using IT.
3. Stakeholders - Business, Consumer, Intermediaries – Suppliers, Purchasers, Market stakeholders. These stakeholders will produce and consume the products developed by Knowledge Economy (K-economy)

It is not only those industries which are directly related to Information technology that leverages the benefit of knowledge and hence contribute to the growth of K-economy. However, every industry directly or indirectly needs science and technology and thus knowledge of some kind to be more efficient which leads to the increase in production function of the industry. It is with the advent of Information technology that

knowledge and intellect have gained more importance. However, the roots of knowledge and data storage, knowledge formation and accumulation can be traced back to the pre-mechanical age. In industrial age also it was always innovation that has helped to solve problems and helped in improving efficiencies. Thus, it can be said that knowledge-based economies have strong relationship with science. Science uses IT in every field to assess, store, share and create new information, thus the link between IT and knowledge-based economies cannot be overlooked. The growth of the economy can be linked to how the science or knowledge can be used to create new knowledge, how knowledge can be used in transformation of the traditional businesses in the new way and how knowledge can help build a knowledge society that can store this vast amount of knowledge and share it with the generations to come. The IT companies can make use of technologies and software methodologies such as Block chain, Artificial intelligence, Internet of Things (IOT), cloud computing, digitalisation, agile frameworks to make meaningful inferences of the large amount of data which shall be useful for the economic growth. IT provides various means for faster knowledge dissemination and knowledge transfer amongst the stakeholders to increase efficiency and productivity of the employees (Kumar et al., 2017; Carter et al., 2019). This study shall analyse the performance of selected IT companies and will try to establish a relationship between growth and development of Indian economy and Indian IT sector and its growth.

1.2 Statement of the Problem

Corporate firms have been operating in a business environment, which is full of risk and uncertainty, particularly the firms, which operate in the international environment and do businesses in different countries generally called transnational corporations or multinationals corporations (MNCs). IT companies from India such as Infosys Ltd. (INFY), Tata Consultancy Services Ltd. (TCS), HCL Technologies Ltd. (HCL), Wipro Ltd. (WPRO), and Tech Mahindra Ltd. (TECHM) etc., are MNCs and get more than 90 per cent of their revenues from exports. The operations of these IT firms and its subsidiaries operating in different countries face significant exchange rate risks that effect their revenues and profit margins.

Exchange rate is the rate at which two foreign currencies are exchanged in the FOREX market. The variations in the rupee-dollar or rupee-euro exchanges rates impact the monetary value of exports and imports in a considerable way. FOREX exposure is defined as the sensitivity of changes in the real domestic currency value of assets and liabilities or operating income to unanticipated changes in exchange rates. There is related concept of FOREX risk which can be defined as the variance of the domestic currency value of an asset, liability, or operating income due to unanticipated changes in the exchange rates. Thus, the FOREX rate risk entails two things, namely, the variability in the exchange rate and exposure. There are basically three types of exposure:

1. Transaction Exposure
2. Translation Exposure
3. Operating Exposure

While the transaction exposure arises from the foreign currency denominated transactions, the translation exposures arise from the need to convert values of assets and liabilities denominated in foreign currency into the domestic currency. The operating exposure can be defined as the extent to which the value of a firm stands exposed to exchange rate movements. Thus, the operating exposure is a result of economic consequences of exchange rate movements on the value of a firm. It is also called economic exposure. As the IT firms of India are having operations in many countries; they operate through subsidiaries also, they certainly face economic exposure beside transaction and translation exposures. It is an established fact that more than 90 per cent revenues of the IT companies in India come from software export. This may certainly require management of transaction and translation exposures through derivatives instruments used for hedging positions. In addition, the management of economic exposure requires taking long-term decisions to protect firm’s value due to large and persistent exchange rate movement in a direction, which is unfavorable. In general, under such circumstances, firms can protect themselves either following the strategy of appropriate input mix or raising their productivity.

1.3 Theoretical Framework

There are many theories that try to explain the reasons behind the appreciation and depreciation of a domestic currency vis-à-vis a foreign currency.

1.3.1 The Purchasing-Power Parity Theory

The purchasing-power parity theory proposed by Gustav Cassel says that the price levels in two different countries determine the exchange rates between the currencies of these two countries. Thus, this theory, based on the law of one price says that the exchange rate between two countries is determined by the inflation rates prevailing in these countries. It is important to note here that inflation and purchasing power of a currency is inversely related. For example, if the cost of a particular model of Apple's iPhone is Rs. 70000 in India and the same model costs USD 800 in the US, then the exchange rate the rupee and dollar would be 70000/950 = Rs.73.6842/USD. The purchasing-power theory predicts that when the purchasing power of a currency declines due to higher rate of inflation, the domestic currency depreciates vis-à-vis the foreign currency. In the case of depreciating domestic currency, while the exporters get benefited however the importers are at loss. Thus, the dollar revenues of all the IT companies are favorably influenced by the depreciation of rupee.

1.3.2 The Interest Rate Parity Theory

The interest rate parity (IRP) theory says that the interest rate differential is equal to the differential between the forward rate and the spot rate between the two countries. Thus, the IRP connects the interest rates, forward rates, and spot exchange rates in the FOREX markets. The IRP is given by the following expression:

$$F_0 = S_0 * \left(\frac{1+i_B}{1+i_A}\right) \qquad \text{--- (1.1)}$$

where,

F_0 = Forward Rate

S_0 = Spot Exchange Rate

i_A= Interest rate in country A

i_B= Interest rate in country B

The difference between the forward rate and the spot rate is called swap points. If the forward rate minus spot rate is positive, it is called forward premium. However, if it is negative then it is called forward discount. It is important to highlight the fact that a currency with lower interest rates trade at forward premium and a currency with higher interest rates trade at forward discount in the FOREX market.

1.3.3 The International Fisher Effect

The Fisher Effect is due to the American economist Irving Fisher which describes the link between expected inflation rate and both real and nominal interest rates. The Fisher Effect says that real interest rate is equal to the nominal interest rate minus expected inflation rate. Thus, the real interest or real return on asset is given as follows:

Real Interest Rate = Nominal Interest Rate – Expected Inflation Rate - (1.2)

The Fisher Effect equation 1.2 shows that when the expected inflation rate rises, then the real interest rate falls. To maintain the equality, the nominal interest rate must rise to offset the fall in the real interest rate or real return on assets.

When extended to the international context, the Fisher Effect, or the International Fisher Effect states that the expected differential between the exchange rates of two countries is equal to the difference between their countries' nominal interest rates. According to this theory, countries with higher nominal interest rates have higher rates inflation, which result in depreciation of currency vis-à-vis other currencies.

1.4 Objectives of the Study

IT firms in India are not only exposed to transaction exposure and translation exposure but are also facing economic exposure. It is also important to highlight that IT firms in India while declaring quarterly results provide details about their dollar revenues and its growth. Thus, it seems that in practice, all types of exposures have become relevant for Indian IT companies. In this context, the study has the following specific objectives:

$O_{1:}$ To examine the performance of the selected IT companies of India.

$O_{2:}$ To identify the factors affecting the performance of the selected IT companies.

$O_{3:}$ To examine the IT-led growth Hypothesis.

$O_{4:}$ To analyse the impact of exchange rate fluctuation on the performance of selected IT companies.

1.5 Hypotheses

The following are the hypotheses to be tested in the study. These hypotheses are listed below objective-wise:

O_1: To examine the performance of selected IT companies of India: This objective of the study is achieved by doing a trend analysis of the selected IT firms in India using descriptive statistics. The first objective of the study has no testable hypothesis.

O_2: To identify factors affecting performance of IT companies: This is the second objective of the study. The various hypotheses to be tested under this objective are given as follows:

H_{2a}: There is no significant relationship between age of company and efficiency of the firm.

H_{2b}: There is no significant relationship between Research & Development (R&D) expenses and efficiency of the firm.

H_{2c}: There is no significant relationship between number of employees and efficiency of the firm.

H_{2d}: There is no significant relationship between asset size and efficiency of the firm.

O_3: To examine the IT-led growth Hypothesis: This is the third objective of the study. The various hypotheses relating to this objective are as follows:

H_{3a}: Indian IT industry has negative impact on the economic growth rate of Indian economy.

H_{3a1}: The aggregate quarterly net sales of IT sector of India have negative impact on the economic growth rate of Indian economy.

H_{3a2}: The aggregate quarterly net profit of IT sector of India and quarterly Gross Domestic Product (GDP) of India are negatively related.

H_{3b}: IT growth does not lead to economic growth.

H_{3b1}: The aggregate quarterly net sales of IT sector of India does not cause quarterly GDP of India.

H_{3b2}: The aggregate quarterly net profit of IT sector of India does not cause quarterly GDP of India.

H_{3c}: Indian economic growth does not lead to IT growth.

H_{3c1}: The quarterly GDP of India does not cause aggregate quarterly net sales of IT sector of India.

H_{3c2}: The quarterly GDP of India does not cause aggregate quarterly net profit of IT sector of India.

O_4: To analyse the impact of exchange rate fluctuation on performance of selected IT companies. The various hypotheses related with the fourth objective are:

H_{4a}: The rupee-dollar exchange rate does not influence the net profit of IT companies.

H_{4b}: The rupee-euro exchange rate does not impact the net profit of IT companies.

H_{4c}: Inflation does not impact the net profit of IT companies

H_{4d}: The rupee-dollar exchange rate does not influence the stock prices of IT companies

H_{4e}: The rupee-euro exchange rate does not impact the stock prices of IT companies.

H_{4f}: Inflation does not impact the stock prices of IT companies

1.6 Data & Methodology

To achieve the various objectives of the study, we looked at data for the selected IT companies of India. It was observed that IT companies having market capitalization greater than ₹10 billion forms a considerable and good sample set for our study. This

is because rest of the companies are either too small as compared to these companies or does not report their data consistently. Hence, the data was collected on top eighteen IT firms of India to meet the various objectives specified in this study, as they comprise of more than 95% of the total sales or total assets of IT software companies of India. The criterion for selecting these firms was their market capitalization and data availability. The data were collected from 2010 to 2017 from the Prowess Database provided by CMIE.

Following Pareto's 20:80 rule (Koluksuz, 2020) the selected companies reflect a good sample size to represent the Industry. Thus, the selected IT firms are not only dominant and market leaders but also dictate policies in the IT sector. Hence, considering the limitations of data availability, these selected IT companies can be taken as adequate data set. Moreover, the IT industry of India is oligopolistic in nature. The top five companies TCS, INFY, WPRO, HCL and TECHM constitute more than 90 per cent market share.

The time duration selected for the study is from 2010 to 2017. Only a few studies have attempted to evaluate the efficiency of the IT firms after the US sub-prime crisis of 2008 (Liu & Huang, 2019; Oruc & Altin, 2015). It is important to highlight that most of the studies evaluating efficiency performance of IT firms after the 2008 sub-prime crisis were researched in foreign countries. The worldwide recession and financial crisis during 2008 forced policy makers to cut down on operational expenses, implement lean methodologies and maximize use of resources (Buttigieg et al., 2016).Thus, there is a need to investigate the efficiency performance of Indian IT firms, to set the target values and to benchmark the IT companies of India after the financial meltdown of 2008. This will enable these companies to manage inefficiency and devise policy measures for improving their overall efficiency. These specific aspects of Indian IT industry need to be addressed. Therefore, based on data availability and above aspects, duration of the study was selected from 2010-2017.

The study employs different mathematical and statistical techniques to investigate the various objectives of the study. The first objective of the study uses the Data Envelopment Analysis (DEA) to evaluate the relative efficiency performance of the selected IT companies of India. The study also employed multi-component DEA

(MC-DEA) analysis. The second objective of the study is to identify the input and output factors affecting the performance of IT companies. The study also employed Tobit regression model for this objective. The third objective of the study makes use of co-integration technique to study the long-run relation between the economic growth of India and aggregate net profit of the Indian IT sector. In addition, the Error-Correction Mechanism (ECM) is used to study the short-term dynamics between the quarterly growth rate of Indian GDP and quarterly net profit of Indian IT sector. The fourth objective of the study uses multiple regression models to study the impact of exchange rate and inflation on the performance IT industry. The methodology section of the respective chapters provides the details of the mathematical and statistical techniques applied in this study.

1.7 Significance of the Study

The IT sector is one of the prominent industries of India. It has been the face of corporate sector in India since liberalization and globalization started in India after the balance of payment crisis in early 1990s. The significance of IT industry in providing employment and contributing to the overall growth and development of the country is well accepted by policy makers and academicians. In this context, this study is trying to try to evaluate the efficiency performance of the IT industry in India. The relative evaluation of selected IT companies will be done by DEA technique, which has gained prominence in measuring the relative efficiency in recent times. This leads us to forming the first objective to examine the relative performance of Top IT Software companies of India using DEA.

This study is trying to establish export-led hypothesis (Siliverstovs & Herzer, 2005) in the context of IT industry. Taking the stock of relationship between exports and economic growth, this study tries to put forward the IT-led growth hypothesis on similar principle. Thus, the second objective of the study is to test whether IT growth contributes to economic growth in India. This study will also establish a relationship between growth of Indian IT sector and Indian economic growth.

Finally, this study is trying to find the impact of exchange rate fluctuation on the performance of IT sector. Most of the revenue, approximately 90 per cent, IT companies get from IT exports to foreign countries especially to Americas. In this

context, it will highly desirable to study the impact of exchange rate volatility on the performance of IT companies and how these IT companies reduce the exchange rate risk.

1.8 Chapterization Scheme

The whole study is divided into VIII chapters. Chapter II provides overview and trends of IT Industry. It provides the overview of Global IT industry followed by an overview of IT industry in India. This is followed by Chapter III that provides review of literature relating to the various objectives of this study. Chapter IV is entitled as the Performance of selected IT companies in India, which analyses the efficiency performance of selected IT firms in India using DEA. This is the first objective of the study. It also identifies and lists the various factors affecting the performance of selected IT companies. Tobit Regression Model is used to study the impact of variables on efficiency of IT companies. This is the second objective of the study. Chapter V further explores the component-wise performance of selected IT companies at global level using MC-DEA analysis and lists the various factors affecting the component-wise performance of IT companies. Chapter VI put forward the IT-led growth hypothesis. In this study, an attempt is made to find out how the IT industry leads the growth process of the various industries in India and overall GDP of the country. This forms the third objective of the study. Chapter VII deals with the impact of exchange rate fluctuations on the performance of selected IT firms in India. Chapter VIII provides the conclusion of the study. Figure 1.1 represents organization flow of chapters

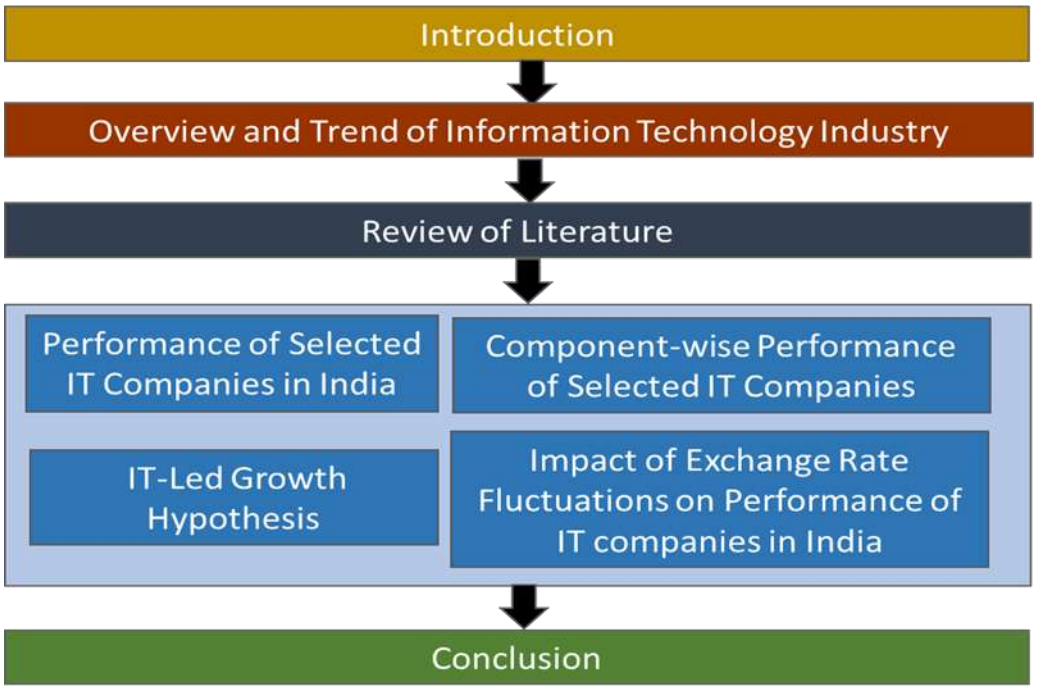


Figure 1.1: Organization Flow of Chapters

CHAPTER II

OVERVIEW AND TREND OF INFORMATION TECHNOLOGY INDUSTRY

The term ‘Information Technology’ emerged half a century ago and it has completely changed the way we live and work. Another popular term was ‘Information Science’, which was very common in 1960s (Buckland & Liu, 1995). The first computer, ENIAC (Electronic Numerical Integrator and Calculator) was delivered in 1941, which has evolved into laptops, tablets, handheld devices now. The era of internet came in 1982.

According to the Information Technology Association of America (ITAA), IT “is the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware”. IT industry has made an indelible imprint on the life of every individual in today’s world. It is not only the enterprises that are impacted by IT, but it has also influenced the life of every individual whether at home or at office. IT has expanded and touched every aspect of business, from the area of transportation to food industry, housing sector, retail and wholesale industry, manufacturing industry, financial and banking sector, communication, and media sector, etc. Thus, it has impacted every sphere of human activities.

Simply put, IT is the Technology that deals with Information. Information is nothing but data in some form. So, IT can be defined as the technology that deals with data. It encompasses data storage, data retrieval, data transmission, data processing, data manipulation, making meaningful inferences using data, etc. Data or information is of key importance to human beings, whether it is related to past, present or future; whether it is related to health, education, finance, banking, retail, communication media or any other field because all kinds of decisions require some kind of data or information. The ways and means of storing, processing, transmitting, communicating information has evolved along with evolution of human beings. Thus, it can be said

that IT is not a new phenomenon. It is the technology to hold and transfer data that has evolved over time. IT in today's era uses computers for data handling, data manipulation, data processing and uses telecommunications for high speed data communication, data transfer through network links, optical fibers etc. The key aspects of IT are listed in Figure 2.1.

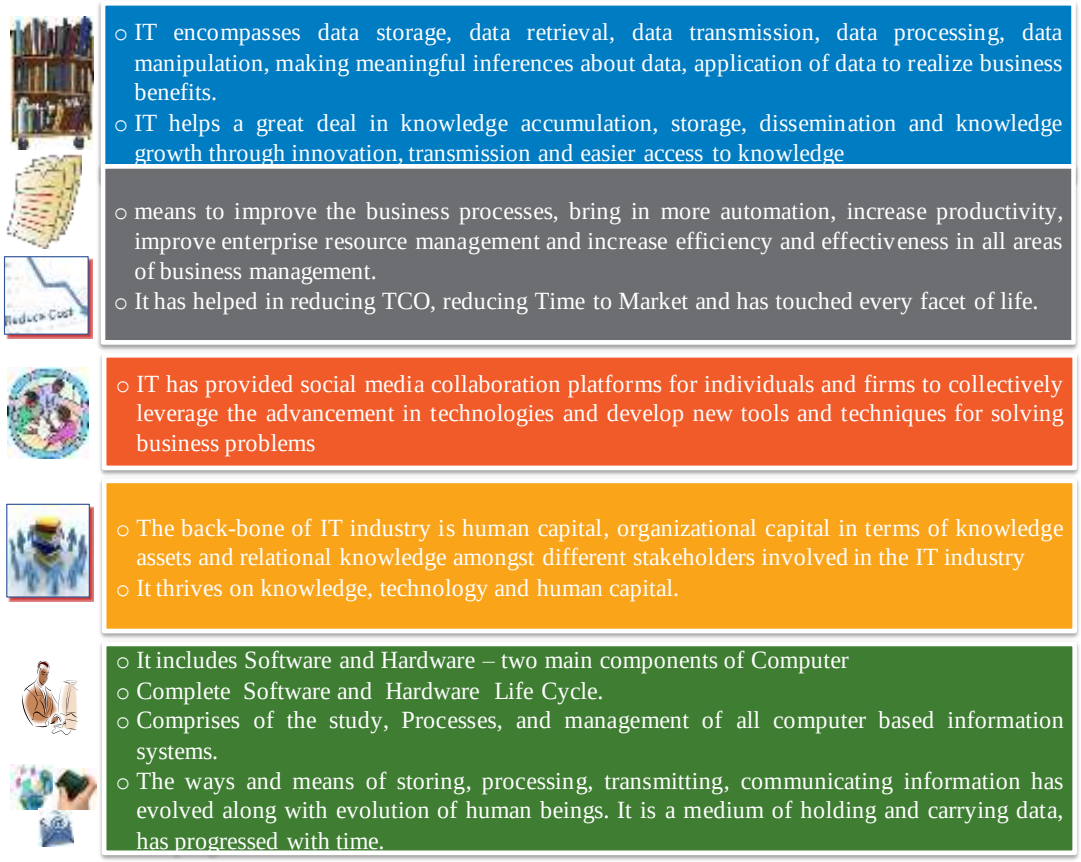


Figure 2.1: Key Aspects of Information Technology

The IT industry uses IT as the means to improve the business processes, bring in more automation, increase productivity, improve enterprise resource management and increase efficiency and effectiveness in all areas of business management – be it marketing, sales, operations, finance or human resource management. The IT has provided social media collaboration platforms for individuals and firms to collectively leverage the advancement in technologies and develop new tools and techniques for solving business problems. It has increased the automation in the processes and productivity of the individuals and the firms. IT is not only helping the private organizations to improve their efficiency and productivity, but the public sector and

government institutions are also moving towards using IT as a tool to improve their productivity. E-Governance, automation/information sharing in healthcare industry, providing benefits to farmers through weather forecasting and internet of things are just few examples where IT has helped immensely. Thus, it can be rightly inferred that IT has played an important role in the overall development of the country and the world. The technology has advanced with time and has made it possible to access information at gigabit speeds. It has tremendous impact on the lives of millions of poor people, marginalized and living in rural and far flung topographies. The Internet has brought revolutionary changes with e-governance, e-health, e-education, e-agriculture, etc. Thus, IT has not only changed the way of doing businesses but also has changed the delivery mechanism of governments worldwide.

2.1 Evolution and Overview of Global IT Industry

The evolution of Global IT can be broadly divided in four basic periods based on the principal technology of that time to solve the input, its processing, output, and its communication.

2.1.1 The Pre-Mechanical Age (3000 B.C – 1450 A.D)

In the pre-mechanical phase, human beings used pictures as artifacts to store information and they communicated through rock paintings. Plants leaves were used to store information and they acted like papers. 6000 B. C., the people of the Indus Valley, also known as Harrapan, were found to be proficient in seal carving and used distinctive seals to stamp clay on trade goods. During 3000 B.C., the Sumerians devised cuneiforms. To facilitate communication around 2000 B.C., Phoenicians created symbols. The Greeks later adopted the Phoenician alphabet and added vowels; the Romans gave the letters and created the alphabets that we use today.

In the field of input technologies, around 2600 B.C., the Egyptians wrote on papyrus plant and around 100 A.D., the Chinese made paper from rags. If we talk about permanent storage devices, around 600 B.C., the Greek began to fold sheets of papyrus vertically into leaves and bind them together.

The first numbering systems like those in use today were invented between 100 and 200 A.D. by Hindus in India who created a nine-digit numbering system.

Brahmagupta, around 650 A.D., was the first from India to formalize arithmetic operations using zero. He used dots underneath numbers to indicate a zero. These dots were alternately referred to as ‘sunya’, which means empty. The first calculator or information processor came in the form of ‘abacus’, which was invented by ancient Babylon in between 300 B.C. to 500 B.C.

2.1.2 The Mechanical Age (1450-1840)

The hallmark achievements of this period were Johann Gutenberg’s invention of movable metal-type printing process in 1450. Punching machines, mechanical slide rulers were built during this era that could help in data processing and data manipulation.

2.1.3 The Electromechanical Age (1840-1940)

This phase of technological development witnessed the invention of telephone. This era also saw the beginning of conversion of knowledge and information into electric impulses. International Business Machines Ltd. (IBM) was started in 1890.

2.1.4 The Electronic Age (1940 – Present)

This phase saw the computers built using vacuum tubes and not mechanical devices (hence termed as Electronic Computers). After the World War II, the most important event in the history of software industry took place on 30 June 1945, when John Von Neumann published the first draft of a report on the EDVAC (Electronic Discrete Variable Automatic Computer). This was the first documented report on the stored program concept and the blueprint for computer architecture. Refer Figure 2.2.

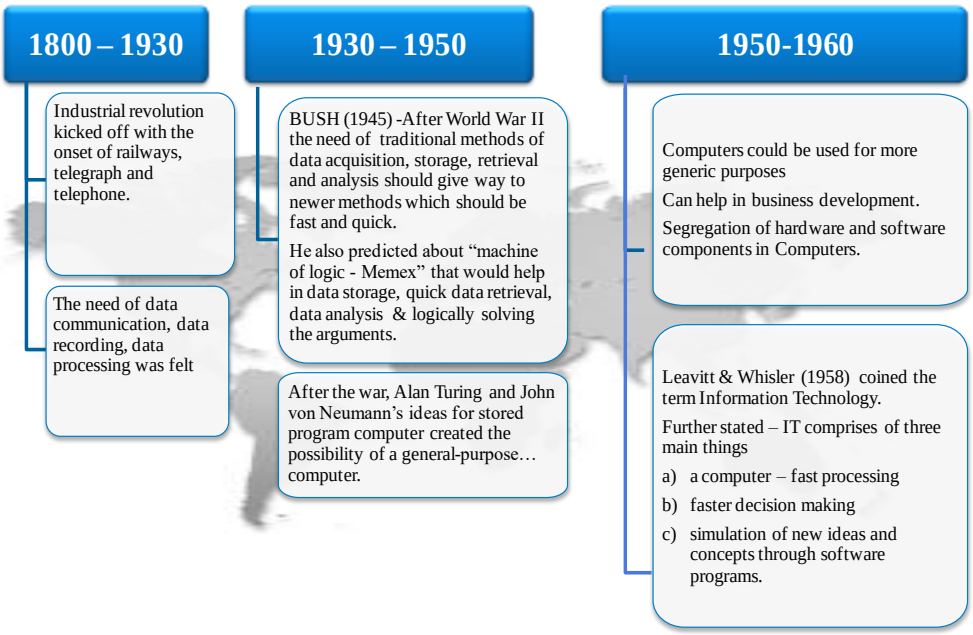


Figure 2.2: Evolution of Global IT Industry (1800-1960)

The Electronic age is divided into 4 generations.

a. The first Generation (1951-1958) used vacuum tubes as main logic entities and programs were written in assembly languages. During this decade, there was a focus on segregation of hardware and software components of the computer. System Development Corporation Ltd. (SDC) was set up in 1956 and IBM started focusing on providing software services as well.

b. The second generation (1959-1963) saw transistors replacing vacuum tubes, magnetic tapes replacing punching cards and invent of high-level programming languages like FORTRAN and COBOL. In 1960, IBM realized the need of a smaller capacity machines for medium enterprise users, while larger enterprises continue to install computers for their needs.

c. In the third generation (1964-1979) Integrated Circuits (ICs) took over from transistors and advanced programming languages were used for programming. During 1960s-1970s, the penetration of medium sized computers was observed. The large enterprises had almost completed the installation of computers. Enterprises outsourced the software development to the service providers, thus

leading to the development of the outsourcing business, software, and service providers. Further, during 1970s, following key events took place:

i. The release of computers by IBM with the common operating system software. This helped the software service providers to provide same software across different customers.

ii. IBM started selling hardware and software separately. This led to the establishment of separate hardware and software service provider industry, which paved way to establishment of US software Industry.

iii. A space was created for the minicomputer industry. The small-scale companies needed minicomputer rather than large mainframe machines, thus increasing the sale of minicomputers.

The software industry continued to grow, and improvisation was set in, standards were formed as the industry grew with time. Refer Figure 2.3

d. The fourth Generation (1979 – present) saw the use of Very Large Scale Integrated (VLSI) Circuits, personal computers, and the usage of fourth generation programming languages with Graphical User Interface (GUI). 1980s saw computer manufactures moving away from software and services business except IBM. Hardware manufacturers focused on providing hardware machines with basic operating system, while software manufacturers focused on providing applications and software to run on the hardware machines. The three key developments of the 1980s with respect to software industry were i) the development of packaged off the shelf software and software licenses by the firms depending upon the customer requirement; ii) the introduction of the workstation that was more powerful than a minicomputer but less costly than mainframe and iii) the growth of software service firms, system integrators that helped solve some of the productivity and organizational problems.

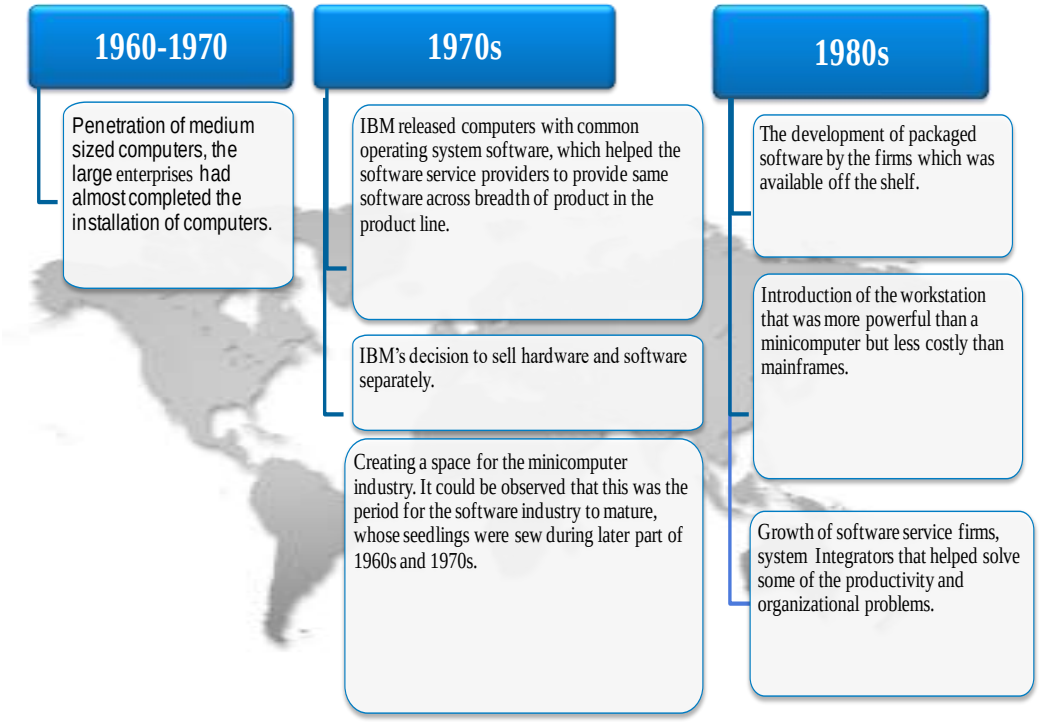


Figure 2.3: Evolution of Global IT Industry (1960-1980)

According to Campbell-Kelly (2003), the IT industry can be generally divided into three: software system integrators, enterprise software products, and consumer software products. However, the software industry has added many other dimensions over the years and a brief taxonomy of the software industry is shown below in the Figure 2.4.

The evolution of IT has passed through the various distinct phases. In pre-industrial era, data storage was achieved through mechanical design such as printing presses and transmission of data happened through audio and video signals used by human beings. This was followed by electro-physical era, which witnessed a) the age of large sized computers being used as processors, b) storage of analogue data through physical and chemical technologies initially and electrical and electronic technologies later and c) transmission through metal cables along with radio spectrum. The next era called microelectronic era witnessed the invention of ICs thus reducing the size of processors, usage of magnetic media as storage devices – floppy discs, digital tapes, CDs, DVDs, and transmission through optical, mobile network and internet.

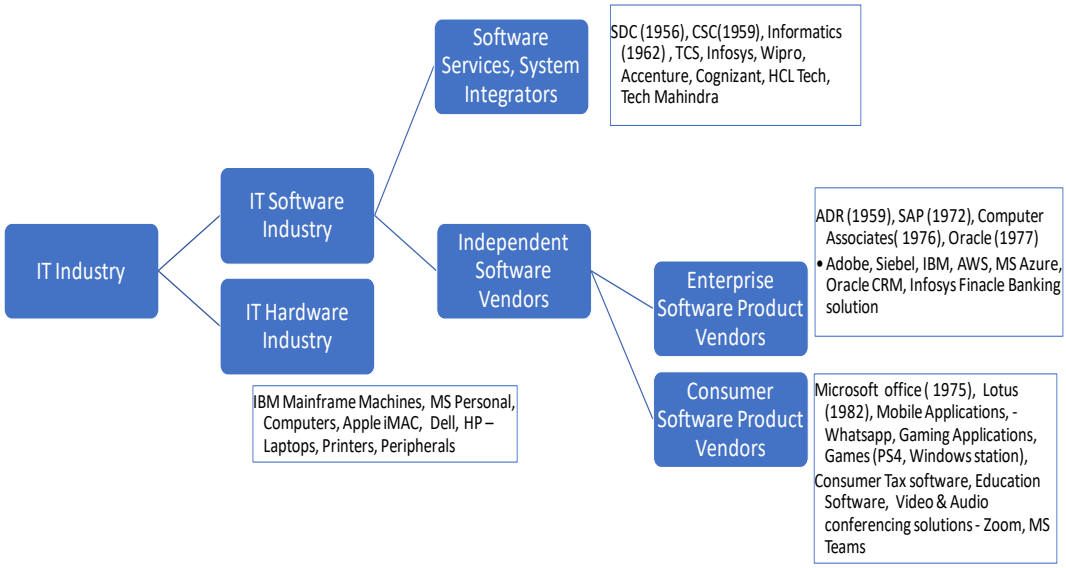


Figure 2.4: Taxonomy of IT industry

The rise of web services or what is called Service Oriented Architecture (SOA), the open source software, usage of web as the core developer platform and using standard web technologies to build applications, the emergence of web frameworks, Web 2.0, the rise of scripting or dynamic languages, etc., were some of the leading developments in the software industry in the 2000s.

When the global COVID-19 pandemic posed a never-before-seen challenges before the businesses, they quickly realized the need to go digital with focus on contactless services, cloud migration, and DevOps activities. Remote work, cloud services, e-commerce software solutions, containers and micro-services, outsourcing, etc., are on the rise. These events may determine the trend of future software industry in coming years.

The IT Industry globally has shown tremendous growth in last 50 years. Table 2.1 shows the trend of global IT user expenditure from 1970 to 2020. The total global IT user expenditure was merely USD Bn 0.994 in 1970. In the next 5 years, it jumped from USD Bn 0.994 to USD Bn 2.162. By 2000 the global IT industry value crossed USD Bn 100.0; in 2000 the global IT spending was USD Bn 138.08. The Global IT spending broadly came from three areas of software industry, namely, system software product, applications software products and programming. The contributions

of these three broad segments were USD Bn 41.68 billion, USD Bn 63.0 and USD Bn 33.4 respectively in 2000.

In the next 20 years, the global IT industry in terms of user expenditure has shown remarkable growth. The global IT spending grew from USD Bn 138.08 to USD Bn 3608.76. This exponential rise in the global IT industry is expected to continue in the future also.

Table 2.1: Global IT User Expenditure (USD Bn)

Year	1970	1975	1980	1985	1990	1995
USD Mn	994	2162	5711	19519	44460	73630
Year	2000	2005	2010	2015	2020	
USD Mn	138080	415400	793000	942000	3608760	

The various emerging areas in the technological sphere like Cloud computing, block chain, DevOps, artificial intelligence, Internet of things etc., is going to fuel the future growth of global software industry in the coming decades.

2.2 Overview of Information Technology Industry in India

Information technology (IT) industry has remained the face of corporate India since 1991 and has transformed the image of India from a rural agriculture-based economy to a knowledge-based economy. The IT industry of India has evolved primarily in three phases. The period before 1984 is said to be part of first phase which is followed by the second phase from 1984 to 1990. The last and the third phase is 1990 and beyond (Malik & Velan, 2019).

2.2.1 The First Phase (up to 1984)

The first thoughts on IT in India were conceived way back in 1766 when electronics committee or Bhabha committee report recommended an all-out effort to build indigenous small-scale and large-scale computers in India to start with. The seeds sowed in 1766 started nourishing no earlier than 1968. India got its independence from the British rule in 1947 and it took another 21 long years before Indian government looked at the recommendation of Bhabha committee report and started focus on attaining self-sufficiency in system engineering and fabrication. The software

industry in India was almost absent till 1960, primarily due to protection of the hardware industry through high tariffs and licensing policy of the government of India. The growth of Indian IT starts with setting up of TCS in 1968 in the domain of outsourced application work. An engineer of India at TCS founded the Computer Society of India in 1969. He took over the management of TCS during this time to form Computer Society of India. Based on the success of TCS model, number of firms was established in India McDowell (1995) and Morck (2007).

The period from 1968 to 1984 of Indian software industry laid down the foundation layer of IT industry in India. However, the growth of IT industry in India was hampered during this phase due to closed economy and restrictive economic policies (Mathur, 2007). Gradually, the government realized the significance of the software industry and in 1972 and it formulated the software export scheme. This scheme made the provision for hardware imports in exchange of software exports. The software industry in India was heavily dependent upon the imports of hardware and lacking infrastructural facilities for software development. The government of India introduced a new computer policy in 1984. Through this policy, the import duty on hardware was reduced and the process towards easiness of doing business was also simplified. The software policy of 1986 further liberalized the IT sector and made the IT software industry independent of the IT hardware industry. Refer Figure 2.5.

The decade of 1970s saw an increased focus of the government to set up institutions, government bodies to define strategies and policies for the growth of Indian IT Industry but the focus of the government remained on utilizing the public sector as the growth engine. This was in line with the overall strategy and focus on public sector – termed as License Raj by some in India.

Computer Maintenance Corporation Ltd. (CMC) was incorporated in mid 1970s to service and maintain government computers, and TCS happened in 1977 when IBM decided to move out of Indian business owing to their dispute with Indian govt. IBM leased reconditioned computers from west to India in 1970s and wanted to retain their 60% equity share in Indian business which Indian govt. declined to comply with. All the major business of IBM went to CMC and TCS, which lead to growth of these companies, Morck (2007).

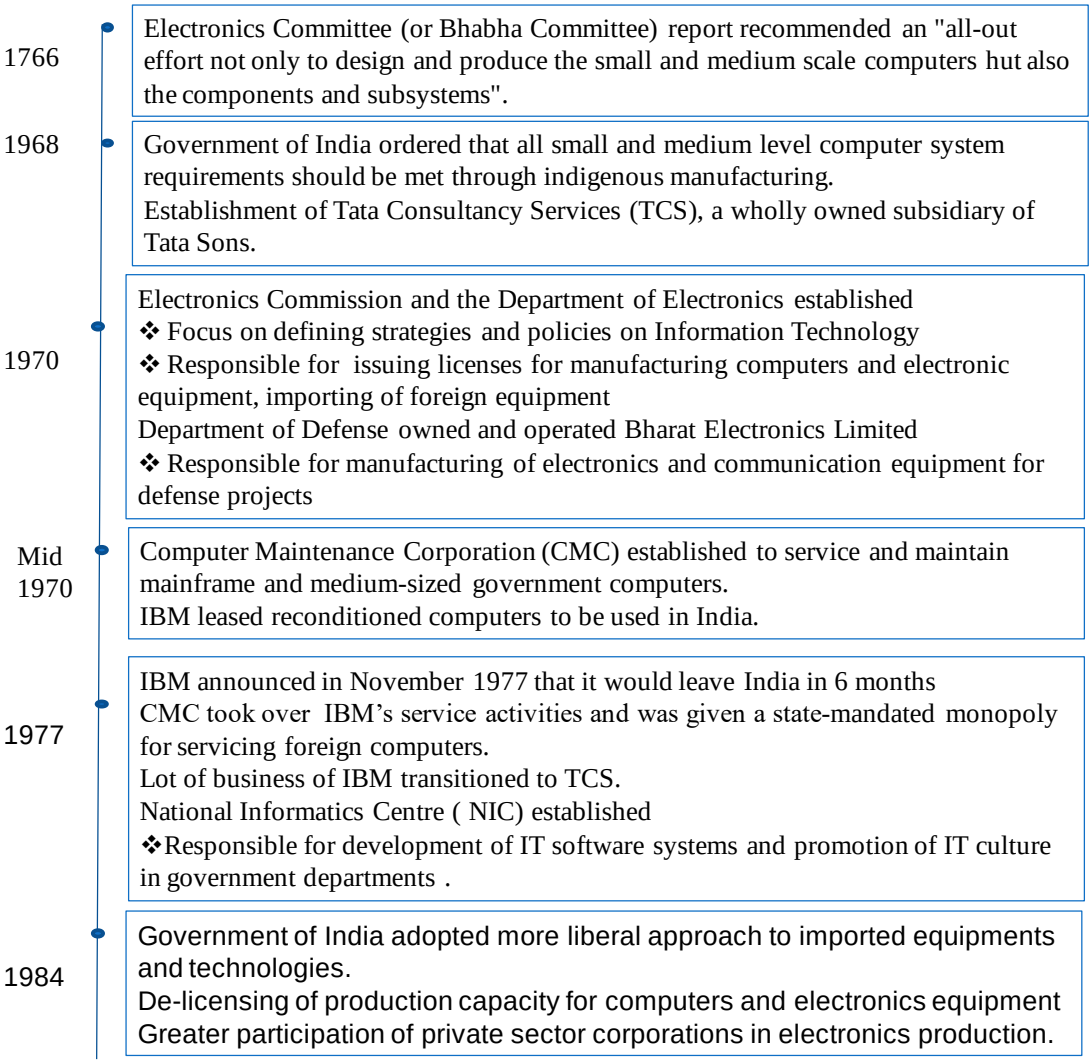


Figure 2.5: Evolution of IT Industry in India (1766-1984)

In 1984, Indians saw a young Indian in Rajiv Gandhi leading the country and he saw education and information as to the main areas that India should focus in, if it were to grow. Policies were rolled out to help the IT sector to grow.

2.2.2 The Second Phase (1985 - 1990)

Indian software policy was rolled out in 1985 as part of 7th five-year plan, 1985-1990. The focus was to establish the world class colleges to improve the education level, set up institutes to improve computer knowledge, develop software technology parks to improve the software exports, and to establish new departments to improve the overall connectivity of Indians and to promote IT culture in the government.

Software Technology Parks (STPs) were established by the government of India in 1990 to boost the exports of IT software from India. After the economic reforms of 1991-92, the governments provided incentives in the form of liberalization of trade, elimination of duties on imports of information technology products, relaxation of controls on Foreign Direct Investments (FDI), and FOREX. Further, the government set up Export Oriented Units, STPs, and Special Economic Zones (SEZs). These initiatives enabled India to put herself on the global horizon in software development and its exports. Refer Figure 2.6

Figure 2.6: Evolution of IT Industry in India (1985-1990)

The overall volume of exports of software and services during 1989-1990 was estimated to be around USD Mn 110.0. 80% of the contribution was from "Body-Shopping" whereas 15% was from Indian Managed Software Exports. "Body Shopping" was the term widely used in 1980s where software companies were sending their employees on individual short term and long-term contracts to work at customer locations. Customer locations were mainly based out of USA. Since these were individual contracts where an individual used to travel and work from the client

location – hence the term “Body Shopping” was used for this kind of work. During early 1990s growth was mainly based on staff-augmentation mode and Global Delivery Model, where software engineers were working closely across geographies in tandem to maximize the benefit of the biological clock, Morck (2007).

2.2.3 The Third Phase (1990 and beyond)

India witnessed a major exchange rate crisis in 1990s, which triggered liberalization in India. The post-liberalization era saw many curbs being lifted for businessmen, which helped in the growth of the overall Industry and Software Industry. Privatization brought in lot of opportunities for everyone to grow together and Indian economy opened for the world. Thus, it can be summarized that the Indian strategy aimed at self-reliance and state-led development in IT in 1970s and early 1980s. It took some steps to move at faster pace in 1984, with the formation of software policy and major growth happened only after privatization and liberalization of reforms that happened under the leadership of PV Narasimha Rao government and then Finance Minister as Dr. Manmohan Singh. Refer Figure 2.7

It can be rightly said that Indian Story has begun….

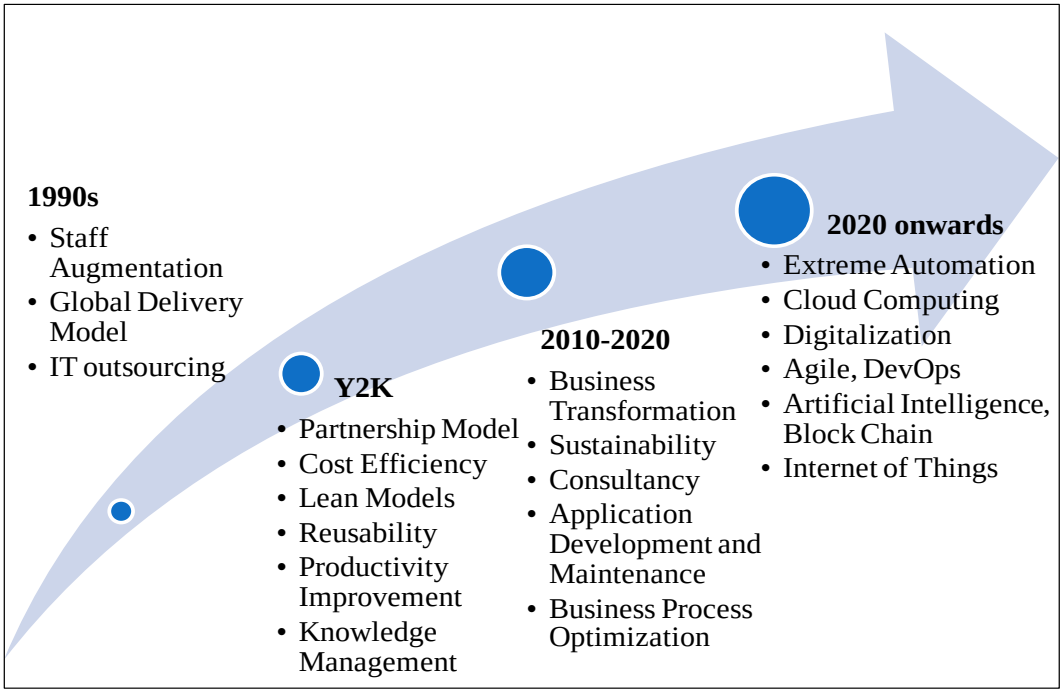


Figure 2.7: Evolution of IT Industry in India (1990 and beyond)

INFY pioneered Global Delivery Model (GDM) model in 1990s and became bellwether for the Indian IT Industry. Through global delivery model, companies deputed the part of their employees at customer location (primarily US), termed as onsite and majority of the workforce worked at India Development centers, termed as offshore. The offshore deployment of engineers not only gave the cost advantage to the companies (high skilled, low cost talent available in developing countries), but the companies also leveraged the 24-hour clock model, thus reducing time to market considerably. Whereas 1990s focused on revenue growth based on staff augmentation and GDM model for the industry, year 2000 started with its own problems - such as Y2K and Dot Com Bubble issues. The growth in IT industry in 1990s led to mushrooming of many small startup companies in the house garages and everybody latched on to catch the dot com syndrome, which was not to happen. The Dot Com bubble burst in early 2000s, and so did dreams of lot of IT companies and software engineers. IT industries worldwide went on for retrenchment, cost cutting and optimization.

The period from 2000-2009, saw Indian IT companies' growth, but they rode on the wave of cost efficiency models, bringing increase productivity improvements to the clients and lean models were much talked about. Indian companies moved on from the pure staff augmentation model into partnership model, where they tried to add value and deliver value in every aspect to their clients. Knowledge management, Re-usability, usage of proprietary tools and components became the unique selling proposition of the Indian IT software companies to woo clients and continue their bull run, albeit on slower pace as compared to 1990s.

The period from 2010 onwards saw more challenges for the Indian IT companies where they struggled to meet both their top line and bottom line goals. On the one hand companies tried hard to achieve their revenue targets and maintain their operating margins because of increased competition; whereas on the other hand companies had to bring in cost optimization in the operations to pass on maximum benefit to their clients. During this phase, the IT companies betted big on consultancy, shed their technology company tags, and went a step further to work in partnership model with their customers. The IT companies geared themselves up to provide

complete end to end solution for their customers. Various new revenue sharing models – such as risk and reward model, Build-Operate-Transfer model, revenue sharing model, cost sharing model, IP Monetization were established by the IT companies to address the competitive environment.

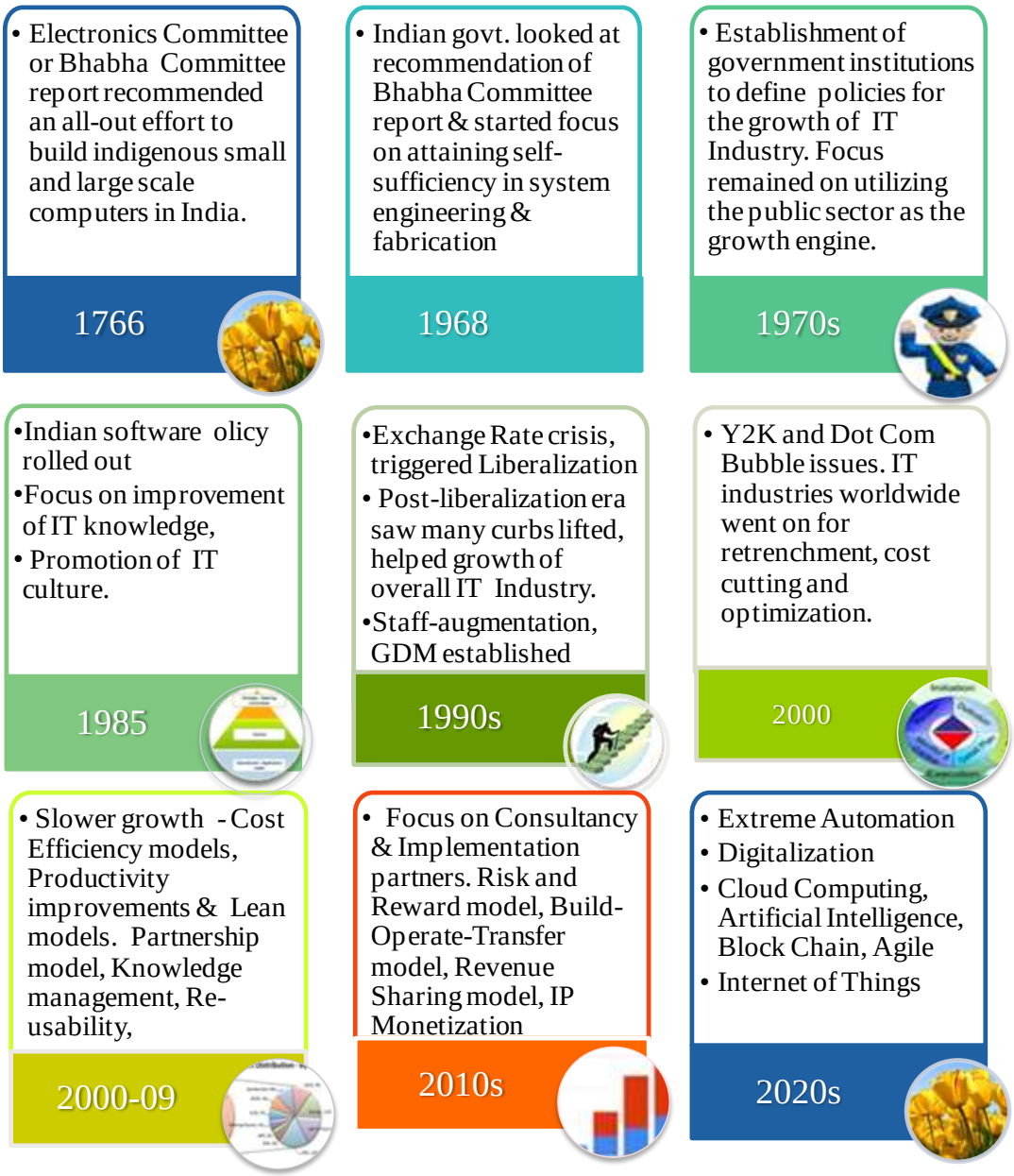


Figure 2.8: Summary View of Evolution of IT industry in India

In 2020s, the focus of IT industry is towards extreme automation, digitalization, enriching customer experience through usage of technologies such as Cloud Computing, Artificial Intelligence, Block Chain, Internet of things and software

methodologies such as Agile development and devOps models. Refer Figure 2.8 for a summary view of evolution of IT industry in India.

The IT industry is one of the prominent industries of India. This sector is the corporate face of India since liberalization and globalization started in India after the balance of payment crisis in early 1990s. It has made significant contribution in the GDP of India. The performance of IT firms and efficiency have implications not only for the growth of the IT sector but also for the whole economy (Alderete, 2018; Kaba & Meso, 2019; Goyal, Sah, Sharma & Puri, 2020). The significance of IT industry in providing employment and contributing to the overall growth and development of the country is well accepted by policy makers and academicians. Also, it is observed that IT industry of India in over dependent on software exports as approximately 90 per cent of revenue for IT companies comes from IT exports to foreign countries especially to US. In this context, it will highly desirable to study the impact of exchange volatility on the performance of IT companies and how these IT companies reduce the exchange rate risk.

2.3 Size of Information Technology Industry in India

The IT and Business Process Management (IT-BPM) industry of India, as it is more commonly known in India, has come a long way since 1991, when the liberalization, privatization and globalization process started in India. The IT sector of India turned the balance of payments crisis of India and the subsequent events in its favor and made it an opportunity. In 2000, the size of the IT sector in India was only USD Bn7.7, which rose to USD Bn 191 by 2020. Figure 2.9 shows the growth of IT-BPM Industry of India from 2000 to 2020 (NASSCOM, 2020).

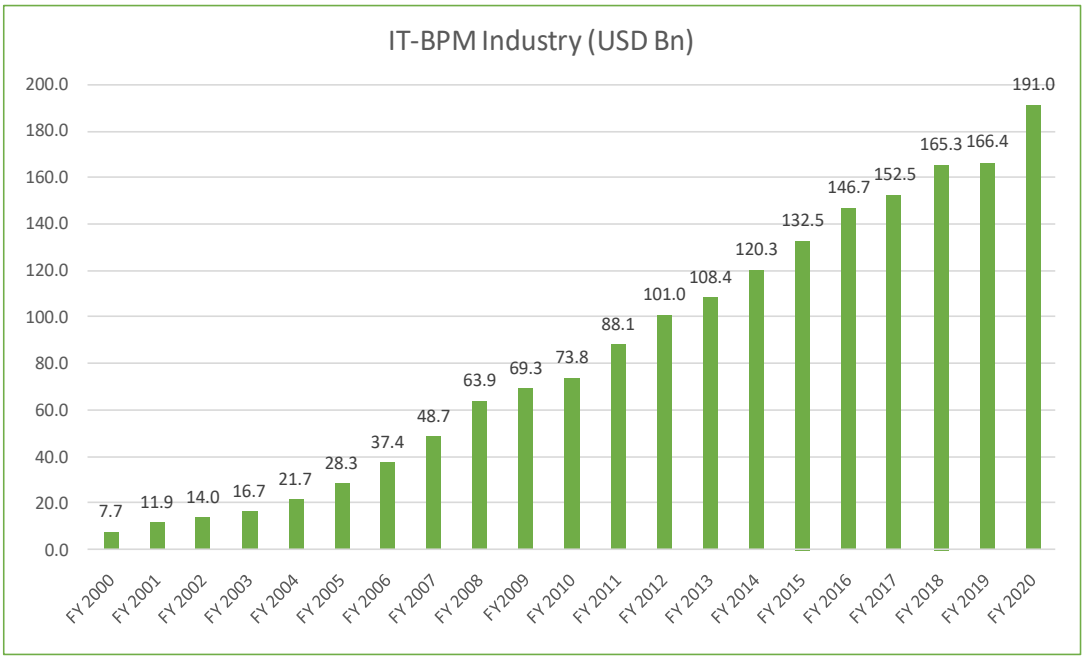


Figure 2.9: IT-BPM Industry of India from 2000 to 2020

The IT industry of India has grown many folds from USD Bn 7.7 in 2000 to USD Bn 191 in 2020. However, the share of IT industry of India in the global IT industry is still less than 20%. Thus, the IT industry of India can increase its share in the total global IT industry by enhancing its efficiency and cost-effective methods.

The total revenue of the IT industry in India comes from two sources. The major source of revenues of the IT industry in India is software exports to other countries. The domestic market provides relatively lower revenue than the foreign markets to the IT industry. Figure 2.10 shows that the IT industry revenue from the domestic sources and software exports including hardware were almost equal in 2000. However, the total revenue of the IT industry in India from export and domestic sources both have risen over the years but while the rise was 10 times in the domestic revenues, the rise in revenues from export was roughly 25 times. In 2020, the total revenue of the IT industry in India was USD Bn 191.0. The revenues received from the domestic sources including hardware was USD Bn 44.0and the revenues received from the software export was USD Bn 147.0.

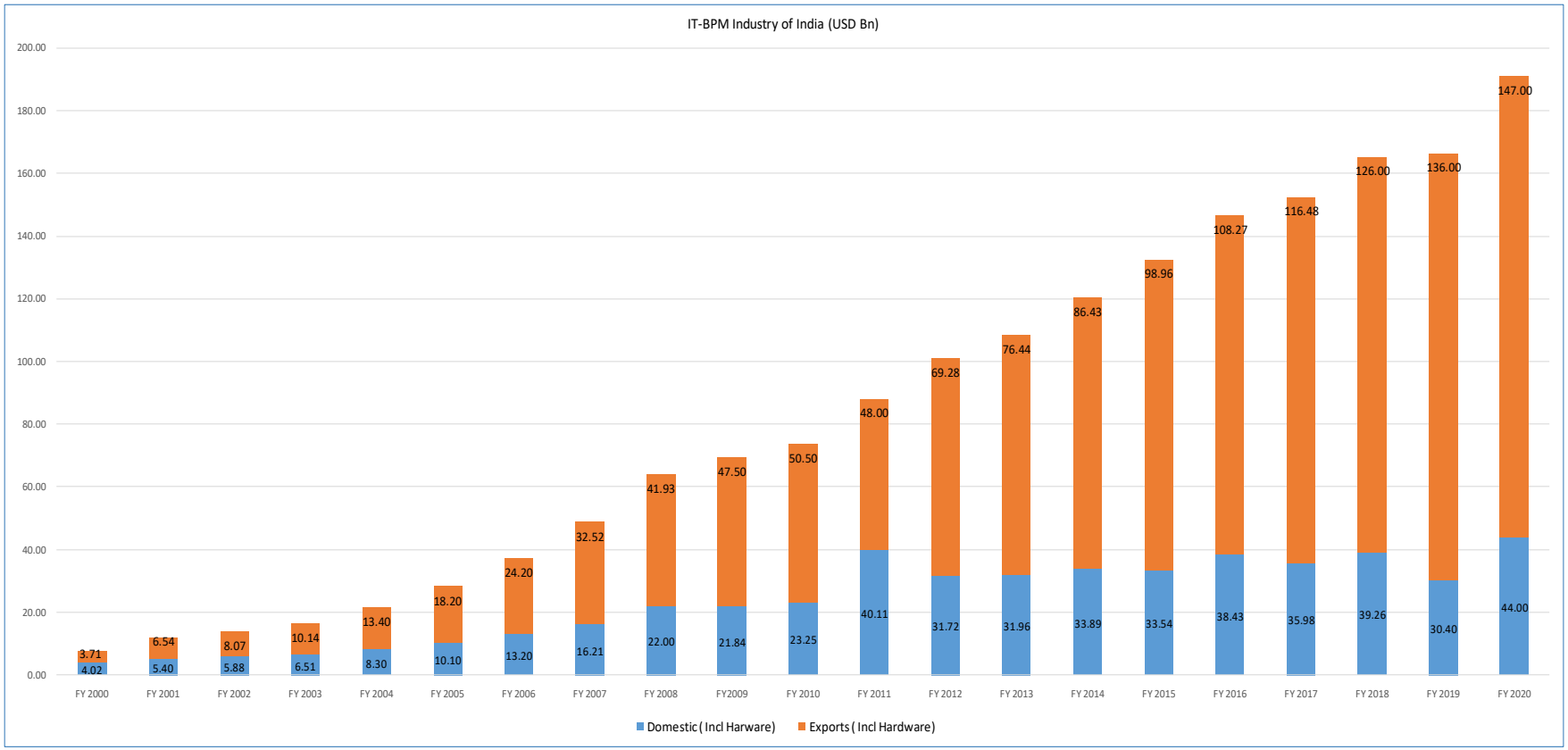
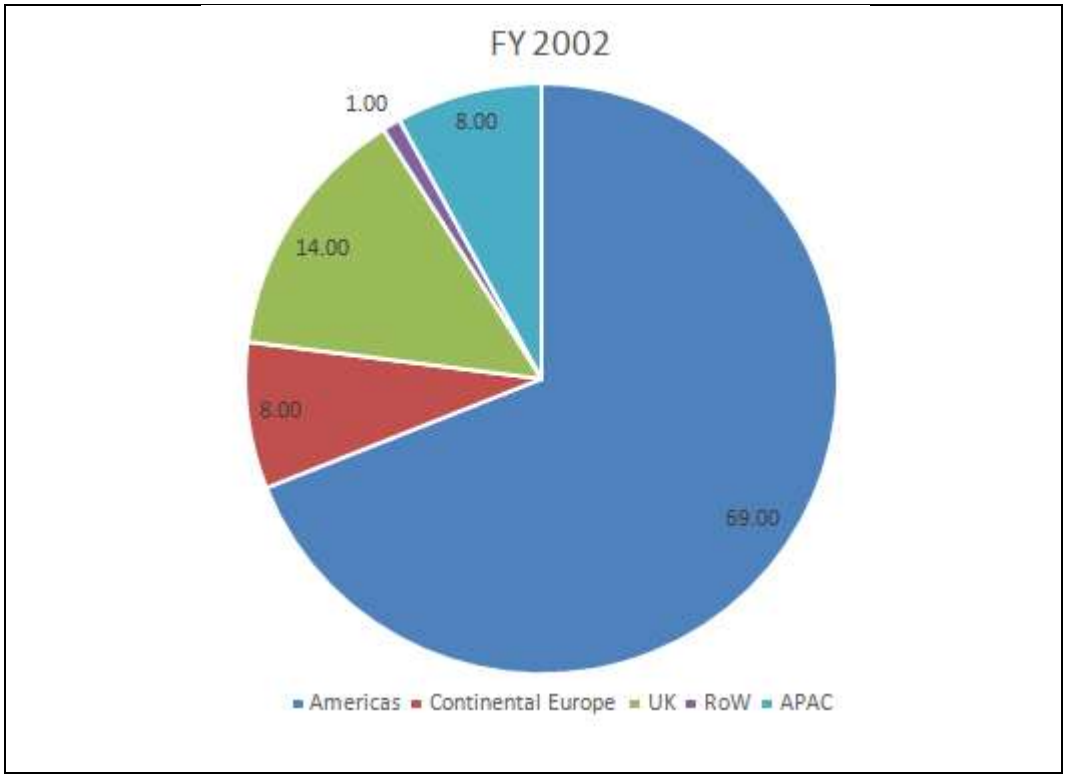


Figure 2.10: IT Industry of India: Exports and Domestic Share (USD Bn)

The size of the IT industry in India is estimated to be USD Bn 191 by 2020 (NASSCOM, 2010; IBEF, 2020, NASSCOM, 2020). The average annual growth rate of Indian IT industry, which was 30 per cent during the period 2002 and 2008, dropped to 8.10 per cent during 2008-09 may be due to the sub-prime crisis of 2008.

2.3.1 Major Software Export Destinations

The IT industry of India receives major portion of its revenues from export of software to different countries. The IT industry primarily exports its software services to USA and European countries. Figure 2.11 shows that the percentage share of IT exports to Americas (USA & Canada) as compared to the total IT software export of India was69% in 2002. This declined to 62% in 2020. The share of UK was 14% in 2002, which marginally increased to 17% in 2020. The share of Continental Europe and Asia Pacific region that includes Australia, New Zealand and China were 8% respectively in 2002. While the share of Continental Europe marginally rose to 11% in 2020, the share of Asia Pacific region was consistent at 8% in 2020. Thus, the directions of software export destinations of Indian IT industry have slightly changed after the 2008 sub-prime crisis but nonetheless the major software export destinations of Indian IT firms have remained the same during the period 2002 and 2020.



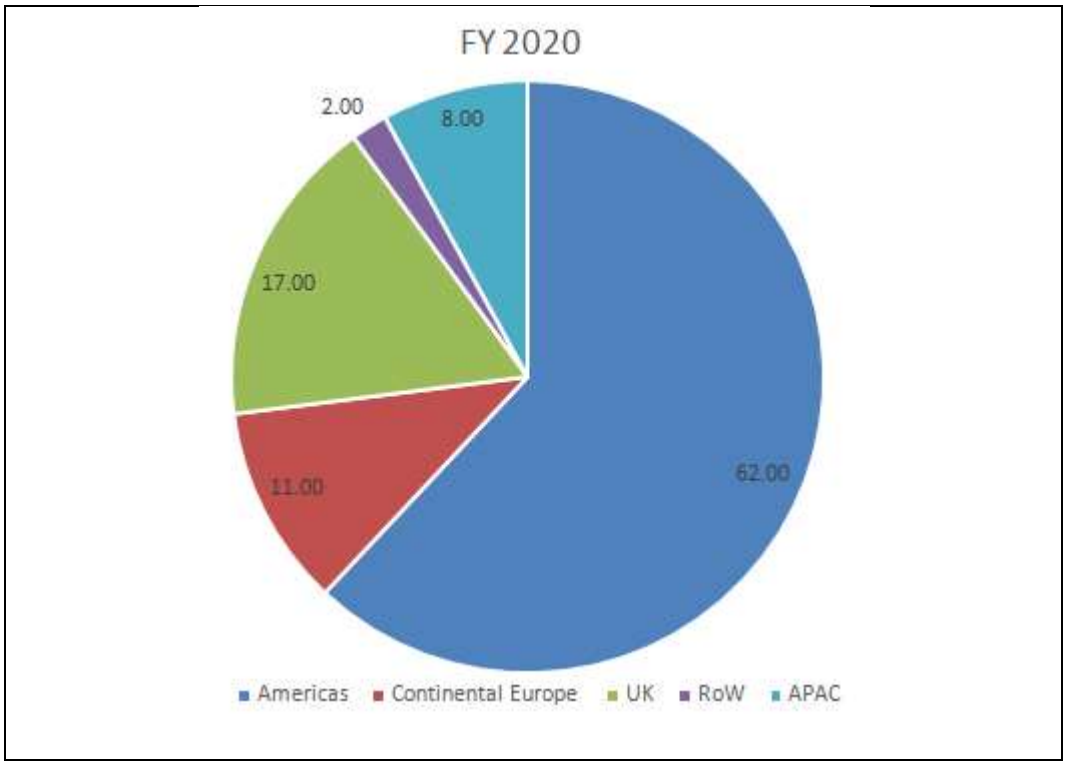


Figure 2.11: Software Export Destinations (%) in 2002 and 2020

The reliance on US market for IT exports from India has decreased to 61% in 2017, whereas contribution of exports to Continental Europe has increased to 12% and to UK to 17% in 2017 respectively. To reduce the risk of dependency only on US market, the exports have steadily increased to non-US markets. Figure 2.12 shows the year-wise software exports to major destinations from 2002 to 2017.

Mathur (2007) and NASSCOM (2017) also mentions that majority of the customers of Indian Software IT industry are from the US and Europe, with the US taking a higher customer base share followed by Europe. With time, though the numbers might have reduced marginally but still most of the customers are based out of America and European countries. The American and European countries accounts for over 90% of Indian IT and ITeS exports. With dependence of revenue of western customers, the exchange rate fluctuations play an important role in controlling the top line revenues and profit margins of the company.

Though the market share of American clients has decreased over last 5-8 years, but still Americas holds the large share of exports for Indian IT industry. Approximately 90% of revenue of Indian IT industry has dependence on the FOREX cash flow and

hence any exchange rate fluctuation has a huge impact on the overall Indian IT industry. This is seen as a big risk.

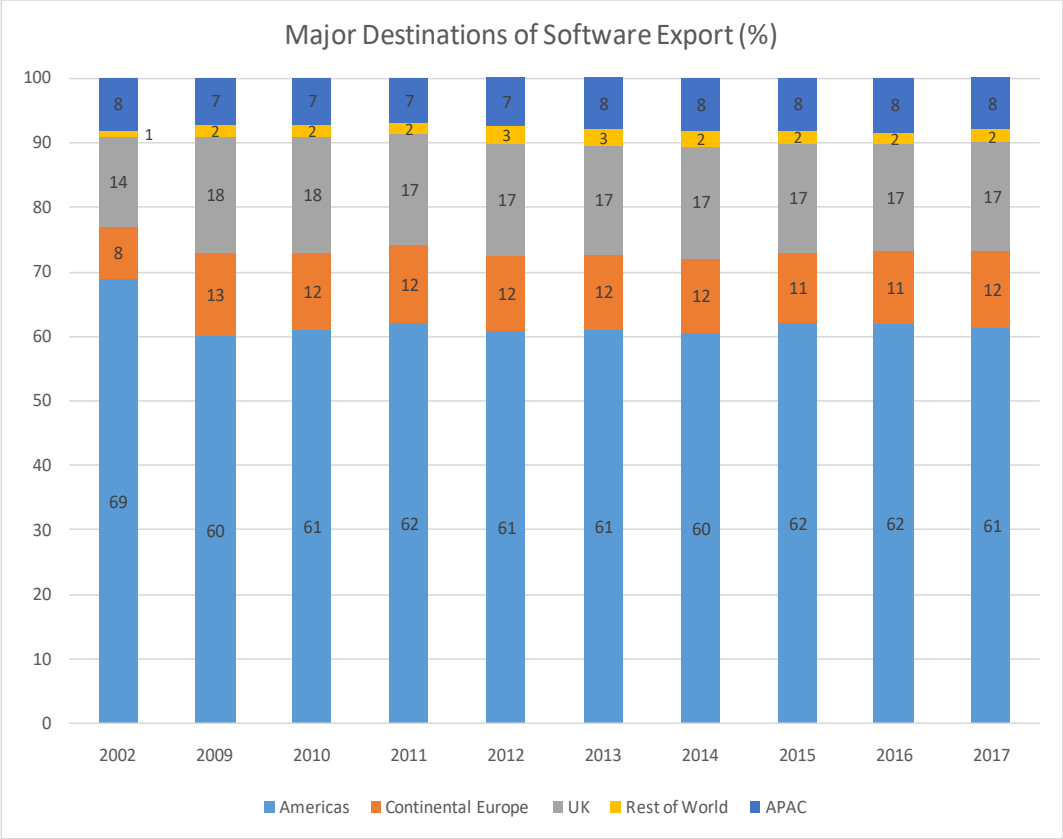


Figure 2.12: Year-wise Software Export Destinations (%)

The IT companies use exchange rate management strategies to safeguard themselves against this risk arising from FOREX fluctuations.

The IT-BPM Industry of India comprises of IT software and services, BPM and Engineering Services, Research & Development. Figure 2.13 shows the structure of IT-BPM industry of India. It clearly depicts that the IT-BPM Industry in India is broadly divided into IT-BPM Software and Services & Hardware. The IT-BPM Software and Services industry is further divided into:

1. IT Software & Services
2. Business Processing Management (BPM) – IT enabled Services (ITeS)
3. Engineering Services, Research & Development – Software Product Development

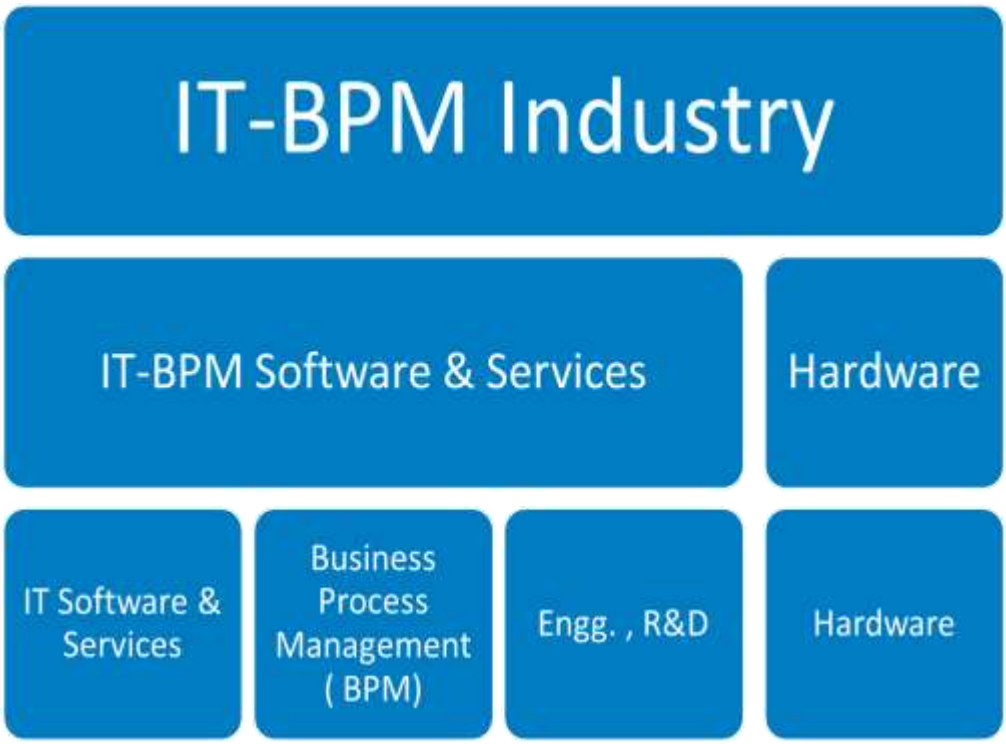


Figure 2.13: IT-BPM industry of India

The performance of three broad segments of IT-BPM industry of India is shown in Table 2.2. The Table shows that in 2000 the size of the BPM & Engineering Services (Engg.) and R&D has hardly any presence in the total output of the Industry. The total size of the IT industry was USD Bn 5.53 and the shares of IT software services, BPM and Engineering and R&D were respectively USD Bn 4.1, USD Bn 0.1, and USD Bn 1.33 respectively. However, by 2002, the BPM segment outperforms the Engineering Services and R&D segment. The shares of IT software services, BPM and Engineering Services and R&D were respectively USD Bn 6.44, USD Bn 2.33, and USD Bn 2.04 respectively in the year 2002.

Prior to 2008 before the US sub-prime crisis, the share of IT software services, BPM and Engineering and R&D were respectively USD Bn 22.58, USD Bn 9.5, and USD Bn 8.19 respectively. However, in 2017, the share of BPM and Engineering and R&D segments had almost equal share of 29%. The IT software and services had a share of USD Bn 80.08 in 2017. In 2020, the total size of the IT-BPM industry of India was USD Bn 175. The three segments viz., IT Software and services, BPM, and

Engineering Services and R&D contributed USD Bn 97.0, USD Bn 38.0, and USD Bn 40.0 respectively.

During the period 2000 and 2020, the average annual growth rate of aggregate IT-BPM industry of India was 19.54%. Before the 2008 financial crisis, the average annual growth rate of aggregate IT-BPM industry was 33.05%. However, this high growth rate dampened due to the recession and fell to 10.54% after the 2008 worldwide economic recession. Thus, the economic recession of 2008 had a very adverse and lasting effect on the performance of the IT industry of India.

The various segments of the IT-BPM industry of India also got impacted adversely. The dominant segment of the IT-BPM industry of India is the IT Software and Services. During the period 2000 and 2020, its average annual growth rate was 17.71%. Before 2008, the growth rate of this segment was highly impressive at 28.68%. However, the impact of 2008 economic recession is clearly visible on the segment; its growth has reduced from 28.68% to 10.39% after 2008. The BPM industry shows that the average annual growth rate before and after the 2008 recession were 165.4% and 9.79% respectively. Moreover, the average annual growth rate of Engineering Services and R&D during 2000-2020 was 19.43%. Before the 2008 recession, this segment grew by 30.19% but its average annual growth rate decline to 12.96%. Thus, the impact of economic recession on the all the segments of the IT-BPM industry of India is clearly visible. The data of IT industry of India show that the industry is yet to recover from the adverse impact of the 2008 economic recession. Nonetheless, a new challenge in form of COVID-19 pandemic has hit the global economy. The impact of the COVID-19 is yet to seen on the IT industry of India.

Table 2.2: IT-BPM Industry of India from 2000 to 2020 (US Billion Dollars)

	IT Software and Services	% Growth	BPM	% Growth	Engg Services,R&D	% Growth	Total Software and Services	% Growth
FY 2000	4.10		0.10		1.33		**5.53**	
FY 2001	5.77	40.69	1.11	1010.00	1.84	38.00	**8.72**	57.55
FY 2002	6.44	11.68	2.33	109.91	2.04	10.65	**10.81**	23.97
FY 2003	7.42	15.10	3.56	52.79	2.30	12.61	**13.27**	22.76
FY 2004	10.41	40.39	3.40	-4.49	3.22	40.31	**17.03**	28.33
FY 2005	13.51	29.78	5.10	50.00	3.95	22.67	**22.56**	32.47
FY 2006	17.80	31.75	7.20	41.18	5.30	34.18	**30.30**	34.31
FY 2007	22.58	26.85	9.50	31.94	8.19	54.53	**40.27**	32.90
FY 2008	30.08	33.22	12.53	31.89	10.53	28.57	**53.14**	31.96
FY 2009	34.03	13.13	13.60	8.54	12.30	16.81	**59.93**	12.78
FY 2010	36.31	6.70	14.65	7.73	12.74	3.58	**63.70**	6.29
FY 2011	44.40	22.28	16.88	15.21	14.81	16.25	**76.09**	19.45
FY 2012	52.00	17.12	19.00	12.56	17.00	14.79	**88.00**	15.65
FY 2013	56.30	8.27	20.90	10.00	17.90	5.29	**95.10**	8.07
FY 2014	65.00	15.45	23.53	12.58	17.07	-4.62	**105.60**	11.04
FY 2015	68.00	4.62	27.00	14.75	24.00	40.57	**119.00**	12.69
FY 2016	75.31	10.75	28.05	3.87	26.70	11.24	**130.05**	9.29
FY 2017	80.08	6.34	29.26	4.33	29.26	9.59	**138.60**	6.57
FY2018	86.00	7.39	32.00	9.36	33.00	12.78	**151.00**	8.95
FY2019	86.00	0.00	32.00	0.00	33.00	0.00	**151.00**	0.00
FY2020	97.00	12.79	38.00	18.75	40.00	21.21	**175.00**	15.89
Average Annual Growth (%)		**17.72**		**72.05**		**19.45**		**19.55**
Average Annual Growth Before 2008 (%)		**28.68**		**165.40**		**30.19**		**33.03**
Average Annual Growth Rate After 2008 (%)		**10.40**		**9.81**		**12.29**		**10.56**

CHAPTER III

REVIEW OF LITERATURE

This chapter deals with review of literature for this study. The past literature lists the contribution of earlier researchers and helps to carve out the objectives of the research. This also helps to avoid duplication of the research, thus providing novelty to the research. A section-wise literature review is presented for each of the selected objectives for this study. The first objective of the study is to examine the performance of the selected IT companies of India. The performance of the IT companies will be evaluated in terms of their efficiency at aggregate as well as component levels. The review of literature relating to this objective is given in the next section.

3.1 Review of Efficiency Performance of IT Companies in India

The researchers worldwide are involved in the measurement and improvement of efficiency as it has lot of implications for organizations in increasing the output and decreasing the overall cost of production (Lampe & Hilgers, 2015; Liu & Huang, 2019; Emrouznejad & Yang, 2018). There are numerous studies that have investigated and analyzed efficiency of IT firms. The researchers have also investigated the impact of IT sector on individual as well as firms' efficiency (Arvanitis & Loukis, 2009; Draca, Sadun & Van Reenen, 2016; Lefever et al., 2018; Abdullahi, Shehu & Usman, 2019). The IT automation processes have reduced operation time and the overall cost of production in the companies. The increase in efficiency has resulted in economic growth and development (Vu, 2011; Chang, Hung& Huang, 2013). However, there are also many research works which have thrown light on the adverse impact of IT on the health of the people both at home (Ciccarelli et al., 2011) and at work (Robertson et al., 2012) , thereby decreasing the overall organizational efficiency.

In the literature, there are primarily five frontier techniques used to estimate the efficiency and performance of the firms, namely, stochastic frontier approach, distribution free approach, thick frontier approach, data envelopment analysis and free

disposal hull (Puri & Yadav, 2013; Choudhary, 2015; Phung & Tröge, 2015; Gupta & Choudhary, 2018; Prabakaran et al., 2020). The first three are parametric techniques which need explicit specification of production frontier. On the other hand, the remaining two techniques are non-parametric which do not require any specification of production frontier. Amongst these two, DEA is the most popular and widely used non-parametric technique to measure efficiency of IT companies (Samoilenko & Osei-Bryson, 2008; Emrouznejad & Yang, 2018). There is enormous literature available on DEA and its application in various fields for efficiency estimation and IT industry is not an exception (Mathur, 2007; Bhattacharjee, 2012; Emrouznejad & Yang, 2018; Puri & Yadav, 2017; Goyal et al., 2020).

According to Ray (2004), DEA is a non-parametric method. A lot of research has been done on the first model introduced in 1978 in European Journal of Operation Research. For efficiency measurement, DEA has evolved as an alternative technique to regression analysis. The first model introduced by Charnes, Cooper and Rhodes (CCR) could be applied only to technologies characterized by constant returns to scale. However, this model was later modified in 1984 by Banker, Charnes and Cooper to include technologies characterized by variable returns to scale too. DEA can be used to measure the efficiency of any Decision Making Unit (DMU). DMU can be a firm, a company, or any government institutions. For example, there is already a research done on measuring the efficiency of Indian telecom operators using DEA. Cooper et al. (2000) defines DEA as technique to evaluate the efficiency performance of the similar entities. As per Bowlin (1998), DEA was developed initially for usage of the non-profit organizations as a performance measurement tool that was enhanced later for the usage of profit organizations too. It could be applied to measure performance of any institutions such as hospitals, education institutions, airline industry, and telecommunications operators and is used where more than one input and output must be used to measure the performance of the institutes. Charnes et al. (1978) described DEA as a mathematical programming model that can be applied to data. It is a method through which we can obtain empirical estimates of relations. DEA is now extended to both forms of industries having a production function that

complies with CRS or variable returns to scale. Further, DEA can be used to measure performance for any kind of DMU, Cooper et al. (2000).

There is vast literature available on the application of DEA methodology and efficiency measurement across the industries (Emrouznejad & Yang, 2018; Lampe & Hilgers, 2015; Oruc & Altin, 2015; Avkiran, 2006).

Thore et al. (1994) applied DEA technique on 44 large computer manufacturers in USA, to measure their efficiency using financial data for the period 1981-1990. They found that though few companies were able to show efficiency throughout the analyzed period but there were other successful companies which lagged. The study analyzed that the inefficient companies were hit hard during the crisis time of the industry whereas efficient companies were able to sail smoothly through the rough waters. They used Cost of Goods sold, Capital expenditures, Expenditure on R&D, Other expenditures, Employees and Assets as input variables. The output variables used for the study were Revenue, Income, and market capitalization.

Further, Shao and Shu (2004) evaluated efficiency growth of ICT in 14 Organization of Economic Co-operation and Development (OECD) countries from 1978 to 1990. The study considered capital and labor as input variables whereas value of total software products developed as output variable. They documented that most of the efficiency growth is due to technological progress. They also concluded that the change in scale economies adversely impacted efficiency. Chen and Ali (2004) applied the DEA Malmquist approach on a set of Fortune Global 500 Computer and Office Equipment companies from 1991 to 1997. This study revealed mixed trend in AOTE. Chen and Zhu (2004) studied the indirect impact of IT on 22 banks for duration 1987-1989 using two-stage DEA. The study illustrated that this model can be applied to measure the impact of IT on firm's performance and highlight those firms that can be further studied for benchmarking.

Mathur (2007) used DEA technique to study the performance of 92 Indian software companies for 2005-2006 and found that 16 out of 92 firms are the most efficient when compared to each other. He concluded that while IT industry of Taiwan was highly efficient, the IT industry of India was least efficient in a sample of 12 countries. He used sales turnover, net exports, total cost, number of employees and

age of the firm as input and output variables. Wu and Ho (2007) evaluated efficiency of 36 integrated circuit companies of Taiwan from 2002 to 2004. They established that the relation between efficiency and asset size is found to be negative. Further, Liu and Wang (2009) found that the efficiency of fifteen IT firms in Taiwan from 2000 to 2003. They documented that none of the selected firms performed efficiently, either at the stage of production acquisition or at the stage of profit earnings. They also suggested that the IT manufacturing companies need to address the issues relating to product improvements and technological innovations to improve the productivity.

Chinubhai (2011) applied DEA on the selected software development projects to analyze the efficiency of the software development process taking one input (work effort) variable and three output (quality, function points developed, duration of project) variables. The study further explored the correlation between efficiency with other factors such as team size, development tool used, type of project etc. using decision tree model. Kassim et al. (2011) applied DEA analysis to measure the impact of IT business value addition on the performance of engineering and construction organizations taking 4 inputs and 6 output variables in consideration. It was observed that usage of this approach has helped to find the answer to the question if application of IT has helped in increasing the business value and firm's performance of the construction companies. The approach also helped to benchmark the most efficient organizations amongst the group. This leads us to the findings that DEA could be used to measure the efficiencies across IT industry as observed in the studies mentioned above. Chen et al. (2011) applied DEA to measure the efficiencies of listed IT companies of China. They analyzed data across 73 IT companies for the period of 2 years, 2005-2007. 4 inputs variables and 3 output variables were considered for the study. The study concluded that only four companies were technically efficient whereas six companies were managerial efficient during this period. Further, the study also estimated the Total Factor productivity (TPI) using Malmquist productivity index (MPI) approach. The MPI results revealed that there was no significant improvement in TFP for the IT companies during this period. Al-Najjar & Al-Jaybajy (2012) applied DEA to analyze the technical efficiency of 12 oil refineries of Iraq during 2009-10, taking 4 inputs and 4 output variables. It was observed that while 50% of the

refineries were efficient in 2009, while 58% of them were efficient in 2010. Furthermore, Bhattacharjee (2012) evaluated the technical efficiency of IT and IT enabled service firms of the eastern region of India from 1993 to 2007 using DEA analysis. He considered employment and capital stock as input variable and total revenue as output variables for all the firms registered under Software Technology Parks of India, Kolkata during this period. He documented that the efficiency of large companies shown an increase in their efficiency over the sample period. He also found that the segment specific policies are better instead of uniform policies to improve efficiency.

Ranga (2013) applied DEA to the financial data of selected 11 Indian pharmaceutical companies to measure the firm's efficiency and relationship of firm's efficiency with the stock returns. It was concluded based on this study that there is weak association between firm's association and stock returns. Further, Chou and Shao (2014) studied the TFP growth for IT sector of 25 Organization of Economic Cooperation and Development (OECD) countries from 1995 to 2007 using DEA. The study took gross output of IT industry as output variable whereas labor and capital as input variables. They applied MPI as performance metric and DEA as measurement methodology. They established that IT service industry showed significant productivity growth when compared to other service sectors during this period. They concluded that the technological innovations are a key driver of efficiency growth. They also found efficiency change and scale change have negative impact on the productivity. Sahoo and Nauriyal (2014) used input-oriented DEA model to examine the trends of efficiency growth of seventy-two Indian IT firms from 1999 to 2008. They took sales revenue as output variable and employment, operating expenditure as input variables. The study established that mean OTE of the software industry was low during this period, thus suggesting software firms were wasting approximately one-third of their inputs. It was also found that number of companies operating on most productive scale size has reduced during this period. They found that Indian IT firms were not able to use their inputs to the extent of almost 35 per cent. They also found in their study, that Indian owned software companies demonstrated high efficiency than the foreign owned IT companies. Dixit (2014) applied DEA to analyze the technical efficiency of

top five IT companies of India for the period 2009 to 2013. He used number of employees as input variable and profit as output variable for the study. The study concluded that TCS is more technical efficient as compared to other firms. In addition, the study indicated that manpower increase has a relation to increase in productivity of the IT service firms and thus manpower is strategic asset for IT organizations.

Oruc and Altin (2015) investigated the effect of 2007 financial meltdown on productivity of 20 IT firms listed in Fortune 500 companies. They applied MPI method to measure the productivity of IT firms for the period 2005-2010. The study used short-term liabilities; long-term liabilities and shareholders' equity as three inputs variables whereas total income and net profit as two output variables. They established that productivity of the firms decreased during 2007, 2008 and 2009. However, productivity of 20 IT firms showed increased during 2010.Samoilenko and Osei-Bryson (2017) studied and developed a methodology to study the impact of ICT on 24 economies of Sub-Saharan Africa using DEA. The study concluded that the relationship between the factors that impact the economy is complex.

The above studies strengthen the findings that DEA could be used to measure the efficiencies across the industries and can also be applied in IT industry.

Further, Seiford and Zhu (1999) examined the performance of the top 55 US commercial banks during 1995 using 2 stage DEA model. The operations of a bank are divided into two processes to measure profitability and marketability and it was observed that about 90% of the banks were inefficient in both profitability and marketability. Ho (2008) performed a DEA analysis to evaluate the performance of the dot com companies for the financial year ending 2005. This study used a two-stage DEA model to measure the profitability and marketability of the U.S. listed dot com companies. The study also explored to find the correlation between these two factors. He concluded that 10 out of 69 dot com companies were CCR-efficient when profitability was used as output variable. However, on marketability factor, 23 out of 69 firms were CCR-efficient.

Furthermore, Liu and Wang (2009) applied a two-stage DEA to measure the efficiency of the production process and profitability of 17 IT firms of Taiwan for the year 2005 and concluded that none of the IT firms performed efficiently in any of the

stages. Kao and Hwang (2010) discussed the application of network DEA model to assess impact of IT on firm performance in banking industry. The results show that the impact of IT on firm performance operates indirectly through fund collection. The impact increases when the IT budget is shared with the profit generation process.

Liu and Zhang (2013) used a three-stage DEA to measure the innovation efficiency of foreign-invested and state-owned IT companies in China and found that the SE of the former set of companies was higher than the latter. Furthermore, Rui and Yang (2015) applied a two stage Network DEA to measure efficiency of IT companies of China in 29 provinces from 1999 to 2013 and concluded that 11 industries had less than 50% efficiency levels. Also, Li, He, Shan, & Cai (2019) utilized a three-stage DEA model to measure the efficiency of IT industry of China and found that the efficiency of the industry improved from 2009 to 2014. Likewise, Chen, Lin & Zou (2020) applied a network DEA analysis to measure the efficiency of IT industry of 29 provinces of China from 1999 to 2018 and found that the efficiency of the eastern provinces was higher than that of the central and the western provinces.

The aforementioned literature suggests that there are numerous studies published on efficiency measurement of IT industry using DEA, two-stage DEA, three-stage DEA and network DEA (Koronakos, 2019; Goyal et al., 2021). The literature review shows a mixed trend in the changes in efficiency of IT firms at the domestic level as well as at the global level. However, there is a need to investigate the efficiency trends of Indian IT sector; and, to examine the impact of various global concerns on the efficiency of the IT industry of India. Also, there is a need to investigate the performance of Indian IT companies and to benchmark the IT companies of India. This will enable the IT companies to manage inefficiency and devise policy measures for improving their overall efficiency. These specific aspects of Indian IT sector need to be addressed. However, there is very scant literature available in this field. This thesis tries to fulfill this gap by studying the efficiency of the IT sector using DEA technique and has utilized workers' effort as key input.

Thus, the first objective of the study is to measure the relative efficiency performance of the selected IT companies using DEA.

Further, to study the performance of IT companies of India, it is important to identify and analyze the various critical factors determining the efficiency performance. The view of literature relating to the second objective of the study is given in the next section.

3.2 Review of Factors Affecting the Performance of IT Companies in India

Broadly, the factors affecting the performance of IT companies can be categorized as number of employees, labor, operating expenses, R&D expenses, revenue, operating profit, age of the company. The academic literature relating to performance of IT companies of India lists a wide range of theoretical determinants. There are various studies that have investigated the internal and external factors influencing the performance of IT companies. These studies have employed various models such as DEA, Tobit regression, Cobb-Douglas function to the name the few, in their respective research work. The literature review on DEA and Tobit regression is mentioned in subsequent sections, highlighting the various variables that were selected for analyzing the performance of IT companies.

This section is further divided into review of literature relating to DEA methodology and Tobit Regression.

3.2.1 Review of Factors Affecting the Performance of IT Companies in India using DEA Methodology

The selection of variables to employ DEA methodology has been debated a lot by various researchers. There are various input and output variables selected in the past research work to study the impact of these variables on the efficiency of the companies. These are listed in Table 3.1.The major variables that have been selected by these studies include number of employees, labor, expenses – employee compensation expenses, operational expenses, utility expenses, R&D expenses, training expenses etc., total sales/revenue and operating profit/net profit.

Apart from DEA methodology, Tobit Regression Model has been applied by various researchers to study the impact of various variables on the performance of IT companies. The next section details the review of literature using Tobit Regression model.

Table 3.1: Determinants Affecting Performance of IT Companies

Variable Type	Variable Name	References from Literature Review
INPUT VARIABLES	No. of Employees, Employment, Labor	Cook et al. (2000), Chen & Ali (2004), Mathur(2007), Wu & Ho (2007), Ho (2008), Samoilenko (2008),Samoilenko & Osei-Bryson (2008), Liu & Wang (2009), Kuo & Yang (2012), Puri & Yadav (2013),Sahoo & Nauriyal (2014),Puri et al., (2017), Puri & Yadav (2017), Gong et al. (2018), An et al. (2018),Lin et al. (2018), Li et al. (2019),Zhang et al. (2019) , Chen et al. (2020)
	Expenses such as operational, Utility, Research and Development, Training etc.	Mathur (2007), Ho (2008), Liu & Wang (2009), Sahoo & Nauriyal(2014),Puri et al. (2017),Puri & Yadav (2017), Gong et al. (2018), An et al. (2018), Lin et al. (2018),Li et al. (2019),Zhang et al. (2019) ,Chen et al. (2020)
OUTPUT VARIABLES	Revenue, Total Income, Sales, Gross Output	Chen & Ali (2004),Wu & Ho (2007), Mathur(2007), Samoilenko & Osei-Bryson (2008), Liu & Wang (2009),Kuo & Yang (2012), Puri & Yadav (2013), Sahoo & Nauriyal (2014), Puri et al. (2017), Puri & Yadav (2017), Gong et al. (2018), Lotfi & Vaez-Ghasemi (2013), An et al. (2018), Lin et al. (2018), Li et al. (2019), Zhang et al. (2019), Chen et al. (2020)
	Revenue per employee	Samoilenko (2008), Samoilenko & Osei-Bryson (2008)
	Operating Profit	Wu & Ho (2007), Ho (2008),Liu & Wang (2009), Gong et al. (2018),Lotfi & Vaez-Ghasemi (2013)

Source: Author's compilation

3.2.2 Review of Factors Affecting the Performance of IT companies in India using Tobit Regression Model

Literature review suggests that Tobit regression model is applied as a second stage analysis by the researchers to compute the influence of background and environmental variables on the estimated efficiency scores. The relationship of different variables is explored with respect to the efficiency of the IT firms. This helps in explaining the variation in the efficiency scores.

The efficiency scores calculated from DEA model is used as dependent variable in the regression analysis. These efficiency scores are regressed on a set of independent variables that is hypothesized to explain the determinant of IT firm efficiency. There are different variables such as age of the company, number of employees, R&D expenses, size of assets , location of company , ownership pattern, utilization, capital-labor ratio , employee productivity that have an effect on the efficiency of the IT companies. To measure the impact of such variables, Tobit regression analysis could be conducted. Table 3.2 shows the details of different variables used by some of earlier studies on Tobit regression analysis.

Table 3.2: Variables used by Earlier Studies in Tobit Analysis

Author	Study Area	Variables
Gunes & Yilmaz (2006)	Impact of variables on efficiency of Turkish banking sector in 2007-13	Size, market share, profitability, loan intensity,
Singh (2006)	Impact of background variables on the efficiencies of 36 sugar mills of India for 2002-03.	Ownership, location, plant size, Net sugar recovery, total working hours lost, capacity utilization, reduced overall extraction
Mathur (2007)	Study on Indian Software Industry	Firm Size, Total Cost, number of employees, number of years in business, and net export
Mukherjee (2008)	Study on Indian manufacturing sector	labour productivity, manufacturing output, output per worker, labour-capital ratio, power availability
San et al.(2011)	To measure impact of different variables on Pure technical efficiency of banks in Malaysia over the period 2002-2009	Asset size, profitability, expenses, Capital strength, loan quality.
Joshi & Singh (2012)	To study the factors affecting efficiency of Indian garment industry for the year 2004-2005	Age; salary per employee; size of firm, region of the firm, labour productivity, capital-labour ratio
Alhassan et al.(2015)	To predict factors associated with efficiency levels of primary health care facilities in Ghana	ownership, location, gender of manager, presence of compliant system

It is evident from the above review of literature that employee cost, assets, age of the company, research &development expenses, and number of employees, total assets, net sales, and net profit are some of the key variables influencing the performance of IT companies.

The third objective of the study is to analyze and explore the IT-led growth Hypothesis. The IT industry has strong relations with other segments of economy. The various past studies highlighting the relation between IT growth and overall growth of Indian economy is given in the next section.

3.3 Review of Relationship between IT Growth and Overall Growth of India

The relationship between IT investment and growth of economy has always remained a topic of great relevance to research scholars as it has a lot of implications for the countries and organizations in increasing the output (Arora & Athreye, 2002; Jorgenson and Vu, 2005; Mora, 2006;Van Reenen et al., 2010; Walsham, 2010; Singh, 2015; Vu, Hanafizadeh & Bohlin, 2020). The initial work in this area was done by Jorgenson and Stiroh (1995, 1999) and Olineret al. (1994). Since then, there is lot of research work done in this area.

The literature suggests that there are studies done to explore the contribution of IT investment towards economic growth of a country (Oladipo et al., 2016) whereas there are other studies that have used panel data to analyze the impact of IT on economic growth across the countries (Bahrini & Qaffas 2019; Vu, 2011).Some of the countries that have been covered by the scholars to explore the relationship between IT investment and economic growth are the UK (Oulton, 2001), Poland (Piatkowski, 2003), Spain (Mas & Quesada, 2005), Singapore (Vu, 2013), Australia (Shahiduzzaman & Alam, 2014) and Nigeria (Oladipo et al., 2016). Whereas some of the regions or group of countries that have been researched by the scholars using panel data across the countries are G7 nations i.e. Germany, Canada, Italy, Japan, US and UK (Schreyer,2000) ; OECD countries (Daveri, 2000); Sub-Saharan African region (Lee et al., 2012); Middle East and North African region (Sassi and Goaied, 2013); Organization of Islamic Cooperation (OIC) countries (Aghaei and Rezagholizadeh, 2017); Oil and petroleum exporting countries (OPEC) (Sepehrdoust, 2018); BRICS countries (Brazil, Russia, India, China and South Africa) (Latif et al., 2018) ; Middle

East , North Africa and the Sub-Saharan Africa region (Bahrini & Qaffas, 2019), G-20 countries (Pradhan et al., 2018) and on other countries (Seo, Lee & Oh 2009; Gruber & Koutroumpis 2010; Vu, 2011). These studies applied growth accounting framework model, generalized method of moment growth model, Cobb Douglas production function, Johansen technique, panel co-integration approach, the Granger causality test and other regression frameworks for the analysis and concluded that there was a positive and significant contribution of IT towards the economic growth of most of the selected countries.

Further, there are studies that have observed a mixed relationship between IT investment and economic growth of the countries. Dewan & Kraemer (2000), Papaioannou & Dimelis (2007) and Yousefi (2011) found a positive relationship between IT and growth for developed, high and upper-middle income group countries whereas the relationship was either showing a low impact or was insignificant in case of developing or lower-middle income countries.

Lee and Khatri (2003) found that IT contributed towards economic growth of the selected countries till 1990s. However, the IT impact was insignificant on productivity for the duration 1995 to 2000.Pradhan et al. (2015) explored the impact of IT on economic growth in 21 countries of Asian region for the duration 2001 and 2012. The study employed panel co-integration techniques and found mixed relation between IT and economic growth for short-run and long-run. Another study by Albiman and Sulong (2016) analyzed the impact of IT on economic growth on 45 countries of Sub-Saharan region for the duration 1990 and 2014. They concluded that in the long run, IT had significant and positive impact on the economic growth. However, the study also found that when they considered a nonlinear effect analysis, they concluded that the IT investment seemed to decrease the economic growth in the selected region. The above literature review reveals a mixed trend in the relationship between IT and economic growth of the countries.

The aforementioned literature also suggests that there are numerous studies published on relationship between IT and economic growth of developed countries and the number of similar studies for Indian region has been limited (Erumban & Das, 2020). Also, there are only hand-full of studies that have investigated the impact of IT on

performance of companies in India (Navyashree & Bhat, 2016). A study by Gangopadhyay, Singh and Singh (2008), explored the impact of IT usage on manufacturing units of India for the duration 1998 and 2002. The study found that plants that used IT were more profitable and displayed increased productivity as compared to plants that did not used IT. Another study by Sharma and Singh (2013) analyzed the impact of IT investment on productivity of selected 2500 manufacturing plants of India for the duration 2003 and 2007. The study concluded that IT investment displayed increase in productivity, as measured by gross value added in the plants. However, the study observed a reduced impact of IT, when plant level fixed effects were included. A similar study performed by Joseph and Abraham (2007) analyzed data of the 52 manufacturing firms of India for the period 1998 to 2002. The results concluded that IT investment had positive impact on the labor productivity of the firms.

Kite (2012) selected listed firms on stock exchange of India and public sector firms of India for the duration 2005 and 2008 to study the impact of IT outsourcing on gross output. She concludes that IT outsourcing had a positive and significant impact on the gross output of the selected enterprises and at aggregate level IT outsourcing leads to the economic growth. Further Erumban & Das (2016) explored the impact of IT on economic growth of India for the duration 1985 to 2011. The study found that IT investment contributed significantly towards the economic growth of India. However, it was observed that this phenomenon was mainly limited to the service sector of India. Mitra et al (2016) investigated the impact of IT on productivity growth and efficiency of selected 8 manufacturing industries of India for the period 1994 to 2008.

The results suggest that IT had a significant and positive effect on the productivity and efficiency of the selected industries. Navyashree and Bhat (2016) explored the impact of IT investment on growth of 85 food processing firms in India for the duration 2010 and 2014. The study demonstrated a lagged IT investment had a positive impact on present year's sales growth of the selected enterprises.

In their study, Inani & Tripathi (2017) found a positive co-relation between IT and economic growth for India. They explored the impact of IT on economic growth of India for the period between 1991 and 2014 and found that IT had a significant and

positive impact on economic growth in the short run. However, the study didn't find any causality between IT and economic growth in the long run. Malik & Velan (2019) investigated the impact of IT investment on growth of India both in the short-run and long-run for the duration 1980 to 2016.The results of the study found that investment in IT had a significant positive contribution towards GDP growth of India.

Erumban & Das (2020) analyzed the impact of IT on 13 manufacturing industries in India and on aggregate Indian economy. They found that IT contributed positively to the growth in manufacturing sector of India. However, IT usage was low in aggregate Indian economy. Further, it was found that India performed better as compared to other developing countries, in terms of the ICT contribution to the economic growth of the country. However, when compared to developed countries, the ICT contribution to the economic growth in India was still on lower side.

Thus, it can be concluded from these studies that there could be some relationship between IT growth in India and economic growth of the India. The spillover effect of good performance of IT industry players on other industry sectors can result in overall growth across the industries. However, there is hardly any study that has explored relationship between IT industry of India and growth of Indian economy. Therefore, there is a need to explore the relationship between IT growth and economic growth of India and this study tries to fulfill this gap. This forms the objective of this study which is to empirically examine the relationship between IT industry of India and economic growth in India. This study is a novel attempt to fulfill this gap in the literature review.

The fourth objective of the study is to analyze the impact of exchange rate fluctuations on the performance of the selected IT companies in India. The performance of the IT companies envisaged in terms of stock prices and net profit of IT industries and the impact of exchange rate fluctuations on them. The literature review relating to this objective is given in the next section.

3.4 Review of Impact of Exchange Rate Fluctuations on Performance of IT Companies

One of the major concerns of all IT software companies in India is volatile currency market. The IT companies in India get almost 90 per cent of its total revenue from exports of software to foreign countries. In this backdrop, fluctuations in exchange rate impacts the performance of IT companies to a great extent. Exchange rate risk management, thus, has become a very important aspect of overall management of a particularly those companies in India, that are involved in foreign currency exchanges.

The impact of exchange rate on firms' performance has remained a topic of great interest to researchers as it has a lot of implications to the industry and displays some interesting analysis. Dumas (1978) laid the foundation of research work done to measure the impact of exchange rate exposure on the performance of the companies. This was further explored by Adler & Dumas (1984) in their research work. They defined exchange rate exposure as the impact of exchange rate fluctuations on the firms' value. Further, Jorion (1990) investigated the extent of correlation between FOREX rate exposure and foreign sales. Since then, lot of research work has been done in this area (Bartram, 2007; Mora, 2008; Bodla, 2013).

Literature review suggests that researchers have investigated the impact of exchange rate fluctuation on various variables such as sales, TFP, profitability, return on capital employed, age of company, size of the company, investment in research and development, IT exports , liquidity, stock prices, cash flow and stock returns of the companies, and IT companies is not an exception. (Bodnar & Wong, 2003; Aghion et al., 2005; Harchaoui, Tarkhani & Yuen, 2005; Upadhyay & Ghosh Roy, 2016;Malik &Velan, 2020; Phung & Troge, 2018;Garg & Dahiya, 2014;Garg & Mitra, 2015). Corporate profitability and stock returns are the two main concerns of any firm (Nanda & Panda, 2018; Nagahisarchoghaei et al., 2018). The literature review for both is presented in next sections.

3.4.1 Literature Review Relating to Impact of Exchange Rate Fluctuations on Profitability

The topic of impact of exchange rate fluctuations on profit of the companies has been explored by scholars in foreign countries such as the US (Clarida 1997; Uctum, 1998; Choi & Prasad 1995; Goldberg & Crockett, 1998), Japan (Uctum, 1998; Matsubayashi 2011)) ; Turkey (Karamlollaoglu, 2017; Toraganli, 2010); Taiwan (Tsui, 2002). The extensive literature on impact of exchange rate fluctuations on profitability of firms is listed in Table 3.3. Most of these studies is done for non-IT related firms.

Choi & Prasad (1995) analyzed data of 409 companies of US for duration 1978-1989. They concluded that operating profit, sales, and assets are positively related to FOREX exposure. Further Tsui (2002) investigated the relationship between the variations in exchange rate and profit margin for 19 manufacturing companies of Taiwan for the duration 1981 to 1994.The study showed that the profit margins can result from the cost side of imports as well as from the revenue generation from exports. Also, Dominguez & Tesar (2006) examined the relationship of exchange rate fluctuation with company value and profitability, measured through stock returns for firms of 8 countries for the duration 1980 and 1999. The study suggested that significant fraction of companies is exposed to exchange rate fluctuation, but which firms are exposed changes over time. They further established that there is a statistically significant relationship between profitability and the exchange rate.

Matsubayashi (2011) investigated the impact of exchange rate shocks on corporate investment and profits in Japan. The study suggested that depreciation of the currency increases the profitability of the company and stimulates corporate investment, especially in manufacturing sector. Karamlollaoglu (2017) investigated the impact of real exchange rate fluctuation on profits of Turkish manufacturing companies for the duration 2005 to 2015. The study used Tobit regression analysis and did not found strong evidence of impact of exchange rate on profit for the given period.

While some scholars have explored the impact of exchange rate fluctuations on profitability of non-IT companies in India (Nanda & Panda, 2018; Dhasmana, 2013) whereas there are others that have analyzed the impact of exchange rate variations on

Indian economy as a whole (Bhasin & Nisa, 2017). However, there are only handfuls of studies done so far that have measured the impact on FOREX rate fluctuations on profitability of IT software services companies in India.

Dash & Madhava (2008) examined the impact of rupee-USD exchange rate fluctuation on the profitability of IT firms. They studied 44 IT companies of India for the duration 2005 and 2007.The study found a positive FOREX exposure for the IT companies for the duration 2005-2006. They further concluded that FOREX fluctuations had a large impact on some of the small-cap IT companies. However, the large-cap and mid-cap IT companies had low to moderate FOREX exposure levels.

Table 3.3: Impact of Exchange Rate on Profitability – Literature Review on Indian and Foreign firms

Literature Review on Impact of Exchange Rate on Profitability - (a): India							
Author	Literature Review	India/ Abroad	IT/ non-IT	Variables studied			
				S/W Exports	Inflation/ WPI/CPI	Profit	Stock Price/ Stock returns Market Value
Nanda & Panda (2018)	They studied the impact of exchange rate fluctuations for the duration 2000 to 2015 on Indian manufacturing firms. They concluded that in the short run, the exchange rate fluctuations have negative impact on profitability. However, in the long run, volatility of exchange rate postively impact the profitability of the firms.	India	non-IT			√	
Dash and Yadav (2014)	They examined the impact of foreign exchange rate fluctuations on IT companies of India, after the recession of 2008. The studied 30 IT firms of India for the duration 2009 and 2012 using Bodnar-Marston (2002) formula. The study indicated a negative impact of forex exposure on profitability of small-cap and mid-cap IT firms, with positive impact for large-cap IT firms.	India	IT			√	
Dash & Madhava (2008)	This paper examined the impact of rupee-USD exchange rate fluctuation on the profitability of IT firms. They studied 44 IT companies of India for the duration 2005 and 2007.The study found a positive FOREX exposure for the IT companies for the duration 2005-2006. They further concluded that foreign exchange fluctuations had a large impact on some of the small-cap IT companies. However, the large-cap and mid-cap IT companies had low to moderate foreign exchange exposure levels.	India	IT			√	
Malik & Velan (2020)	They analyzed the impact of exchange rate fluctuations on IT exports of India for the duration 1980 and 2017. The results established that in long-run exchange rate variations has a positive impact on the IT software and services exports from India.	India	IT	√			

Table 3.3 : Impact of Exchange Rate on Profitability – Literature Review on Indian and Foreign firms (Contd.)

Literature Review on Impact of Exchange Rate on Profitability - (b): Foreign Countries					
Author	Literature Review	India/ Abroad	IT/ non-IT	Variables studied	
				S/W Exports	Profit
Karamlollaoglu (2017)	The study investigated the impact of real exchange rate fluctuation on profits of Turkish manufacturing companies for the duration 2005 to 2015. The study used Tobit regression analysis and did not found strong evidence of impact of exchange rate on profit for the given period.	Abraod	non-IT		√
Matsubayashi, (2011)	The study investigated the impact of exchange rate shocks on corporate investment and profits in Japan. The study suggested that depreciation of the currency increases the profitability of the company and stimulates corporate investment, especially in manufacturing sector.	Abraod	non-IT		√
Toraganli (2010)	The research applied investigated the impact of exchange rate fluctuation on profit and export prices of the manufacturing companies of Turkey for the period 1995-2007.The study found mixed evidence on the relationship between exchange rate fluctuation and profitability. However, the results were not found to be robust.	Abraod	non-IT	√	√
Dominguez & Tesar (2006)	This paper examined the relationship of exchange rate fluctuation with company value and profitability, measured through stock returns for firms of 8 countries for the duration 1980 and 1999. The study suggested that significant fraction of companies is exposed to exchange rate fluctuation but which firms are exposed changes over time. They further established that there is a statistically significant relationship between profitability and the exchange rate.	Abraod	non-IT		√

Table 3.3 : Impact of Exchange Rate on Profitability – Literature Review on Indian and Foreign firms (Contd.)

Literature Review on Impact of Exchange Rate on Profitability - (b): Foreign Countries (contd.)					
Author	Literature Review	India/ Abroad	IT/ non-IT	Variables studied	
				S/W Exports	Profit
Tsui (2002)	He investigated the relationship between the variations in exchange rate and profit margin for 19 manufacturing companies of Taiwan for the duration 1981 to 1994.The study showed that the profit margins can result from the cost side of imported inputs as well as from the revenue side of export (import) activities. The study concluded that that the selected firms took advantage of appreciation of their currency.	Abraod	non-IT		√
Goldberg & Crockett (1998)	The study analyzed the appreciation of US dollar during 1997-98. They suggested that change in exchange rate may significantly reduce the profit margin of the manufacturing sector of the country.	Abraod	non-IT		√
Uctum (1998)	The study investigated on the relation between profit and exchange rate volatility. He revealed that exchange rate appreciation impacted US profit more as compared to Japanese profits.	Abraod	non-IT		√
Clarida (1997)	This paper analyzed the relationship between profits and the real exchange rate for the period 1975-1993 of manufacturing companies of USA. He concluded that in the long-run, during the strong dollar period, the appreciation of the dollar reduced the profits.	Abraod	non-IT		√
Choi & Prasad (1995)	They analyzed data of 409 companies of US for duration 1978-1989. They concluded that operating profit, sales and assets are positively related to foreign exchange exposure.	Abraod	non-IT		√

Further, Dash and Yadav (2014) examined the impact of FOREX rate fluctuations on IT companies of India, after the recession of 2008. They studied 30 IT firms of India for the duration 2009 and 2012 using Bodnar-Marston (2002) formula. The study indicated a negative impact of FOREX exposure on profitability of small-cap and mid-cap IT firms, with positive impact for large-cap IT firms.

The aforementioned literature further confirms that there are not many studies done to study the impact of exchange rate fluctuations on net profit of IT software service companies in India, which is taken up as part of this study.

3.4.2 Literature Review Relating to Impact of Exchange Rate Fluctuations on Stock Prices

The impact of exchange rate fluctuation on stock prices, company's value, and firm's performance is studied by various researchers (Jorion 1990; Choi & Prasad, 1995; Bodnar & Wong, 2003; Nagahisarchoghaei et al., 2018). The results of these studies have been mixed. While there are many studies that have investigated the impact of exchange rate fluctuations on the performance of the companies at global level (Bartam, 2008; Dominguez & Tesar, 2006) ; there are studies done to explore the impact of exchange rate volatility on the performance of Indian companies as well (Dhasmana, 2013; Sharma & Dhiman, 2016). Refer Table 3.4.

Cheu and Cook (2008) explored the impact of FOREX at firm level in India and fourteen other developing countries for the duration 1999 to 2006. They found that only very few firms were exposed to FOREX risk in emerging markets for the duration 1999 and 2002. Further, Patnaik and Shah (2010) also found that their sample of 100 Indian firms had greater exposure in periods when exchange rates were less flexible. Moreover, Kanagaraj & Sikarwar (2011) studied the relationship between exchange rate fluctuations and stock returns on 361 Indian firms for the duration 2006 and 2011. The study concluded that only 58 firms are exposed to exchange rate at 10 % significance level. Lin (2011) also explored the relationship between FOREX exposure and firms in six Asian countries including India from 1997 to 2010. The study reported that only 9 percent of the companies were exposed to exchange rate exposure during 2008.

Table 3.4: Impact of Exchange Rate on Stock Returns – Literature Review

Literature Review on Impact of Exchange Rate on Stock Returns							
Author	Literature Review	India/ Abroad	IT/ non-IT All	Variables studied			
				S/W Exports	Inflation/ WPI/CPI	Profit	Stock Price/ Stock returns Market Value
Upadhyay & Ghosh Roy (2016)	Upadhyay & Ghosh Roy (2016) explored the impact of exchange rate fluctuation on IT software exports from India for the duration 2001 to 2012 using multiple regression analysis.They found that US-dollar-Indian rupee exchange rate has no significant impact on IT software exports from India.	India	IT	√			
Dash (2019)	The study explored various strategies followed by IT firms of India to manage exchange rate risk for the duration Jan'07 and Dec'07. He concluded that most large-cap IT firms adopted hedging strategies in the short-run and currency-swaps in the long run to mitigate exchange rate fluctuations risk. The strategies were more suitable for fixed price projects as compared to time and material type of projects.	India	IT		√		
Nagahisarchoghaei et al. (2018)	This paper measured the impact of real effective exchange rate on performance of 242 firms of India for the duration 2011 and 2012. The study found weak relationship betweenexchange rate and stock prices.	India	IT/ non-IT			√	√
Mohapatra (2016)	This study examined the exchange rate exposure of 232 Indian firms including 29 Indian IT firms for the duration 2000 to 2013. The results concluded that Indian firms had very high exposure to exchange rate fluctuations. Further the degree of exposure was higher for manufacturing firms as compared to service sector firms.	India	IT/ non-IT				√
Sikarwar (2014)	This paper analyzed the exposure of exchange rate on 342 Indian companies for the duration 2006 to 2011 including 20 IT companies and 6 communication services companies of India. The study reported that the some of the selected companies were exposed to exchange rate fluctuation. The results concluded that Indian IT companies gain from the depreciation of rupee and viceversa.	India	IT/ non-IT				√

Table 3.4: Impact of Exchange Rate on Stock Returns – Literature Review (contd.)

Literature Review on Impact of Exchange Rate on Stock Returns							
Author	Literature Review	India/ Abroad	IT/ non-IT All	Variables studied			
				S/W Exports	Inflation/ WPI/CPI	Profit	Stock Price/ Stock returns Market Value
Lin (2011)	The study explored the relationship between forex exposure and firms in six Asian countries including India from 1997 to 2010. The study reported that only 9 percent of the companies were exposed to exchange rate exposure during 2008.	India	All				√
Ye et al. (2014)	They investigated the foreign exchange exposure in emerging markets including India for the duration 1999 to 2010. The data was taken from 1523 firms from 20 countries and it was concluded that approximately 800 firms were significantly exposed to the exchange rate fluctuations.	India	All				√
Kanagaraj & Sikarwar (2011)	They studied the relationship between exchange rate fluctuations and stock returns on 361 Indian firms for the duration 2006 and 2011. The study concluded that only 58 firms are exposed to exchange rate at 10 % significance level.	India	All				√
Cheu and Cook (2008)	The study explored the impact of foreign exchange at firm level in India and fourteen other developing countries for the duration 1999 to 2006. They found that only very few firms were exposed to forex risk in emerging markets for the duration 1999 and 2002.	India	All				√
Badhani, Chhimwal and Suyal (2009)	This study examined the relationship between exchange rate fluctuations on stock returns of Indian companies and found a mixed correlation between the two. It was observed that the sensitivity of IT companies towards exchange rate fluctuations was high, in particular.	India	IT				√

A similar study was done by Ye et al. (2014) to investigate the FOREX exposure in emerging markets including India for the duration 1999 to 2010. The data was taken from 1523 firms from 20 countries and it was concluded that approximately 800 firms were significantly exposed to the exchange rate fluctuations. Nagahisarchoghaei et al. (2018) measured the impact of real effective exchange rate (REER) on performance of 242 firms of India. The duration of the study selected was Dec 2011 to Dec 2012. The study found weak relationship between REER and stock price per sales.

While the above literature lists the studies done in the past that have explored the relationship of exchange rate fluctuations and performance of non-IT firms in India; there are also few studies that have explored this relationship with respect to Indian IT companies. Badhani, Chhimwal and Suyal (2009) examined the relationship between exchange rate fluctuations on stock returns of Indian companies and found a mixed correlation between the two. It was observed that the sensitivity of IT companies towards exchange rate fluctuations was high. Also, Sikarwar (2014) analyzed the exposure of exchange rate on 342 Indian companies for the duration 2006 to 2011. The sample included 20 IT companies and six communication services companies of India. The study reported that the some of the selected companies were exposed to exchange rate fluctuation. The results concluded that Indian IT companies gain from the depreciation of rupee and vice versa. Further, Mohapatra (2017) examined the exchange rate exposure of 232 Indian firms. The sample included 29 Indian IT firms for the duration 2000 to 2013. The results concluded that Indian firms had very high exposure to exchange rate fluctuations. He also found that the degree of exposure was higher for manufacturing firms as compared to IT firms. Moreover, Dash (2019) explored various strategies followed by IT firms of India to manage exchange rate risk for the duration Jan’07 and Dec’07. He concluded that most large-cap IT firms adopted hedging strategies in the short-run and currency-swaps in the long run to mitigate exchange rate fluctuations risk. The strategies were more suitable for fixed price projects as compared to time and material type of projects. The extensive literature on impact of exchange rate fluctuations on stock returns of firms is listed in Table 3.4.

After going through the existing literature and the above facts, it is suggested that an investigation into the impact of exchange rate on profitability and stock prices of Indian IT industry can provide valuable insights and findings for the researchers, investors, policy makers etc. The literature also suggests that while there are numerous studies published on analyzing the impact of exchange rate on the performance and growth of global and non-IT firms in India. However, there are only very few studies that have investigated the impact of exchange rate fluctuations on the profitability and stock returns of IT software services companies in India. In this context an attempt is made to examine the impact of exchange rate fluctuations on the profit margins and market share price of the top Indian IT companies. This is probably the first study that has analyzed the company specific impact for the selected IT companies in India, considering rupee-dollar and euro-dollar rate fluctuations. This is important, as each IT company is unique in its behavior and hence it is important to analyze the impact of each selected company at individual level.

It was observed from the review of literature that there is lot of work done on performance of IT companies in the developed countries; IT led growth hypothesis and impact of exchange rate fluctuations on the IT companies. However, there is not much work done in these areas with an Indian perspective. Hence, a detailed and comprehensive model related to IT software service industry in India needs to be developed. This study aims to further enrich the existing literature on the performance of IT companies in India and the factors influencing the performance of IT software service companies in India. To the best of our knowledge, there are hardly any studies done on Indian IT industry in particular for the duration 2010 to 2017 considering the above factors. This research work is a study in that direction, and it tries to fulfill this gap particularly towards Indian IT software services industry.

CHAPTER IV

PERFOMANCE OF SELECTED IT COMPANIES IN INDIA

This chapter evaluated the performance of the selected IT companies in India using DEA. It also focuses on the various factors critical factors determining the performance of the selected IT firms in India.

The IT industry impacts all the sectors of an economy. The demands for software from all industries have significantly risen globally as well as in India as every industry wants to improve its efficiency. The main sectors of any economy such as transportation, logistics, retail, banking, manufacturing, healthcare, communication and media, education etc., get impacted by the IT industry. The technology has been changing very rapidly in recent years and the IT sector has played a dominant role in these transformations. The IT sector is coming with new solutions every day and the various upcoming new horizons of the IT applications may be digitalization, artificial intelligence, cloud computing, human-computer interactions and block chain in near future (Gartner, 2009; Gartner, 2018; IDC, 2018; NASSCOM, 2017; NASSCOM, 2010). All these depend on the performance of the IT sector itself both at global as well as India levels. The IT sector of India has seen several challenges from its humble beginning in 1980s.

The process of globalization, privatization, and liberalization, which started in India in 1991-92, provided an opportunity to IT sector of India and it exploited the new business environment in India in its favor. Since then, the IT industry has transformed the economic image of India from an agrarian economy to a knowledge economy (NASSCOM, 2010; Kumar, Charles & Mishra, 2016). The role of IT sector in Indian economy and its impact on different sectors of the economy can be ascertained from the fact that IT sector in India has increased its contribution to GDP of India from 1.2 per cent in 1998 to 7.9 per cent in 2018. The IT industry of India has grown considerably from 8.2 billion (USD) in 2000 to 154 billion (USD) in 2017

(NASSCOM, 2010; NASSCOM, 2017b; IDC, 2017). As a result, the IT industry has become one of the leading sectors of Indian economy in 2018. However, Indian IT sector suffered a set-back on the technological front due to the sub-prime crisis of 2008 (Kumar et al., 2016; Adler et al., 2017). Moreover, the various challenges such as stringent visa conditions, technological innovations in the IT industry and enhanced global competition, especially from China and the Philippines, had an adverse impact on the efficiency of Indian IT firms. The average annual growth of the Indian IT industry, which was 30 per cent from 2002 to 2008, dropped to 8.10 per cent from 2008 to 2009. Since then, the IT industry of India has not been able to regain its growth momentum (NASSCOM, 2010; NASSCOM, 2017). While the demand for automation and skilled talent exists globally, the IT sector of India only accounted for a dismal 17 per cent of the total IT services spending worldwide in 2017 (NASSCOM, 2010; NASSCOM, 2017).

In this scenario providing low cost partially skilled people by Indian IT firms, cannot be considered an effective solution. The past literature suggests that efficiency of IT companies has been evaluated by various frontier and non-frontier approaches. DEA is one of the frontier approaches that have been widely used to analyze the efficiency of IT firms (Kuo & Yang, 2012; Lampe & Hilgers, 2015; Sahoo & Nauriyal, 2014).

The data envelopment analysis approach was conceptualized in 1978. It is a non-parametric technique and it has evolved as an alternative to regression analysis for efficiency evaluation. DEA is a technique to evaluate the efficiency of the similar entities known as DMUs in terms of multiple inputs and multiple outputs. DMUs may include manufacturing units, banks, IT companies, educational institutions, oil companies etc. (Cooper, Seiford & Tone, 2007; Chang & Hung, 2013; Emrouznejad & Yang, 2018). The past literature suggested that there are only few studies that have attempted to analyze the efficiency of the IT firms after the sub-prime crisis of 2008 (Liu & Huang, 2019; Oruç & Altın, 2015). The IT firms selected for most of these studies were from the foreign countries. Thus, there is a need to evaluate the efficiency of IT companies in India and to benchmark the IT firms in India after 2008. This study attempts to fulfill this gap by evaluating the performance of the IT companies using DEA approach.

The rest of the chapter is structured as follows: The next Section lists the objectives with respect to efficiency measurement of the selected IT companies. The subsequent section after that details the methodology used in the study. This is followed by a Section that shares data collection approach and process used for selection of input-output variables for this study. The next Section discusses the results followed by a section that lists the findings of the study. The last Section concludes the discussion on efficiency measurement of selected IT companies using DEA.

4.1 Objectives Addressed in this Chapter

The objectives addressed in this chapter are as follows:

O_1: To examine the performance of selected IT companies of India.

O_2: To identify factors affecting performance of the selected IT companies.

The first objective of the study is achieved by doing a trend analysis of the selected IT firms in India using descriptive statistics. The first objective of the study has no testable hypothesis.

The related Hypotheses for the second objective are:

H_{2a}: There is no significant relationship between age of company and efficiency of the firm.

H_{2b}: There is no significant relationship between R&D expenses and efficiency of the firm.

H_{2c}: There is no significant relationship between number of employees and efficiency of the firm.

H_{2d}: There is no significant relationship between asset size and efficiency of the firm.

4.2 Research Methodology: DEA and Tobit Regression Model

This section details the DEA methodology and Tobit Regression model applied for this study.

4.2.1 DEA Methodology

The DEA methodology is extensively applied to analyze the relative efficiency of companies in different industries (Lampe & Hilgers, 2015; Emrouznejad & Yang, 2018; Puri & Yadav, 2013). Using this approach, the relative efficiency of

homogenous units also called DMUs, with multiple inputs and multiple outputs are evaluated. The efficiency of a DMU is evaluated as the ratio of output to input. In case of multiple outputs and multiple inputs, it is the ratio of the weighted sum of outputs to the weighted sum of inputs as shown below (Cooper, Seiford & Tone, 2007; Puri & Yadav, 2013; Puri & Yadav, 2017; Avkiran, 2006).

$$Efficiency = \frac{weighted\ sum of\ outputs}{weighted\ sum of\ inputs} \qquad \text{- (4.1)}$$

To evaluate the relative efficiency, there are two commonly known DEA models, named as, Charnes, Cooper and Rhodes (CCR) model and Bankers, Charnes and Cooper (BCC) model. The formulae to calculate efficiency using CCR and BCC models are detailed in Appendix A. In this study, the efficiency scores are measured by applying these two DEA models (Cooper, Seiford & Tone, 2007; Puri & Yadav, 2013; Avkiran, 2006).Using DEA models, three type of efficiency are calculated, i.e., overall technical efficiency (OTE), pure technical efficiency (PTE) and scale efficiency (SE). CCR model is used to measure the OTE. The OTE score provides an indication towards the inefficiency in the company. This inefficiency could be because of the input variables, the output variables, and/or the size of the firm (Refer Appendix B). BCC model provides the PTE score for the company. The PTE score reflects on the managerial efficiency of the firms. Scale efficiency or SE reflects on the impact of the size of selected companies or DMUs. SE is measured as a ratio of OTE to PTE. The CCR and BCC models also estimate the returns to scale for the selected IT company. The returns to scale refer to the response of output when all the input variables change in the long run. Constant returns to scale (CRS), increasing returns to scale (IRS) and decreasing returns to scale (DRS) are the three type of returns to scale that can be calculated using these models (Cooper, Seiford & Tone, 2007; Puri & Yadav, 2013; Puri & Yadav, 2017; Avkiran, 2006). A unit is termed as overall efficient, if the DMU has OTE, PTE and SE score of one. The overall efficiency DMU are considered as benchmark units for the remaining inefficient units. An output-oriented DEA model is applied for the estimation of efficiency in this study. This is keeping in mind that sales maximization and/or market share maximization is the guiding principle of IT firms (Avkiran, 2001).

4.2.2 Data and Variables Selection

To meet the above stated objectives in this chapter, data was collated on top 18 IT software service companies in India for the duration 2010 to 2017. The IT companies were selected based on their market capitalization. The IT firms having market capitalization of greater than ₹10 billion are selected for this study. The data is collected primarily from the Prowess Database provided by CMIE. The IT firms selected for this study are listed in Table 4.1

Table 4.1: List of all IT Firms Selected for this Study - DEA

IT Company Name	IT Company Acronym	IT Company Code
Tata Consultancy Services	TCS	IT1
Infosys Ltd.	INFY	IT2
Wipro Ltd.	WIPRO	IT3
HCL Technologies Ltd.	HCL	IT4
Tech Mahindra Ltd.	TECHM	IT5
Oracle Financial Services Software Ltd.	ORCLF	IT6
MindTree	MNDTR	IT7
Mphasis	MPHSI	IT8
Hexaware Technologies Ltd.	HXWR	IT9
Cyient	CYENT	IT10
Persistent Systems	PRSTN	IT11
Tata Elxsi Ltd.	TLXI	IT12
Zensar Technologies	ZNSR	IT13
NIIT Technologies	NIIT	IT14
Polaris Consulting and Services	POLRS	IT15
Hinduja Global Solutions Ltd.	HNDG	IT16
Hinduja Venture	HNDV	IT17
Geometric	GEOMR	IT18
Source: Author's compilation		

Table 3.1 highlights the different input variables and output variables used in past studies on DEA. We selected the input and output variables for this study based on the literature review provided in Table 3.1. Also, this research study focuses on evaluating and analyzing the relative efficiency of the Indian IT firms with respect to their financial performance. Therefore, the variables that impact the financial performance of the IT firms were analyzed in detail to identify the input variables and output

variables in this study. The input variables selected are total assets (I_1), workers' cost (I_2), total expenses (I_3) and tax paid (I_4). The worker's cost is taken as proxy of the worker's effort. The workers' effort provides an indication of the health of the IT firm and thus is a key input variable for the IT firms. The output variables used in this study are net sales turnover (O_1) and net profit after tax (O_2). DEA software (DEAP) is used for the estimation purpose (Avkiran, 2006).

4.2.3 Tobit Regression Model

Tobit Regression model is applied as a second stage analysis to compute the influence of background and environmental variables on the estimated efficiency scores. This helps in explaining the variation in the efficiency scores. The same model was applied by Singh (2006) and Alhassan et al. (2015) for their studies on sugar mills in India and health care facilities in Ghana respectively. San et al. (2011) applied DEA and Tobit model to compare the efficiency of domestic and foreign banks of Malaysia for period 2002-2009.

The efficiency scores computed from DEA analysis are used as dependent variable in the regression analysis. The efficiency scores are regressed on a set of independent variables that is hypothesized to explain the determinant of IT efficiency. The efficiency scores lie between 0 and 1, hence variables are said to be censored. Tobit regression model provides better and consistent estimates in this scenario. Conventional Ordinary least squares (OLS) regression method cannot be applied due to censored values of dependent variable (Singh, 2006). Hence Tobit regression is applied to measure the influence of environmental variables on efficiency scores. The efficiency scores calculated from DEA model is used as dependent variable in the Tobit Regression analysis. These efficiency scores are regressed on a set of independent variables that is hypothesized to explain the determinant of IT firm efficiency.

For IT Company, the Tobit regression model can be defined as follows:

$$y_i^* = \beta X_i + \varepsilon_i \qquad -(4.2)$$
$$y_i = y_i^*, \; if \; y_i^* > 0$$
$$y_i = 0, otherwise$$

Where y_i= 1-θ, i.e., a dependent variable representing inefficiency score which is obtained by deducting the value of respective efficiency score (θ) from 1. And y_i^* is a latent dependent variable, X_i is a vector of explanatory variables and (β) is a vector of parameters to be estimated, ε_i is an independently distributed error term assumed to be normally distributed with zero mean and constant variance. As in the above model, inefficiency is taken as a dependent variable; an explanatory variable explains in-efficiency rather than efficiency. Negative value of a coefficient implies that an increase in its value would reduce the value of inefficiency. Alternatively, it can be said that the variable has positive impact on efficiency improvement. For this study, OTE, PTE and SE have been used separately as dependent variables. Independent variables are discussed below.

There are different variables such as age of the company, number of employees, Research and development expenses, size of assets , location of company , ownership pattern, utilization, capital-labor ratio , employee productivity that have an effect on the efficiency of the IT companies. To measure the impact of such variables, Tobit regression analysis could be conducted. As part of literature review done earlier, Table 3.2 lists the different variables used by some of earlier studies on Tobit regression analysis.

Literature review and Table 3.2 suggests that there is lot of variance in the selection of independent variables across the studies. This could be because of relevance of independent variables to the given industry. This study has selected following variables for conducting the Tobit regression analysis based on data availability and context of this study. The impact of these variables on OTE, PTE and SE is measured.

1. Age of the company
2. Research and Development expenses
3. Number of employees
4. Dummy = 1 for asset size > 30,000 Cr, 0 otherwise

4.3 Results and Discussions

The OTE, PTE and SE are evaluated using CCR or BCC model, through DEAP software. Appendix A details different DEA models and their methodologies. Appendix B lists the definitions of OTE, PTE, SE, and other efficiency measures. The efficiency results obtained by executing these models are discussed below.

4.3.1 Results - Efficiency Analysis for 2010-2017 using DEA

The descriptive statistics of efficiency results for all the selected Indian IT firms for the duration 2010 to 2017 is shown in Table 4.2. As shown in Table 4.2, the average overall technical efficiency (AOTE) has shown mixed trends. The AOTE has decreased to 94.86 per cent in 2014 from 95.97 per cent in 2010. The lowest average pure technical efficiency (APTE) at 96.37 per cent was found in 2014. Also, in the year 2012, the average scale efficiency (ASE) was lowest amongst all at 96.9 per cent. The average pure technical inefficiency (APTIE) represents the inefficiency evaluated due to inappropriate management practices and processes. The APTIE score was found to be highest at 3.63 in the year 2014. The remaining part of average overall technical inefficiency (AOTIE) can be attributed to inappropriate size.

Table 4.2: Descriptive Statistics of Efficiency Results for all IT Firms: 2010-2017 -DEA

Descriptive Statistics	All IT companies -Overall Technical Efficiency (OTE)							
	2010	2011	2012	2013	2014	2015	2016	2017
Average Efficiency (AOTE)	0.960	0.944	0.957	0.952	0.949	0.955	0.953	0.970
Minimum	0.880	0.766	0.790	0.782	0.708	0.838	0.872	0.861
Maximum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Std. Deviation	0.044	0.066	0.060	0.057	0.072	0.054	0.051	0.042
Avg. Inefficiency %=1-AOTE	4.03	5.61	4.30	4.78	5.14	4.49	4.74	3.05
Descriptive Statistics	All IT companies - Pure Technical Efficiency (PTE)							
Average Efficiency (APTE)	0.985	0.969	0.987	0.981	0.964	0.967	0.975	0.984
Minimum	0.920	0.787	0.933	0.902	0.790	0.856	0.892	0.868
Maximum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Std. Deviation	0.024	0.056	0.023	0.031	0.056	0.046	0.037	0.034
Avg. Inefficiency % = 1-APTE	1.52	3.09	1.29	1.94	3.63	3.31	2.53	1.65
Descriptive Statistics	All IT companies - Scale Efficiency (SE)							
Average Efficiency (ASE)	0.974	0.974	0.969	0.971	0.983	0.988	0.977	0.986
Minimum	0.880	0.838	0.790	0.782	0.896	0.926	0.885	0.916
Maximum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Std. Deviation	0.033	0.042	0.054	0.051	0.027	0.019	0.031	0.022
Avg. Inefficiency % = 1-ASE	2.56	2.58	3.06	2.87	1.67	1.24	2.29	1.42

It was found that AOTE is showing a reducing trend for the period 2010 to 2014. This could be because of the unfavorable business environment prevailing during 2010 and 2014. During this period, IT firms were offering generic services with low innovations. The focus on providing specialized niche services was low during this period. Also, decline in offshore centric business due to unfavorable changes in macro-economic conditions, increase in FOREX rate risks; and matured vendor management processes followed by clients of IT firms could be other reasons for this trend.

It is further found from Table 4.2 that the OTE of IT firms in India ranges between 0.88 and 1 for the year 2010. The OTE reduces to 0.86 and 1 for the year 2017. Table 4.2 also shows that the AOTE was 0.96 in 2010. The AOTE increased to 0.97 in 2017. This increase in AOTE could be because of various reasons. It could be on account of high focus towards people management by IT companies. They established dedicated practices to increase the focus on people management during this period. Other reasons could be skill enrichment of the employees that could have led to increase the overall efficiency. Automation of manual processes by selected IT companies could be another reason which might have led to increase in the OTE of the firms during this period. The IT firms in India also attempted to adopt different strategies to induct talents from Mexico and Brazil to meet time zone requirements from the clients. The IT companies also increased their focus on implementation of agile methodologies in IT projects, and improved employees' utilization rate. Figure 4.1 depicts the most efficient and least efficient selected IT firms for the duration.

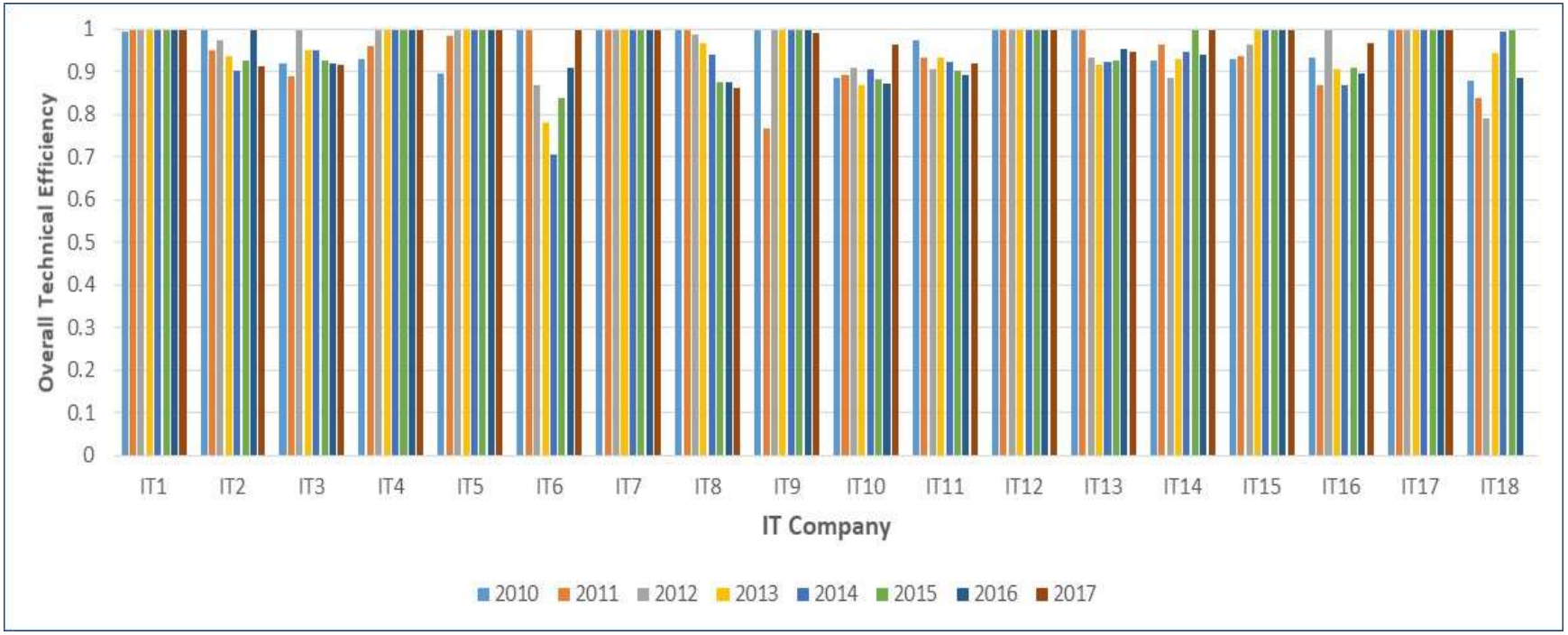


Figure 4.1 (a): Overall Technical Efficiency for the Selected IT Companies: 2010-2017.

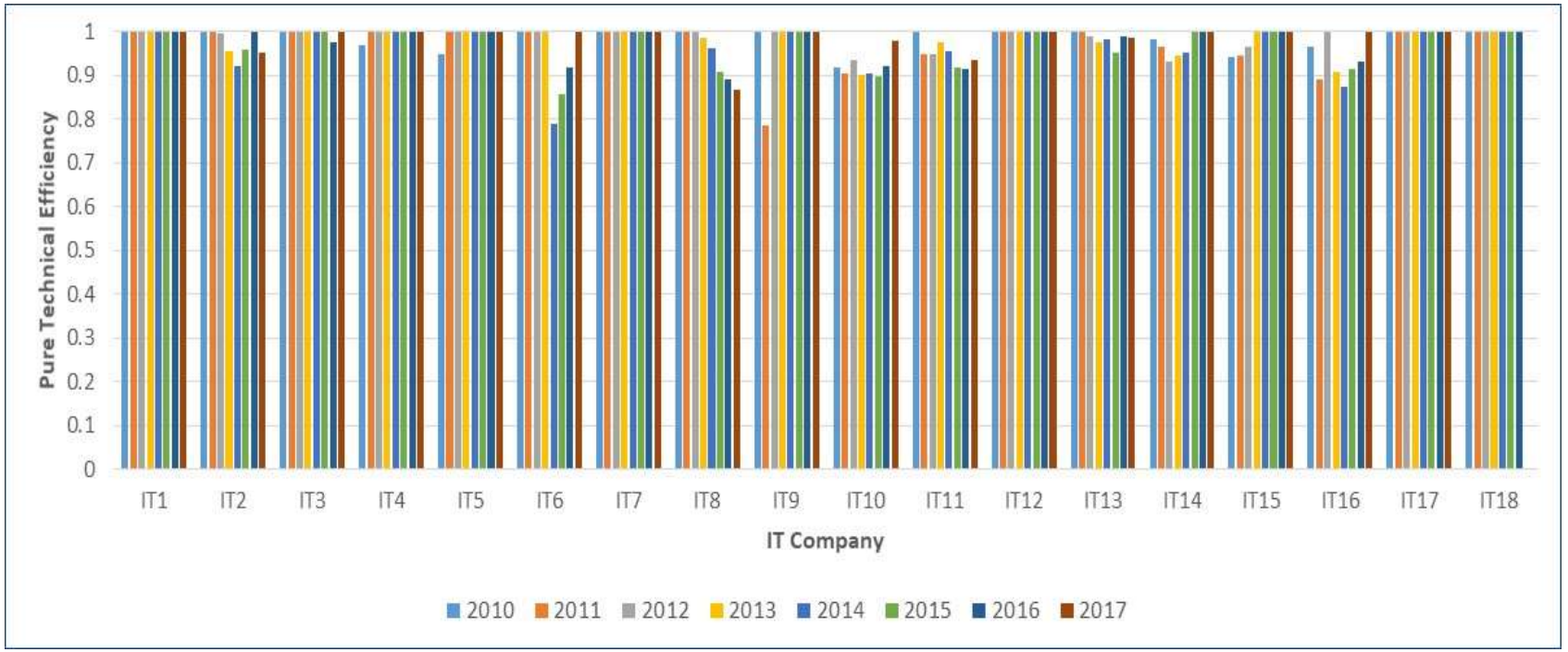


Figure 4.1 (b): Pure Technical Efficiency for the Selected IT Companies: 2010-2017.

Figure 4.1 (c): Scale Efficiency for the Selected IT Companies: 2010-2017.

Figure 4.2 shows the average inefficiency score for all the selected IT firms for the duration 2010 to 2017. It is found from Figure 4.2 that the inefficiency of IT firms in India varied in significant manner over the selected sample period. It is also shown with the help of Figure 4.2 that the average inefficiency declined to 3.05 per cent in 2017 from 4.03 per cent. This also shows that that the average efficiency increased from 2010 to 2017. Also, the APTIE rose to 1.65 per cent in 2017 from 1.52 per cent in 2010. This indicates a decline in PTE during the same period. Similarly, the Average Scale Inefficiency (ASIE) declined to 1.42 per cent from 2.56 per cent in 2010, implying increase in the SE.

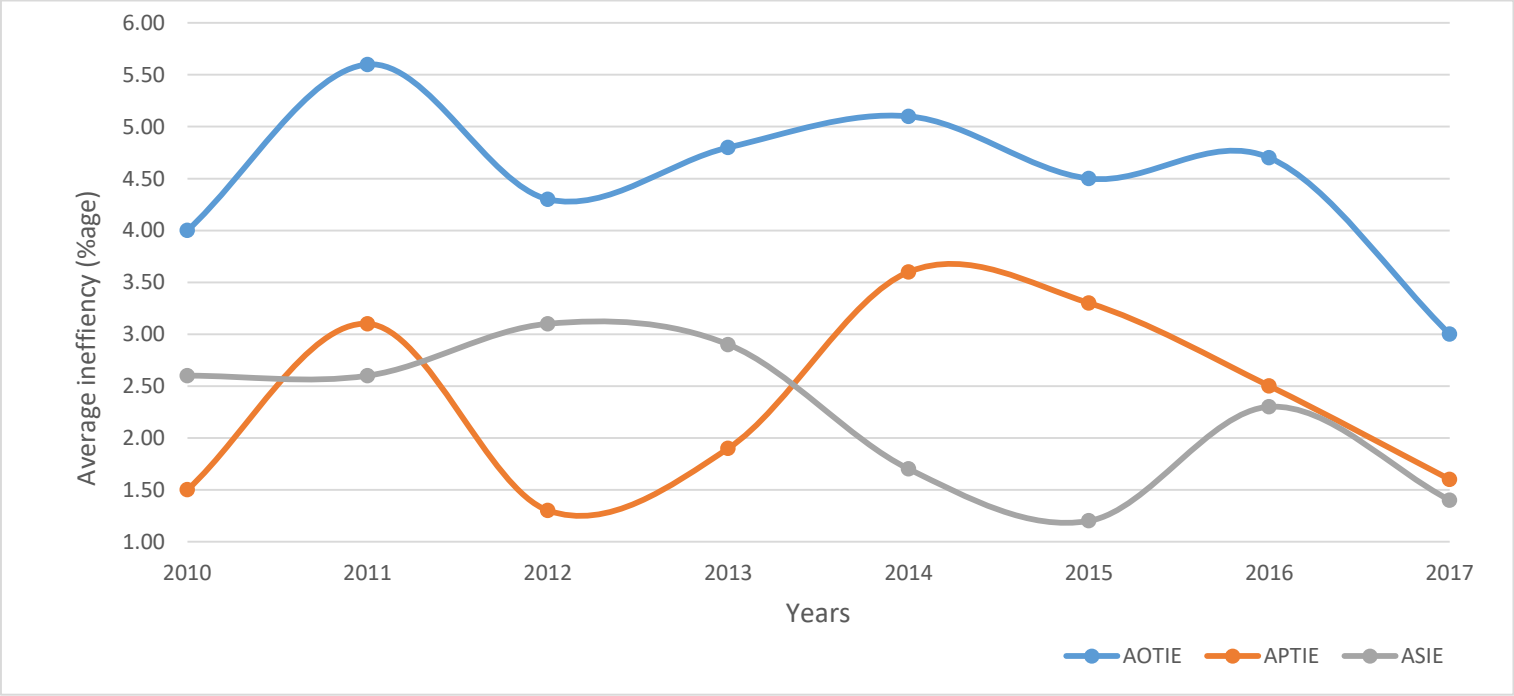
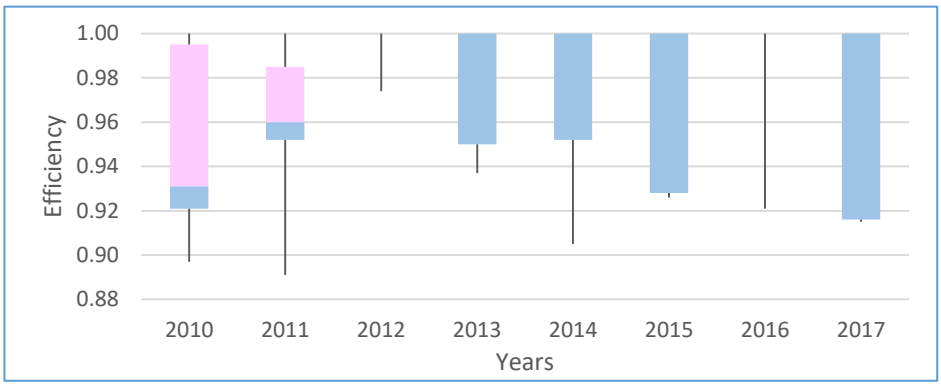


Figure 4.2: Average Inefficiency for Selected IT firms: 2010-2017

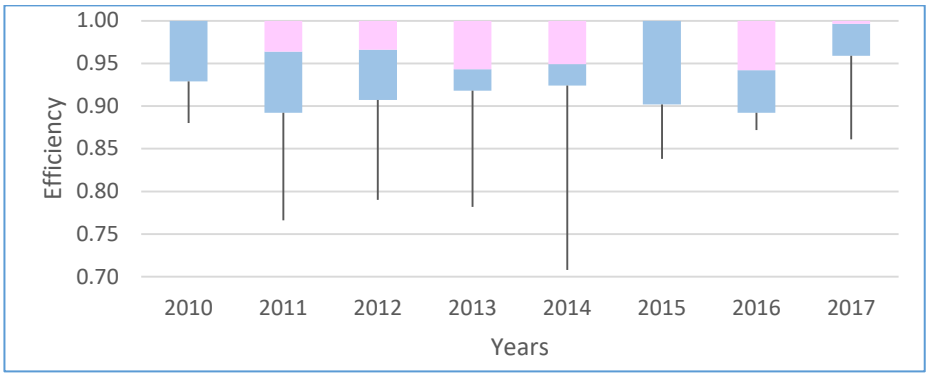
4.3.1.1 Cluster-wise Efficiency Results -DEA

The IT companies selected for this study are bifurcated into two clusters for further analysis. The top five IT firms with a market capitalization more than ₹100 billion and net profit more than ₹10 billion were included in the first cluster. The second cluster comprises remaining IT firms. The results indicated that the OTE of the first cluster was higher than that of the second cluster for the duration 2010 to 2016.This clearly shows that IT firms in first cluster are more efficient than the IT firms in the second cluster. The higher efficiency of large IT firms could be because of their well-established processes and large and stable client base. Because of their large size, they could take more risks and are able to handle minor blips in the business. However, the overall technical inefficiency (OTIE) of the first cluster was higher than that of the second cluster in 2017. This could be attributed to the fact that perhaps during this phase, the firms in the second cluster taking cue from the IT firms in the first cluster tried to improve their employees' efficiency, employees' skills, provided good office environment, and implemented ergonomic principles at offices. This might have built an overall positive work environment in these companies. This could have led the second cluster IT firms to achieve higher efficiencies.

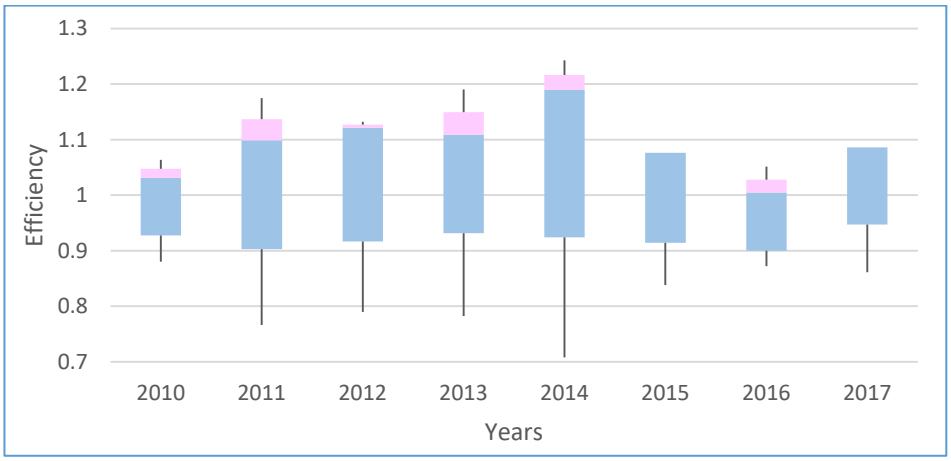
In this study, we also compared the efficiency of the top five IT firms with the rest of the selected IT firms using box plots. This is depicted in Figure 4.3 (Puri & Yadav, 2017). As shown in Figure 4.3, the substantial tall boxes for the top five IT firms indicate that there is greater fluctuation in the performance scores of the top five IT firms. Also, it was interpreted from Figure 4.3 that slightly small boxes for the rest of the IT firms indicate relatively high stability in their efficiency scores.



4.3(a) Top five IT firms



4.3(b) Rest of selected IT firms



4.3(c) - All selected IT firms

Figure 4.3: Overall Technical Efficiency Comparison for Selected IT Firms

It was found that in the year 2010, amongst the top five IT firms, only one IT firm was efficient. Also, it was found that in 2017, three out of five IT firms were operating

efficiently. Moreover, 44.44 per cent of the selected IT firms were efficient in 2010, whereas it was found that 53 per cent of the IT firms operating efficiently in 2017.

4.3.2 Efficiency Results of Selected IT Firms using DEA: 2016-2017

This section discusses on the efficiency scores, returns to scale, reference sets and peer count for the selected IT firms in India for the duration 2016-2017. Table 4.3 shows the results obtained. The total number of the selected IT firms was reduced from 18 to 17 for this period as HCL acquired GEOMR in 2016.

Table 4.3: Efficiency Results for all IT Firms: 2016-17-DEA

IT Co.	OTE	PTE	SE	RTS	Peers	Peer Count
TCS	1.000	1.000	1.000	crs	1	4
INFY	0.915	0.953	0.961	drs	1,4	0
WIPRO	0.916	1.000	0.916	drs	4,5,7,14	0
HCL	1.000	1.000	1.000	crs	4	8
TECHM	1.000	1.000	1.000	crs	5	5
ORCLF	1.000	1.000	1.000	crs	6	0
MNDTR	1.000	1.000	1.000	crs	7	5
MPHSI	0.861	0.868	0.993	irs	4,5,14	0
HEXWR	0.993	1.000	0.993	irs	1,4,7	0
CYENT	0.963	0.980	0.983	irs	4,5,14	0
PRSTN	0.920	0.934	0.985	irs	1,4,5,7	0
TLXI	1.000	1.000	1.000	crs	12	0
ZNSR	0.947	0.985	0.961	irs	1,4,5,7	0
NIIT	1.000	1.000	1.000	crs	14	4
POLRS	1.000	1.000	1.000	crs	15	0
HNDG	0.967	1.000	0.967	irs	4,7,14	0
HNDVR	1.000	1.000	1.000	crs	17	0
	0.970	0.984	0.986	<--- Average Efficiency		
	3.00	1.60	1.40	<--- Average Inefficiency(%age)		

Table 4.3 depicts that the average OTE score of the selected IT firms was 0.97 for the duration 2016-2017. The results further show that that nine firms had an OTE of one during this period. These firms were TCS, HCL, TECHM, ORCLF, MNDTR, TLXI, NIIT, POLRS and HNDV. These efficient IT firms collectively formed the efficient frontier. The inefficient firms compared were INFY, WIPRO, MPHSI, HXWR,

CYENT, PRSTN, ZNSR and HNDG. This study also evaluated the PTE and the SE of the selected IT firms utilizing BCC model. The results showed that twelve firms formed the variable returns to scale frontier. Three firms, namely, WPR, HXWR and HNDG were PTE efficient. These three firms were found to be scale inefficient. Five firms were neither overall technical efficient nor pure technical efficient. Thus, these firms required improvement in managerial performance as well as improvement in scale utilization. The findings show that there were nine firms that had SE of one. These firms were TCS, HCL, TECHM, ORCLF, MNDTR, TLXI, NIIT, POLR and HNDV. The SE of one indicates that these nine firms were able to utilize their scale effectively. There were eight firms that were scale inefficient indicating that they were deviating from their optimal size.

The study established that MPHSI had OTE score of 0.861, and INFY had OTE score of 0.91. These firms were found to be the lowest efficient firms for the selected duration. This also implies that INFY was approximately 10 per cent less efficient as compared to other firms. INFY was found to be the least efficient on every aspect. Also, it was found that the production system of INFY exhibited DRS for the selected duration. It was also found that out of the top five firms, TCS and HCL were peers of INFY.

The study further shows that nine firms showed constant returns to scale. These firms were TCS, HCL, TECHM, ORCLF, MNDTR, TLXI, NIIT, POLRS and HNDV. The results further indicated that the six scale inefficient companies exhibited increasing returns to scale. These firms were MPHSI, HXWR, CYENT, PRSTN, ZNSR and HNDG. This has implications on efficiency enhancement. These firms can increase their productivity by expanding their employee base by recruitments or through merger & acquisitions.

4.3.2.1 Benchmarking – Overall Technical Efficient Firms

The empirical results pointed out that there were nine IT firms that were highly efficient. These nine firms become the benchmark for the remaining eight firms. The efficient frontier formed by these firms was used as the basis for performance improvement of the inefficient firms. Table 4.3 depicts the peer count of the DMUs. The peer count is used to determine the robustness of the DMUs. The higher the score

of peer count, the more robust is the firm. It was found that HCL had the largest peer count for the duration 2016-2017. Hence, it was identified as the most robust firm. The efficient firms with lower peer count, such as ORCLF, TLXI, POLRS and HNDV were likely to be less robust. Based on the peer count, the DMUs were classified as high robust, medium robust and low robust. HCL, TECHM and TCS were respectively high robust, medium robust and low robust firms.

4.3.2.2 Sensitivity Analysis

Sensitivity analysis was conducted to check the robustness of the DEA results obtained as part of this study. Sensitivity analysis measures the robustness of the results by removing one of the efficient firms at a time, and then investigating the results (Puri & Yadav, 2013; Avkiran, 2006). Five models were developed for the sensitivity analysis based on the efficiency results obtained for this study. The results are depicted in Table 4.4.

An efficient firm is considered as an outlier if its removal from the selected DMUs significantly changes the average OTE of the firms. The findings of this study depict that the average OTE was not altered significantly in any of the five models. This established that the initial results obtained were stable.

Table 4.4: Sensitivity Analysis Results –DEA

IT Co. removed from the analysis	Model	AOTE	Effect of removing of an IT co. on AOTE	Number of efficient IT cos.
Initial		0.97	-	9
HCL	Model -I	0.98	Increase	10
TECHM	Model -II	0.98	Increase	8
MNDTR	Model -III	0.97	No Change	8
TCS	Model - IV	0.97	No Change	9
NIIT	Model -V	0.97	No Change	9
Source: Author's calculation				

Note: *AOTE – Average Overall technical efficiency*

4.3.2.3 Factors Impacting the Efficiency of IT Firms: Output Slacks and Target Setting for Inefficient Firms

In this study, we utilized an output-oriented DEA approach, so we analyzed only output slacks. The output slacks provided details about the potential output and actual

output. We evaluated the information to determine how to achieve the desired efficiency by varying only the outputs and holding the inputs constant. The optimal output slacks for inefficient DMUs were computed for the year 2016-17, based on CCR model. Refer Appendix A for details.

The results showed that ten firms had no output slack. Nine firms out of these ten were overall technically efficient. These firms made maximum utilization of the skills of their employees. The results also indicated that there were no slacks in the net sales turnover of any selected IT firm. The average slack in the net profit after tax of all the 17 IT firms was found to be approximately ₹4.05billion. Out of the top five IT firms, INFY had the maximum slack in profit after tax of ₹38.75billion. This implies that INFY must reduce its inputs by 8.5 percent. Not only this, INFY must augment its profit after tax also by ₹38.75billion to become efficient. In the case of medium-sized firms, MPHSI had the maximum slack in profit after tax of ₹2.49 billion. The results indicated that CYENT was the only IT firm that was overall technically inefficient, but it had zero slack. This indicates that optimal SE may be one of the reasons for inefficiency of the firms. There could be other factors responsible for inefficiency of firms as well.

The DEA model also helps in setting up targets for the inefficient firms/DMUs so that they can become efficient. The input-output target values provide data on how much outputs can be increased or how much inputs can be reduced for a particular inefficient IT firm/DMU to become efficient (Puri& Yadav, 2013; Avkiran, 2006).The targeted and actual values for input and output variables for the inefficient firms are estimated using Equation 5 and depicted in Table 4.5. The values in parenthesis in Table 4.5 are the percentage augmentations in the corresponding outputs and percentage reduction in the corresponding inputs to make the IT company efficient. Appendix A has details of the formulae used for this purpose.

Table 4.5 depicts that MPHSI was the least efficient IT firm in the sample. MPHSI can improve its efficiency by increasing its sales turnover by 16 percent, increasing net profit by 56 percent and by reducing its total assets by 4.2 percent. In general, all the inefficient IT firms can increase their sales turnover by an average of 9 per cent, and their net profit by an average of 38 per cent to meet the efficiency of the

benchmark firms. This clearly implies that selected IT firms must focus on increasing their net profit and sales output to become more efficient.

Table 4.5: Peers and Target Values (in Rupee million) of Input and Output Variables under CCR Output-Oriented Model - DEA

Inefficient IT co.		*Target values of input variables*				*Target values of output variables*	
	Peers	I_1	I_2	I_3	I_4	O_1	O_2
INFY	IT1, IT4	805940 (0)	297845 (3.75)	490750 (0)	45686 (10.77)	648383 (9.24)	189695 (37.28)
WIPRO	IT4, IT5, IT7, IT14	636486 (0)	218544 (0)	403692 (0)	25254 (0)	498195 (9.16)	113245 (38.75)
MPHSI	IT4, IT5, IT14	52601 (4.2)	13791 (0)	25786 (0)	2013 (0)	34269 (16.08)	9746 (55.94)
HXWR	IT1, IT4, IT7	16819 (0)	6654 (8.32)	10799 (0)	943 (0)	14030 (0.72)	3885 (9.1)
CYENT	IT4, IT5, IT14	18119 (32.75)	6781 (0)	11113 (3.74)	501 (0)	13429 (3.81)	2459 (3.81)
PRSTN	IT1, IT4, IT5,IT7	21020 (0)	8732 (0)	15344 (0)	1097 (0)	18845 (8.74)	4376 (48.85)
ZNSR	IT1, IT4, IT5, IT7	13463 (0)	7116 (0)	11253 (0)	728 (0)	13546 (5.62)	2804 (55.62)
HNDG	IT4, IT7, IT14	14100 (0)	10051 (3.33)	14688 (0)	545 (0)	16515 (3.38)	2065 (103.49)

4.4 Empirical Results and Discussions - Tobit Regression Model

Tobit regression was estimated using software Eviews12. For this analysis, OTE score, PTE score, and SE score were utilized as dependent variables. The efficiency scores were obtained using DEA for the year 2016-2017 and the results were discussed earlier. The independent variables selected for this study are described in Section 4.2.3. Parameters are computed by maximum likelihood method. The result of regression which focuses on the relationship between IT company efficiency and the five explanatory variables are shown in Table 4.6. The table shows the results for OTE, PTE and SE.

Table 4.6: Tobit Regression Output – Overall Technical Efficiency (OTE), Pure Technical Efficiency (PTE), Scale Efficiency (SE)

OTE			
Variables	Coefficient	Std. Error	Z-statistic
Age	0.051382	0.00352	14.59761*
R & D Expenses	-0.000669	0.00035	-1.9138**
Employee Count	5.76E-06	3.44E-06	1.673612***
Asset Size	-1.001241	0.379043	-2.641494*
PTE			
Variables	Coefficient	Std. Error	Z-statistic
Age	0.077925	0.009228	8.444448*
R & D Expenses	-0.000895	0.000465	-1.925152**
Employee Count	2.68E-06	3.17E-06	0.846309
Asset Size	-1.15487	0.435133	-2.654063*
SE			
Variables	Coefficient	Std. Error	Z-statistic
Age	0.05164	0.003496	14.77227*
R & D Expenses	-0.000618	0.000346	-1.785089**
Employee Count	5.67E-06	3.45E-06	1.641159*
Asset Size	-1.011017	0.380705	-2.655642*
Degree of freedom (n-4) = 44			
*significant at 0.01 level, **significant at 0.05 level, ***significant at 0.1 level			

The findings of this study reveals that for OTE as a dependent variable, age of company and R&D expenses are significant at 5% level , number of employees is significant variables at 10% level, whereas asset size of the company is significant at

1% level. We find that the relationship between R&D expenses and OTE is negative which seems to be contradictory in nature. In general R&D expenses increases productivity or efficiency. However, the results of this study do not support this hypothesis. The result for PTE and SE as dependent variable also reveals similar results except for one variance which reveals that relationship between number of employees and PTE is not significant.

In this study using Tobit Regression analysis, we have tested the following hypotheses:

Hypothesis H_{2a}: There is no significant relationship between age of company and firm efficiency. Our empirical analysis reveals that age of the firm and efficiencies are positively correlated and statistically highly significant relation is there between age of the company and efficiency scores. Thus, the null of no relation between age of the company and efficiency score is rejected.

Hypothesis H_{2b}: There is no significant relationship between R&D expenses and firm efficiency. The study shows that Research &Development expenses have statistically significant negative impact on the efficiencies. Thus, the null of no relationship between R&D and efficiency is rejected.

Hypothesis H_{2c}: There is no significant relationship between number of employees and firm efficiency. Number of employees of the firm is positively correlated with the efficiency score of the IT companies and has significant relationship. Therefore, this hypothesis is rejected on basis of statistical analysis.

Hypothesis H_{2d}: There is no significant relationship between asset size and firm efficiency. There is negative relationship between asset size and firm efficiency and the results are significant. Thus, the null of no relation between asset size and firm efficiency is rejected at conventional levels.

4.5 Findings of the Research

The efficiency of the firms is central to economic growth and employees' development (Chang et al., 2013; Iqbal, Hassan & Peng, 2019; Vu, 2011). The IT industry helps to improve the overall efficiency of the eco-system (Draca et al., 2016; Abdullahi et al., 2019). The IT industry, however, is itself passing through difficult

times following the US sub-prime crisis of 2008, and due to increase in competition in IT industry worldwide. This prompted us to examine the efficiency of IT industry of India. The major findings of the analysis are listed below. The findings could be of benefit to policy makers for strategizing for the way forward to IT industry.

The results of the study indicated that MNDTR, TLXI and HNDV were overall technical efficient across all the years for the duration 2010 to 2017. All these firms had an efficiency score of one. The three less efficient IT firms for this duration were ORCLF, CYENT and GEOMR. The OTE increased for TCS, HCL, TECHM, CYENT, NIIT, POLRS, HNDG and GEOMR during the selected duration of the study. For the same duration, the OTE of INFY, WIPRO, MPHSI, HXWR, PRSTN and ZNSR decreased over time. The AOTE of selected IT firms increased to 96.95 per cent in 2017 from 95.97 per cent in 2010. This implies that to operate at higher efficiencies, these firms should continue to implement the strategies adopted in 2017. It was also found that the top five IT firms were overall technically efficient when compared to the rest of the selected IT firms for the duration 2010 to 2017. Thus, rest of the selected IT firms should follow the strategies and best practices followed by top five IT firms to improve their efficiency. It was also noticed that the top five IT firms showed more fluctuations in the efficiency as compared to the rest of the IT firms.

The study also found that for the year 2016-2017, the results depicted that nine firms had an OTE score of one. These firms were TCS, HCL, TECHM, ORCLF, MNDTR, TLXI, NIIT, POLRS and HNDV. These efficient IT firms collectively define the efficient frontier of all the selected IT firms for the study. The study established that MPHSI, INFY, WPRO and PRSTN are amongst the companies that have low OTE values. The study also found that MPHSI, INFY, PRSTN and ZNSR are pure technical inefficient IT firms. It was also concluded from the study that WPRO, INFY, ZNSR and HNDG are amongst the companies with low SE values. It was noticed from the analyses of the study that OTIE of WPRO, HXWR and HNDG is primarily due to SIE rather than PTIE. Therefore, these IT firms can be said to be facing problems pertaining to the number of employees rather than managerial problems. The efficiency of these inefficient IT firms could probably increase by reducing the number of un-utilized employees and scale optimization.

The results of the study indicated that INFY was the least efficient on every parameter for the selected duration. Also, the production system of INFY exhibited DRS over the sample period. This is while INFY is one of the leading IT software service companies in India and has remained the corporate face of India. This implies that policy makers of INFY should first focus on addressing the technical inefficiency before fixing the scale of operations. The co-ordination between the management and the employees and employees' skills enrichment could be the primary issues causing inefficiency that needs to be fixed.

The study also found that that HCL can be considered as the benchmark IT firm followed by TECHM and MNDTR. INFY had maximum slack. CYENT was the only IT firm that was overall technically inefficient but had zero slack. This indicates that there are other factors responsible for inefficiency. Optimal SE may be one of the reasons for the inefficiency. MPHSI was found to be the least efficient company.

Also, in this study we tried to examine the impact of various factors on the efficiency of the selected IT companies in India using Tobit Regression model. The results of Tobit regression analysis depict that the factors like age of the company, Research and Development expenses, and number of employees and asset size of the IT companies have a significant impact on the OTE of the selected IT companies. Also, the efficiency of IT companies is positively influenced by the age of the company and number of employees.

CHAPTER V

COMPONENT-WISE PERFOMANCE OF SELECTED IT COMPANIES

This chapter focuses and analyzes the component-wise performance of the selected IT companies in India using MC-DEA. It also explores the various factors affecting the performance of IT industry and the component-wise performance of selected IT firms in India.

IT firms are structured internally into various sub-business units or components to provide focused and customized service to their customers in the banking, finance, insurance, manufacturing, retail, energy, communications, education, life sciences and healthcare sectors. These sub-business units act as autonomous components comprising parallel units in the organization. In a global competitive market, the performance of an IT company depends on the efficiency of the various components in the organization. According to the latest forecast by Gartner (2020), banking and securities, communications and media, manufacturing and natural resources are the key segments for the growth in the IT industry.

Literature review suggests that the impact and performance of the sub-business units or internal activities is not taken into consideration in the traditional DEA analysis. These sub-business units, which utilize the inputs to convert into outputs, are treated as “black box” (Färe & Grosskopf, 2000). In practice, each DMU may consist of various components that are independent or interdependent on each other. These components are called decision making sub-units (DMSUs). In this context, it is better to evaluate the efficiency performance of the DMUs along with their components.

To measure efficiency of firms along with their components, researchers have extended the traditional DEA to MC-DEA and network DEA. Some researchers like Färe and Grosskopf (1996), Färe, Grabowski, Grosskopf and Kraft (1997), Cook,

Hababou and Tuenter (2000) and Lewis & Sexton (2004) made earlier attempt in this direction. Further, the estimation and evaluation of efficiency performance of each component along with overall efficiency has gained momentum over time (Kao, 2014). As the revenue and the profit of IT companies depend on the efficiency of their DMSUs or components, it is important to measure the efficiency of each IT company segment-wise.

The present study also employed MC-DEA approach to the selected IT companies using quarterly data from 2014 to 2017 focusing on various components such as FSI (Banking, Financial, Securities, and Insurance), MFG (Manufacturing), RCL (Retail, Consumer Packaged Goods, and Logistics), ERU (Energy, Utilities and Resources), CME (Communication, Media, and Entertainment) and LSH (Life Sciences and Health Care Services). Moreover, the present study also incorporated revenue loss due to unutilized resources as the undesirable output into the performance model of MC-DEA which is subject to decrease along with the inputs. No studies, so far, on the IT sector efficiency in India have considered the impact of revenue loss arising due to non-utilized resources in multi-component efficiency analysis.

The significance of investigating efficiency of the various components lies in the fact that an IT firm, in general, comprises various components or sub-business units and the performance of each component influences the ultimate performance of an IT firm. Thus, the performance of an IT company cannot be visualized in isolation. Therefore, it is imperative not only to evaluate the overall performance of an IT firm but also the performance of its various components.

The study proceeds as follows. The next section lists the objectives of the study. The study then describes the performance model and the input-output variables selected for the MC-DEA analysis. Further, the empirical results are presented and discussed with focus on the geography-wise evaluation of the efficiency trends of the DMSUs at the international level. Thereafter, implications and limitations of the study are presented followed by the concluding remarks.

5.1 Objectives Addressed in this Chapter

The objectives addressed in this chapter are as follows:

O_1: To examine the performance of selected IT companies of India.

O_2: To identify factors affecting the performance of the selected IT companies.

To meet the above objectives, we employed MC-DEA methodology and descriptive statistics to analyze the following:

a) The efficiency of six components, namely, FSI, MFG, RCL, ERU, CME and LSH of the top selected five IT firms using quarterly data from 2014 to 2017.
b) The component-wise efficiency analysis of selected IT companies across three geographical regions, viz. North America (NA), Europe (EUR) and Rest of World (ROW) to perform international comparison.

5.2 Research Methodology: Multi-Component DEA Methodology

Puri and Yadav (2013) presented DEA methodology mathematically as Model-1 based on the assumption that inputs and undesirable outputs must be minimized whereas desirable outputs must be maximized. It is a fractional programming problem which is reduced to the linear form by using Charnes-Cooper transformation (Cooper et al., 2007).

Model 1:

$$\text{Max } E_k = \frac{\sum_{r=1}^{s_1} u_{rk}^g y_{rk}^g - \sum_{p=1}^{s_2} u_{pk}^b y_{pk}^b}{\sum_{i=1}^{m} v_{ik} x_{ik}}$$

$$\text{subject to } 0 \le E_j = \frac{\sum_{r=1}^{s_1} u_{rk}^g y_{rj}^g - \sum_{p=1}^{s_2} u_{pk}^b y_{pj}^b}{\sum_{i=1}^{m} v_{ik} x_{ij}} \le 1, \forall j = 1,2,\dots,n;$$

$$u_{rk}^g \ge \varepsilon \forall r = 1,2,\dots,s_1; u_{pk}^b \ge \varepsilon \forall p = 1,2,\dots,s_2; v_{ik} \ge \varepsilon \forall i = 1, \varepsilon > 0.$$

Definition 1: The DMU_k is said to be efficient if optimal objective function value $E_k^* = 1$ in Model-1.

5.2.1 Multi-Component DEA (MC-DEA) with Shared and Undesirable Resources

Nomenclature: Let *n* be the number of DMUs and *d* be the number of DMSUs. Let I^S and I_i be the number of shared inputs and external inputs respectively consumed by $DMSU_i$. Let K^{SG}, K^{SB}, K_i^G and K_i^B be the number of shared desirable outputs, shared undesirable outputs, desirable outputs and undesirable outputs respectively produced by $DMSU_i$. For DMU_k and $i = 1,2,\dots,d$, let

- $X_k^S = (x_{1k}^S, x_{2k}^S, \ldots, x_{I^S k}^S)^T$: Vector of shared inputs.
- $X_k^{(i)} = (x_{1k}^{(i)}, x_{2k}^{(i)}, \ldots, x_{I_i k}^{(i)})^T$: Vector of external inputs consumed by DMSU$_i$.
- $Y_k^{SG} = (y_{1k}^{SG}, y_{2k}^{SG}, \ldots, y_{K^{SG} k}^{SG})^T$: Vector of shared desirable outputs.
- $Y_k^{SB} = (y_{1k}^{SB}, y_{2k}^{SB}, \ldots, y_{K^{SB} k}^{SB})^T$: Vector of shared undesirable outputs.
- $Y_k^{G(i)} = (y_{1k}^{G(i)}, y_{2k}^{G(i)}, \ldots, y_{K_i^G k}^{G(i)})^T$: Vector of desirable outputs produced by DMSU$_i$.
- $Y_k^{B(i)} = (y_{1k}^{B(i)}, y_{2k}^{B(i)}, \ldots, y_{K_i^B k}^{B(i)})^T$: Vector of undesirable outputs produced by DMSU$_i$.

Let $\alpha_{ik} = (\alpha_{ik}^1, \alpha_{ik}^2, \ldots, \alpha_{ik}^{I^S})^T$ be vector for DMSU$_i$such that $\alpha_{ik}^t x_{tk}^S$ be the portion of t^{th} shared input consumed by DMSU$_i$ and $\sum_{i=1}^d \alpha_{ik}^t = 1, \forall t = 1, 2, \ldots, I^S$. Let $\beta_{ik}^G = (\beta_{ik}^{1G}, \beta_{ik}^{2G}, \ldots, \beta_{ik}^{K^{SG}G})^T$ be vector for DMSU$_i$ such that $\beta_{ik}^{pG} y_{pk}^{SG}$ be the portion of p^{th} shared desirable output produced by DMSU$_i$ and $\sum_{i=1}^d \beta_{ik}^{pG} = 1, \forall p = 1, 2, \ldots, K^{SG}$. Let $\beta_{ik}^B = (\beta_{ik}^{1B}, \beta_{ik}^{2B}, \ldots, \beta_{ik}^{K^{SB}B})^T$ be vector for DMSU$_i$ such that $\beta_{ik}^{qB} y_{qk}^{SB}$ be the portion of q^{th} shared undesirable output produced by DMSU$_i$ and $\sum_{i=1}^d \beta_{ik}^{qB} = 1, \forall q = 1, 2, \ldots, K^{SB}$. The production process of a multi-component DMU$_k$ with shared and undesirable resources is depicted in Figure 5.1.

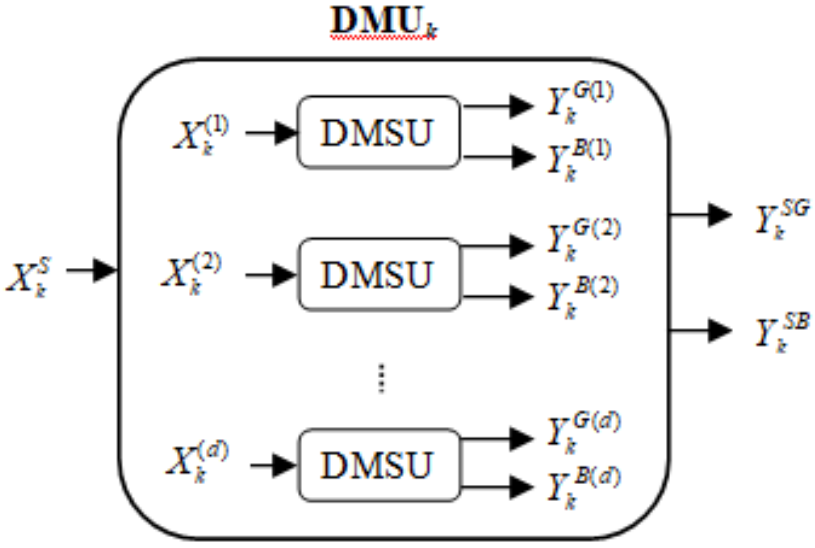


Figure 5.1: Multi-component DMU in DEA

The aggregate efficiency $E_k^{(a)}$ of DMU_k along with DMSUs' efficiencies $E_k^{(i)}{}'s$ are given by

$$E_k^{(a)} = \frac{\sum_{i=1}^{d} U_k^{G(i)} Y_k^{G(i)} + \sum_{i=1}^{d} U_k^{SG(i)} (\beta_{ik}^{G} Y_k^{SG}) - \sum_{i=1}^{d} U_k^{B(i)} Y_k^{B(i)} - \sum_{i=1}^{d} U_k^{SB(i)} (\beta_{ik}^{B} Y_k^{SB})}{\sum_{i=1}^{d} V_k^{(i)} X_k^{(i)} + \sum_{i=1}^{d} V_k^{S(i)} (\alpha_{ik} X_k^{S})}$$

and

$$E_k^{(i)} = \frac{U_k^{G(i)} Y_k^{G(i)} + U_k^{SG(i)} (\beta_{ik}^{G} Y_k^{SG}) - U_k^{B(i)} Y_k^{B(i)} - U_k^{SB(i)} (\beta_{ik}^{B} Y_k^{SB})}{V_k^{(i)} X_k^{(i)} + V_k^{S(i)} (\alpha_{ik} X_k^{S})}, i = 1, 2, \ldots, d$$

where $U_k^{G(i)}$, $U_k^{B(i)}$, $U_k^{SG(i)}$, $U_k^{SB(i)}$, $V_k^{(i)}$ and $V_k^{S(i)}$ are the vectors associated with desirable outputs, undesirable outputs, shared desirable outputs, shared undesirable outputs, inputs and shared inputs of $DMSU_i$ for DMU_k respectively.

Also

$$\beta_{ik}^{G} Y_k^{SG} = (\beta_{ik}^{1G} y_{1k}^{SG}, \beta_{ik}^{2G} y_{2k}^{SG}, \ldots, \beta_{ik}^{K^{SG}G} y_{K^{SG}k}^{SG})^T,$$
$$\beta_{ik}^{B} Y_k^{SB} = (\beta_{ik}^{1B} y_{1k}^{SB}, \beta_{ik}^{2B} y_{2k}^{SB}, \ldots, \beta_{ik}^{K^{SB}B} y_{K^{SB}k}^{SB})^T \text{ and } \alpha_{ik} X_k^{S} = (\alpha_{ik}^{1} x_{1k}^{S}, \alpha_{ik}^{2} x_{2k}^{S}, \ldots, \alpha_{ik}^{I^S} x_{I^S k}^{S})^T.$$

Theorem 1 $E_k^{(a)}$ is a convex combination of $E_k^{(i)}s$.

Proof: The same can be proved as Theorem 1 in Puri and Yadav (2017).

To derive $E_k^{(a)}, E_k^{(1)}, E_k^{(2)}, \ldots, E_k^{(d)}$, we solve the mathematical Model-2 in which aggregate efficiency of DMU_k ($E_k^{(a)}$) is maximized subject to the conditions that aggregate efficiency and DMSUs efficiencies for each DMU are less than or equal to 1 and greater than or equal to 0. In Model-2, the sets Ω_1, Ω_2, Ω_3, Ω_4, Ω_5, Ω_6, Ω_7, Ω_8, and Ω_9 are assurance regions defined by any restrictions imposed on multipliers (Puri & Yadav, 2017). Model-2 reduces to Model-3 after the removal of redundant constraints $E_j^{(a)} \geq 0$ ($j = 1, 2, \ldots, n$) as follows from Theorem 1 and the constraint set $E_j^{(i)} \geq 0$ ($\forall i = 1, 2, \ldots, d; \forall j = 1, 2, \ldots, n$).

Model – 2

Max $E_k^{(a)}$

subject to $0 \leq E_j^{(a)} \leq 1, \forall j = 1, 2, \ldots, n;$

$$0 \le E_j^{(i)} \le 1, \forall i = 1,2,\dots,d; \forall j = 1,2,\dots,n;$$

$$\sum_{i=1}^{d} \alpha_{ik}^{t} = 1, \forall t = 1,2,\dots,I^S;$$

$$\sum_{i=1}^{d} \beta_{ik}^{pG} = 1, \forall p = 1,2,\dots,K^{SG};$$

$$\sum_{i=1}^{d} \beta_{ik}^{qB} = 1, \forall q = 1,2,\dots,K^{SB};$$

$$U_k^{G(i)} \in \Omega_1, U_k^{B(i)} \in \Omega_2, U_k^{SG(i)} \in \Omega_3, U_k^{SB(i)} \in \Omega_4,$$

$$V_k^{(i)} \in \Omega_5, V_k^{S(i)} \in \Omega_6, \forall i = 1,2,\dots,d;$$

$$\alpha_{ik} \in \Omega_7, \beta_{ik}^{G} \in \Omega_8, \beta_{ik}^{B} \in \Omega_9, \forall i = 1,2,\dots,d.$$

Model -3

Max $E_k^{(a)}$

subject to $E_j^{(a)} \le 1, \forall j = 1,2,\dots,n;$

$$0 \le E_j^{(i)} \le 1, \forall i = 1,2,\dots,d; \forall j = 1,2,\dots,n;$$

$$\sum_{i=1}^{d} \alpha_{ik}^{t} = 1, \forall t = 1,2,\dots,I^S;$$

$$\sum_{i=1}^{d} \beta_{ik}^{pG} = 1, \forall p = 1,2,\dots,K^{SG};$$

$$\sum_{i=1}^{d} \beta_{ik}^{qB} = 1, \forall q = 1,2,\dots,K^{SB};$$

$$U_k^{G(i)} \in \Omega_1, U_k^{B(i)} \in \Omega_2, U_k^{SG(i)} \in \Omega_3, U_k^{SB(i)} \in \Omega_4,$$

$$V_k^{(i)} \in \Omega_5, V_k^{S(i)} \in \Omega_6, \forall i = 1,2,\dots,d;$$

$$\alpha_{ik} \in \Omega_7, \beta_{ik}^{G} \in \Omega_8, \beta_{ik}^{B} \in \Omega_9, \forall i = 1,2,\dots,d.$$

Further, Model–3 is a fractional model and can be reduced to the following linear form (Model-4) using Charnes-Cooper transformation (Cooper et al., 2007) and the variable substitutions

$$\alpha_{ik}^{t} v_{tk}^{S(i)} = \overline{v}_{tk}^{S(i)}, \beta_{ik}^{pG} u_{pk}^{SG(i)} = \overline{u}_{pk}^{SG(i)}, \ \forall p; \ \beta_{ik}^{qB} u_{qk}^{SB(i)} = \overline{u}_{qk}^{SB(i)}, \ \forall t, p, q, i:$$

Model - 4

$$\text{Max} \quad E_k^{(a)} = \sum_{i=1}^{d}\sum_{r=1}^{K_i^G} u_{rk}^{G(i)} y_{rk}^{G(i)} + \sum_{i=1}^{d}\sum_{p=1}^{K^{SG}} \bar{u}_{pk}^{SG(i)} y_{pk}^{SG} - \sum_{i=1}^{d}\sum_{h=1}^{K_i^B} u_{hk}^{B(i)} y_{hk}^{B(i)} - \sum_{i=1}^{d}\sum_{q=1}^{K^{SB}} \bar{u}_{qk}^{SB(i)} y_{qk}^{SB}$$

$$\text{subject to} \ \sum_{i=1}^{d}\sum_{l=1}^{I_i} v_{lk}^{(i)}\, x_{lk}^{(i)} + \sum_{i=1}^{d}\sum_{t=1}^{I^S} \bar{v}_{tk}^{S(i)} x_{tk}^{S} = 1;$$

$$\sum_{i=1}^{d}\sum_{r=1}^{K_i^G} u_{rk}^{G(i)} y_{rj}^{G(i)} + \sum_{i=1}^{d}\sum_{p=1}^{K^{SG}} \bar{u}_{pk}^{SG(i)} y_{pj}^{SG} - \sum_{i=1}^{d}\sum_{h=1}^{K_i^B} u_{hk}^{B(i)} y_{hj}^{B(i)} - \sum_{i=1}^{d}\sum_{q=1}^{K^{SB}} \bar{u}_{qk}^{SB(i)} y_{qj}^{SB} - \sum_{i=1}^{d}\sum_{l=1}^{I_i} v_{lk}^{(i)}\, x_{lj}^{(i)}$$

$$- \sum_{i=1}^{d}\sum_{t=1}^{I^S} \bar{v}_{tk}^{S(i)} x_{tj}^{S} \le 0, \forall j = 1,\ldots,n;$$

$$\sum_{r=1}^{K_i^G} u_{rk}^{G(i)} y_{rj}^{G(i)} + \sum_{p=1}^{K^{SG}} \bar{u}_{pk}^{SG(i)} y_{pj}^{SG} - \sum_{h=1}^{K_i^B} u_{hk}^{B(i)} y_{hj}^{B(i)} - \sum_{q=1}^{K^{SB}} \bar{u}_{qk}^{SB(i)} y_{qj}^{SB} - \sum_{l=1}^{I_i} v_{lk}^{(i)}\, x_{lj}^{(i)} - \sum_{t=1}^{I^S} \bar{v}_{tk}^{S(i)} x_{tj}^{S} \le 0,$$

$$\forall i = 1,\ldots,d\ ,\ \forall j = 1,\ldots,n;$$

$$\sum_{r=1}^{K_i^G} u_{rk}^{G(i)} y_{rj}^{G(i)} + \sum_{p=1}^{K^{SG}} \bar{u}_{pk}^{SG(i)} y_{pj}^{SG} - \sum_{h=1}^{K_i^b} u_{hk}^{B(i)} y_{hj}^{B(i)} - \sum_{q=1}^{K^{SB}} \bar{u}_{qk}^{SB(i)} y_{qj}^{SB} \ge 0, \forall i = 1,\ldots,d\,; \forall j = 1,\ldots,n;$$

$$\sum_{i=1}^{d} \alpha_{ik}^{t} = 1, \ \forall t = 1,\ldots,I^S; \ \sum_{i=1}^{d} \beta_{ik}^{pG} = 1, \ \forall p = 1,\ldots,K^{SG}; \sum_{i=1}^{d} \beta_{ik}^{qB} = 1, \ \forall q = 1,\ldots,K^{SB};$$

$$\left(u_{1k}^{G(i)}, u_{2k}^{G(i)},\ldots,u_{K_i^G k}^{G(i)}\right) \in \bar{\Omega}_1, \left(u_{1k}^{B(i)}, u_{2k}^{B(i)},\ldots,u_{K_i^B k}^{B(i)}\right) \in \bar{\Omega}_2, \left(\bar{u}_{1k}^{SG(i)}, \bar{u}_{2k}^{SG(i)},\ldots,\bar{u}_{K^{SG}k}^{SG(i)}\right) \in \bar{\Omega}_3,$$

$$\left(\bar{u}_{1k}^{SB(i)}, \bar{u}_{2k}^{SB(i)},\ldots,\bar{u}_{K^{SB}k}^{SB(i)}\right) \in \bar{\Omega}_4, \left(v_{1k}^{(i)}, v_{2k}^{(i)},\ldots,v_{I_i k}^{(i)}\right) \in \bar{\Omega}_5, \left(\bar{v}_{1k}^{S(i)}, \bar{v}_{2k}^{S(i)},\ldots,\bar{v}_{I^S k}^{S(i)}\right) \in \bar{\Omega}_6,$$

$$\left(\alpha_{ik}^{1}, \alpha_{ik}^{2},\ldots,\alpha_{ik}^{I^S}\right) \in \bar{\Omega}_7, \left(\beta_{ik}^{1G}, \beta_{ik}^{2G},\ldots,\beta_{ik}^{K^{SG}G}\right) \in \bar{\Omega}_8, \left(\beta_{ik}^{1B}, \beta_{ik}^{2B},\ldots,\beta_{ik}^{K^{SB}B}\right) \in \bar{\Omega}_9, \forall i = 1,\ldots,d.$$

The form of $\bar{\Omega}_1$, $\bar{\Omega}_2$, $\bar{\Omega}_5$, $\bar{\Omega}_7$ and $\bar{\Omega}_8$ in Model-4 will depend upon the structure of Ω_1, Ω_2, Ω_5, Ω_7 and Ω_8 respectively. The form of $\bar{\Omega}_3$, $\bar{\Omega}_4$ and $\bar{\Omega}_6$ depend upon how the pairs of assurance regions (Ω_3, Ω_8), (Ω_4, Ω_9) and (Ω_6, Ω_7) respectively are structured. The optimal objective function value of Model – 4 is the measure of aggregate efficiency $E_k^{(a)}$ for DMU$_k$ and the optimal solution (weights) obtained from Model – 4 are used to evaluate DMSUs efficiencies $E_k^{(1)}, E_k^{(2)}, \ldots, E_k^{(d)}$.

Definition 2 The efficiency of each DMSU$_i$ of DMU$_k$ can be obtained by using the optimal solution $(u_{rk}^{G(i)*} \forall i,r;\ \bar{u}_{pk}^{SG(i)*} \forall i,p;\ u_{hk}^{B(i)*} \forall i,h;\ \bar{u}_{qk}^{SB(i)*} \forall i,q;\ v_{lk}^{(i)*} \forall i,l;\ \bar{v}_{tk}^{S(i)*} \forall i,t)$ of Model-4 and is defined by

$$E_k^{(i)} = \frac{\sum_{r=1}^{K_i^G} u_{rk}^{G(i)*} y_{rk}^{G(i)} + \sum_{p=1}^{K^{SG}} \bar{u}_{pk}^{SG(i)*} y_{pk}^{SG} - \sum_{h=1}^{K_i^B} u_{hk}^{B(i)*} y_{hk}^{B(i)} - \sum_{q=1}^{K^{SB}} \bar{u}_{qk}^{SB(i)*} y_{qk}^{SB}}{\sum_{l=1}^{I_i} v_{lk}^{(i)*} x_{lk}^{(i)} - \sum_{t=1}^{I^S} \bar{v}_{tk}^{S(i)*} x_{tk}^{S}}, \ \forall i = 1,2,\ldots,d.$$

Theorem 2 A DMU$_k$ is said to be overall efficient if and only if each DMSU of DMU$_k$ is efficient. Equivalently $E_k^{(a)} = 1$ if and only if each $E_k^{(i)} = 1 \ \forall i = 1,2,\ldots,d.$

Proof It can easily be proved by using Theorem 1.

Remark Let $E_k^{(a)}$ be the aggregate efficiency of DMU$_k$ and $E_k^{(i)}$ $(\forall i = 1,2,\ldots,d)$ be the efficiency of DMSU$_i$ of DMU$_k$ in MC-DEA. If $M_k^L = \min_i\{E_k^{(i)}\}$ and $M_k^U = \max_i\{E_k^{(i)}\}$, then $M_k^L \le E_k^{(a)} \le M_k^U$.

5.3 Performance Model for Multi-Component Analysis of Selected IT Companies

In this study, the IT companies are represented as DMUs whereas the various industry-specific components are represented as DMSUs. To meet the objectives of the study, 100 large IT software services companies of the world were considered based on their annual revenues ("Services Top 100 - The World's Largest IT Service Companies", 2010). However, only the selected five multinational IT software services companies provided quarterly segmental data from 2014 to 2017. These are listed in Table 5.1. In the sample, the top three IT software companies in India that

were selected have approximately 20% share in the total estimated value of Indian IT software service industry in FY20 (IBEF, 2020). Following, Pareto's 20:80 rule (Koluksuz, 2020) this reflects a good sample size to represent the Industry. Further, in the sample, 2 foreign companies are also included. These 2 companies have annual revenue of approximately 60 billion (USD). Thus, the selected IT firms are not only dominant and market leaders but also dictate policies in the IT sector. Also, these 2 foreign companies have large offshore development centers in India. Hence, considering the limitations of data availability at the component level, these five IT companies can be taken as adequate data set.

Table 5.1: List of Selected IT Companies (DMUs) for Multi-Component Analysis

IT Company Name (Decision Making Unit - DMU)	*IT Company Acronym*
Infosys Ltd.	INFY
Tata Consultancy Services Ltd.	TCS
Wipro Ltd.	WPRO
Cognizant	CTS
Accenture PLC	ACCN

Source : Author's Compilation

In general, a large IT organization consists of multiple components and each component is run as a separate profit and a cost center commonly termed as DMSUs. Based on the literature review and the segmental data shared by the identified five IT companies (DMUs) in their respective financial reports, the various DMSUs identified are FSI, MFG, RCL, ERU , CME and LSH and are listed in Table 5.2 (Gartner, 2020). These components form the key segment areas of any IT company. Further, the duration of the study was restricted because the segmental data on the various DMSUs of the five identified IT companies were available 2013 onwards. Therefore, the duration of the study was selected from 2014-2017.

Table 5.2: List of DMSUs for the Selected IT Companies

Decision Making Sub-Unit (DMSU)	***Description***
FSI	Banking, Financial , Securities , Insurance
MFG	Manufacturing
RCL	Retail, Transport and Logistics
ERU	Energy , Utilities and Resources
CME	Communication , Media, Entertainment
LSH	Life Sciences and Health Care Services

Source: Author's Compilation

The production process of a multi-component DMU_k employed in this study is depicted in Figure 5.2.The six components form a parallel structure to utilize the inputs and shared inputs in the production process to produce individual component level output and shared undesirable output.

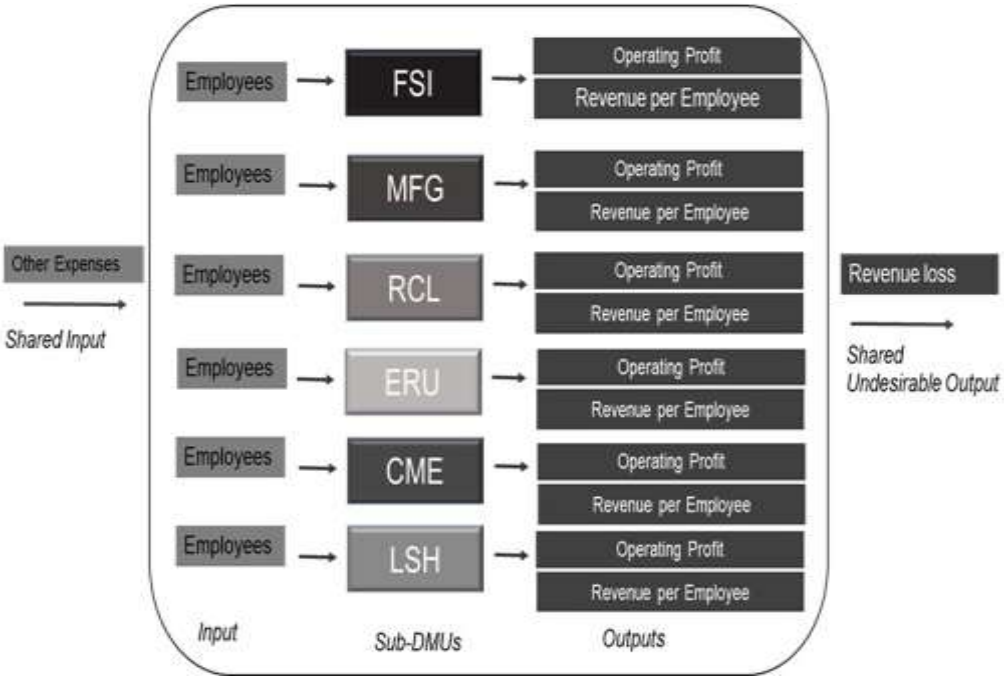


Figure 5.2: Production Process of DMSUs in Typical IT Company

5.3.1 Selection of Input and Output Variables

According to Wu and Ho (2007) and Li et al. (2019), the input variables selected for evaluating efficiency using DEA model should be the key factors that contribute to business outcomes. Similarly, the output variables must reflect the main business objective of the selected IT firms, which is profit maximization (Wong, Soh, Le Chong & Karia, 2015; Ghondaghsaz, Kordnaeij & Delkhah, 2018).This study focuses on the measurement and the comparison of the financial performance of the IT software service companies and their components. Accordingly, the various variables that highlight the financial performance of IT companies were selected as the input variables and output variables in this study. In this regard, the study also took into consideration the previous studies, while selecting the input and output variables. Table 5.3 provides the list of past studies which guided in the selection of the input and output variables.

Table 5.3: Literature Review: Input Variables and Output Variables used during 2000-2020

Variable Type	Variable Name	References from Literature Review
INPUT VARIABLES	No. of Employees, Employment, Labor	Cook et al. (2000), Chen & Ali (2004), Mathur(2007), Wu & Ho (2007), Ho (2008), Samoilenko (2008),Samoilenko & Osei-Bryson (2008), Liu & Wang (2009), Kuo & Yang (2012), Puri & Yadav (2013),Sahoo & Nauriyal (2014),Puri et al., (2017), Puri & Yadav (2017), Gong et al. (2018), An et al. (2018),Lin et al. (2018), Li et al. (2019),Zhang et al. (2019) , Chen et al. (2020)
	Expenses such as operational, Utility, Research and Development, Training etc.	Mathur (2007), Ho (2008), Liu & Wang (2009), Sahoo & Nauriyal(2014),Puri et al. (2017),Puri & Yadav (2017), Gong et al. (2018), An et al. (2018), Lin et al. (2018),Li et al. (2019),Zhang et al. (2019) ,Chen et al. (2020)
OUTPUT VARIABLES	Revenue, Total Income, Sales, Gross Output	Chen & Ali (2004),Wu & Ho (2007), Mathur(2007), Samoilenko & Osei-Bryson (2008), Liu & Wang (2009),Kuo & Yang (2012), Puri & Yadav (2013), Sahoo & Nauriyal (2014), Puri et al. (2017), Puri & Yadav (2017), Gong et al. (2018), Lotfi & Vaez-Ghasemi (2013), An et al. (2018), Lin et al. (2018), Li et al. (2019), Zhang et al. (2019), Chen et al. (2020)
	Revenue per employee	Samoilenko (2008), Samoilenko & Osei-Bryson (2008)
	Operating Profit	Wu & Ho (2007), Ho (2008),Liu & Wang (2009), Gong et al. (2018),Lotfi & Vaez-Ghasemi (2013)

Source: Author's compilation

Based on Table 5.3, and keeping in mind the profit maximizing motive of the selected companies, input and output variables selected for this study are:

1. *Number of employees (Input)*: This is the total number of employees working in an IT company for a particular DMSU. The talents' skills, effort, and individual performance have a huge influence on the efficiency of the IT firms (Harriss, 2010; Kuo & Yang, 2012) and thus employees are one of the major input variables for the IT firms.
2. *Other expenses (Shared input*): The largest expense of IT companies is the expenditure on employees' compensation (Infosys, 2020; TCS, 2020). All "other expenses" comprises the expenditure on IT hardware, software tools, and maintenance of buildings and other equipment, training of IT staff etc. (Sahoo & Nauriyal, 2014).
3. *Operating profit (Output)*: It is a measure of profit at which the company is providing the services to its customer and reflects the performance of an IT company (Gong, Zhu, Chen & Cook, 2018).
4. *Revenue productivity per employee (Output)*: It is the measure of revenue generated per employee by the company. It reflects the efficiency of each employee to generate revenue for IT company and is a key performance indicator (Samoilenko & Osei-Bryson, 2008).

5. *Revenue loss (Shared undesirable output)*: This is a proxy for the revenue lost because of unproductive employees in the organization. The unutilized employees are shared across the organization and any DMSU can utilize them as per their requirement. Following Puri, Yadav and Garg (2017), this is considered as shared undesirable output variable in this study.

The descriptive statistics of input and output variables are depicted in the Appendix C. Following Sahoo and Nauriyal (2014) and Thakurta and Guha Deb (2018) the source of the data is the Prowess Database provided by CMIE. The worldwide quarterly data were collected from 2014 to 2017 relating to three Indian IT firms, namely, INFY, TCS and WPRO. Also, the data relating to the two foreign IT firms, namely, Cognizant (CTS) and Accenture PLC (ACCN) were collected from their respective financial reports accessed from their websites.

5.4 Empirical Results and Discussion

The efficiency measures for each DMU (IT Company) and its DMSUs were evaluated using the MATLAB program of Model- 4 with assurance regions given below:

$$\bar{\Omega}_1 = \left\{ \left(u_{1k}^{G(i)}, u_{2k}^{G(i)}, \ldots, u_{K_i^G k}^{G(i)} \right) \middle| u_{rk}^{G(i)} \geq \varepsilon, \varepsilon > 0, \forall r = 1,2,\ldots,K_i^G, \forall i = 1,2,\ldots,d \right\} \text{ , } \bar{\Omega}_2 = \emptyset \text{ ,}$$

$$\bar{\Omega}_3 = \emptyset \quad , \quad \bar{\Omega}_5 = \left\{ \left(v_{1k}^{(i)}, v_{2k}^{(i)}, \ldots, v_{I_i k}^{(i)} \right) \middle| v_{lk}^{(i)} \geq \varepsilon, \varepsilon > 0, \forall l = 1,2,\ldots,I_i, \forall i = 1,2,\ldots,d \right\} \text{ ,}$$

$$\bar{\Omega}_7 = \left\{ \left(\alpha_{ik}^1, \alpha_{ik}^2, \ldots, \alpha_{ik}^{I^S} \right) \middle| 0.2 \leq \alpha_{ik}^t \leq 0.8, \forall t = 1,2,\ldots,I^S, \forall i = 1,2,\ldots,d \right\} \quad , \quad \bar{\Omega}_8 = \emptyset \text{ ,}$$

$$\bar{\Omega}_9 = \left\{ \left(\beta_{ik}^{1B}, \beta_{ik}^{2B}, \ldots, \beta_{ik}^{K^{SB}B} \right) \middle| 0.2 \leq \beta_{ik}^{qB} \leq 0.8, \forall q = 1,2,\ldots,K^{SB}, \forall i = 1,2,\ldots,d \right\} \text{ ,}$$

$$\Omega_6 = \left\{ \left(v_{1k}^{S(i)}, v_{2k}^{S(i)}, \ldots, v_{I^S k}^{S(i)} \right) \middle| v_{tk}^{S(i)} \geq \varepsilon,\ \varepsilon > 0, \forall t = 1,2,\ldots,I^S, \forall i = 1,2,\ldots,d \right\} \text{ ,}$$

$$\bar{\Omega}_6 = \left\{ \left(\bar{v}_{1k}^{S(i)}, \bar{v}_{2k}^{S(i)}, \ldots, \bar{v}_{I^S k}^{S(i)} \right) \middle| \bar{v}_{tk}^{S(i)} = \alpha_{ik}^t v_{tk}^{S(i)} \geq \alpha_{ik}^t \varepsilon \geq 0.2\varepsilon,\ \varepsilon > 0, \forall t = 1,2,\ldots,I^S, \forall i = 1,2,\ldots,d \right\}$$

$$, \quad \Omega_4 = \left\{ \left(u_{1k}^{SB(i)}, u_{2k}^{SB(i)}, \ldots, u_{K^{SB}k}^{SB(i)} \right) \middle| u_{qk}^{SB(i)} \geq \varepsilon,\ \varepsilon > 0, \forall q = 1,2,\ldots,K^{SB}, \forall i = 1,2,\ldots,d \right\} \text{ ,}$$

$$\bar{\Omega}_4 = \left\{ \left(\bar{u}_{1k}^{SB(i)}, \bar{u}_{2k}^{SB(i)}, \ldots, \bar{u}_{K^{SB}k}^{SB(i)} \right) \middle| \bar{u}_{qk}^{SB(i)} = \beta_{ik}^{qB} u_{qk}^{SB(i)} \geq \beta_{ik}^{qB} \varepsilon \geq 0.2\varepsilon,\ \varepsilon > 0, \forall q = 1,2,\ldots,K^{SB}, \forall i = 1,2,\ldots,d \right\}$$

.

All the input variables considered for this study are flexible (controllable) as per the requirements, whereas output variables for this study may not be under the direct

control of IT firms. Hence input-oriented model is more suitable for this study (Puri& Yadav, 2017;Ghondaghsaz et al., 2018) and an analysis for each DMSUi.e. FSI, MFG, RCL, ERU, CME and LSH, for the selected IT companies were carried out.

Table 5.4 shows the quarterly average efficiency trend for all the DMSU from 2014 to 2017. The average efficiency of the FSI sub-DMU was 97% over the sample period. The lowest efficiency level of this DMSU was registered during the first quarter of 2014. The third and the fourth quarter of 2014 recorded the highest level of efficiency for the FSI component, which was 100%. Also, the second quarter of 2015 and the first quarter of 2016 reported 100% efficiency levels. Moreover, from the third quarter of 2016 to the second quarter of 2017, the FSI component continuously registered the efficiency score of 1 or 100%.

The MFG component exhibited only 88% efficiency level over the sample period. This component recorded less than 90% efficiency level from 2014Q1 to 2015Q2 except in 2014Q4. It operated at the lowest efficiency level of 55.3% in 2016Q1. However, it achieved 100% efficiency level in the next quarter, and it remained above 91% level over the remaining quarters of 2016 and 2017.

Likewise, the RCL component recorded the highest efficiency level of 97% in 2014Q4. The average efficiency of the RCL component was 90% over the sample period. The average efficiency of the MFG, ERU, and LSH DMSUs were 88.9%, 85.1% and 87.9% respectively. However, the FSI, RCL, and CME components performed with 97%, 90.5%, and 90.1% efficiency level respectively over the entire sample period of 2014 to 2017. Thus, the FSI, RCL, and CME components outperformed the MFG, LSH and the ERU components.

As indicated by the standard deviation of quarterly efficiency scores, the standard deviation of the RCL DMSU was only 3.79% over the sample period. This establishes that it was the most consistent component during 2014 and 2017 period. On the contrary, the MFG, LSH and ERU components had shown large variations of 9.63%, 7.26% and 7.16% respectively. These components remained the most volatile components during the 2014 and 2017 period. The FSI and CME components had shown slightly lower amount of variations than the other components during this

period as reflected by their standard deviation scores of 4.97% and 6.43% respectively.

Table 5.4: Average Efficiency Trend of DMSU for the Period 2014-2017

Quarters	FSI	MFG	RCL	ERU	CME	LSH
2014 Q1	0.852	0.839	0.932	0.933	0.768	0.87
2014 Q2	0.894	0.856	0.911	0.927	0.792	0.949
2014 Q3	1	0.895	0.945	0.842	0.885	0.854
2014 Q4	1	0.934	0.97	0.94	0.845	0.835
2015 Q1	0.992	0.896	0.831	0.91	0.951	0.856
2015 Q2	1	0.88	0.86	0.894	0.88	0.867
2015 Q3	0.884	0.924	0.88	0.84	0.942	0.842
2015 Q4	0.995	0.919	0.864	0.872	0.865	0.924
2016 Q1	1	0.553	0.86	0.964	0.901	0.992
2016 Q2	0.962	1	0.889	0.788	0.874	0.992
2016 Q3	1	0.928	0.902	0.798	0.938	0.986
2016 Q4	1	0.914	0.923	0.75	0.947	0.904
2017 Q1	1	0.921	0.911	0.744	0.902	0.813
2017 Q2	1	0.923	0.922	0.791	1	0.771
2017 Q3	0.996	0.915	0.931	0.851	0.94	0.764
2017 Q4	0.94	0.924	0.944	0.774	0.988	0.849
Average	0.97	0.889	0.905	0.851	0.901	0.879
Standard Deviation	0.05	0.096	0.038	0.072	0.064	0.073
Coefficient of variation (%)	5.13	10.84	4.19	8.42	7.14	8.27

Relative measure of variability called the coefficient of variation (CoV) was also used to evaluate the stability of each component, which is defined as standard deviation divided by arithmetic mean multiplied by 100. The CoV measure also established that the MFG was the most volatile component, which had coefficient of 10.84% followed by the ERU and LSH components having the CoV of 8.42% and 8.27% respectively. The RCL component was the least volatile component with a CoV value of 4.19% during 2014 and 2017 period.

The results show that the FSI component has performed at a relatively higher average level when it is compared with the other DMSUs. A report by Gartner (2020) highlighted that 25% of IT expenditure is spent globally on the FSI component. FSI is the core sector (IBEF, 2020) of the software industry, which drives the growth in the other sectors. Any innovation or technology breakthrough is first experienced in the financial sector. The banking and the insurance sectors are the backbone of any

economy, which act as a catalyst and drive the overall economy of the world. Further, the low standard deviation for this component shows the consistent focus by IT firms on the FSI component. The relatively low efficiency and high variability in the ERU, and LSH may be attributed to component-specific reasons. Gartner (2020) shows that IT expenditure on an average for ERU and LSH components are 5.14% and 3.89% respectively. Thus, it is inferred that that these components are new and evolving sectors and is relatively smaller than the other DMSUs (IBEF, 2020). The LSH sector has very strong regulations and compliance set by the regulatory bodies. The ERU component being a very domain intensive sector has a high learning curve for the workers. This component is probably operating in a traditional IT business models, which are conventional operating models based on low automation and serial (waterfall) way of working. This is impacting the efficiency of the component (IDC, 2018).

5.4.1 Component-Wise Analysis of Efficiency Trends

We conducted a detailed analysis of efficiency performance trends for each DMSU i.e. FSI, MFG, RCL, ERU, CME and LSH for the selected IT firms for the period 2014-2017. Figure 5.3(a) shows the efficiency score for the FSI component of various selected IT firms from 2014Q1 to 2017Q4. In 2014Q1, the efficiency scores of INFY, CTS and ACCN were 1(100%) and these companies outperformed the companies like TCS and WPRO, which had efficiency scores of 0.484 and 0.777 respectively. In 2014Q2, likewise, INFY, CTS and ACCN had efficiency levels of 100%. However, TCS and WPRO reported efficiency levels of 57.6% and 89.2% respectively implying that compared with the benchmark, INFY, TCS and WPRO were operating with 43% and 11% less efficiency respectively. From 2014Q3 to 2017Q4, all the selected IT firms performed with almost 100% efficiency in the FSI component except in 2015Q3. Thus, it is evident that the efficiency performance of the selected IT firms in the FSI component was very close to 100% leaving aside few of the quarters.

Figure 5.3(b) shows the efficiency trends for the MFG DMSU. It shows that INFY and CTS showed the efficiency score of 1 in all the quarters over the sample period. However, TCS and WPRO achieved only 41.8% and 70.6% efficiency in 2014Q1 and 35.6% and 92.2% in 2014Q2 respectively. TCS and WPRO showed mixed trend in the

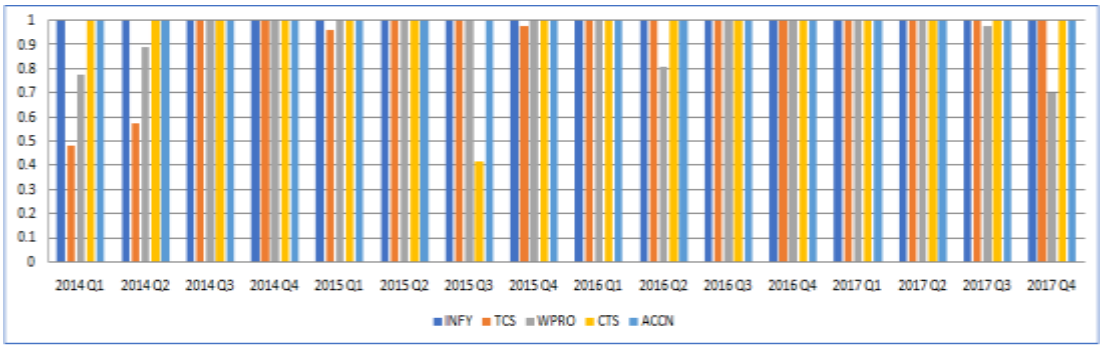
efficiency levels between 2014Q3 and 2016Q1. It is also important to note that ACCN had also reported a very low efficiency level of 34.8% compared to the benchmark INFY in the 2016Q1. In 2016Q2, all the selected IT firms achieved 100% efficiency level in the MFG component. However, from 2016Q3 to 2017Q4, all the selected IT companies reported 100% efficiency in the MFG component except WPRO.

Figure 5.3(c) exhibits the efficiency trends of the RCL component during 2014 to 2017. In 2014Q1, INFY, CTS and ACCN achieved 100% efficiency levels. However, TCS and WPRO reported 95.5% and 70.6% of efficiency levels respectively. The firm-wise efficiency performance of the selected IT firms shows that the efficiency score of INFY, TCS and CTS were maintained at 100% level in 2014Q2. The efficiency trend of ERU component is shown in Figure 5.4(d), which shows that from 2014Q1 to 2015Q2, all the selected IT companies attained 100% efficiency in this component except TCS. TCS showed mixed trend in efficiency level from 2014Q1 to 2015Q2.

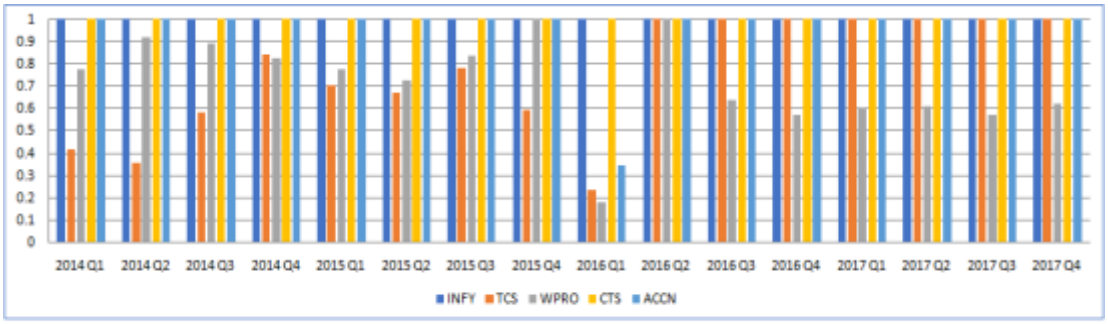
Figure 5.5(e) shows the efficiency trend of CME component. In 2014Q1 and 2014Q2, INFY, CTS and ACCN achieved 100% efficiency except TCS and WPRO, which had 21.5% and 62.3% and 27.8% and 68% efficiency respectively. From 2014Q3 to 2015Q3, all the selected IT firms were showing 100% efficiency except WPRO. This component had mixed trend in efficiency between 2014Q3 and 2015Q3. However, in the next quarter, TCS became inefficient, while all other selected companies exhibited 100% efficiency. Surprisingly, in the second quarter of 2017, all selected firms were showing 100% efficiency in the CME component. In the fourth quarter of 2017 also, all selected IT firms exhibited 100% efficiency leaving aside ACCN, but its efficiency was also 94.1%.

The quarterly efficiency performance trend of LSH component from 2014 to 2017 is depicted in Figure 5.3(f), which shows that during 2014Q1 and 2015Q3 period, all the selected IT firms displayed 100% efficiency level except TCS and WPRO. From 2015Q4 to 2016Q3, all the firms exhibited 100% efficiency except TCS. TCS displayed mixed trend in efficiency in those respective quarters. Since the fourth quarter of 2016, INFY, CTS and ACCN showed 100% efficiency level. However, TCS and WPRO during this period exhibited 78.6% and 73.5%, 100% and 55.3%, 100% and 61.1%, 100% and 65.5%, and 100% and 71.8% efficiency in the respective

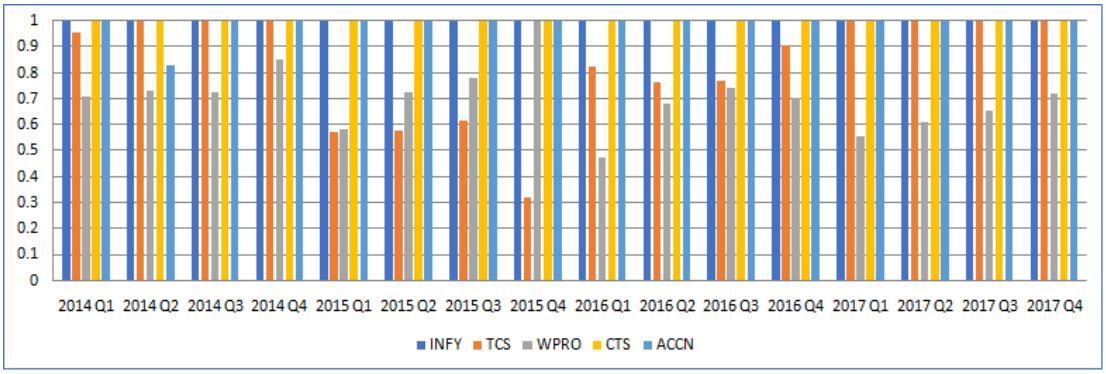
quarters. In the last quarter, ACCN also became inefficient roughly by 17% in this component. It is important to note that INFY achieved 100% efficiency level in all the components and served as the benchmark IT firm.



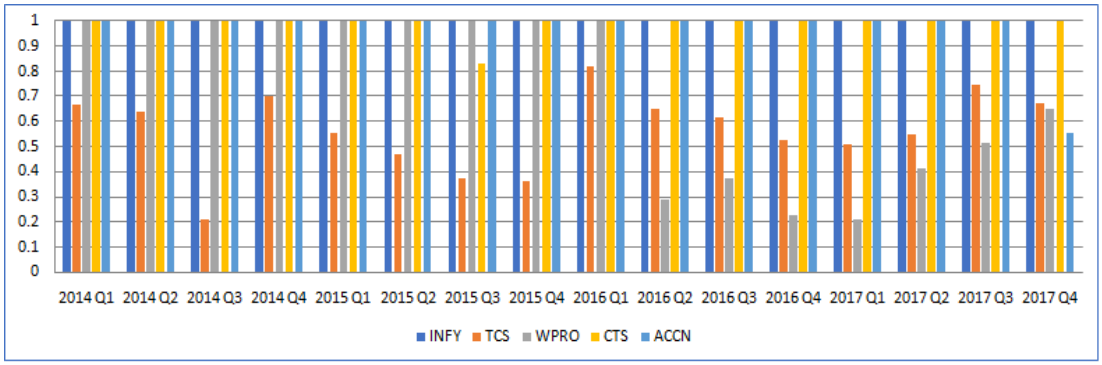
(a): FSI



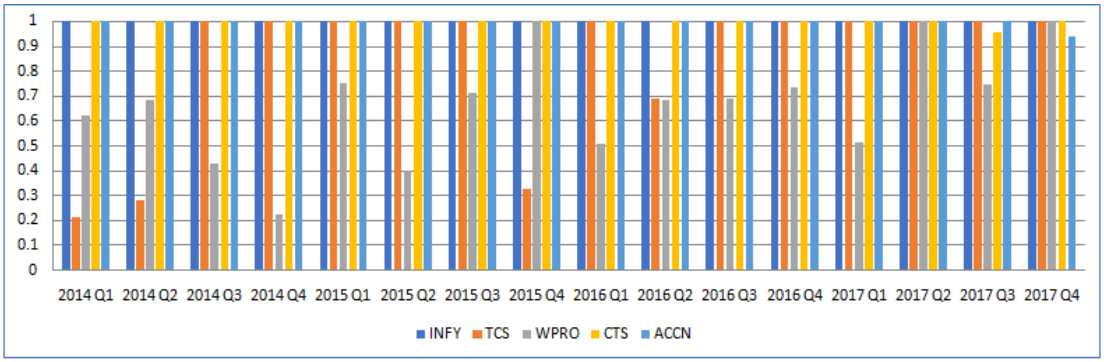
(b): MFG



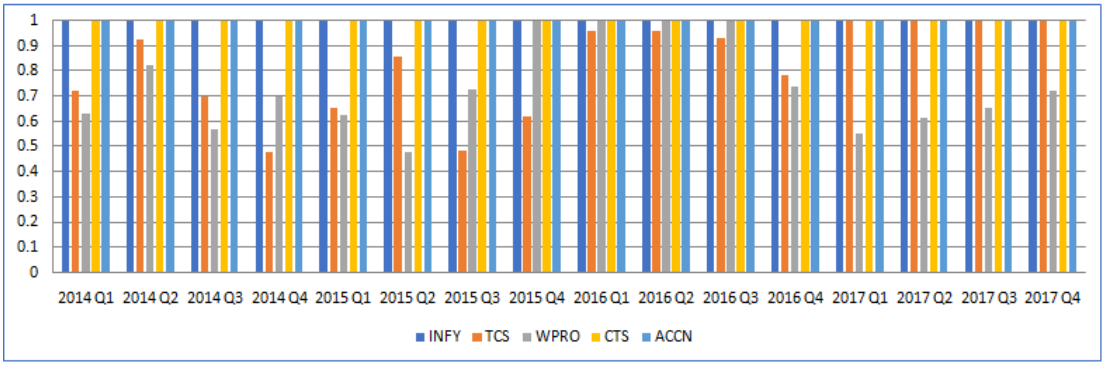
(c): RCL



(d): ERU



(e): CME



(f): LSH

Figure 5.3: Efficiency Trend: 2014-2017

5.4.2 International Comparison – Geography-wise Efficiency Trends of DMSUs

The selected IT firms are multinational corporations and have operations in many countries. We evaluated the efficiency of the selected IT firms and their components geography-wise at the international level. Based on the data shared by the selected IT firms, the revenues received by the IT firms from the various locations can be broadly divided into three major regions – NA, EUR and ROW. The NA comprises the United States of America, Canada, and Mexico. The Continental Europe, the United Kingdom and Ireland are included in the EUR, and the ROW includes all other

countries and India (Infosys, 2020; TCS, 2020; Accenture, 2021). The performance trend for all the three regions for all the DMSUs is evaluated below.

Figure 5.4 shows the efficiency trend of the selected IT companies from 2014 to 2017 internationally. It is evident from the panel (a) of Figure 5.4 that in 2014, the efficiency score of INFY was 0.79, 0.57 and 1.0 respectively for NA, EUR, and ROW. The efficiency performance of INFY was almost 50% less in EUR and 20% less in NA as compared to the ROW. The performance of TCS region-wise in 2014 was 0.85, 0.87 and 0.88 respectively for the NA, EUR, and ROW. Likewise, WPRO had a score of 0.97, 0.99 and 0.99 for the year 2014 respectively for NA, EUR, and ROW. Similarly, CTS had efficiency scores of 0.93, 0.99 and 1 respectively for NA, EUR, and ROW. ACCN had a score of 0.97, 0.97 and 0.99 respectively for NA, EUR, and ROW in 2014. It also shows that for the NA and EUR region, INFY and TCS are less efficient compared to WPRO, CTS and ACCN in the year 2014. TCS was relatively inefficient as compared to other companies for the ROW region in the year 2014.

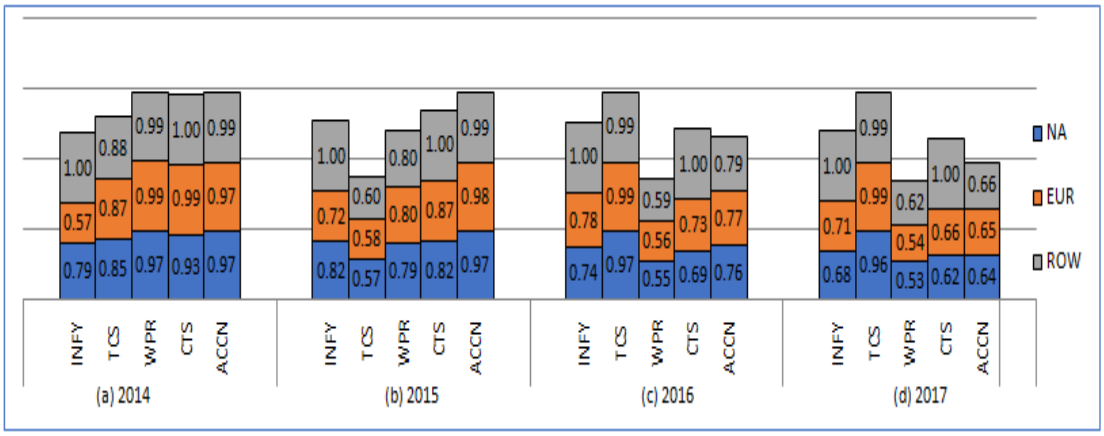


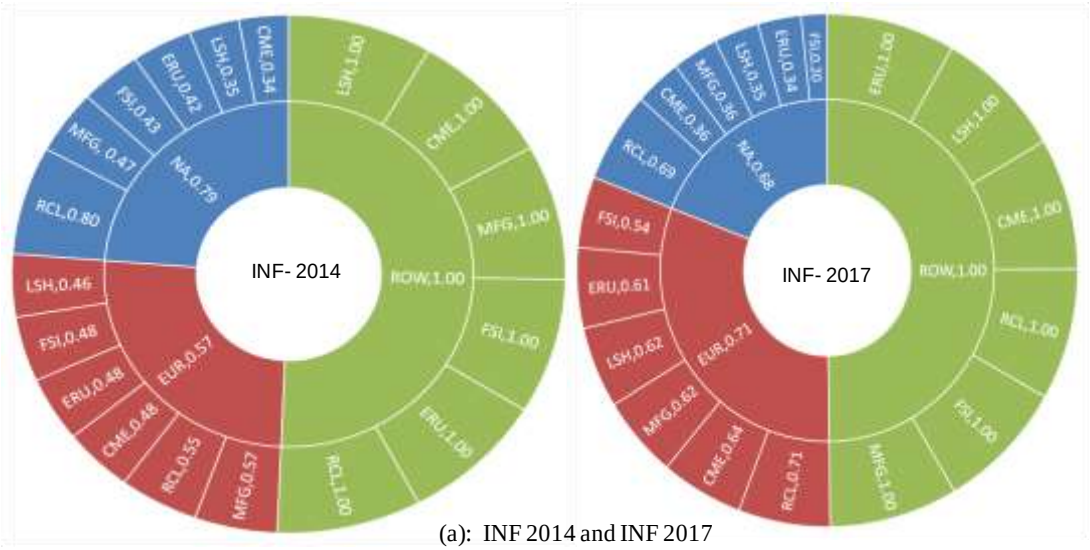
Figure 5.4: Average Efficiency Trend for all the Three Geographical Regions for 2014-2017

Panel (b) of Figure 5.4 shows that the efficiency scores of INFY was 0.82, 0.72 and 1 respectively for NA, EUR, and ROW in 2015. The performance of TCS in 2015 was very poor as its efficiency score declined from 0.85 to 0.57 in NA, from 0.87 to 0.58 in EUR and from 0.88 to 0.60 in ROW. Its efficiency score compared to other IT firms like WPRO, CTS and ACCN was significantly lower.

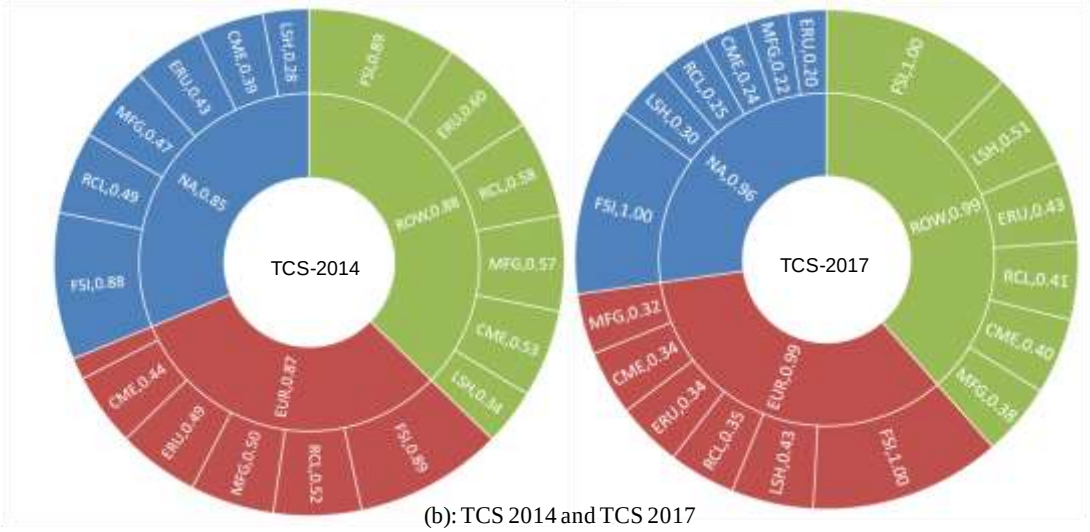
Panel (c) of Figure 5.4 shows that in the year 2016, INFY had an efficiency score of 0.74, 0.78 and 1.0 respectively in the NA, EUR, and ROW regions. TCS significantly

improved its efficiency score from 0.57 to 0.97 in the NA region, from 0.58 to 0.99 in the EUR region and 0.60 to 0.99 in the ROW region in 2016.In the year 2016, WPRO had efficiency score of 0.55, 0.56 and 0.59 in NA, EUR and ROW regions respectively. CTS also had similar kind of performance in 2016, with efficiency scores of 0.69, 0.73 and 1 respectively in the NA, EUR, and ROW regions. ACCN had scores of 0.76, 0.77 and 0.79 in the NA, EUR, and ROW regions respectively. In 2016, TCS was the most efficient company region-wise. Finally, the panel (d) of Figure 5.4 depicts that in 2017, TCS was found to be the most efficient company in all the regions. WPRO had a dismal performance in 2017 and it had efficiency score of 0.53, 0.54 and 0.62 respectively in NA, EUR, and ROW regions.

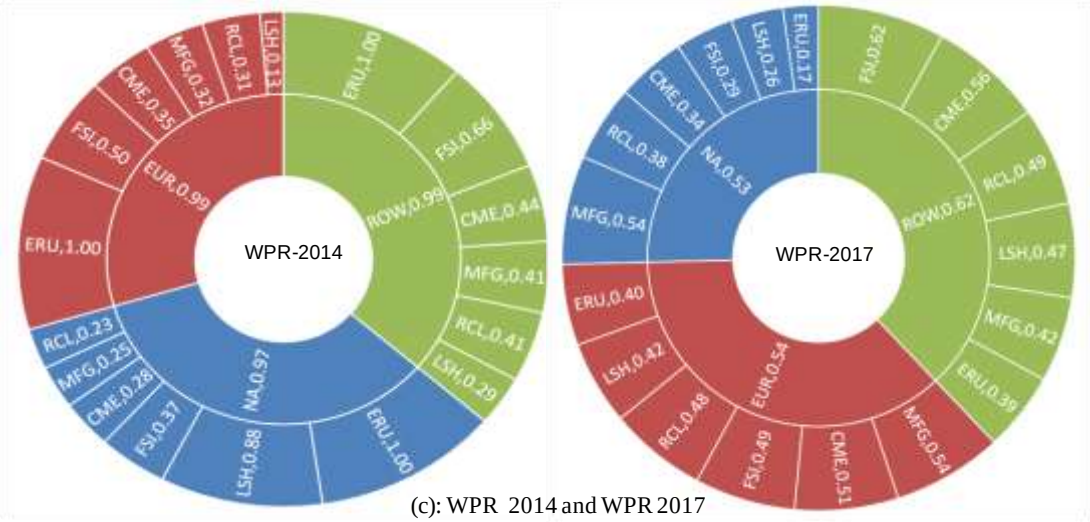
Further, a comparative analysis of IT firms was also carried out for the period 2014 and 2017 for all their components across the three regions. The results of this analysis are shown in Figure 5.5, where the values against each component or the region depict its efficiency score. Panel (a) of Figure 5.5 shows the comparative efficiency scores of INFY between 2014 and 2017 in six DMSUs across the three regions. It establishes that in NA region; RCL component was the highest performing component at 80% efficiency level in 2014 and 69% efficiency level in 2017, as compared to other components. All other components performed at less than 50% efficiency level. Further, the performance of INFY declined in 2017 as compared to 2014 by 12.65% in NA region. The decrease in efficiency could be attributed to the decrease in efficiency of all its components except CME and LSH. CME was the least performing component in 2014, whereas FSI was least performing in 2017. In the EUR region, the performance of INFY increased by 24.56% in 2017 when compared to 2014. The component analysis shows that this increase was because of increase in efficiency of all its components from 8%-34% over the same period. The performance of INFY in the ROW region as indicated by the aggregate efficiency had a score of 1. In all the components in 2014 as well as in 2017, INFY had an efficiency score of 1.



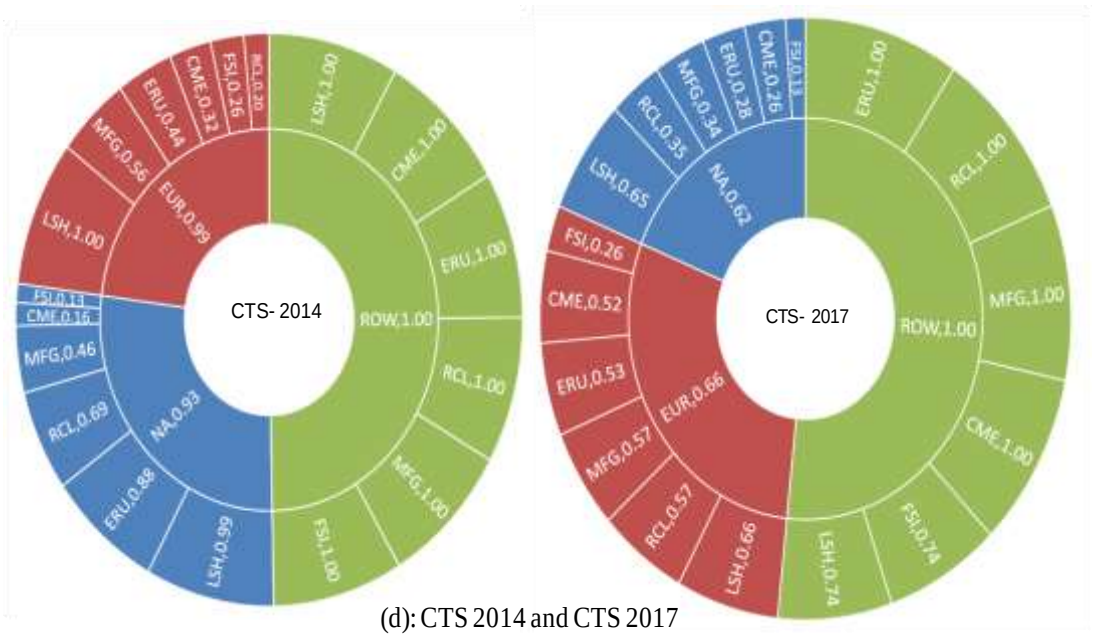
(a): INF 2014 and INF 2017



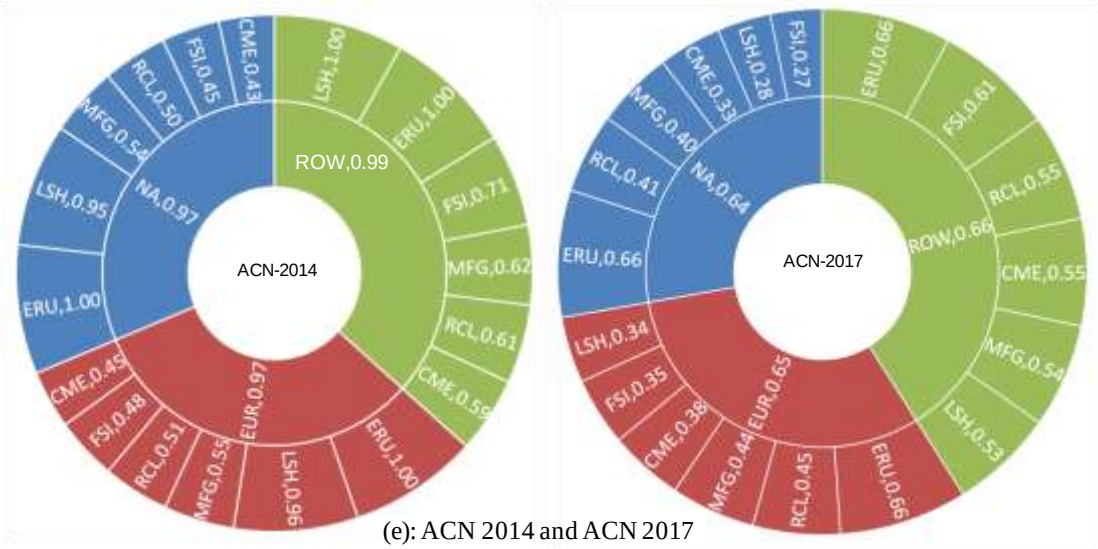
(b): TCS 2014 and TCS 2017



(c): WPR 2014 and WPR 2017



(d): CTS 2014 and CTS 2017



(e): ACN 2014 and ACN 2017

Figure 5.5: Geography-wise Comparison of IT Companies and their Components

Panel (b) of Figure 5.5 depicts that the aggregate efficiency of TCS has increased from 2014 to 2017 in all the regions. In addition, while the FSI and the LSH DMSUs had shown improvement in efficiency, other components had not performed efficiently. The efficiency of FSI had increased in the range of 12%-13%, however, the LSH component had shown an increase in the range of 7%-50% across all the three regions from 2014 to 2017. FSI was the highest performing component across all the three regions both in 2014 and 2017. Here, with the help of multi-component approach, it can be concluded that MFG, RCL, ERU and CME DMSUs need to

improve their efficiency in the case of TCS, as they are negatively impacting the efficiency of the company across the regions.

Panel (c) of Figure 5.5 shows the comparative efficiency scores of WPRO between 2014 and 2017 in six DMSUs across the three regions. It can be inferred from the figure that the aggregate efficiency of WPRO has decreased across all the three regions from 2014 to 2017. The component analysis reveals that though efficiency of MFG, RCL, CME and LSH components increased from 2014 to 2017; however, the impact of increase was nullified by the efficiency decrease of FSI and ERU components across the three regions. There was significant drop in efficiency of ERU component, ranging from 60%-80% across the three regions. The efficiency of MFG was relatively high in the NA and EUR region in 2017 as compared to other components, while FSI component performed efficiently in ROW region in 2017. ERU component was the most efficient component in 2014 across all the three regions, performing at 100% efficiency level.

Further, Panel (d) of Figure 5.5 depicts that CTS performed at a very high efficiency level across all the three regions in 2014. However, the efficiency of CTS decreased by approximately 33% in 2017 in NA. In NA region, FSI performed consistently in both the years and the efficiency of CME increased by 62.5% in 2017 as compared to 2014. However, efficiency of rest of the components decreased in 2017 when compared to 2014. In EUR region, the decrease in efficiency of LSH component in 2017 as compared to 2014 by 34%, could have led to the decrease of the aggregate efficiency of CTS by 33% in 2017 as compared to 2014. CTS performed at high efficiency level in ROW region for both the years. It is noteworthy to point that LSH component was the most efficient component in NA and EUR region, both in 2014 and 2017.

Finally, panel (e) of Figure 5.5 depicts that the aggregate efficiency of ACCN has declined from 2014 to 2017 in all the regions. All the components exhibited decrease in the efficiency from 2014 to 2017. ERU component was the high performing component in 2014 and 2017 across all the three regions. LSH component displayed maximum fall in the efficiency score in 2017 as compared to 2014, followed by FSI. Hence, with the help of multi-component approach, it could be found that ACCN

should primarily focus on LSH and FSI components, followed by other components to improve its efficiency across the three regions.

5.5 Implications for Component-wise Performance Analysis using MC-DEA

This section lists the implications of this study, both for researchers and practitioners.

5.5.1 Implications for Researchers

The research model used in this study indicated that the overall efficiency depends on the efficiency of the various components such as FSI, MFG, RCL, ERU, CME and LSH of the firm which has been theoretically given in Theorem 1 and hence component level efficiency must be analyzed to measure the overall efficiency of IT companies.

This study builds on the existing literature on IT efficiency. This study opens new doors for the researchers to explore and analyze (i) the overall efficiency of the IT software services companies using MC-DEA approach considering the components, namely, FSI, MFG, RCL, ERU, CME and LSH , (ii) the impact of undesirable output, i.e., revenue loss arising due to non-utilized resources in multi-component efficiency analysis, and (iii) international comparison to investigate the component-wise efficiency analysis of selected IT companies across three regions, viz. NA, EUR and ROW.

5.5.2 Implications for Practitioners

The findings of the study have not only implications for the domestic IT firms but also for the global IT industry. The various implications for practitioners of IT industry globally are:

i. Any industry comprises various components and the performance of these components determines the overall performance of that industry. In this thesis, we studied the overall efficiency and the efficiency of the various components of the top 5 IT companies namely, INF, TCS, WPRO, CTS and ACCN and found that the efficiency of their components viz. FSI, MFG, RCL, ERU, CME and LSH determined the overall efficiency of the selected IT firms.
ii. This study performed international comparison to investigate the component-wise efficiency analysis of selected companies across NA, EUR and ROW

regions. This study points out that overall efficiency depends on the efficiency of the components of the firm. Therefore, the results of this study can be helpful for the policy makers and IT business managers in formulating appropriate strategies and policies to increase the efficiency of IT firms and its various components across the three regions.

iii. Inefficient IT firms can improve their efficiencies in underperforming components by focusing on skill development, talent management, and cross-leveraging of talents across various components, and automation following the policies adopted by the benchmark company.

iv. The efficiencies of LSH and ERU components were found to be comparatively lower than the other components which adversely impacted the overall efficiency of the selected IT firms such as TCS as well as WPRO.

   a. To reduce and remove the inefficiency of the LSH component, the IT firms can explore the enhanced usage of digital technology for health care services (IBEF, 2020).

   b. Similarly, to improve efficiency of ERU component, the governments can take initiatives towards new and cleaner ways of energy generation and new technologies which can address the issues of global emissions and global warming. To work in these areas and to realize the goals of sustainable development certainly improving the efficiency of the ERU component is the need of the hour.

v. In addition, the IT firms can also develop strategies that could increase the utilization of inputs. Moreover, all the IT firms can also improve their efficiency by making investments in software tools, emerging technologies, agile process management and enhancing its human capital.

We studied the relative efficiency of the top five selected IT firms namely, INF, TCS, WPRO, CTS, and ACCN from 2014 to 2017 using quarterly data. The study not only tried to evaluate the overall efficiency of the selected firms, but also the efficiency of their components namely FSI, MFG, RCL, ERU, CME and LSH using MC-DEA technique.

The present study contributed in many ways:

i. This study is a novel attempt to study and analyze the efficiency performance of 5 IT companies and its various components, region-wise, using MC-DEA.

ii. There exist several studies that have analyzed the efficiency of IT companies and treated them as a "black-box". This study highlights the significance of investigating efficiency of the various components of an IT firm as the performance of each component influences the overall performance of an IT firm. Therefore, the performance of an IT company cannot be visualized in isolation.

iii. An important theoretical contribution of this study is the application of revenue loss due to unproductive employees in the IT firm as a shared undesirable output in the performance model.

iv. The empirical results established that INFY is found to be the most efficient in all components and emerged as the benchmark company followed by CTS and ACCN for the selected period. However, TCS and WPRO were found to be inefficient in some of the components. The empirical results show that the selected IT firms performed efficiently in FSI, RCL and CME components. However, the efficiency of ERU, LSH and MFG components require improvements.

v. Moreover, the study also builds on and advances the existing literature in investigating the component-wise efficiency analysis of selected IT companies across three regions, viz. NA, EUR and ROW to perform international comparison for the period 2014 and 2017. The results established that the performance of all the IT companies in its various components is found to be more efficient in the ROW region followed by the EUR region and very poor in the NA region. The efficiency of all the components of the selected IT firms except TCS deteriorated in the last quarter of 2017 compared to the last quarter of 2014.

CHAPTER VI

IT-LED GROWTH HYPOTHESIS

The IT industry is the corporate face of India and has significant contribution in the GDP of India. The performance of IT firms and efficiency have implications not only for the growth of the IT sector but also for the whole economy (Alderete, 2018; Kaba & Meso, 2019; Goyal et al., 2020; Goyal et al., 2021). The global IT services spending is estimated to grow up to 931 billion (USD) in 2018 from USD 747 billion in 2007and depicting an increase of 24.63 per cent over 2007. The global IT services spending is estimated to increase to 1,140 billion (USD) by 2021 (Gartner, 2009, 2018, 2020b). In this backdrop, the study of IT firms is critical for the growth of the industry itself and the economy as well. The IT sector of India has been producing enormous work opportunities in recent years and is expected to provide employment to 4.1 million people by 2020 (NASSCOM, 2010; IBEF, 2020;Malik 2011).

The rest of the chapter is structured as follows. The next Section lists the objectives of the study. This is followed by the methodology utilized in the study. Further, the data collection and selection of variables for the study is discussed. Thereafter, the empirical results are discussed. The next section lists the findings of the study and finally the last section provides the conclusion.

6.1 Objective Addressed in this Chapter

The objective addressed in this chapter is as follows:

O_3: To examine the IT-led growth Hypothesis.

The related Hypotheses are:

H_{3a}: Indian IT industry has negative impact on the economic growth rate of Indian economy.

H_{3a1}: The aggregate quarterly net sales of IT sector of India have negative impact on the economic growth rate of Indian economy.

H_{3a2}: The aggregate quarterly net profit of India and quarterly GDP of India are negatively related

H_{3b}: IT growth does not lead to economic growth.

H_{3b1}: The aggregate quarterly net sales of IT sector of India does not cause quarterly GDP of India

H_{3b2}: The aggregate quarterly net profit of IT sector of India does not cause quarterly GDP of India

H_{3c}: Indian economic growth does not lead to IT growth.

H_{3c1}: The quarterly GDP of India does not cause aggregate quarterly net sales of IT sector of India

H_{3c2}: The quarterly GDP of India does not cause aggregate quarterly net profit of IT sector of India

6.2 Research Methodology: Co-Integration Technique & Error-Correction Mechanism using Engle-Granger Method

To test the IT-led growth hypothesis, the study utilizes the co-integration technique and an ECM using the Engle-Granger method, (Engle & Granger, 1987). This methodology captures both the short run and the long run dynamics of IT growth and economic growth of India.

Engle-Granger advocated two-step procedure for testing co-integration between two variables. The procedure is as follows:

The first step is to find out whether Y and X are integrated of order 1 or I(1). If in the step 1, it is established that both the series are integrated of the same order, then go to next step and estimate the parameters of co-integrating regression equation as given below:

$$Y_t = \alpha + \beta X_t + \mu_t$$

If X_t and Y_t are co-integrated, then ordinary least squares regression gives 'super-consistent' estimates for parameters α and β. To find if X_t and Y_t are actually co-integrated, obtain the OLS residual $\hat{\mu}_t$ and test whether or not residual is stationary. If residual is stationary, then Y and X are co-integrated that means they move very closely over time.

Historically, the accepted practice for overcoming the possible spurious relationship between two time series has been to first difference each series and then run regression. The problem with this practice was that it led to loss of valuable long-run information. The question was how to capture both short run and long run effects between two variables. Co-integration formed the basis through which this can be done. Engle and Granger (1987) have shown that if Y and X are both I(1) variables, an error correction model exists. Engle and Granger method for testing existence of co-integration is as follows:

$$\Delta Y_t = \theta_1 + \sum_{i=1}^{m} \alpha_{1i} \Delta Y_{t-i} + \sum_{i=1}^{m} \beta_{1i} \Delta X_{t-i} + \psi_1 \mu_{t-1} + \varepsilon_{1t}$$

$$\Delta X_t = \theta_2 + \sum_{i=1}^{m} \alpha_{2i} \Delta Y_{t-i} + \sum_{i=1}^{m} \beta_{2i} \Delta X_{t-i} + \psi_2 \mu_{t-1} + \varepsilon_{2t}$$

with $$|\psi_1| + |\psi_2| \neq 0$$

where μ_{t-1} is the error lagged one period derived from the co-integrating regression. In the above error correction model, the coefficient of one period lagged error term indicates the long run in-equilibrium deviations from the equilibrium point. Ψ being the adjustment factor which takes values between 0 and 1.

6.3 Data Description and Variables Used

To meet the objectives of this study, quarterly GDP, aggregate quarterly IT sector Net Sales and aggregate quarterly IT sector Net Profit were collected for the duration 2010Q1 to 2017Q4. The data was collected from CMIE PROWESS Database and from the Handbook of Statistics on Indian Economy published by the Reserve Bank of India.

6.4 Empirical Results and Discussions

In this study, we tried to find out the relationship between quarterly GDP, aggregate quarterly IT sector net sales of India and aggregate quarterly IT sector net profit of India. The objective was to find out how the performance of IT sector in terms of its quarterly total revenue influences quarterly GDP of India or the causality runs from quarterly GDP to quarterly total IT sector revenue. Also, another objective of this study was to find the relationship between aggregate quarterly IT sector net profit of India and GDP of India and the direction of causality between the two variables. To find out the relation between quarterly GDP, aggregate quarterly IT sector net sales aggregate quarterly IT sector net profit, we collected data from 2010Q1 to 2017Q4. These variables are plotted in Figure 6.1, which shows quarterly GDP, aggregate quarterly IT sector net sales and aggregate quarterly IT sector net profit are trending variables.

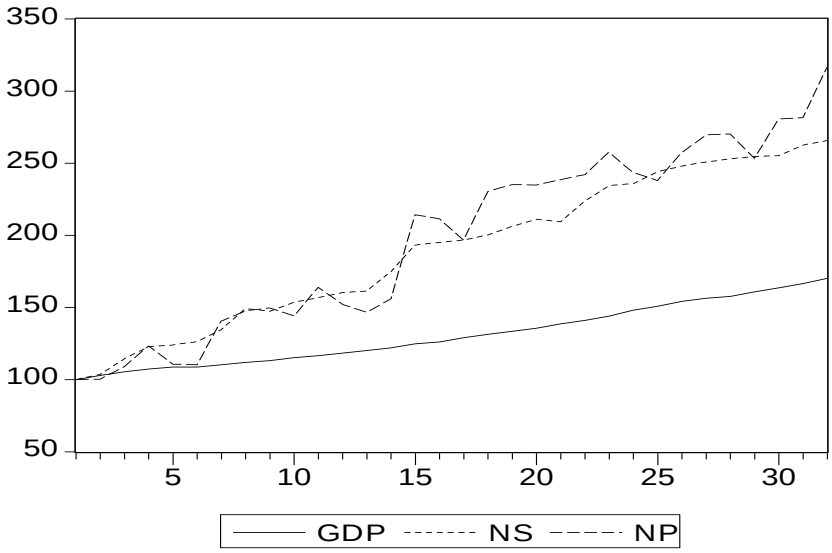


Figure 6.1: Trend of Quarterly GDP, Net Sales (NS) and Net Profit (NP) of IT Sector of India

When two or more variables are trending over time in the same direction, we may encounter the problem of spurious regression or nonsense regression. To overcome this problem, now it is customary to conduct Unit Root Test to check the stationarity of time-series data before running regression analysis.

Table 6.1 shows results of Unit Root Test by two methods, namely, Augmented Dickey-Fuller and Phillips-Perron Test.

Table 6.1: Unit Root Test

Unit Root Test (Augmented Dickey-Fuller)			
Series	Levels (Intercept & Trend)	First Difference	Mackinnon Critical Value at 5%
QGDP	-0.7589	-3.9258	-3.5614
IT Net Sales	-2.6502	-5.3084	-3.5614
IT Net Profit	-3.4235	-5.9127	-3.5614
Unit Root Test (Phillips-Perron Test)			
QGDP	-0.2084	-5.079	-3.5614
IT Net Sales	-2.291	-5.7096	-3.5614
IT Net Profit	-3.5877	-6.9178	-3.5614

The results show that quarterly GDP of India, aggregate quarterly IT sector Net Sales and aggregate quarterly IT sector Net Profit variables are not stationary respectively in their levels implying they contain unit root problem. However, the null of unit root in case of all the variables are rejected at 5% significance level in their first differencing. This implies that these variables are becoming stationary after first differencing i.e., I(1).

6.4.1 Empirical Results of Relationship between Quarterly GDP and Aggregate Quarterly IT Sector Net Sales

The stationarity test established that all the variables under the analysis are of integrated of order 1. To establish the long run relationship between quarterly GDP of India and aggregate quarterly IT sector net sales, the following co-integrating regression is specified as follows:

$$QGDP_t = \alpha + \beta\ (NetSales_t) + \mu_t \quad \text{---- (6.1)}$$

We estimated the equation (6.1), and the results of co-integrating regression are reported as follows:

$$QGDP_t = 56.5394 + 0.3927\ (NetSales_t)$$

$$[2.8462] \quad [0.0144]$$

$$(19.8646) \quad (27.1138)$$

$$R^2 = 0.96 \quad df = 30 \qquad D\text{-}W = 0.25$$

The regression results show that the sign of the long term co-integrating parameter is positive, which indicates the quarterly GDP and aggregate quarterly IT Net Sales are positively related. The magnitude of the co-integrating parameter is 0.3927, which shows that when the aggregate quarterly IT sector net sales increases by one time, the quarterly GDP of India increases by 0.3927 times. The estimated co-efficient of aggregate quarterly IT sector net sales is statistically highly significant at 1% level. The R^2 value of 0.96 indicates that a 96% variation is explained by the independent variable aggregate quarterly IT sector net sales. The D-W statistic of 0.25 implies that the results suffer from positive serial autocorrelation. It is important to note here that the quarterly GDP and quarterly Net Sales are non-stationary series as they are trending variables.

To find the long-run equilibrium i.e. co-integration between the quarterly GDP and quarterly Net Sales, the residuals obtained from the co-integrating equation (1) must be stationary. The results of stationarity test on residuals obtained from the co-integrating equation are shown in Table 6.2.

Table 6.2: Unit Root Test on Residuals obtained from Co-integrating Equation

Series	ADF	Phillips-Perron	Mackinnon Critical Value at 5%
Residual	-0.9701	-0.7847	-2.9627

The results of stationarity test on the residuals obtained from the co-integrating equation indicate that the quarterly GDP of India and the aggregate quarterly net sales of IT sector are not co-integrated. This implies that there exists no long-run relationship between the quarterly GDP of India and the aggregate quarterly IT sector net sales of IT sector.

We established that there exists no long run equilibrium relation between quarterly GDP and aggregate quarterly IT sector net sales of IT sector of India. Further, we also conducted the Granger Causality tests, the results of which are reported in Table 6.3.

The Granger Causality test shows that the null of aggregate quarterly IT sector net sales does not Granger Cause quarterly GDP cannot be rejected at 5% level of significance. Likewise, the null of quarterly GDP does not Granger cause aggregate quarterly IT sector net sales cannot be rejected at 5% level of significance also.

Table 6.3: Granger Causality Tests– Net Sales

Lags: 4			
Null Hypothesis:	Observations	F-Statistic	Probability
Net Sales does not Granger Cause GDP	28	1.01933	0.42246
GDP does not Granger Cause Net Sales	28	0.33383	0.85175
* significant at 0.01 level, ** significant at 0.05 level, ***significant at 0.1 level			

The results established that there is no functional relationship between quarterly GDP and aggregate quarterly IT sector net sales of India. It also established that the aggregate quarterly IT sector net sales of India are not statistically having functional relationship with quarterly GDP of India.

6.4.2 Empirical Results of Relationship between Quarterly GDP and Aggregate Quarterly IT Sector Net Profit

We also tried to study the long-run relationship between the quarterly GDP of India and the aggregate quarterly IT sector net profit of India. The results of stationarity test established that both the quarterly GDP and the aggregate quarterly IT sector net profit variables are non-stationary in their levels but stationary in their first differencing. Thus, they are integrated of order one variables.

To establish the long run relationship between quarterly GDP of India and aggregate IT sector Net Profit, we specified the following co-integrating regression:

$$QGDP_t = \alpha + \beta\ (NetProfit_t) + \mu_t \quad \text{---- (6.2)}$$

We estimated the equation (6.2), and the results of co-integrating regression are reported as follows:

$$QGDP_t = 68.7077 + 0.3152\ (NetProfit_t)$$

$$[3.4713] \quad [0.0167]$$

$$(19.7925) \quad (18.8344)$$

$$R^2 = 0.92 \quad df = 30 \qquad D\text{-}W = 0.80$$

The regression results show that the sign of the long term co-integrating parameter is positive, which indicates the quarterly GDP and aggregate quarterly IT sector net profit are positively related. The magnitude of the co-integrating parameter is 0.3152, which shows that when the aggregate quarterly IT sector net profit increases by one time, the quarterly GDP of India increases by 0.3152 times. The estimated co-efficient of aggregate quarterly IT sector net profit is statistically highly significant at 1% level. The R^2 value of 0.92 indicates that 92% variations are explained by the independent variable aggregate quarterly IT sector net profit. The D-W statistic of 0.80 indicates that the result suffers from positive serial autocorrelation. It is important to note here that the quarterly GDP and aggregate quarterly IT sector net profit are non-stationary series as they are trending variables.

In order to find the long-run equilibrium i.e. co-integration between the quarterly GDP and aggregate quarterly IT sector net profit, the residuals obtained from the co-integrating equation (2) must be stationary. The results of stationarity test on residuals obtained from the co-integrating equation are shown in Table 6.4.

Table 6.4: Unit Root Test on Residuals obtained from Co-integrating Equation

Series	ADF	Phillips-Perron	Mackinnon Critical Value at 5%
Residual	-2.3661	-2.6754	-1.95

The results of stationarity test on the residuals obtained from the co-integrating equation (6.2) indicates that the quarterly GDP of India and the aggregate quarterly IT sector net profit are co-integrated. The null of unit root in residuals obtained from the co-integrating equation (2) is rejected at 5% significance level. This implies that there

exists a long-run relationship between the quarterly GDP of India and the aggregate quarterly IT sector net profit.

We established that there exists a long run equilibrium relationship between quarterly GDP and aggregate quarterly IT sector net profit of India. In this context, the Granger Representation Theorem becomes relevant in the study, which says that if two variables Y and X are co-integrated, then the relationship between the two can be expressed as ECM as shown below:

$$\Delta QGDP_t = \alpha + \beta \Delta NetProfit_t + \delta \mu_{t-1} + v_t \text{ ----- (6.3)}$$

The Error Correction model as represented in the equation (3) is estimated and the results are given below:

$$\Delta QGDP_t = 0.7332 + 2.7363\ \Delta NetProfit_t - 0.4360\ \mu_{t-1} \text{ ----- (6.4)}$$

[8.0139] [3.3208] [0.1564]

(0.0914) (0.8239) (-2.7876)

$R^2 = 0.22$ df = 29 D-W =1.93

The above ECM equation (6.4) says that change in quarterly GDP depends on change in aggregate quarterly IT sector net profit and also on equilibrium error term. If the equilibrium error term is non-zero, then the model is out of equilibrium. In case, change in aggregate quarterly IT sector net profit is zero and μ_{t-1} is positive; this means $QGDP_{t-1}$ is too high to be in equilibrium i.e. $QGDP_{t-1}$ is above its equilibrium value. Since, δ is expected to be negative, the term $\delta\ \mu_{t-1}$ is negative and therefore, $\Delta\ QGDP_t$ will be negative to restore the equilibrium.

The Error Correction Model shows that the co-efficient of one lagged residual term is statistically significant at 5% level, which indicates that in the short term the relation between quarterly GDP and aggregate quarterly IT sector net profit may deviate from the long-run equilibrium. In short-run, changes in aggregate quarterly IT sector net profit have a positive impact on short-run changes in quarterly GDP. The co-efficient of aggregate quarterly IT sector net profit is 2.7363 in short run indicating that one time increase in aggregate quarterly IT sector net profit causes 2.7363 times increase in quarterly GDP of India. The result is statistically highly significant at 1% level.

Furthermore, we also conducted the Granger Causality tests between the quarterly GDP of India and aggregate quarterly IT sector net profit of India. The results of the Granger Causality tests are reported in Table 6.5.

Table 6.5: Granger Causality Tests–Net Profit

Lags: 2			
Null Hypothesis:	Observations	F-Statistic	Probability
NP does not Granger Cause GDP	30	0.8532	0.43808
GDP does not Granger Cause NP	30	2.98791	0.06862
* significant at 0.01 level, ** significant at 0.05 level, ***significant at 0.1 level			

The Granger Causality test shows that the null of aggregate quarterly IT sector net profit does not Granger Cause GDP cannot be rejected at 5% level of significance. However, the null of GDP does not Granger cause aggregate quarterly IT sector net profit can be rejected at 6% level of significance. The results established that there is no functional relationship between aggregate quarterly IT sector net profit and quarterly GDP of India. However, the results of the study established that the aggregate quarterly IT sector net profit of India is caused statistically significantly by the quarterly GDP of India. Thus, it is established from the Granger Causality test that there is unidirectional relationship between the quarterly GDP of India and the quarterly Net Profit of IT sector of India.

6.5 Findings of the Study

We tried to find out the relationship between quarterly GDP of India, aggregate quarterly IT sector Net Sales and aggregate quarterly IT sector Net Profit of IT industry of India. We collected quarterly data for the duration 2010Q1 to 2017Q4.

The major findings of the study are as below:

i. There exists no long-run relationship between the quarterly GDP of India and the aggregate quarterly IT sector net sales of India.
ii. The results established that there is no functional relationship between quarterly GDP and aggregate quarterly IT sector net sales of India. It also established that the aggregate quarterly IT sector net sales of India is not statistically having functional relationship with quarterly GDP of India.

iii. There exists a long-run relationship between the quarterly GDP of India and the aggregate quarterly IT sector net profit.

iv. In short-run, changes in aggregate quarterly IT sector net profit have a positive impact on short-run changes in quarterly GDP. The result is statistically highly significant at 1% level.

v. The results established that there is no functional relationship between aggregate quarterly IT sector net profit and quarterly GDP of India. However, the results of the study established that the aggregate quarterly IT sector net profit of India is caused statistically significantly by the quarterly GDP of India.

6.6 Implications for Researchers & Practitioners

This study builds on the existing literature on IT industry in India. This study opens new doors for the researchers to explore and analyze the relationship between quarterly aggregate IT sector net sales of India, quarterly aggregate IT sector net profit of India and quarterly economic growth rate of India both in short-term and in long-term.

This study investigates whether the quarterly aggregate IT sector net sales of India and the quarterly aggregate IT sector net Profit of India is co-integrated with quarterly economic growth rate. Therefore, the results of this study can be helpful for the policy makers and IT business managers in formulating appropriate policies and strategies to improve investment in IT sector of India. To sum up, this study opens new doors for the researchers to analyze and explore IT led growth hypothesis in India.

CHAPTER VII

IMPACT OF EXCHANGE RATE FLUCTUATIONS ON PERFORMANCE OF IT COMPANIES IN INDIA

This chapter focuses and analyzes the impact of exchange rate fluctuations on the performance of the selected IT companies in India.

In the era of globalization, organizations are affected by macroeconomic variables and FOREX rate is one of them (Helhel, 2015). It is an important source of uncertainty for firms (De Jong et al., 2006), particularly engaged in export-import activities. Exchange rate has a large impact on macroeconomic policies, especially for the developing world (Aghion et al., 2005). The IT sector of India is not an exception and is influenced by exchange rate risk. In fact, Indian IT software industry gets 90 percent of its revenue from software exports to the US and European Union (NASSCOM, 2017). Due to strong reliance of IT companies of India on international trade, their sales and profit margins are highly sensitive to the fluctuation in exchange rate. Therefore, the impact of exchange rate risk on sales growth and profitability of companies and in particular IT sector companies have been of greater interest by academics and policy makers.

Exchange rate volatility impacts the trade, investment, operating cash flows, financial decisions, and stock price of the companies and in particular IT sector companies. IT sector companies are exposed to exchange rate risk through various channels. The price fluctuations of hardware cost and software licenses increase in employees cost of foreign subsidiaries, training expenses, and sales and marketing expenses are impacted by FOREX rate fluctuations. This adversely impact profit of IT sector companies. The sales turnover from exports of software is primarily in foreign currency and it has huge dependency on FOREX rate fluctuation. As a result of exchange rate fluctuations, the sales of IT sector companies are adversely impacted. This also led to the decline in profitability and market share of the companies.

The IT sector has remained the face of the corporate sector of India since 1991, when the process of globalization, privatization and liberalization began. The Indian IT sector has been faced with several challenges in recent years. The Indian economy was hit by recession in 2008 (GDP growth rate 3.9 per cent), and further, significant inflation in 2012 (GDP growth rate 5.5 per cent), (Goyal et. al., 2020; Goyal et al., 2021). There is considerable ongoing change in global government policies with respect to IT business outsourcing, including increased visa restrictions by the USA, UK, and Australia. These developments, in addition to exchange rate fluctuations have had a large impact on the Indian IT industry. In this backdrop, this thesis tries to study the impact of exchange rate fluctuation on the profitability and sales of IT companies in India during 2009 and 2017.

It was found in various studies that depreciation of exchange rate is favorable to exporters as their competitiveness gets enhanced (Aghion et al., 2016, Toraganli, 2010). The higher exports act as an incentive for companies to invest more in research and development and in innovation. This enhances firm's productivity. In this context, this study tries to assess the impact of exchange rate volatility on IT growth in India between 2009 and 2017.

7.1 Objective Addressed in this Chapter

The objective addressed in this chapter is as follows:

O_4: To analyze the impact of exchange rate fluctuation on the performance of selected IT companies.

The related Hypotheses are:

H_{4a}: The rupee-dollar exchange rate does not influence the net profit of IT companies.

H_{4b}: The rupee- euro exchange rate does not impact the net profit of IT companies.

H_{4c}: Inflation does not impact the net profit of IT companies

H_{4d}: The rupee-dollar exchange rate does not influence the stock prices of IT companies

H_{4e}: The rupee- euro exchange rate does not impact the stock prices of IT companies.

H_{4f}: Inflation does not impact the stock prices of IT companies

7.2 Research Methodology: Regression Technique

In this study, we applied following methodology to capture both the short run and the long run dynamics of stock prices of the selected IT companies and rupee-dollar exchange rates. In this study, we also tried to study the impact of rupee-dollar exchange rate fluctuations on the profitability of the selected IT companies.

In this study, we have analyzed the data in following three stages.

Stage I: As the study deals with time series data, and time series data are customarily de-seasonalized using quarterly dummies to remove seasonality present in the data in the first stage.

This is required, at times though the two variables may not be related but they trend with time. Hence to remove any false relationship, de-seasonalization of data is required to be done.

Stage II: In the second stage, from the de-seasonalized series, the dominant trend component is also removed using time regressor. This exercise generally addresses the non-stationarity issues in time series data.

Stage III: In the third stage, the study transformed the de-trended and de-seasonalized series into logarithms. Thus, the natural logs of net profit, stock prices, rupee-dollar exchange, rupee-Euro exchange rate and inflation were obtained.

This step helps in following:

a) The interpretation of logarithmic data is easier than otherwise. We can relate the interpretation in %age saying a increase of a dependent variable by x % leads to increase of independent variable by y%.

b) The outliers get suppressed by taking the logarithmic data.

Finally, regression technique is used to find the impact of these variables on two proxies of performance – net profit & stock prices

7.3 Data Description and Variables Used

To meet the above stated objectives depicted in Section 7.1, we collated data on top eighteen IT software service companies in India. The basis of selecting these companies was their market capitalization and data availability. The companies having market capitalization of greater than ₹5 billion comprise our sample. We collected the data from 2010 to 2017. However, it was noticed that these companies follow oligopolistic structure. The top eight companies have more than 97% of market share in terms of revenue (leaving L&T Infotech, as it got listed only in 2016). Also, top eight companies have more than 94% market share in terms of total assets. The details are represented in Table 7.1 and Table 7.2.

Table 7.1: Market Share of IT companies (Net Sales)

IT Company Name	Net Sales (Rs. Crores)	Market Share % (as of 2020)	Cumulative Market Share (%)
TCS	135963.00	36.76	36.76
INFY	85912.00	23.23	59.99
WIPRO	50299.40	13.60	73.59
HCL	32606.00	8.81	82.40
TECHM	29225.40	7.90	90.30
L& T Infotech*	10184.20	2.75	93.05
MNDTR	7967.80	2.15	95.20
MPHSI	4347.14	1.18	96.38
ORCLF	3676.38	0.99	97.37
COFORGE*	2231.00	0.60	97.97
* L&T Infotech listed in 2016 and Coforge Ltd listed in 2020			

Table 7.2: Market Share of IT Companies (Total Assets)

IT Company Name	Total Assets (Rs. Crores)	Market Share % (as of 2020)	Cumulative Market Share (%)
TCS	109381.00	26.96	26.96
INFY	93939.00	23.16	50.12
WIPRO	65736.30	16.20	66.32
HCL	53515.00	13.19	79.51
TECHM	30322.00	7.47	86.98
L& T Infotech*	8316.70	1.50	88.48
MNDTR	6360.60	1.57	90.05
MPHSI	5512.36	2.05	92.10
ORCLF	6066.76	1.36	93.46
CYIENT	2672.70	0.66	94.12
* L&T Infotech listed in 2016			

Thus, Following Pareto's 20:80 rule (Koluksuz, 2020) these eight companies reflect a good sample size to represent the Industry. Moreover, the selected eight IT companies have quarterly revenue of approximately ₹ 798 billion which is approximately 95% of the total revenue of IT industry of India. Thus, keeping in mind the oligopolistic structure of the IT industry in India, the selected eight IT firms are not only dominant and market leaders but also dictate policies in the IT sector. The IT companies selected for this study are listed in Table 7.3

Based on the study of previous literature, the Table 3.3 and Table 3.4 lists the various variables used in studies related to impact of exchange rate fluctuations on stock returns of the IT companies and profitability of the IT companies. This research study focuses on measuring and analyzing the impact of exchange rate fluctuations on the performance of the selected Indian IT firms with respect to their financial performance. Therefore, the variables relating to financial performance were particularly kept in mind while selecting the dependent variables in this study. The variables selected are Net Profit, Stock prices, which are proxies for measuring performance of the selected IT companies. Quarterly data is taken for all the selected IT companies.

The net profit is a well-established matrix for measuring the performance of any business entity. The second matrix which is the closing stock prices of the selected IT companies is also taken as a proxy for measuring performance, which is consistent with the wealth maximization notion of any corporate firm.

Table 7.3: List of all IT Companies Selected for this Study

IT Company Name	*IT Company Acronym*	*IT Company Code*
Tata Consultancy Services	TCS	IT1
Infosys Ltd.	INFY	IT2
Wipro Ltd.	WIPRO	IT3
HCL Technologies Ltd.	HCL	IT4
Tech Mahindra Ltd.	TECHM	IT5
Oracle Financial Services Software Ltd.	ORCLF	IT6
Mindtree	MNDTR	IT7
Mphasis	MPHSI	IT8
Source: Author's compilation		

The following variables were taken for the analysis purpose:

Profit (P): Net profit after tax as reported by the selected IT companies on quarterly basis is used in this study to represent profit. In this research study, profit is considered as dependent variable.

Stock Price (K): The closing price of stock on quarterly basis is used in this study to represent the stock price of the selected IT companies. The stock price data is taken from Bombay Stock Exchange (BSE).

Exchange Rate (E): The rupee-dollar and rupee-EURO exchange rates on quarterly basis are used in this study to represent the exchange rate. The exchange rate data is taken as average of the quarter and is taken as reported by Reserve Bank of India (RBI) website www.rbi.org.in (Reserve Bank of India, 2021). All our data is collected from Prowess database and website – www.moneycontrol.com (Money Control, 2021) and Reserve Bank of India website (Reserve Bank of India, 2021). The primary source of the data is the Prowess Database of CMIE. This study employed software named as Eviews 12 for the estimation purpose.

7.4 Empirical Results and Discussions

The study makes uses of various mathematical and statistical techniques to achieve the objectives of the study.

In this study, we analyzed 8 IT software companies using quarterly data from 2010 to 2017. We collected data relating to Net Profit, Stock prices, Rupee-Dollar exchange rate, Rupee-Euro exchange rate and Inflation rate, which is a proxy for inflation in India.

In order to find the impact of exchange rate fluctuations on the performance of IT companies, in this study we took two variables namely, Net Profit and Stock prices, which are proxies for measuring performance of the selected IT companies. The net profit is a well-established matrix for measuring the performance of any business entity.

The second matrix which is the closing stock prices of the selected IT companies is also taken as a proxy for measuring performance, which is consistent with the wealth

maximization notion of any corporate firm. All the corporate firms are listed on stock exchange on India and have wealth maximization as their core objective. Moreover, all eight selected IT companies are debt free and hence the wealth is completely owned by the owners of the respective companies and shareholders. Keeping this in perspective, the second objective of this study is consistent with wealth maximization. Stock prices and Stock returns is a crucial indicator of firms' performance and wealth maximization. Hence the second objective of the study is taken as impact of exchange rate fluctuations on stock prices of selected IT companies.

The Table 7.4 provides descriptive statistics on Rupee-Dollar exchange rate, Rupee-Euro exchange rate and Wholesale Price Index (WPI) variable.

Table 7.4 Descriptive Statistics of Variables

	USD	*EURO*	*WPI Index*
Mean	57.45009468	71.52929536	169.8678571
Standard Error	1.522933855	1.355801176	2.628200008
Median	60.17747572	71.46774167	175.7
Mode	#N/A	#N/A	168.8
Standard Deviation	8.058608487	7.174225476	13.90712723
Sample Variance	64.94117074	51.46951118	193.4081878
Kurtosis	-1.311885525	-0.416755693	-0.458588193
Skewness	-0.363860886	0.087482896	-0.87021815
Range	22.76445681	26.62856624	45.5
Minimum	44.73949153	58.0047541	139.8
Maximum	67.50394833	84.63332034	185.3
Sum	1608.602651	2002.82027	4756.3
Count	28	28	28

In this study, we have analyzed the data using regression techniques to find the impact of these variables on two proxies of performance – net profit & stock prices. We found that although there is slight presence of seasonality in the quarterly net profit and stock prices data, but the trend component is very dominant in case of the selected IT firms. Though, the selected IT companies in India are from the same industry but they may have unique characteristics. To capture uniqueness of individual companies we estimated data for each of the selected IT Company.

7.4.1 Empirical Results for Impact of Exchange Rate Fluctuations on Profitability

Table 7.5 below depicts the relationship between exchange rate and net profit of selected IT companies in India.

The Table 7.5 shows that the relationship between rupee-dollar exchange rate and net profit of selected IT companies in India are positively related (except for MPHASIS). Also, the results are statistically significant at 5%. Thus, it can be said that the null of the rupee-dollar exchange rate does not influence the net profit is rejected in the case of all IT companies. This implies that rupee-dollar exchange rate is a major variable impacting the profitability of IT companies in India.

The analysis of impact of exchange rate on the net profit of TCS shows that elasticity of rupee-dollar exchange rate is 1.20 implying that when rupee-dollar exchange rate appreciates by 1 percent on an average, the net profit of TCS increases by 1.20 percent keeping all other independent variables constant. The relationship between rupee-dollar exchange rate and net profit of TCS is positively related. The intercept values of the 8 selected companies shown in Table 7.5 are statistically different from each other. For instance, the coefficients of intercept for INFY, WPRO, HCL, TECHM, ORCLF and MNDTR were 1.38, 1.03, 1.04, 1.81, 0.29, and 1.28 respectively. These differences in the intercept may be due to unique features of each company such as differences in management style, work culture or talent management.

Table 7.5: Results-Impact of Exchange Rate on the Net Profit of the Selected IT Firms

$LN(DNETPROFIT) = \alpha+\beta_1 LN(USD)+\beta_2 LN(EURO)+\beta_3 LN(INF)+\beta_4 MA(1)+ \mu$									
Coefficients	α	β_1	β_2	β_3	β_4	Adj R^2	df	F-Stat	D-W
TCS	-7.52	1.20	-1.33	3.68	0.38	0.94	27	131.22	1.97
	(-3.99)	(3.03)	(-3.09)	(5.11)	(2.13)			(p=0.000)	
INFY	-1.52	1.38	-0.62	1.7	0.86	0.93	27	121.79	1.82
	(-0.81)	(3.63)	(-1.63)	(2.91)	(7.8)			(p=0.000)	
WIPRO	2.21	1.03	-0.74	1.27	NA	0.88	28	80.92	1.96
	(1.96)	(4.28)	(-2.80)	(2.70)				(p=0.000)	
HCL	-22.85	1.04	-2.49	7.48	NA	0.96	28	282.54	2.12
	(-12.22)	(2.63)	(-5.63)	(9.61)				(p=0.000)	
TECHM	-26.45	1.81	-1.79	6.83	NA	0.89	28	87.10	2.16
	(-6.80)	(2.18)	(-1.95)	(4.21)				(p=0.000)	
ORCLF	4.84	0.29	-0.51	0.79	-0.98	0.69	27	18.91	1.67
	(7.57)	(2.83)	(-5.01)	(2.86)	(-27.40)			(p=0.000)	
MNDTR	-11.10	1.28	-1.54	3.76	0.29	0.96	27	226.56	1.83
	(-8.01)	(4.34)	(-4.82)	(6.91)	(1.53)			(p=0.000)	
MPHSI	11.18	-0.83	0.67	-0.64	0.57	0.87	27	54.80	1.86
	(10.60)	(-3.80)	(2.89)	(-1.71)	(3.85)			(p=0.000)	
* significant at 0.01 level, ** significant at 0.05 level, ***significant at 0.1 level									

Also, Table 7.5 shows that the relationship between rupee-Euro exchange rate and net profit of selected IT companies in India are negatively related (except for MPHSI). Also, the results are statistically significant at 5% for TCS, WPRO, HCL, ORCLF, MNDTR and MPHSI. Thus, it can be said that the null of rupee-euro exchange rate does not influence the net profit is rejected in the case of six companies except INFY & TECHM. This implies that net profit of INFY and TECHM are not influenced by the rupee-euro exchange rates. However, the other IT firms must hedge its exchange rate exposure not only in rupee-dollar but also in rupee-Euro.

The analysis of impact of exchange rate on the net profit of WPRO shows that elasticity of rupee-euro exchange rate is -0.74 implying that when rupee-euro exchange rate appreciates by 1 percent on an average, the net profit of WPRO decreases by 0.74 percent keeping all other independent variables constant. The relationship between rupee-euro exchange rate and net profit of WPRO is negatively related. The intercept values of the 8 selected companies shown in Table above are different from each other. These intercept values of these companies are statistically different as shown in the Table 7.5 above. For instance, the coefficients of intercept for TCS, INFY, HCL, TECHM, ORCLF and MNDTR were -1.33, -0.62, -2.49, -1.79, -0.51 and -1.54 respectively.

The third variable shown in the Table 7.5 above is inflation. The Table 7.5 above shows that the relationship between Inflation and net profit of selected IT companies in India are positively related (except for MPHSI). Also, the results are statistically significant at 5% for all selected IT companies except MPHSI. Thus, it can be said that the null of inflation has no impact on the net profit of IT companies is rejected in the case of all IT firms in India except MPHSI. This has lot implications for all the IT firms.

The analysis of impact of exchange rate on the Inflation of HCL shows that elasticity of Inflation rate is 7.48 implying that when Inflation increases by 1 percent on an average, the net profit of HCL increases by 7.48 percent keeping all other independent variables constant. The relationship between Inflation rate and net profit of HCL is positively related. The intercept values of the 8 selected companies shown in Table above are different from each other. These intercept values of these companies are

statistically different as shown in the Table above. For instance, the coefficients of intercept for TCS, INFY, WPRO, TECHM, ORCLF and MNDTR were 3.68, 1, 7, 1.27, 6.83, 0.79 and 3.76 respectively.

7.4.2 Empirical Results for Impact of Exchange Rate Fluctuations on Stock Prices

Table 7.6 below depicts the relationship between exchange rate and Stock Prices of selected IT companies in India.

The Table 7.6below shows that the relationship between rupee-dollar exchange rate and stock price of selected IT companies in India are positively related. Also, the results are statistically significant at 5%. Thus, it can be said that the null of the rupee-dollar exchange rate does not influence the stock prices is rejected in the case of all IT companies. This implies that rupee-dollar exchange rate is a major variable impacting the stock prices of all the IT companies in India.

Also, Table 7.6 shows that the relationship between rupee-Euro exchange rate and stock prices of selected IT companies in India are negatively related. Also, the results are statistically significant at 5% except WIPRO. Thus, it can be said that the null of rupee-euro exchange rate does not influence the stock prices is rejected in the case of all selected companies except WPRO. This implies that stock prices of WPRO are not influenced by the rupee-euro exchange rates. However, the other IT firms must hedge its exchange rate exposure not only in rupee-dollar but also in rupee-Euro.

Table 7.6: Results -Impact of Exchange Rates on the Stock Prices of the Selected IT Firms

$LN(DSTOCKPRICE) = \alpha+\beta_1 LN(USD)+\beta_2 LN(EURO)+\beta_3 LN(INF)+\beta_4 MA(1)+ \mu$									
Coeff.	α	β_1	β_2	β_3	β_4	Adj R^2	df	F-Stat	D-W
TCS	-6.02 (-4.73)	1.54 (-6.16)	-1.12 (-4.36)	2.53 (-6.12)	0.94 (-10.49)	0.97	27	335.17 (p=0.000)	1.95
INFY	1.37 (-1.29)	0.88 -3.95	-0.49 (-2.05)	0.75 (-1.9)	0.43 (-2.59)	0.89	27	68.65 (p=0.000)	2
WIPRO	2.07 (-2.29)	0.67 (-3.51)	-0.3 (-1.45)	0.38 (-1.09)	0.34 (-1.88)	0.83	27	40.39 (p=0.000)	2.04
HCL	-20.95 (-11.65)	1.52 (-3.97)	-1.73 (-4.08)	5.52 (-7.39)	0.04 (-0.24)	0.96	27	206.29 (p=0.000)	1.93
TECHM	-9.42 (-5.43)	1.58 (-4.45)	-1 (-2.63)	2.55 (-4.15)	0.6 (-4.44)	0.95	27	175.84 (p=0.000)	1.99
ORCLF	1.03 (-1.36)	0.84 (-5.32)	-0.6 (-3.55)	1.19 (-4.36)	0.59 (-3.55)	0.96	27	206.65 (p=0.000)	1.33
MNDTR	-28.19 (-12.90)	1.21 (-2.61)	-2.09 (-4.16)	7.39 (-8.45)	0.27 (-1.39)	0.97	27	258.16 (p=0.000)	1.85
MPHSI	3.97 (-9.03)	0.28 (-3.08)	-0.22 (-2.15)	0.38 (-2.09)	NA	0.8	28	43.95 (p=0.000)	1.84
* significant at 0.01 level, ** significant at 0.05 level, ***significant at 0.1 level									

The third variable shown in Table 7.6 is inflation. The Table 7.6 shows that the relationship between Inflation and stock prices of selected IT companies in India are positively related. Also, the results are statistically significant at 5% for all selected IT companies except INFY and WPRO. Thus, it can be said that the null of inflation has no impact on the stock prices of IT companies cannot be rejected in the case of INFY and WPRO. However, in case all other IT firms in India inflation found to be a highly statistically significant variable. This has lot implications for TCS, HCL and TECHM.

7.5 Findings of the Study

- The null of the rupee-dollar exchange rate does not influence the net profit is rejected in the case of all IT companies implying that rupee-dollar exchange rate is a major variable impacting the net profit of IT companies in India.
- The null of rupee-euro exchange rate does not influence the net profit is rejected in the case of six companies except INFY and TECHM. This implies that net profit of INFY and TECHM are not influenced by the rupee-euro exchange rates. However, the other IT firms have to hedge its exchange rate exposure not only in rupee-dollar but also in rupee-Euro.
- The null of inflation has no impact on the net profit of IT companies is rejected in the case of all IT firms in India except MPHSI. This has lot implications for all the IT firms.
- The null of the rupee-dollar exchange rate does not influence the Stock Prices is rejected in the case of all IT companies implying that rupee-dollar exchange rate is a major variable impacting the stock prices of all the IT companies in India.
- The null of rupee-euro exchange rates does not influence the stock prices are rejected in the case of seven companies except WPRO. This implies that a stock price of WPRO is not influenced by the rupee-euro exchange rates. However, the other IT firms have to hedge its exchange rate exposure not only in rupee-dollar but also in rupee-Euro.
- The null of inflation has no impact on the stock prices of IT companies cannot be rejected in the case of INFY and WPRO implying that inflation variable is not critical factor determining their stock prices. However, in case all other IT firms in

India inflation found to be a highly statistically significant variable. This has lot implications for TCS, HCL, TECHM, ORCLF, MNDTR and MPSHI.

The IT firms make use of different strategies or a combination of strategies such as currency options contract, cross-currency hedging, foreign currency contracts, forward contracts, etc. to protect their profit and sales from exchange rate exposure. The choice of strategy followed by the company depends on the risk profile of the company, geographical location of clients, type of business model etc. (Dash et al., 2008). Hedging of funds is one of the very effective instruments used by the firms to protect themselves from exchange rate fluctuations (Dash, 2009). It is also observed by the scholars that the companies that have developed an exchange rate risk management structure are better placed than the others, hence managing exchange rate risk is very important for especially for firms dealing with exports such as IT firms (Dash & Chopra, 2009).

The empirical results of this study show that some of the companies exhibited insignificant impact on profit and sales turnover because of exchange rate exposure. The possible explanation for this phenomenon could be that these firms made a very effective use of hedging instruments or any other strategy to safeguard themselves from exchange rate exposure (Toraganli, 2000).

CHAPTER VIII

CONCLUSION

This chapter provides conclusion of the study. Section 8.1 of this chapter covers the major findings of the current research. Revisiting of the objectives to discover how the objectives have been achieved is covered in Section 8.2. Figure 8.1 provides a complete view of research. The implications of the current research are projected in Section 8.3. The final section 8.4covers the limitation and future scope.

8.1 Major Findings of the Study

The research has been undertaken to examine the impact of exchange rate risk on the performance and growth of IT companies in India. The present research also identifies the factors impacting the performance of IT companies in India and examines the performance of IT companies in India.

The efficiency of the firms is central to economic growth and development (Chang et al., 2013; Vu, 2011). The IT industry helps to improve the efficiency of individual as well as organizational efficiency (Draca et al., 2016; Abdullahi et al., 2019). Based on the analysis of Objective 1 (O1), following are the key findings of the study for the benefit of policy makers for strategizing for the way forward.

i. The results of the study indicated that MNDTR, TLXI and HNDV were overall technical efficient across all the years for the duration 2010 to 2017. All these firms had an efficiency score of one. The three less efficient IT firms for this duration were ORCLF, CYENT and GEOMR. The OTE increased for TCS, HCL, TECHM, CYENT, NIIT, POLRS, HNDG and GEOMR during the selected duration of the study. For the same duration, the OTE of INFY, WIPRO, MPHSI, HXWR, PRSTN and ZNSR decreased over time.

ii. The AOTE of selected IT firms increased to 96.95 per cent in 2017 from 95.97 per cent in 2010. This implies that in order to operate at higher efficiencies, these firms should continue to implement the strategies adopted in 2017.

iii. It was also found that the top five IT firms were overall technically efficient when compared to the rest of the selected IT firms for the duration 2010 to 2017. Thus, rest of the selected IT firms should follow the strategies and best practices followed by top five IT firms to improve their efficiency. It was also noticed that the top five IT firms showed more fluctuations in the efficiency as compared to the rest of the IT firms.

iv. The study also found that for the year 2016-2017, the results depicted that nine firms had an OTE score of one. These firms were TCS, HCL, TECHM, ORCLF, MNDTR, TLXI, NIIT, POLRS and HNDV. These efficient IT firms collectively define the efficient frontier of all the selected IT firms for the study. The study established that MPHSI, INFY, WPRO and PRSTN are amongst the companies that have low OTE values. The study also found that MPHSI, INFY, PRSTN and ZNSR are pure technical inefficient IT firms. It was also concluded from the study that WPRO, INFY, ZNSR and HNDG are amongst the companies with low SE values. It was noticed from the analyses of the study that OTIE of WPRO, HXWR and HNDG is primarily due to SIE rather than PTIE. Therefore, these IT firms can be said to be facing problems pertaining to the number of employees rather than managerial problems. The efficiency of these inefficient IT firms could probably increase by reducing the number of un-utilized employees and scale optimization.

v. The results of the study indicated that INFY was the least efficient on every parameter for the selected duration. Also, the production system of INFY exhibited DRS over the sample period. This is while INFY is one of the leading IT software service companies in India and has remained the corporate face of India. This implies that policy makers of INFY should first focus on addressing the technical inefficiency before fixing the scale of operations. The co-ordination between the management and the employees and employees' skills enrichment could be the primary issues causing inefficiency that needs to be fixed.

vi. The study also found that that HCL can be considered as the benchmark IT firm followed by TECHM and MNDTR. INFY had maximum slack. CYENT was the only IT firm that was overall technically inefficient but had zero slack.

This indicates that there are other factors responsible for inefficiency. Optimal SE may be one of the reasons for the inefficiency. MPHSI was found to be the least efficient company.

To meet the objective 2 (O2), in this study we tried to examine the influence of background and environmental variables on the estimated efficiency scores using Tobit Regression model as a second stage analysis. The findings of this study reveal that

i. For OTE as a dependent variable, age of company and R&D expenses are significant at 5% level, number of employees is significant variables at 10% level, whereas asset size of the company is significant at 1% level.
ii. We find that the relationship between R&D expenses and OTE is negative which seems to be contradictory in nature. In general R&D expenses increases productivity or efficiency. However, the results of this study do not support this hypothesis.
iii. The results for PTE and SE as dependent variable also reveal similar results except for one variance which reveals that relationship between number of employees and PTE is not significant.

Further, the component-wise performance of selected five IT software companies (INFY, TCS, WPRO, CTS and ACCN) based on components like FSI, MFG, RCL, ERU, CME and LSH was evaluated using multi-component data envelopment analysis. The quarterly data was collated for the duration 2014 to 2017. The major findings of this study are as bellow:

i. The empirical results established that INFY is found to be the most efficient in all components and emerged as the benchmark company followed by CTS and ACCN for the selected period. However, TCS and WPRO were found to be inefficient in some of the components. The empirical results show that the selected IT firms performed efficiently in FSI, RCL and CME components. However, the efficiency of ERU, LSH and MFG components require improvements.
ii. Moreover, the study also builds on and advances the existing literature in investigating the component-wise efficiency analysis of selected IT companies

across three regions, viz. NA, EUR and ROW to perform international comparison for the period 2014 and 2017. The results established that the performance of all the IT companies in its various components is found to be more efficient in the ROW region followed by the EUR region and very poor in the NA region. The efficiency of all the components of the selected IT firms except TCS deteriorated in the last quarter of 2017 compared to the last quarter of 2014.

Following are the key findings based on the research performed to meet Objective 3 (O3):

i. This implies that there exists no long-run relationship between the quarterly GDP of India and the quarterly aggregate net sales of IT sector of India.

ii. There is no functional relationship between quarterly GDP of India and quarterly aggregate net sales of IT sector of India. It also established that the quarterly aggregate net sale of IT sector of India is not statistically having functional relationship with quarterly GDP of India.

iii. The quarterly GDP and aggregate quarterly IT Net Profit are positively related. The R^2 value of 0.92 indicates that 92% variations are explained by the independent variable quarterly Net Profit. The D-W statistic of 0.80 shows that the results suffer from positive serial autocorrelation. It is important to note here that the quarterly GDP and quarterly Net Profit are non-stationary series as they are trending variables.

iv. There exists a long-run relationship between the quarterly GDP of India and the quarterly Net Profit of IT sector.

v. In short-run, changes in quarterly Net Profit have a positive impact on shortrun changes in quarterly GDP. The co-efficient of Net Profit is 2.7363 in short run indicating that one time increase in quarterly Net Profit of IT industry causes 2.7363 times increase in quarterly GDP of India. The result is statistically highly significant at 1% level.

vi. The results established that there is no functional relationship between quarterly aggregate net profit of IT sector of India and quarterly GDP of India. However, the results of the study established that the quarterly aggregate net

profit of IT sector of India is caused statistically significantly by the quarterly GDP of India.

Lastly, the investigation towards Objective 4 (O4) lists following key findings for the benefit of researchers and scholars:

i. The null of the rupee-dollar exchange rate does not influence the net profit is rejected in the case of all IT companies implying that rupee-dollar exchange rate is a major variable impacting the performance IT companies in India.

ii. The null of rupee-euro exchange rate does not influence the net profit is rejected in the case of six companies except INFY & TECHM. This implies that net profit of INFY and TECHM are not influenced by the rupee-euro exchange rates. However, the other IT firms have to hedge its exchange rate exposure not only in rupee-dollar but also in rupee-Euro.

iii. The null of inflation has no impact on the net profit of IT companies is rejected in the case of all IT firms in India except MPHASIS. This has lot implications for all the IT firms.

iv. The null of the rupee-dollar exchange rate does not influence the Stock Prices is rejected in the case of all IT companies implying that rupee-dollar exchange rate is a major variable impacting the stock prices of all the IT companies in India.

v. The null of rupee-euro exchange rates does not influence the stock prices is rejected in the case of seven companies except WPRO. This implies that stock price of WPRO is not influenced by the rupee-euro exchange rate. However, the other IT firms have to hedge its exchange rate exposure not only in rupee-dollar but also in rupee-Euro.

vi. The null of inflation has no impact on the stock prices of IT companies cannot be rejected in the case of INFY and WPRO implying that inflation variable is not critical factor determining their stock prices. However, in case all other IT firms in India inflation found to be a highly statistically significant variable. This has lot implications for TCS, HCL, TECHM, ORCLF, MNDTR and MPHSI.

8.2 Conclusion - Revisiting the Objectives

It is necessary to revisit the research objectives to see whether the study has been able to accomplish the same.

The first objective of the present research has been:

O_1: *To examine the performance of selected IT companies of India.*

The first objective was to investigate the performance of the selected IT companies of India. This study evaluated the relative efficiency of top 18 IT firms of India. The duration of the study was from 2010 to 2017. The study used DEA technique for this objective. The results conclude that the average efficiency of the selected IT firms is very high i.e. 96%. This indicates that there is small room for improvement of about 4% in their outputs, at the existing input levels. The positive government policies of India towards IT industry and availability of skilled resources have strengthened the IT industry to continue performing at high level of efficiencies. There are some IT firms that are not able to efficiently use their inputs resulting in managerial or scale inefficiency.

The findings established that AOTE, APTE and ASE displayed mixed trends. The study concluded that AOTE reduced from 0.960 to 0.953 during the duration 2010 to 2016. The reasons for reduction in AOTE could be on account of IT services being offered as generic services rather than value added services by Indian IT firms. The APTE reduced from 0.985 to 0.975 during the same period. This could be because of implementation of inappropriate management practices and processes by inefficient IT firms. During the same duration from 2010 to 2016, the ASE improved from 0.974 to 0.977. This indicates that on an average the IT firms have marginally shown improvement in managing their size. However, the findings of the study also depicted that overall efficiency of all the IT firms increased in 2017. This improvement in overall efficiency may be on account of high focus on employee management and implementation of IT systems automation processes by the selected IT companies.

The study established that in 2017, the top five IT firms exhibited higher efficiency as compared to the rest of the firms. It was further discovered that three amongst the top five companies were overall efficient. These were TCS, HCL and TECHM. The less

efficient IT companies are MPHSI and INFY. The study also conducted the benchmarking exercise. The findings of the study showed that HCL had the largest peer count. Hence, HCL can be considered as the most robust company. The sensitivity analysis depicted that the results were found to be stable.

On an average, it is recommended that all the inefficient IT firms can increase their sales turnover by an average of 9 per cent, and their net profit by an average of 38 per cent to meet the efficiency of the benchmark IT firms. This implies that IT firms must focus on increasing their sales output and net profit to become more efficient. The results further suggest that IT firms should additionally focus on improving employees' utilization rate and employees' skills; thus, increasing employees' productivity.

Further, we also studied the relative efficiency of the top five selected IT firms namely, INF, TCS, WPRO, CTS, and ACCN from 2014 to 2017 using quarterly data. The study not only tried to evaluate the overall efficiency of the selected firms, but also the efficiency of their components namely FSI, MFG, RCL, ERU, CME and LSH using MC-DEA technique. The empirical results established that INFY is found to be the most efficient in all components and emerged as the benchmark company followed by CTS and ACCN for the selected period. However, TCS and WPRO were found to be inefficient in some of the components. The empirical results show that the selected IT firms performed efficiently in FSI, RCL and CME components. However, the efficiency of ERU, LSH and MFG components require improvements.The results established that the performance of all the IT companies in its various components is found to be more efficient in the ROW region followed by the EUR region and very poor in the NA region. The efficiency of all the components of the selected IT firms except TCS deteriorated in the last quarter of 2017 compared to the last quarter of 2014. It may possible that an IT firm may be efficient at aggregate level but may not be efficient at component level due to extreme performance in one or the other component may unduly influence the overall efficiency score.

The second objective of the present research was:

O_2: *To identify factors affecting the performance of the selected IT companies.*

We used Tobit regression model on the efficiency scores obtained using DEA to analyze the impact of external factors on efficiency of IT companies. We used separately OTE, PTE, and SE, as dependent variables against the independent variables. The findings of this study reveals that for OTE as a dependent variable, age of company and R&D expenses are significant at 5% level , number of employees is significant variables at 10% level, whereas asset size of the company is significant at 1% level. We find that the relationship between R&D expenses and OTE is negative which seems to be contradictory in nature. In general R&D expenses increases productivity or efficiency. However, the results of this study do not support this hypothesis. The results for PTE and SE as dependent variable also reveal similar results except for one variance which reveals that relationship between number of employees and PTE is not significant. Table 8.1 depicts the results of Hypotheses testing of external factors influencing IT companies.

Table 8.1: Hypotheses Testing of the External Factors influencing IT Companies

	Hypotheses	Findings	Result
H_{2a}	***There is no significant relationship between age of company and efficiency of the firm.***	*Age of the firm and efficiencies are positively correlated and relationship is statistically highly significant Thus the null of no relation between age of the company and efficiency score is rejected.*	**Rejected**
H_{2b}	***There is no significant relationship between R&D expenses and efficiency of the firm.***	*R&D expenses has statistically significant negative impact on the efficiencies. Thus the null of no relationship between R&D and efficiency is rejected.*	**Rejected**
H_{2c}	***There is no significant relationship between number of employees and efficiency of the firm.***	*Number of employees of the firm is positively correlated with the efficiency score of the IT companies and has significant relationship. Therefore this hypothesis is rejected on basis of statistical analysis.*	**Rejected**
H_{2d}	***There is no significant relationship between asset size and efficiency of the firm.***	*There is negative relationship between asset size and firm efficiency and the results are significant. Thus the null of no relation between asset size and firm efficiency is rejected at conventional levels.*	**Rejected**

The next objective is:

O_3: *To examine the IT-led growth Hypothesis.*

The results as shown in preceding chapter highlighted in Table 8.2

Table 8.2: Hypotheses Testing of the Relation among IT-led Growth Hypothesis

	Hypotheses	Findings	Result
H_{3a}	**H_{3a}: Indian IT industry has no impact on the economic growth rate of Indian economy.**		
	H_{3a1} : The aggregate quarterly net sale of IT sector of India have no impact on the economic growth rate of Indian economy.	*There exists no long-run relationship between the quarterly GDP of India and the quarterly net sales of IT sector. Hence the null of the aggregate quarterly net sale of IT sector of India have negative impact on the economic growth rate of Indian economy cannot be rejected*	**Accepted**
	H_{3a2} :The aggregate quarterly net profit of IT Sector has no impact on the quarterly GDP of India.	*The null of aggregate quarterly net profit of IT sector India has no impcat on the quarterly GDP of India cannot be rejected at 5% level.*	**Accepted**
H_{3b}	**H_{3b}: IT growth does not lead to economic growth.**		
	H_{3b1} :The aggregate quarterly net sales of IT sector of India does not cause quarterly GDP of India	*The null of aggregate quarterly net sales of IT sector of India does not Granger Cause GDP of India cannot be rejected at 5% level of significance*	**Accepted**
	H_{3b2} :The aggregate quarterly net profit of IT sector of India does not cause quarterly GDP of India	*The null of aggregate quarterly net profit of IT sector of India does not Granger Cause quarterly GDP of India cannot be rejected at 5% level of significance*	**Accepted**
H_{3c}	**H_{3c}: Indian Economic growth does not lead to IT growth.**		
	H_{3c1} :The quarterly GDP of India does not cause aggregate quarterly net sales of IT sector of India	*The null of quarterly GDP of India does not Granger cause aggregate quarterly net sales of IT sector of India cannot be rejected at 5% level of significance*	**Accepted**
	H_{3c2} :The quarterly GDP of India does not cause aggregate quarterly net profit of IT sector of India	*The null of quarterly GDP of India does not Granger cause aggregate quarterly net profit of IT sector of India can be rejected at 6% level of significance*	**Rejected**

The last objective of this study is:

O_4: *To analyze the impact of exchange rate fluctuation on performance of selected IT companies.*

The results as shown in preceding chapter highlighted in Table 8.3.

Table 8.3: Hypotheses Testing of the Impact of Exchange Rate Fluctuation on Performance of Selected IT Companies

	Hypotheses	Findings	Result
H_{4a}	**The rupee-dollar exchange rate does not influence the net profit of IT companies.**	*The null of the rupee-dollar exchange rate does not influence the net profit is rejected in the case of all IT companies implying that rupee-dollar exchange rate is a major variable impacting the performance IT companies in India.*	**Rejected**
H_{4b}	**The rupee-euro exchange rate does not impact the net profit of IT companies.**	*The null of rupee-euro exchange rate does not influence the net profit is rejected in the case of six IT companies except INFY & TECHM. This implies that net profit of INFY & TECHM are not influenced by the rupee-euro exchange rate. However, the other IT firms have to hedge its exchange rate exposure not only in rupee-dollar but also in rupee-Euro.*	**Rejected**
H_{4c}	**Inflation does not impact the net profit of IT companies**	*The null of inflation has no impact on the net profit of IT companies is rejected in the case of all IT firms in India except MPHSI. This has lot implications for all the IT firms.*	**Rejected**
H_{4d}	**The rupee-dollar exchange rate does not influence the stock prices of IT companies**	*The null of the rupee-dollar exchange rate does not influence the stock prices is rejected in the case of all IT companies implying that rupee-dollar exchange rate is a major variable impacting the stock prices of all the IT companies in India.*	**Rejected**
H_{4e}	**The rupee-euro exchange rate does not impact the stock prices of IT companies.**	*The null of rupee-euro exchange rate does not influence the stock prices is rejected in the case of seven IT companies except Wipro. This implies that stock prices of WPRO is not influenced by the rupee-euro exchange rate. However, the other IT firms have to hedge its exchange rate exposure not only in rupee-dollar but also in rupee-euro.*	**Rejected**
H_{4f}	**Inflation does not impact the stock prices of IT companies**	*The null of inflation has no impact on the stock prices of IT companies cannot be rejected in the case of INFY and WPRO implying that inflation variable is not critical factor determining their stock prices. However, in case all other IT firms in India inflation found to be a highly statistically significant variable. This has lot implications for TCS, HCL, TECHM, ORCLF, MNDTR and MPHSI*	**Accepted**

The study takes a holistic perspective of the IT industry of India and includes the analysis on factors impacting the growth of IT services industry, performance of IT software service companies in India, relationship between IT growth and economic growth of India and impact of exchange rate on the performance of IT companies in India. The complete view of research has been presented through Figure 8.1 as depicted below.

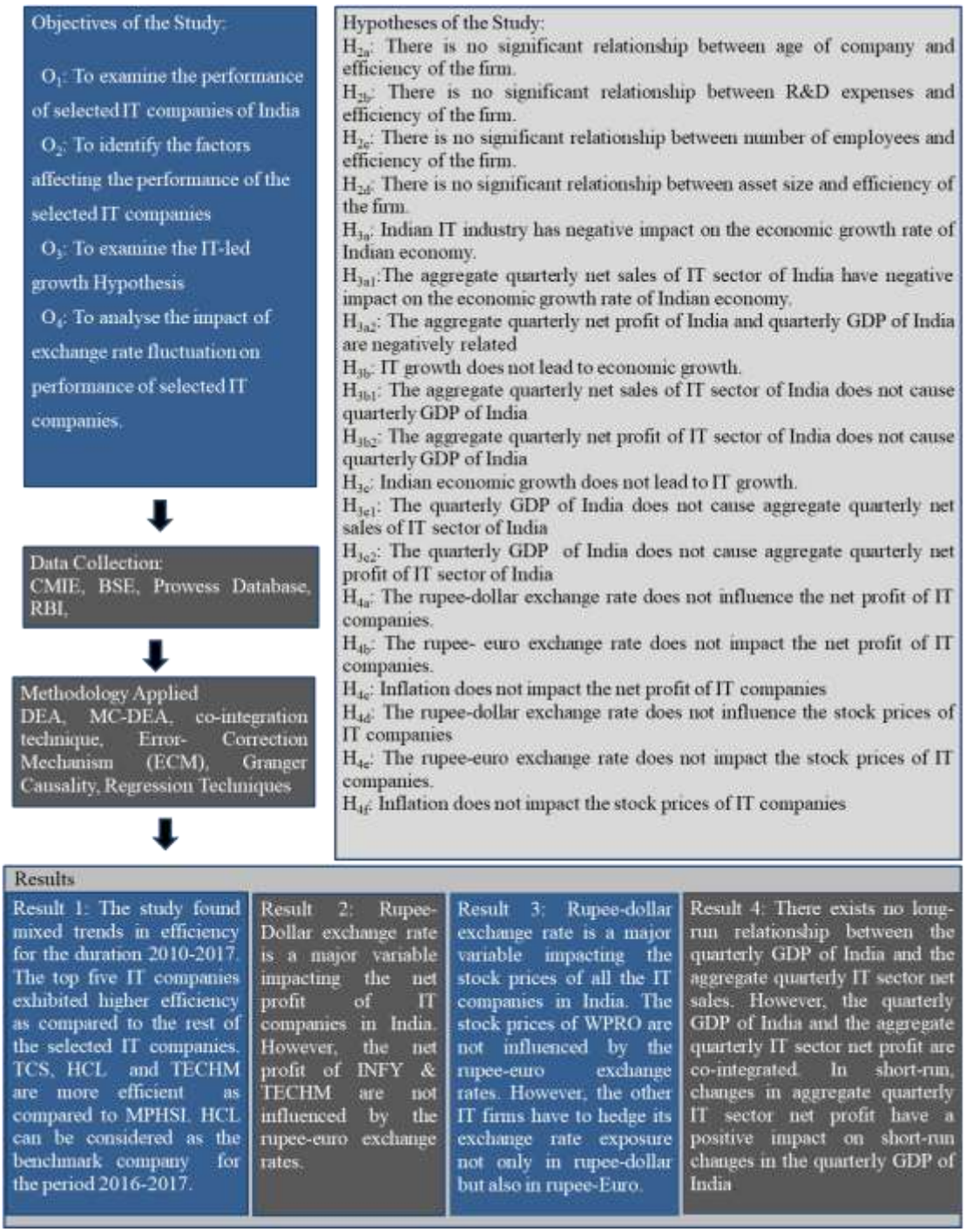


Figure 8.1: Complete Overview of Research

8.3 Implications of the Study

This study has many implications for the IT industry of India. The results of this study can help the executives and policy makers in framing appropriate policies and strategies. The appropriate policies can improve efficiency of IT companies and pave

the way for the IT companies to remain competitive in the global IT industry. The implications of the study that can be utilized to improve the performance of selected IT companies are as follows:

The inefficient IT firms must catch- up and follow the best practices of the benchmark IT firm HCL, in terms of better project management practices, improving employees' productivity, employees' utilization, reducing operational expenses, managing employees' costs effectively and effective utilization of organizational assets. The overall inefficiency could be because of poor utilization of inputs (i.e., managerial inefficiency) and/or failure to operate at an optimized scale (i.e., scale inefficiency). To improve SE, IT firms exhibiting DRS can optimize the employees' strength force either by retrenching or by the skill enrichment of the employees. However, the IT firms showing IRS can increase their efficiency by expanding their employees' strength either by routine recruitments or by merger & acquisitions.

In general, the IT firms in India can develop strategies that could improve utilization of inputs that include investment in software tools that increase employees' collaborations, enrich employees' competency, improve employees' work environment, increased focus on employees' health and their well-being. Moreover, enhanced focus on inclusivity and diversity has also implications for overall productivity.

The study on IT-led growth hypothesis can be helpful for the policy makers and IT business managers in formulating appropriate policies and strategies to improve investment in IT sector of India. Further, the study on impact of exchange rates on sales and net profit of IT companies has major implications for the policy makers and researchers. The results of the study can be useful for the corporate strategy groups to decide the exchange rate risk management strategy for the IT companies. As supported by Dash & Chopra (2009), the management of exchange rate risk is very important for IT companies in India.

The Government of India has recently taken many initiatives such as the introduction of Goods and Services Tax (GST), demonetization to curb black money, and various other reforms to promote various industries in India (Dhameja et al., 2016). In particular, the Government of India slashed its corporate tax by nearly 10 per cent,

which is a revolutionary step and certainly going to promote start-ups and the whole corporate sector. The IT industry of India will also get a boost from this bold economic reform initiative as most of the start-ups are from the technology sector. These recent initiatives by the government are certainly going to address the issues faced by the IT industry and enhance the reputation of the corporate face of India.

8.4 Limitations and Future Research

Like in any research study, the current study has also some limitations. However, the limitations enhance the scope for future research. Due to time and money constraints, the efficiency performance of IT firms in India was restricted to the study of selected eighteen IT firms in India. This study can be extended to include a greater number of IT firms. Also, an efficiency analysis of IT firms in India can be done for the period before recession and after recession. Moreover, this study can also be extended to examine the efficiency of IT firms of the developed countries such as USA, Canada, UK, and Australia, as well as of the new emerging economies. The software product companies can be included in the study. Further, the study may be extended to evaluate other factors influencing the efficiency of IT software service companies in India, and to compare them, to detect any differences made by their impact. The study can be further enhanced to include Research and development expenses as one of the input variables.

The study can be extended by researchers to explore IT-led growth hypothesis on IT enabled services, IT hardware companies in India, and on the global set of data from IT companies. The study can be extended to include a greater number of foreign currencies in order to mitigate FOREX risk arising from different parts of the world. This study analyzed the FOREX rate risk exposure with respect to US Dollar and euro only. The Great Britain and Australia New Zealand regions also have a good volume of IT exports from India. Thus, the impact of FOREX rate risk exposure can be studied separately for each foreign currency, (De Jong et al., 2006). Further, the study can be extended to include a greater number of IT firms, as each IT firm has unique characteristics and work culture, although the structure of the IT firms in India is oligopolistic in nature.

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APPENDIX A

DEA Methodology - Models

CCR Model

Assuming that there are 'n' DMUs (DMUj; j=1,...,n), the relative efficiency of DMUj is calculated by a production process of 'm' inputs (x_{ij}; i= 1, …..,m) to yield 's' outputs (y_{rj}; r = 1,….,s). The ratio of virtual output to virtual input of any DMU_k called the efficiency E_k of the k^{th} DMU, is to be maximized with the condition that the ratio of virtual output to virtual input of every DMU should be less than or equal to unity, (Cooper, Seiford & Tone, 2007; Puri & Yadav, 2013; Sahoo & Nauriyal, 2014; Goyal et al., 2020; Goyal et al., 2021). By using Charnes Cooper transformation, the CCR ratio model can be replaced by an equivalent linear programming problem (Cooper, Seiford & Tone, 2007; Puri & Yadav, 2013; Avkiran, 2006).

Nomenclature: where,

- y_{rk} : Amount of the r^{th}output produced by the k^{th} DMU.
- x_{ik} : Amount of the i^{th} input produced by the k^{th} DMU.
- v_i^k, u_r^k : weights corresponding to the i^{th} input and r^{th} output of the k^{th} DMU respectively.

Max $E_k = \sum_{r=1}^{s} u_r^k y_{rk}$

Subject to $\sum_{i=1}^{m} v_i^k x_{ik} = 1,$ -- (A.1)

$$\sum_{r=1}^{s} u_r^k y_{rj} - \sum_{i=1}^{m} v_i^k x_{ij} \le 0, \forall j = 1,....,n,$$

$$u_r^k \ge 0, v_i^k \ge 0, \forall r = 1,....,s, \forall i = 1,.....,m, \forall k = 1,....,n.$$

Model 1 depicts that the objective is to maximize the virtual output of DMU_k subject to unit virtual input of DMU_k while maintaining the condition that virtual output cannot exceed virtual input for every DMU. This is called CCR multiplier model

whose dual linear programming problem is as provided below. Model 2 is commonly known as CCR envelopment model.

Nomenclature: where,

- s_{rk}^{+} : slack in the rthoutput of the kth DMU.
- s_{ik}^{-} : slack in the ith input of the kth DMU.
- λ_{jk} : non-negative dual variables
- θ_k (scalar) is the (proportional) reduction applied simultaneously to all inputs and results in a radial movement towards the envelopment surface.

Min $Z_k = \theta_k$ - (A.2)

Subject to $\sum_{j=1}^{n} \lambda_{jk} y_{rj} - s_{rk}^{+} = y_{rk} \forall r = 1,\ldots..,s,$

$$\sum_{j=1}^{n} \lambda_{jk} x_{jk} + s_{ik}^{-} = \theta_k x_{ik} \forall i = 1,\ldots..,m,$$

$$\lambda_{jk} \geq 0 \forall j = 1,\ldots.,n,$$

$$\theta_k is \cdot unrestricted \cdot in \cdot sign,$$
$$s_{rk}^{+}, s_{ik}^{-} \geq 0 \forall r = 1,.....,s, \forall i = 1,.....,m,$$
$$k = 1,.....,n.$$

The non-zero slacks and/or $\theta_k^{*} \leq 1$ identifies the sources and amount of any inefficiency that may exist in the DMU_k. If the optimal value λ_{jk}^{*} of λ_{jk} is non-zero then the jth DMU represents the reference set (peers) of the kth DMU. The reference set depicts how outputs can be increased and inputs decreased to make the kth DMU efficient.

BCC model

BCC model is a different version of DEA (Cooper, Seiford&Tone, 2007; Puri& Yadav, 2013; Puri& Yadav, 2017; Avkiran, 2006). In this model, λ_{jk} 's are restricted summing to one which is known as convexity constraint. PTE is calculated using BCC

model for the given DMU (Cooper, Seiford & Tone, 2007). Further, scale efficiency is defined as below.

$$Scale\ Efficiency\ of\ k^{th}\ DMU = \frac{OTE\ of\ k^{th}\ DMU}{PTE\ of\ k^{th}\ DMU} \quad \text{- (A.3)}$$

Target Setting

The DEA analysis further helps in setting up target for the inefficient DMUs to make it efficient. The input-output level can be used as the basis for setting targets for the inefficient k^{th} DMU as follows,

Nomenclature: where,

- $\overline{x_k}$: target input for the k^{th} DMU.
- $\overline{y_k}$: target output for the k^{th} DMU.
- x_i : actual input of the k^{th} DMU.
- y_i : actual output of the k^{th} DMU.
- θ : optimal efficiency score of the k^{th} DMU.
- s_k^+ : optimal output slack of the k^{th} DMU.
- s_k^- : optimal input slack of the k^{th} DMU.

$$\begin{aligned} \bar{x}_k &= x_k - S_k^- \\ \bar{y}_k &= \theta y_k + S_k^+ \end{aligned} \quad \text{- (A.4)}$$

The input-output level ($\bar{x}_i, \bar{y}_i$) provides information on how much the inputs can be reduced or outputs can be increased for the particular DMU in order to make it efficient (Cooper, Seiford&Tone, 2007; Puri& Yadav, 2013; Puri& Yadav, 2017; Avkiran, 2006).

APPENDIX B

Table B-1: Technical Abbreviations (in alphabetical order)

Abbreviation	Full Form	Definition
AOTE	average overall technical efficiency	Average of the OTE measured for selected IT companies
AOTIE	average overall technical inefficiency	AOTIE = (1-AOTE)*100
APTE	average pure technical efficiency	Average of the PTE measured for selected IT companies
PTIE	average pure technical inefficiency	APTIE = (1-APTE)*100
ASE	average scale efficiency	Average of the SE measured for selected IT companies
ASIE	average scale inefficiency	ASIE = (1-ASE)*100
CRS	constant returns to scale	on increasing the inputs by x times, output will be increased by x times.
DRS	decreasing returns to scale	on increasing the inputs by x times, output will be increased by less than x times. DRS implies that company is too large to utilize its scale effectively.
IRS	increasing returns to scale	on increasing the inputs by x times, output will be increased by greater than x times. IRS means IT company is too small for its scale operations.
OTE	overall technical efficiency	Measured using CCR model. The inefficiencies due to inputs and outputs because of size of the company are reflected through OTE scores.
OTIE	overall technical inefficiency	(1-OTE)*100
PTE	pure technical efficiency	Measured using BCC model. PTE represents the managerial efficiency of the DMUs to utilize the inputs in the production process.
PTIE	pure technical inefficiency	(1-PTE)*100
SE	scale efficiency	To measure the effect of magnitude of the DMU. SE = OPE/PTE
SIE	scale inefficiency	(1-SE)*100
Source: Author's compilation		

APPENDIX C

Descriptive Data used for this study

Table C-1: Descriptive Data of Input and Output variables selected for this study (2010-2017) – used for DEA Analysis

Year	Sales Turnover{O}	Net Profit {O}	Total Asset Size {I}	Employee Cost {I}	Total Expenses {I}	Tax {I}
2010	49119.17	11499.11	61707.50	22624.11	39520.72	2064.44
2011	58945.39	13205.28	69424.22	28000.22	47784.28	2699.11
2012	72417.44	16533.44	83927.39	34747.28	60720.28	4577.72
2013	85728.11	19493.50	100016.39	42498.39	70336.50	5451.78
2014	111108.78	27012.50	127297.11	53480.17	90319.89	8165.78
2015	121418.94	28638.39	142774.00	59789.44	100669.06	8717.44
2016	134062.94	30911.22	161081.06	64735.00	110576.11	6857.61
2017	155044.00	35096.47	188779.94	75650.00	128382.59	10363.00
Note: Yearly Average data for all selected IT companies in Rs. Crores.						

Table C-2: Descriptive Data of Input and Output variables selected for this study (2017) – used for DEA Analysis

IT Company	Sales Turnover{O}	Net Profit {O}	Total Asset Size {I}	Employee Cost {I}	Total Expenses {I}	Tax {I}
TCS	926980	236530	906820	481160	737280	64130
INFY	593540	138180	805940	309440	490750	51200
WIPRO	456396	81617	636486	218544	403692	25254
HCL	193183	68727	326538	69257	133659	14030
TECHM	231763	30473	246473	78027	214523	8314
ORCLF	38784	12881	51023	18109	30336	3945
MNDTR	47526	4891	34950	30215	43268	1426
MPHSI	29522	6250	54907	13791	25786	2013
HXWR	13930	3561	16819	7258	10799	943
CYENT	12936	2369	26941	6781	11544	501
PRSTN	17330	2940	21020	8732	15344	1097
TLXI	12331	1733	9773	6717	10780	882
ZNSR	12825	1802	13463	7116	11253	728
NIIT	15951	1649	19327	9501	14100	319
POLRS	15110	993	10508	10979	13723	590
HNDG	15975	1015	14100	10397	14688	545
HNDV	1666	1029	14171	26	979	254

Table C-3: Descriptive Data of Input and Output variables - used for MC-DEA Analysis

		DMSU (FSI)			DMSU (MFG)			DMSU (RCL)			DMSU (ERU)			DMSU (CME)			DMSU (LSH)				
	DMU	Employee (I1)	Operating profit (O1)	RP per employee (O2)	Employee (I1)	Operating profit (O1)	RP per employee (O2)	Employee (I1)	Operating profit (O1)	RP per employee (O2)	Employee (I1)	Operating profit (O1)	RP per employee (O2)	Employee (I1)	Operating profit (O1)	RP per employee (O2)	Employee (I1)	Operating profit (O1)	RP per employee	Other expenses (SI2)	Revenue loss (SO3)
2014	INFY	38983	10873	0.94	31620	6130	0.86	23076	5553	0.91	7418	2016	0.94	13776	3744	0.94	9975	1873	0.85	33515	46622
	TCS	105437	28789	0.83	22048	5128	0.79	34145	9184	0.83	10107	2068	0.76	30686	6871	0.78	15555	3178	0.76	86840	65278
	WPR	32177	6038	0.82	22463	4337	0.83	16248	2928	0.82	18268	4355	0.88	17102	2892	0.81	13138	1909	0.78	41767	55916
	CTS	59015	19605	1.00	8703	3094	1.02	11604	4126	1.02	8703	3094	1.02	15875	5100	0.99	34230	13130	1.05	50728	53982
	ACCN	55329	14792	1.69	34758	7372	1.64	34886	7708	1.65	43784	14098	1.75	32824	6737	1.63	27028	5681	1.64	164622	61758
2015	INFY	40327	11278	0.94	29168	6268	0.87	23019	6663	0.95	8962	2318	0.92	16644	4304	0.92	12389	2870	0.89	36688	45354
	TCS	112383	26486	0.86	28092	5558	0.82	38385	8136	0.84	11756	2326	0.82	32818	6927	0.83	18567	3621	0.82	99018	54787
	WPR	33272	6845	0.87	23844	4282	0.84	16651	2968	0.84	20126	4473	0.89	17921	3394	0.85	14840	2641	0.84	45933	51816
	CTS	71784	20166	0.94	10031	3143	0.98	13374	4190	0.98	10031	3143	0.98	19687	6024	0.97	47832	13486	0.95	61228	69598
	ACCN	61776	15409	1.64	40243	8977	1.62	39300	9232	1.63	46995	12348	1.66	36823	7861	1.61	32407	7312	1.62	174122	55349
2016	INFY	44155	12098	0.97	17896	5000	1.01	26780	7093	0.95	12321	3358	0.96	22881	6236	0.96	21258	5703	0.96	44173	52108
	TCS	121921	32023	0.91	31080	7286	0.88	43169	10034	0.88	12400	3025	0.89	32860	8510	0.90	21831	5326	0.89	80110	60785
	WPR	37371	7036	0.86	27308	4438	0.83	20328	3127	0.82	21110	3596	0.84	19572	3079	0.83	17227	3040	0.85	51366	58470
	CTS	72356	28110	1.16	10103	4130	1.18	13470	5507	1.18	10103	4130	1.18	20499	7909	1.16	52022	20445	1.17	78419	83903
	ACCN	70255	17993	1.57	45954	10300	1.53	45810	9839	1.52	52876	10419	1.51	42966	9957	1.54	40962	8180	1.51	189308	57162
2017	INFY	46477	13025	1.00	19718	4618	0.96	27778	8123	1.01	13405	3881	1.01	24894	7207	1.01	21346	5770	0.99	48880	49562
	TCS	134580	32745	0.88	34863	8935	0.90	57539	14350	0.89	15060	2987	0.84	54641	13880	0.89	26241	5205	0.84	85523	69178
	WPR	39878	6235	0.85	29223	4984	0.87	19803	2899	0.84	19553	3605	0.88	20578	2960	0.84	26134	2370	0.79	56320	55002
	CTS	83785	28090	1.09	12828	4199	1.09	17103	5598	1.09	12828	4199	1.09	25802	8174	1.08	62678	18965	1.06	87821	89085
	ACCN	76096	19516	1.59	46339	11078	1.57	52805	13779	1.59	52954	9593	1.51	48840	10663	1.55	46011	10535	1.56	204731	52672

Table C-4: Year-wise Quarterly Average Data for IT companies. (Rs Mn.) - used for IT-Led Growth Analysis

	Aggregate Net Sales	Aggregate Net Profit After Tax
2010	312480.38	63334.98
2011	378591.30	74537.00
2012	438122.25	89250.45
2013	513550.38	106652.85
2014	577321.00	131334.10
2015	640453.25	132050.23
2016	706130.75	151577.58
2017	735901.60	165785.00

Table C-5: Year-wise Quarterly Average Net Profit data for selected IT companies. (Rs Mn.) – used for Exchange Rate Analysis

	2010	2011	2012	2013	2014	2015	2016	2017
TCS	17152.70	26417.05	30824.70	42152.95	51070.55	52010.65	58870.00	60795.00
INFY	15357.50	18602.50	23925.00	24040.00	30057.50	30815.00	34115.00	41400.00
WIPRO	11856.75	11678.50	13648.75	16292.25	21011.50	20922.00	19579.00	20672.75
HCL	2453.10	4022.30	6208.65	12172.53	16854.53	15122.15	17058.78	18105.00
TECHM	1865.30	1407.00	1492.60	5744.90	5876.48	7096.33	8062.13	9008.55
ORCLF	1945.28	2312.28	3156.25	2838.05	2839.88	2233.08	3006.33	2800.30
MNDTR	365.00	454.25	823.00	1079.25	1265.00	1356.00	1281.00	1430.00
MPHSI	2407.70	1801.28	1532.13	1362.75	1267.95	1258.25	1354.43	1717.93

Table C-6: Year-wise Quarterly Average Stock Price data for selected IT companies. (Rs Mn.) - used for Exchange Rate Analysis

	2010	2011	2012	2013	2014	2015	2016	2017
TCS	904.89	1140.40	1249.49	1796.96	2460.15	2531.54	2464.00	2483.21
INFY	743.10	715.19	638.75	742.76	888.46	1089.66	1109.38	973.63
WIPRO	218.48	204.43	201.74	227.51	279.71	291.11	259.17	277.69
HCL	199.81	220.81	269.39	490.43	774.79	934.58	792.96	872.20
TECHM	190.44	158.98	208.18	330.53	564.14	546.83	472.61	450.51
ORCLF	2281.75	2005.50	2870.18	2898.68	3251.01	3679.74	3330.40	3780.96
MNDTR	138.14	95.78	154.80	281.35	500.12	690.46	580.00	513.65
MPHSI	619.23	373.15	390.35	409.21	410.69	424.89	537.25	631.01

APPENDIX D

Step-wise Process/Algorithm followed for execution of MC-DEA Model

Step 1. Five multinational IT software services companies (DMUs) were selected as a sample. Quarterly segmental data from 2014 to 2017 was collated for the selected IT companies. The identified five IT companies (DMUs) in their respective financial reports were selected. Refer Section 5.3.

Step 2. The production process of a multi-component DMU_k employed in this study is depicted in Figure 5.2.

Step 3. The Input and Output variables selected are identified. See Section 5.3.1.

Step 4. The selected IT companies provide a) segment-wise revenue and b) segment-wise operating profit at DMSU level in their respective quarterly and annual reports. Further, following assumptions were taken to calculate the data for rest of the variables.

1. Per employee cost is same across the organization. This is based on the assumption that an employee is hired for the organization and can work in any of the DMSUs and any geography.

2. The major expense of IT companies is on employee cost.

3. Revenue productivity is revenue earned/employee.

4. Not utilized employees or employees on bench in the organization amounts to revenue loss.

The data used for evaluation is provided in Table C-2, Appendix C.

Step 5. The efficiency measures for each DMU (IT Company) and its DMSUs were evaluated using the MATLAB program of Model- 4 with assurance regions. Refer Section 5.2.1 and Section 5.4.

APPENDIX E

List of Publications

1. Goyal, S., Sah, A. N., Sharma, R. K., & Puri, J. (2020). Estimating technical efficiencies of Indian IT companies for setting improvement targets for inefficient companies: An empirical analysis with workers' effort as key input. *Work*, *66*(4), 885-900.
2. Goyal, S., Sah, A. N., & Puri, J. (2021). Effectiveness of Top-Tier Information Technology Software Service Companies: A Multi-Component Perspective**.** *Journal of Global Information Technology Management*, *24*(2), 98-119.

APPENDIX F

Papers Presented in Conferences

Goyal, Sumit & Puri, Jolly (2019). Effectiveness of Energy Sector in Top-tier Information Technology Software Service Companies across the World: A Multi-Component Perspective, *International Conference on Measurement of Efficiency and Productivity in Emerging Economies*, South Asian University, New Delhi .