IMPLEMENTATION OF SIX SIGMA IN INDIAN MANUFACTURING INDUSTRIES

A DISSERTATION

SUBMITTED IN PARTIAL FULFILMENT OF THE

REQUIREMENT FOR

THE AWARD OF THE DEGREE

OF

MASTER OF TECHNOLOGY

IN

[PRODUCTION ENGINEERING]

Submitted by

[MR. ASHSISH VASHISTHA]

(Roll No- 2k11/PIE/02)

Under the supervision of

PROF. QASIM MURTAZA

(Professor)

DEPARTMENT OF MECHANICAL ENGINEERING
DELHI TECHNOLOGICAL UNIVERSITY
(Formerly Delhi College of Engineering)
Bawana Road, Delhi -110042.

CANDIDATE'S DECLARATION

I, Ashsih Vashistha, 2k11/PIE/02hereby declare that the major project dissertation titled "IMPLEMENTATION OF SIX SIGMA IN INDIAN MANUFACTURING INDUSTRIES" Submitted to the department of MECHANICAL, PRODUCTION AND INDUSTRIAL ENGINEERING, Delhi Technological University Delhi in partial fulfilment of the requirement for the award of the **Master of Technology, in Production & Industrial Engineering** was original not copied from any source without paper citation. This was further to declare that the work embodied in this report has not previously formed the basis for the award of any Degree, Diploma, Fellowship, or other similar title or recognition.

Place: Delhi **Ashish Vashistha**

Date: **(2k11/PIE/02)**

CERTIFICATE

I hereby certify that the major project entitled **"IMPLEMENTATION OF SIX SIGMA IN INDIAN MANUFACTURING INDUSTRIES"** in partial fulfilment of the requirements for the award of the degree of **Master Of Technology In Production & Industrial Engineering** and submitted to the department of mechanical, production and Industrial engineering of Delhi technological University has been an authentic record work of **Mr. Ashish Vashistha, (2k11/PIE/02)** carried out under my supervision.

It is to further certify that the matter embodied in this report has not been submitted to any other university or institution by him for the award of any other Degree/certificate and the declaration made by him is correct to the best of my knowledge and belief.

Prof. Qasim Murtaza,
Professor
Department of Mechanical Engineering
Delhi Technological University

Place:

Date:

ACKNOWLEDGEMENT

I would like to express my special thanks to **Prof. Qasim Murtaza** for their guidance, unwavering support and encouragement. This project work could not have attained its present form, both in content and presentation, without his active interest, direction and guidance. His personal care has been the source of great inspiration. He has devoted his valuable time and took personal care in motivating me whenever I was disheartened.

I would like to thank Prof. Vipin, HOD (Mechanical Engineering department), Dr. N. Yuvraj, Prof. Vijay Gautam for their support and guidance, although they had a very busy schedule in managing the corporate and academic affairs.

I am thankful to the Technical Staff of Delhi Technological University, Mr. Girish Anand, Mr. Om Prakash, Mr. Tek Chand for their support.

My deep and sincere gratitude to my family for their continuous an unparalleled love, help and support. I am grateful to my brothers for always being there for me as a friend and always with me in every situation. I am forever indebted to my parents for giving me the opportunities and experiences that have made me who I am. They selflessly encouraged me to explore new direction in life and seek my own destiny. This journey would not have been possible if not for them, and I dedicate this milestone to them. I cannot forgot to take the name of my cousin for helping me to manage the time and managing my journey to complete the project work.

I also want to thanks all those who directly or indirectly support me for my project.

Mr. Ashish Vashistha,

2k11/PIE/02

INDEX

LIST OF FIGURE

LIST OF TABLE

LIST OF ABBREVIATION

TQM	Total Quality Management
ISM	Interpretive Structural Modeling
SEM	Structural Equation Modeling
DPMO	Defects Per Million Opportunities
CTQ	Critical-To-Quality
SCM	Supply Chain Management
TOC	Theory of Constraints
ERP	Enterprise Resource Planning
ISI	Indian Statistical Institute
CAGR	Compounded Annual Growth Rate
ACMA	Auto Component Manufacturers Association
SPSS	Statistical Package of Social Science
TMCL	Top Management Commitment and Leadership
TRE	Training and Education
PSE	Project Selection and Execution Methodology
CRM	Customer Relationship Management

ECS	Effective Information Technology and Communication System
QIT	Quality Improvement Tools and Techniques
SCM	Supply Chain Management
HRM	Human Resource Management
STD	Standardization

Abstract

Higher Productivity achievement is very crucial factor for the field of production. With the High productivity various other factors must be taken in to consideration in manufacturing industries such as global competitors, diversity in product range, lead time and customer demand in terms of quality and quantity. A new benchmark called Six Sigma has been invented for dealing with all these needs. Six sigma is a quality initiative which reduces variations in a process and helps to lower the cost of product as well as process. To sustain in today's global completion, organizations key to long-term success is being able to do certain things better than your competitors can do. Hence many companies are in the process of trying to 'do it right the first time' in every process of the business like new product development, supply chain management, marketing and manufacturing processes also. Traditional manufacturing approaches are no longer sufficiently competitive weapons by themselves. Organizations must consequently develop new methods and perspectives to meet these market needs in a timely and cost effective manner. In response to this, many organizations have started to adopt different philosophies like Total Quality Management, Total Preventive Maintenance, Six Sigma, Lean Enterprise etc., in their business processes to stay in the competitive world market.

In the pursuit of improved operational performance and higher customer satisfaction, six sigma has been recognized as a systematic and structured methodology that attempts to improve process capability through focusing on customer needs. Although many Indian industries have started embraced the six sigma business improvement strategy, the adoption of said strategy in Indian industries is not as encouraging as it should be. There is no clear consensus among the manufacturers about six sigma implementation and also the absence of a practical and detailed framework to follow is an issue of concern to those organizations interested to implement six sigma principles especially for Indian organizations. Hence, there is a need for an empirical investigation of six sigma in the Indian industry.

To fulfill this requirement this study was undertaken. In the first phase literature review of six sigma is undertaken and the existing frameworks for six sigma were identified. Their validity and reliability in the present Indian industrial scenario was analyzed. It was found that none of the existing frameworks were fulfilling the requirements of the present

manufacturing scenario. Hence, a framework for six sigma was proposed. The proposed framework was developed by performing a comparative analysis of the existing frameworks and empirical data collected from validation of existing six sigma frameworks. The proposed framework is represented in the form of a house having nine pillars supporting the roof of six sigma. The foundation was made up of key element top management commitment and leadership.

To validate the same the systematic approach for empirical investigation was used. A survey instrument was developed to do empirical study across five important sectors of Indian manufacturing industry viz. – automobile, electrical and electronics, machines and equipment's, process industries and textile. Further, the data obtained from the survey is subjected to statistical analysis using statistical computing package SPSS® 18.0v. Various data analysis methods such as descriptive statistics, correlation analysis, reliability and validity analysis, factor analysis and inter item analysis were used and the analysis indicated that the developed framework is valid in the Indian scenario. Apart from the ISM model and structural equation modeling were also used. Finally, the applicability of the proposed framework for six sigma was checked by providing empirical survey and ISM model also. Thus, it is believed that the proposed framework can help the managers to understand the various initiatives they have to take, to move towards implementation of six sigma and being the best or excellent organizational activities.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Six sigma is a taught and information driven approach that was created to upgrade item quality and friends productivity by improving assembling and business forms [1-2]. It is viewed as the most recent and best system in quality building. Execution of six sigma in an association brings about considerable addition in their benefit, limits a wide range of waste and augments consumer loyalty [3]. Six sigma improves the quality yield of a procedure by recognizing and expelling the reasons for deserts and limiting changeability in assembling and business forms which diminishes cost and builds benefit [4-5]. The historical backdrop of value is as old as progress. Different quality administration procedures have been applied for a long time and those systems are consistently associated with the quality improvement for the consumer loyalty's. There are a few distinct meanings of the Quality Concept and various assessments of what ought to be enveloped in the idea of item quality. "The nature of an item is its capacity to fulfill and ideally surpass the necessities and desires for the clients". In the later history of the quality advancement, the quality improvement program Six Sigma has been fruitful. Six Sigma was made at Motorola during the 1980s. Attributable to Six Sigma, Motorola figured out how to diminish their low quality expenses and abatement variety in numerous procedures. Thus, Motorola turned into the primary beneficiary of America's Malcolm Baldrige National Quality Award in 1988. Six Sigma is one of the last increments in the field of value improvement strategies as well as business process enhancements techniques. In spite of the fact that it has been executed for a long time for the most part in huge assembling organizations, as Motorola, GE and Honeywell and so on. Six Sigma drives predominantly to decrease of low quality expense.

The DPMO concept is not just a slogan but a much grounded way to measure how successfully Six Sigma objectives are implemented. Current manufacturing environment have become extremely competitive due to global competition, rapidly changing

technologies and shorter product life cycles. Organizations face significant uncertainties and continuous changes. Traditional quality improvement approaches used by the companies are no longer sufficiently competitive weapons by themselves. Customers always demands of high quality, low cost products and services.

Organizations must consequently look for new methods and perspectives to meet these customer demands in a timely and cost effective manner. Embracing practices like six sigma will create world class organizations, produce high quality products and can deal with these challenges. An organization, which is following quality practices like six sigma, possesses a set of strategic options and can deal effectively to ever changing and volatile environments. Six sigma is one of the fastest evolving areas of interest to industries and practitioners because it is a powerful business improvement strategy that enables companies to use simple but powerful statistical methods for achieving and sustaining operational excellence and many companies have reported significant benefits of implementation of six sigma.

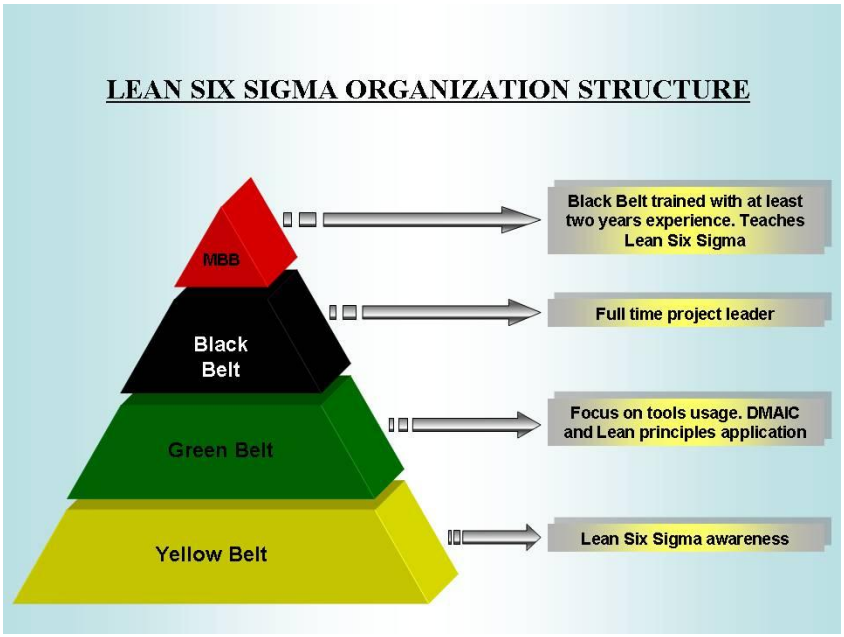

Figure No 1: Six Sigma Organization Structure

Varieties of definitions are available for the said concept. Prominent ones are discussed below. “Six sigma is a systematic, highly disciplined, customer-centric and profit-driven organization-wide strategic business improvement initiative that is based on a rigorous process focused and data-driven methodology”. It attempts to achieve customer

satisfaction by systematically reducing variation in processes and thereby promotes a competitive advantage. “Six sigma is considered a strategic corporate initiative to boost profitability, increase market share and improve customer satisfaction through statistical tools and techniques that can lead to breakthrough quantum gains in quality”. “Six sigma blends management, financial and methodological elements to make improvement to processes and products concurrently”. “Six sigma provides business leaders and executives with the strategy, methods, tools and techniques to change the culture of organizations”. “Six sigma as a philosophy seeks to measure current performance and determine how desired or optimum performance can be achieved. Any deviation in the performance of any critical-to-quality characteristic may be considered a defect”

1.2 Need for empirical investigation of six sigma practices in Indian industry

It utilizes a lot of value the executive’s strategies, for the most part exact and factual techniques. It makes an extraordinary foundation of individuals inside the association who are specialists in these techniques. It is a business system that enables organizations to apply logical strategies to improve their exhibition radically by structuring and observing ordinary business exercises in a manner that limit waste and assets while expanding consumer loyalty [6].Six sigma is an incredible business improvement procedure which empowers organizations to accomplish and continue operational greatness by utilizing basic however ground-breaking measurable techniques. The term Six sigma started from phrasing related with assembling, explicitly terms related with measurable displaying of assembling forms. In the wake of doing overview of Indian ventures about use of six sigma, announced that Indian enterprises need generally operational and administration greatness to contend all around and are at present occupied with Quality Circles, Total Quality Management (TQM) and ISO Certifications. The study also reported that, these methods have failed to deliver required performance in Indian industries over the last decade or so. It seems that six sigma is yet not fully explored by Indian industries. During industrial reforms, initially the focus has been on large-scale public and private sectors, mainly in core infrastructural production organizations. After globalization and liberalization, quality was viewed as one of the major areas to improve along with productivity. In view of reduction in geographical

barriers and pressure to compete in the global market, improvement in overall operational and service excellence has surfaced as important parameter for the Indian industries to remain globally competitive.

Figure No 2: Six Sigma Themes

With the intense competition, customers started demanding higher quality products and services from organizations. As a result organizations started looking for newer ways in order to improve their operational efficiency to meet customer expectations. In order to improve operational performance and customer satisfaction, six sigma has been recognized as a systematic and structured methodology that attempts to improve process capability through focusing on customer needs. Described six sigma "as an approach form organizational change, which incorporates elements of quality management and business process re-engineering". General Electric's operating margins increased from 13.8% to 14.5%, an increase valued at about $600 Million, which resulted from six sigma quality initiatives. In 2002, at least 25% of Fortune 200 companies claimed they have the six sigma programmer. By focusing on needs and defining quantifiable measures for achieving specific goals, six sigma projects result in greater customer satisfaction, and enhance organizational performance and profitability. during survey on Indian companies has collected some interesting data on usage, awareness and status of six sigma and stated

that, “although many Indian industries have successfully embraced the six sigma business improvement strategy, the adoption of said strategy in Indian industries is not as encouraging as it should be.”

At first organizations like Motorola, Honeywell, GE, Sony, Caterpillar, and Johnson Controls guaranteed significant money related advantages from six sigma usage and consequently there was increment in the appropriation of six sigma in different organizations additionally However, regardless of the asserted advantages from TQM and six sigma execution, there are various reports of issues during the time spent actualizing them. So as to have better knowledge and comprehension about whether and how quality administration methodologies influence hierarchical execution, it is important to contemplate the authoritative settings in which these methodologies have been actualized.

Organizations, for example, General Electric and Motorola have revealed extensive reserve funds from the six sigma activities. Anyway pundits of six sigma contend that different quality-based activities will come up short on account of the extreme business aggressiveness. Henceforth there is a need to address the issue of viable execution of six sigma. We accept that building up a structure of six sigma execution will support specialists and experts to pick up knowledge into its viable usage. It will likewise help associations for powerful usage of their assets and will be profited by this system.

The purpose of this work is to develop a six sigma framework for effective implementation with special reference to Indian industries. We will begin by defining the methodology and identify key variables and crucial factors for its successful implementation. In order to develop a framework that can suggest Indian industries as to what are the best practices in six sigma, or in other words what practices constitute a six sigma implementation framework, an empirical investigation of six sigma practices in Indian industry has been carried out.

Limited empirical research has been carried out in terms of application of six sigma in Indian industry. The role of an empirical study is pivotal in presenting the facts. Thus this empirical study intends to develop a framework for Indian industry and overcome the

shortcomings (found from literature review) generally present in empirical studies such as:

- Emphasis on theory verification is less in comparison to theory building.
- Performance measurement indices are generally applied at firm level only.
- Empirical studies are generally focused on North America or Europe.
- Research designs like panel study and use of focus group are very rare and seldom used by researchers in six sigma.
- Empirical studies suffer from small sample sizes.
- The potential of multi variety data analysis techniques is not utilized to a larger extent.
- Involvement of practitioners and consultants is very limited in development of six sigma frameworks.
- Majority of frameworks are novel and very few authors actually adapt and improve on already existing frameworks
- Framework verification is not a standard practice of researchers.

Hence, the proposed research will focus on addressing all these shortcomings while making efforts to present an empirical investigation of six sigma practices in Indian industry.

We believe that the proposed framework can serve as a guideline for further research in implementing the concept at the same time helping organizations to oversee their quality programmers.

1.3 Objectives of the research

The overall objective of the present study is to do an empirical investigation of six sigma implementation in Indian industry. The overall objective is achieved by focusing on following sub objectives:

1. To study existing frameworks/elements/constructs for six sigma implementation as suggested by various authors through in-depth literature review.
2. To evaluate reliability and validity of identified frameworks
3. To develop a new framework suitable for Indian Manufacturing Industries

4. To evaluate reliability and validity of suggested framework in context to Indian Manufacturing Industries
5. To explore the applicability of proposed six sigma implementation framework in Indian Manufacturing Industries

1.4 Methodology

Methodology used to achieve the objectives defined in the previous section is given below:

1. A thorough review of literature related to six sigma elements/constructs/frameworks
2. Development and testing of a survey instrument.
3. Data collection from Indian automobile, electronics, engineering, process and manufacturing industries.
4. A comparative analysis of six sigma frameworks and frequency analysis of six sigma constructs in these frameworks is carried out in order to identify the prominent constructs (referred as pillars of six sigma), which will eventually lead to development of a conceptual six sigma implementation framework
5. Evaluation of reliability and validity of six sigma implementation constructs in Indian industry so as to establish a definitive set of pillars and constructs for six sigma implementation framework. It is achieved by performing a survey in nine sectors of Indian industry followed by principle component analysis, internal consistency analysis and confirmatory factor analysis to find underlying pillars of six sigma implementation framework
6. Development of a six sigma framework for Indian industry
7. Validity and reliability analysis on proposed six sigma framework in Indian manufacturing industries with the help of empirical survey.
8. Path analysis of six sigma framework in Indian manufacturing industry.

It involves:

- ✓ Development of interpretive structural modeling (ISM) for six sigma framework in Indian manufacturing industry.
- ✓ Development of structural equation modeling (SEM) for statistical testing and path analysis.

1.5 Scope and limitations

The proposed study is based on the secondary data available through published research papers. Primary data has been collected for the selected parameters through direct consultation with practitioners. The work is purely empirical in nature. This work is primarily applicable to manufacturing industry in India but can be extended to any other industry.

1.6 Organization of the thesis

The thesis is organized into seven chapters;

1. Chapter one includes introduction, background of the research work, objectives, scope and limitations of the study.
2. Chapter two discusses the in-depth literature review about important six sigma constructs/frameworks.
3. Chapter three presents research methodology, questionnaire design and data collection process used for the study.
4. Chapter four discusses the validity and reliability of existing six sigma implementation frameworks in Indian industries. It also carries out a critical review of six sigma frameworks and frequency analysis of six sigma constructs in these frameworks is carried out in order to identify the prominent constructs (referred as pillars of six sigma), which will eventually lead to development of a conceptual six sigma framework.
5. The development of a framework for six sigma implementation is discussed in the Chapter five.
6. The chapter six describes an empirical investigation of proposed six sigma implementation in Indian industry and demonstrates the applicability of proposed framework. The study also performed path analysis of proposed six sigma framework in Indian manufacturing company.
7. The summary of the work done, contributions of the research, limitations of the study and scope for future work is presented in Chapter seven.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction/Research Gap

Antony and Banuelas, (2002). Six sigma is a leap forward procedure improvement methodology that yields emotional decrease in deformities or blunders or errors in any procedure. Improved procedures lead to improved consumer loyalty, expanded piece of the pie, business benefit, etc. "Six sigma is an incredible methodology created to quicken improvement in item, procedure and administration quality by perseveringly concentrating on variety decrease and disposal of waste". It is viewed as one of the essential designers of six sigma. Give understanding to what six sigma is around; a change methodology that constantly drives deformities out of items, procedures, and administrations to expand productivity and shows how it is functioning at organizations, for example, General Electric, Polaroid, and Allied Signal. It is a thorough and adaptable framework for accomplishing, continuing and boosting business gainfulness. It is extraordinarily determined by close comprehension of client needs of today and tomorrow, taught and orderly utilization of information to help choices and persistent thoughtfulness regarding overseeing and improving business forms. Albeit six sigma way to deal with quality and procedure improvement have been dominatingly utilized by assembling associations, today the ubiquity of six sigma in different areas is developing exponentially, particularly in banks, emergency clinic segment, budgetary administrations, aircraft industry, utility administrations, etc.

(Antony et al.2007). Give understanding to what six sigma is around; a change procedure that tirelessly drives deformities out of items, procedures, and administrations to build gainfulness and shows how it is functioning at organizations, for example, General Electric, Polaroid, and Allied Signal. It is a complete and adaptable framework

for accomplishing, supporting and expanding business benefit. It is interestingly determined by close comprehension of client needs of today and tomorrow, restrained and deliberate utilization of information to help choices and persistent consideration regarding overseeing and improving business forms. Albeit six sigma way to deal with quality and procedure improvement have been prevalently utilized by assembling associations, today the prominence of six sigma in different divisions is developing exponentially, particularly in banks, medical clinic area, money related administrations, aircraft industry, utility administrations, etc

Ronald Snee (1999) calls attention to that "albeit a few people trust it is the same old thing, six sigma is one of a kind in its methodology and sending; it is a key business improvement approach that looks to increment both consumer loyalty and an association's money related wellbeing". Numerous creators have proposed distinctive meaning of six sigma and not many of them are recorded beneath. Following are a portion of the instances of six sigma definitions that reflect alternate points of view. Six sigma has been the subject important to numerous specialists throughout the years. Six sigma procedures improve quality and produce enormous cost investment funds. Numerous analysts contemplated six sigma programs and distinguished six sigma as a significant device to improve item quality and friends productivity. For instance, in a paper scientists imply usage of six sigma DMAIC (Define-Measure-Analyze-Improve-Control) system in a little size heater fabricating industry. It was recognized from the Pareto outline that general execution of the shell and cylinder heat exchanger (a basic part of heater) is for the most part influenced by the adequacy of the warmth exchanger. Round balances over the exposed containers of the warmth exchanger were acquainted with increment the viability of the shell and cylinder heat exchanger from 0.61 to 0.664. It merits referencing that sparing of INR 0.34 million every year was accomplished by improving sigma level from 1.34 to 2.01.

Andersson et al., (2006) have defined six sigma as “Improvement program for reducing variation, which focuses on continuous and breakthrough improvements. Antony (2002) has stated that “six sigma is a business performance improvement strategy that aims to reduce the number of mistakes/defects to as low as 3.4 occasions per million

opportunities". Six sigma indicates standard deviations from mean. The maturity of a manufacturing process can be described by a sigma rating. When a process reaches six sigma level it is said to be running at near perfection and it produces a mere 3.4 defective parts per million opportunities (DPMO). One of the basic reason due to which six sigma became very popular all over the world is that it is considered to be a fresh quality management strategy by which TQC (Total Quality Control), TQM (Total Quality Management) and other can be replaced. The most vital part of six sigma is that it is the integration of customer, process, manpower and strategy. Six sigma is a new paradigm in the area of manufacturing strategies to achieve various quality goals.

Banuelas and Antony (2003), "six sigma is a way of thinking that utilizes a well-organized persistent improvement procedure to lessen process changeability and drive out waste inside the business procedures utilizing measurable apparatuses and strategies. In another paper activity was taken to apply six sigma in auto part assembling firm to lessen the degree of deformities. At first characterize stage was applied and factual instrument, for example, Pareto outline was additionally utilized . Another endeavor was made for finding the ramifications of six sigma procedure in little scale businesses (SSI), taking a particular instance of Hydraulic jack producing industry.

Bendell (2006), "six sigma is a key, vast methodology concentrating on variety decrease and having the capability of all the while diminishing expense and expanding consumer loyalty". By applying DMAIC technique shrubbery breadth variety is diminished during the time spent bike chain bramble fabricating, which results an expansion in sigma level from 1.40 to 5.46. This expansion in sigma level brought about money related investment funds of INR 0.288 million for every annum. In a paper Srinivasan et al. attempt to lessen the high dismissal rate in the painted damper external container of safeguard in a main safeguard assembling organization by applying six sigma DMAIC strategy. It was obvious from the Pareto outline that Peel off and Blisters are the two significant explanations for high dismissal rate. Fish bone outline was utilized to recognize the different causes which results in the arrangement of strip off and rankles. It was seen that significant causes which impact the strip off and rankle are cleaning temperature,

phosphate PH and phosphate temperature. From reaction graph for strip off and rankles plainly the two rankles and strip off can be improved viably by setting cleaning temperature, phosphate PH and phosphate temperature at 700C, 3.5 and 600C separately . **Black and Revere (2006)** defined six sigma as "a quality movement, a methodology, and a measurement. As a quality movement, six sigma is a major player in both manufacturing and service industries throughout the world. As a methodology, it is used to evaluate the capability of a process to perform defect-free, where a defect is defined as anything that results in customer dissatisfaction".

Chakrabarty and Tan (2007) expressed six sigma as "A quality improvement program with an objective of decreasing the quantity of imperfections to as low as 3.4 parts per million chances or 0.0003 percent". In paper Desai and Shrivastava classified the procedure yield of SAW blast machines for a time of one year and the Saw blast machine having most reduced procedure yield have been considered for development. Pareto diagram examination distinguished the significant reason for low procedure yield as absence of work which is primarily subject to the planning of the exercises. Different info factors were distinguished and moves were made to streamline these contributions to improve the procedure. It was seen that sigma level improved from 1.8 to 3 and relating procedure yield improvement is 61.8% to 93%. This expanded sigma level outcomes a cost sparing of INR. 1.2 million Per annum.

Kwak and Anbari (2006) have characterized six sigma as "A business procedure used to improve business productivity, to improve the adequacy and effectiveness of all tasks to meet or surpass client needs and desires." Six sigma is one of the developing ways of thinking. Numerous writers have added to the writing of six sigma bringing about numerous articles distributed in different production entryways. As opposed to the development of distributions, according to the information of writers, there are just four to five writing survey articles in English language till date. Thus, the present examination has endeavored to audit the present status of six sigma and give bearings to assist improvement. The writers have assessed 179 research articles distributed from 1995 to 2011 out of 52 diaries having center towards six sigma.

The structure of the work done is given in resulting areas: Section 2 presents writing survey identified with six sigma. Area 3 arrangements with strategy and examination, which incorporates choice of articles and time conveyance of distributed articles, order of articles based on look into approach, initiation example contemplated as for writer's experience, grouping of the article dependent on segment of use, coordination of six sigma theory with other famous assembling ways of thinking, recognizable proof of existing systems/models in present writing audit and the status of usage of their proposed structures/models. The consequent Section 4 is committed to result and investigation which portrays noteworthy discoveries of the present examination and headings for future research.

2.2 Literature review

Gowen C R, et al., (2008) the six sigma techniques was formalized in the mid-1980s at Motorola. New hypotheses and thoughts were joined with fundamental standards and factual strategies that had existed in quality designing circles for quite a long time. The structure squares were improved with business and authority standards to frame the premise of a total administration framework. The outcome was a stunning increment in the degrees of value for a few Motorola items. Thus the debut Malcolm Baldrige National Quality Award was presented on the organization in 1988. A model was set up by Al Muhareb and Graham-Jones dependent on the six sigma DMAIC way to deal with apply in the flight region at KKIA (King Khalid International air terminal). The utilization of the proposed model outcomes in a diminishing in holding up time of travelers and furthermore improves the degree of various administrations in the flight region. Segments, for example, medicinal services, control age are likewise not abandoned far in six sigma rehearses. In late year's components, for example, rivalry, persistent security, human services costs and so forth have turned out to be all the more predominant in social insurance industry and rivalry inside the business has been increased. Yeh et al. set up a model which built up an appropriate structure of Lean Six sigma to improve administration conveyed to AMI (intense myocardial localized necrosis) patients.

Jin T. et al., (2011). Everyone wanted to know how Motorola had done it. The then-president Robert Galvin chose to share Motorola's six sigma secret openly, and by the mid-1990s, other corporations like ABB, Texas Instruments, Allied Signal, and General Electric had begun to reap similar rewards. By 2000, many of the world's top corporations had a six sigma initiative underway, and by 2003, over $100 Billion in combined savings had been reported. Six sigma became the global standard of quality business practice. One of the advantages of six sigma methodologies over other improvement programs is that it enables practitioners to accurately remove hindering issues and demonstrate the improvements using statistical tools such as Pareto Chart and control charts

Schroeder et al., (2008) have identified four core advantages of six sigma over quality philosophies. These advantages involve the focus on financial and business results, use of a structured method for process improvement or new product introduction, use of specific metrics such as defects per million opportunities (DPMO), critical-to-quality (CTQ), and use of a significant number of full-time improvement specialists. Ford found that six sigma is more profit orientated, while TQM focuses on fixing the quality problem regardless of the cost. In a paper Bandyopadhyay and Coppens explains how six sigma can be implemented successfully in healthcare industry to improve quality of services offered to the patients and reduces healthcare cost. An initiative was taken by Kaushik and Khanduja to implement six sigma in Thermal Power Plant. It has been observed that an increase of 0.1 % in DM (De-mineralize) make up water consumption resulted an increase of INR 82.82 lakhs per annum in generation cost. Fish bone diagram was used to find out the causes for consumption of more DM water during the combined cycle. The implementation also helped to reduce the DM-make up water consumption from 0.90% to 0.54% of MCR (maximum continuous rating), which resulted in energy savings of INR 304.77 lakhs per annum.

Antony, J. and Desai, D.A., (2009). Now, six sigma is well established in almost every industry and many organizations worldwide have modified the said methodology and

tools to fit their own operations. In this current era of global competitiveness, not only the manufacturing organizations are facing enormous pressure from their customers (to reduce the costs) and competitors (so as to win the market share) but it is a challenge for other industries too. These factors have contributed to integrate six sigma concepts with the complete production process (starting from suppliers to delivery to customer). Focus of six sigma is on producing the products without defects and lean focuses on elimination of waste. A defect is a kind of waste as per lean. Hence integration of these two philosophies can help organization to achieve manufacturing excellence. This has given rise to integration of six sigma with other philosophies like lean. Six sigma has evolved into a powerful business improvement methodology in many Indian industries and its importance is growing. Very little research has been carried out relating to the status of six sigma implementation in the Indian industry.

Pulakanam et al., (2010) have emphasized only on review of empirical research articles published on six sigma. Although the term six sigma was introduced two decades ago, limited number of literature review papers are available.

Mohamed Gamal Aboelmaged (2010) has classified the articles on the basis of year of publication and journal, major theme and subject, research type and application sector.

Brady, J.E. and Allen, T.T. (2006) have reviewed articles till year 2003 but used different classification scheme like definition of six sigma, society or area, journal impact factor, industrial sector, success factors.

Nonthaleerak, P. and Hendry, L.C. (2006) have classified the articles according to their research content.

B. Tjahjono and P. Ball et.al (2010) have considered the articles from year 2004 to 2009 and classified the articles according to definition of six sigma, its applications, main enablers and barriers to its application etc. It is clear from the above discussion that none

of the literature reviews had focused on research methodology, integration with other manufacturing philosophies, and implementation status and performance measurement of the six sigma model or framework.

Hence authors have made an attempt to classify and review the six sigma articles by time distribution of articles, research methodology (conceptual qualitative, conceptual quantitative, empirical qualitative and empirical quantitative) with various subcategories, authorship patterns, sector wise focus of articles, integration with other manufacturing philosophies, implementation status and performance measurement of the model or framework.

2.3 Methodology

The methodology and analysis of literature is discussed in the following sections.

2.3.1 Selection of articles

The aim of the review was to search and analyze the diversity of research being conducted in the six sigma field. Accordingly, six sigma articles were searched from publication houses like Emerald, Elsevier, Taylor and Francis. An initial article search was made using articles containing any of the terms of the phrase "six sigma" from the year 1995 to 2018.

This unique philosophy only became well known after GE's Jack Welch made it a central focus of his business strategy in 1995.

Six sigma started getting popularity through research articles by 1995 and hence the authors have chosen 1995 as start year for searching articles. This search has resulted in a list of more than 750 articles. The text of each article was reviewed in order to eliminate those articles, which were not related to 'six sigma' improvement strategies. For example, articles focused on detailed synthesis of chemicals and used the term six sigma in totally different context were removed. This search resulted in list of 450 articles. To get control over quality articles, search was further refined to peer-reviewed journals only. With this additional restriction, the number of articles was reduced to 200.

The research targeted peer-reviewed journal papers having more than two pages, as academics and practitioners alike most often use journals to obtain information and disseminate the highest level of research findings, both in width and breadth. Therefore

editorial notes, book reviews, prefaces articles were excluded, leaving 179 relevant articles.

Similar methodology is used by Mohamed Gamal Aboelmaged (2010) to exclude book reviews, preface articles. This search had given comprehensive set of good quality papers on six sigma in different fields. However, there is a possibility that there may be an article that is not reviewed in this paper. Full bibliographic details of the 179 articles considered for review are given in appendix A in order to make the adopted research processes transparent, and allow independent assessment of our classification and analysis.

Similar procedure was adopted by Kevin Burgess et al., (2006) for structured review of supply chain management. The list of selected journals considered for this review is shown in Table 2.1. It was found that maximum articles on six sigma have been published in four journals only viz. Total Quality Management, The TQM Journal (previously The TQM Magazine), Quality Engineering and International Journal of Quality and Reliability. It can be seen from the Table 2.1 that TQM constitutes around 20% of the total articles considered for this review.

Table 2.1: List of selected journals considered for six sigma review

Journal Title	**No. of articles**	**Acronym**	**Percentage**
Applied Soft Computing	1	ASC	0.56
Asian Case Research Journal	1	ACRJ	0.56
Benchmarking: An International Journal	2	BAIJ	1.12
Business Process Management	3	BPM	1.68
Construction Management and Economics	1	CME	0.56
Development and Learning in Organizations	1	DLO	0.56
Engineering Failure Analysis	1	EFA	0.56
Engineering Management Journal	1	EMJ	0.56
Expert Systems with Applications	2	ESA	1.12
Global Journal of Flexible Systems	1	GJFSM	0.56

Management			
Handbook of Business Strategy	2	HBS	1.12
Industrial Management & Data Systems	2	IMDS	1.12
Int. J. Six Sigma and Competitive Advantage	8	IJSSCA	4.47
Int. J. Production Economics	6	IJPE	3.35
International Journal of Logistics: Research and Applications	1	IJLRA	0.56
International Journal of Operations & Production Management	3	IJOPM	1.68
International Journal of Production Research	8	IJPR	4.47
International Journal of Productivity and performance management	4	IJPPM	2.23
International Journal of Quality & Reliability Management	10	IJQRM	5.59
International Review of Business Research Papers	1	IRBRP	0.56

2.3.2 Research methodology

According to Nakata and Huang (2005) and Guo (2008), the nature of the study can be classified in four major categories. These are conceptual qualitative, conceptual quantitative, empirical qualitative and empirical quantitative. Conceptual qualitative consists of the literature reviews and arguments to develop new perspectives and to build qualitatively explored theoretical framework. Conceptual quantitative uses mathematical tools and secondary data to present cases and proofs to developed new models. A schematic tree of classification of articles is as shown in figure 2.1

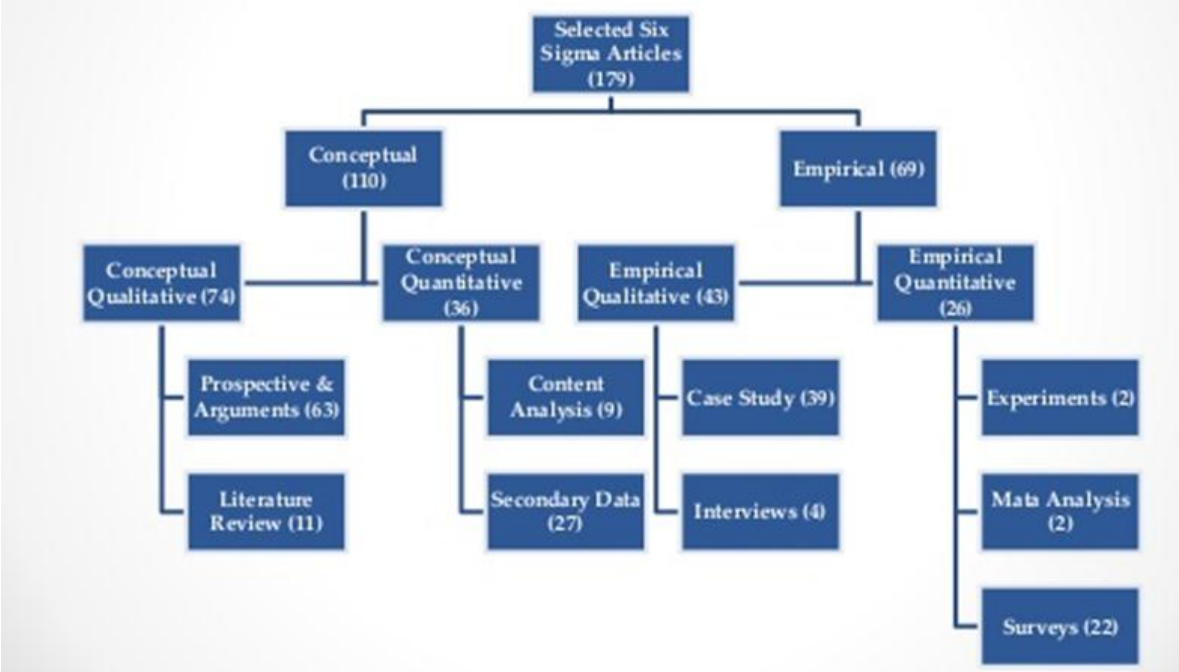

Figure 3: A schematic tree of classification of articles by research methodology

On the other hand, empirical qualitative studies employ qualitative approaches to collect primary data, whereas empirical quantitative studies require data collection through surveys or experiments and quantitatively analyze the records. The authors have grouped all the articles into these four methodologies. These four methodologies were split up into nine sub-categories.

Table 2.3: Research methodology with various sub-categories

Research Methodology	**No. of articles**	**Percentage**
Conceptual Qualitative	**74**	**41%**
Perspectives and Arguments	63	35%
Literature Reviews	11	6%
Conceptual Quantitative	**36**	**20%**
Content Analysis	9	5%
Secondary Data	27	15%

Empirical Qualitative	43	24%
Case Study	39	21%
Interviews	4	2%
Empirical Quantitative	**26**	**14%**
Experiments	2	1%
Meta-Analysis	2	1%
Survey	22	12%
Total	179	100 %

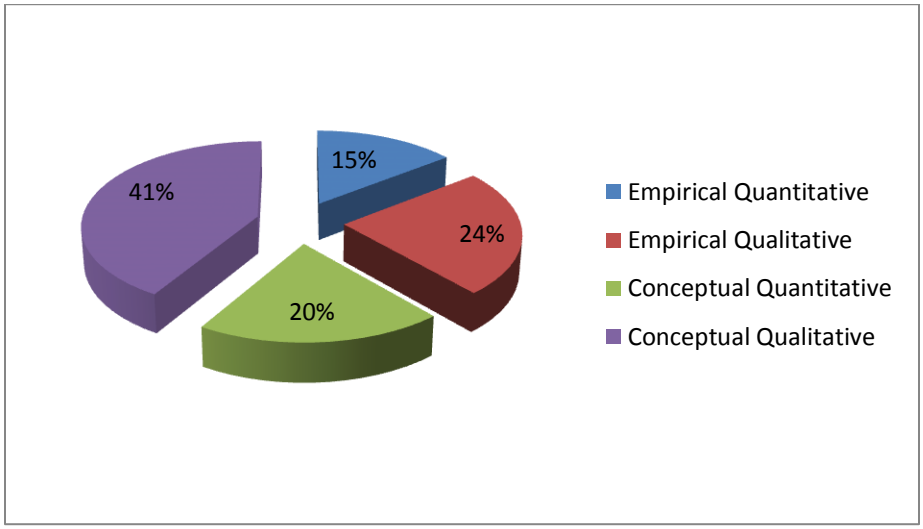

Figure 4: Classification of articles according to research methodology

It is clear from Table 2.3 that about 38 % of empirical articles were published till the year 2011 clearly suggesting the positive change towards the empirical approach. Overall, the study has found a rise in empirical approach (either quantitative or qualitative) over the years but still it is in minority as compared to conceptual approach.

2.3.3 Authorship patterns

To make any research field abundant, there is a need for researchers from versatile backgrounds to come forward and work in greater collaboration, especially by breaking barriers of regions, institutions, countries and continents. This will have more impact on the quality of research and its advancement in various regions. The authors of the present research have studied pattern of authorship, the location (country or continent) of researchers and their background (academic or professional) with this in mind.

The pattern of authorship is shown in Table 2.4. From the Table it is evident that the multi-authored articles are predominant (138 out of 179), thus signifying the collaboration among the authors. Table 2.4 also shows single and multi-country authorship pattern. It clearly depicts that single country authorship (87.7%) was prevalent in comparison to multi-country authorships, i.e., 12.3% of authors were affiliated to institutions in more than one country.

Table 2.4: Authorship pattern

Number of authors	**No. of articles**	**Percentage**
1 (Single Author)	41	24%
2 (Two Author)	69	38%
More than 2	69	38%
Total	179	100%

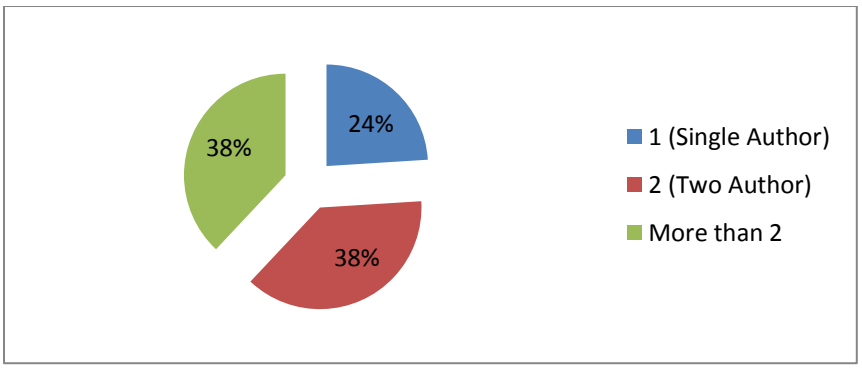

Figure 5: Authorship pattern showing number of authors

Number of Country	No. of articles	Percentage
Single Country	157	87%
Multiple Country	22	13%
Total	179	100%

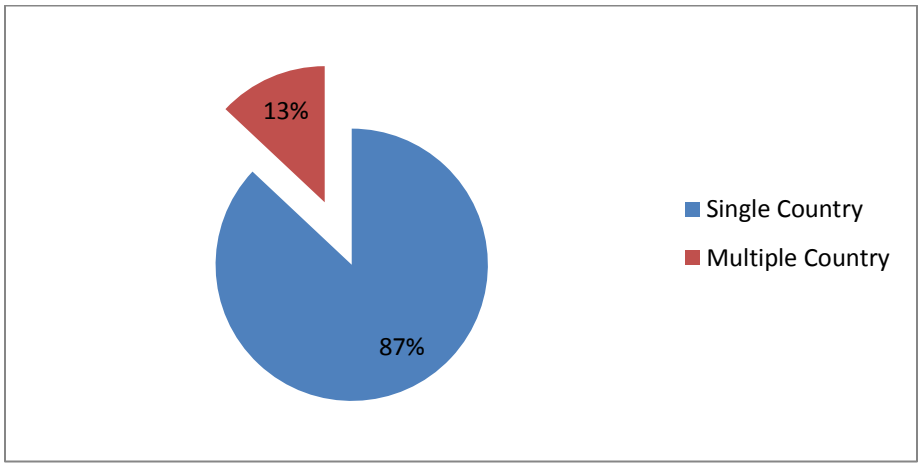

Figure 6: Authorship pattern showing country details

Furthermore, the information pertaining to the background of authors is reported in Table 2.5. The research in this field has been predominantly carried out by academicians with approximately 76.5% of contribution, which greatly exceeded that of professionals (13.9%) and is also more than blended participation (academicians and professionals) which is 9.4%. Hence there is need to bring academicians and professionals to a common platform to carry out extensive research for achieving higher standards.

Table 2.5: Background of authors

Background of authors	No. of articles	Percentage
Academic	137	76%
Professional	25	14 %
Both	17	10%

Total	179	100%

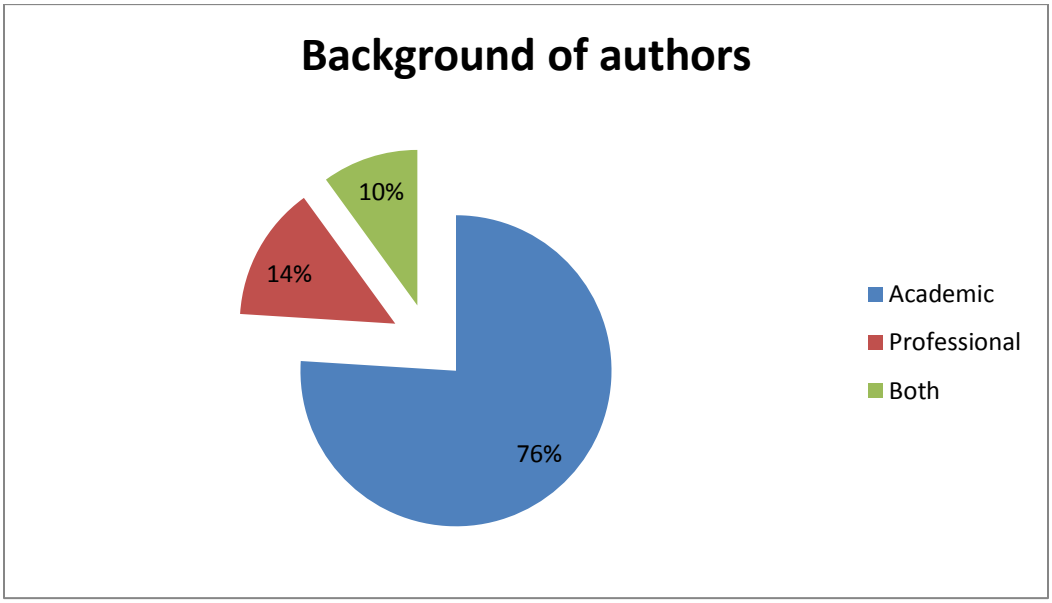

Figure 7: Background of authors

2.3.4 Articles: Sector wise focus

There is a growing recognition that six sigma can be applied to non-manufacturing operations and also it is not limited to US-based corporations where it was developed, but it is applicable to all types of organizations around the world.

The concept of six sigma is not restricted to automobile, manufacturing and related industry but it is applicable to almost all the industries. Now it has spread over all the verticals such as chemicals, aerospace, electronics in manufacturing sector. In order to improve understanding of sectorial influences on six sigma, the sample articles are classified on the basis of the industry sector they are covering. The Confederation of Indian Industry (CII) code was used for this purpose. Table 2.6 gives the frequency distribution of type of sectors covered by researchers.

It may be clearly seen in Table 2.6 that researchers are more inclined towards carrying out research in manufacturing sector (54.74 %) and the related industries like automobile industries. In other words, out of 179 total articles 98 were from these manufacturing industries. The service, infrastructure and agricultural sector drew least attention of the

researchers. Few researchers have performed investigations in multiples industries (7.26%) in multiple sectors. This is because the concept of six sigma was first originated to reduce the number of defects in manufacturing domain and then subsequently this was extended to other sectors.

Table 2.6: Frequency distribution of type of sectors covered by researchers

Sr.no	Industry	Number of Article	Percentage
1	Manufacturing Sector	98	54%
2	Service	21	12%
3	Infrastructure	12	6%
4	Agriculture	02	3%
5	None	46	25%
	Total	**179**	**100**

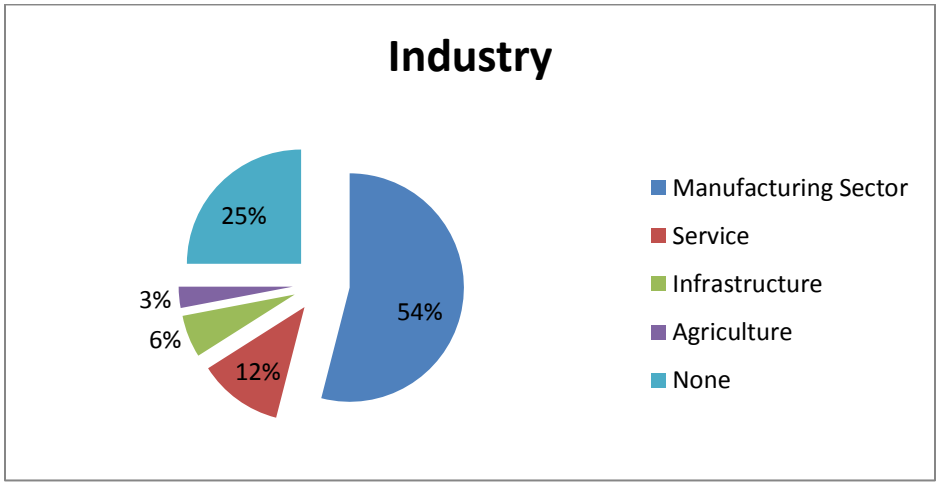

Figure 8: Frequency distribution of type of sectors

2.3.5 Integration with other manufacturing philosophies

Different elements have contributed to the success of six sigma philosophy. In the past, many researchers have discussed about the importance of integrating six sigma

philosophy with different manufacturing philosophies. Yeh D.Y. et al., (2007) discussed about the need to combine supply chain management and six sigma, while Su T. C. et al., (2006) highlighted the need of combining six sigma and lean philosophy to improve service quality. Shah, R. et al., (2008) have focused on combining Lean with six sigma for implementation of quality practices. Chen, M. et al., (2009) has elaborated on lean six sigma approach for employing a well-structured continuous improvement methodology.

Kumar M. et al., (2006) have discussed about integration of Lean and six sigma strategies into a more powerful and effective hybrid model, addressing many of the weaknesses and retaining most of the strengths of each strategy. Furterer S. et al., (2005) deliberated on combining the principles and tools of Lean Enterprise and six sigma in a more synergistic manner.

All the above mentioned researchers' perspectives show the importance of integration of six sigma philosophy with other manufacturing philosophies to achieve manufacturing excellence and social responsibilities. So the authors in this study have evaluated the present status of the integration of six sigma philosophy with other manufacturing philosophies. The five different philosophies were listed (refer Table 2.7) and later on, the research articles were examined for consolidation with any of the five manufacturing philosophies. Table 2.7 shows summary of integration with other manufacturing philosophies.

As Table 2.7 exhibits, only 26 research articles of the total articles considered for this review are identified under this category. Among these, "lean" has the largest number of studies covering 46.15% of the total (26) articles in present study, whereas, total quality management (TQM) is placed second with 23.07% articles. Other three out of the five selected philosophies had few integration articles with six sigma philosophy as compared to the earlier mentioned philosophies. These were supply chain management (SCM) (19.23%), enterprise resource planning (ERP) (3.84%) and theory of constraints (TOC) (7.69%). The review of papers with respect to integration with other manufacturing philosophies shows that there is need to increase the efforts for blending six sigma philosophy with other manufacturing philosophies.

Table 2.7: Summary of integration with other manufacturing philosophies

Integrating with other philosophies	Total	Percentage
SCM (supply chain management)	5	19%
ERP (enterprise resource planning)	1	5%
Lean	12	46%
TQM (total quality management)	6	23%
TOC (theory of constraints)	2	7%
Total	**26**	**100%**

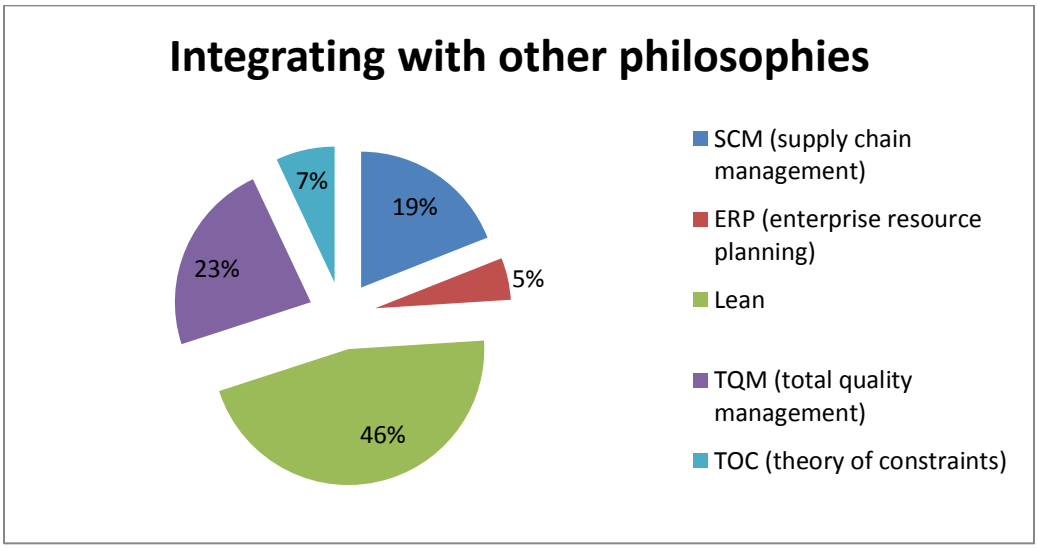

Figure 9: Summary of integration with other manufacturing philosophies

2.3.6 Framework/Model of six sigma

The term framework doesn't have clear cut definition from the research world. Many researchers are using model in the place of framework or vice-versa. It is all happening due to lack of clarity about what is framework or model. The present study investigated what is a framework. Model is one in which the six sigma elements are defined but do not discuss the relation between the elements whereas a framework can be defined as one where the six sigma elements are defined and also discuss the relation between the

elements. Yusuf and Aspinwall (2000) while reviewing the frameworks of Total Quality Management (TQM) have explained that 'a model' answers the question of "what is TQM" with the overall concept or elements put down together, whereas a framework answers "how to" questions and provides an overall 'way forward'. A framework is not only a recommended bunch of elements to be considered in that system, but it should give information about the complete relationships amongst the elements of system under study.

The same concept has been followed in the present study while studying the frameworks/models. It was checked whether the corresponding article featured any kind of model or framework. So far, many of the researchers including Kifayah Amar and Douglas

Davis (2008) have proposed few models in different articles discussing about only elements/constructs of six sigma but most of them did not discuss the relationship between of elements and the status of implementation of their proposed frameworks/models in real environment. Table 2.8 shows distribution of model/frameworks proposed vs. proposed and implemented in the industry.

Table 2.8: The distribution of model/framework proposed vs. proposed and implemented

Type	**Proposed**	**Proposed and Implemented**	**Neither**	**Total**
Model/Framework	55	12		67
Neither (None of the above)			112	112
Total	55	12	112	179

From Table 2.8, it can be easily seen that only 67 frameworks/models exist in the present review. Only 12 articles (of both types) had their proposed framework/models reported implementation. It apparently shows the lack of attempts in implementing the proposed models or frameworks. Logical conclusion is not reached in majority of cases as framework/ model has not been tested and found suitable/ successful.

2.4 Research gaps

The study has included a large sample size of the articles as well as the number of journals (52 journals) in conducting the critical review of content oriented classification and empirical research methodology in six sigma. The number of articles reviewed has given clear idea about history of six sigma, present status of six sigma and future of empirical research in the field of six sigma. The major research gaps after conducting the literature review are presented as follows: (i) Need for more empirical research in six sigma (ii) Need for collaborative research between academicians and industry professionals (iii) Need for implementation of six sigma in other Industry sectors (iv) Need for development of six sigma implementation framework. This is the first of its kind attempt to solely discuss the descriptive statistics of empirical research methodology and content oriented classification in the field of six sigma.

(i) Need for more empirical research in six sigma:

In the section on research methodology, it is found that most of theory building is taking place through the process of conceptual methodologies and a few through the empirical methodologies. The focus of researchers should now be on establishing and testing new hypothesis with the help of techniques like case studies and surveys etc. rather than working solely on theory building. It have reported the importance of empirical research study and its effects on operations management. According to them, the term "empirical," which means "knowledge based on real world observations or experiment," is used here to describe field-based research which uses data gathered from naturally occurring situations or experiments, rather than via laboratory or simulation studies, where the researchers have more control over the events being studied. Empirical research can be used to document the state of the art in any research, as well as to provide a baseline for longitudinal studies. It can also be invaluable in the development of parameters and distributions for mathematical and simulation modeling studies. A very important use for empirical data is in theory building and verification. Information derived from actual practice can enhance six sigma researches in a number of ways. Gathering systematic information about six sigma practices provides information about the state of the art in six sigma. Anecdotal articles may describe current practices at a single firm; however, systematic data gathering can provide more generalizable evidence about trends and

norms in specific populations of firms. This may be used to make inferences about firms in general. Empirical data can also be used in conjunction with simulation and mathematical programming research. Subsequently, other researchers started focusing on empirical research.

Found that empirical studies consisted of only 18% of published research articles in operations management when conducted survey during 1992-1997. They had conducted the survey during the early stage of the empirical research. That is one of the reasons why he got less number of articles involving empirical approach in his review. In this present review, it is found that approximately 38 % of empirical approach articles were published from period considered for this study, clearly suggesting the positive change towards the empirical approach. As evident from analysis in research methodology section, the study found a rise in empirical approach (either quantitative or qualitative) over the years but still it is in minority as compared to conceptual approach. Hence there is further need for more empirical research to get better benefits to the organizations.

(ii) Need for collaborative research between academicians and industry professionals:

One of the important observations that are reflected in this research is about authorship patterns. Previous international business reviews addressed the importance of collaboration among researchers, particularly from diverse countries and cultural backgrounds to enhance the overall quality of research. In spite of the increasing globalization of research interests and researchers themselves, academicians or researchers dominate over others. There is an urgent need to bring down the geographical domination of the authors and geographic concentration of authorships, which otherwise may lead to ineffective results when referred to by other countries. To achieve the object of globalization of authorship pattern, the authors suggest that the developed countries' research institutes like Centre for Research in Six

Sigma and Process Excellence (CRISSPE) in UK need to collaborate with undeveloped and developing nations' research institutes like Indian Statistical Institute (ISI) in India to encourage research in their regions and to get culture independent results. Another important factor coming out from this authorship pattern is back ground of authors. The present study has found that the contribution of research articles is mainly from

academicians with very few professional being involved. To overcome this kind of the problem, the academicians have to collaborate with the professionals to get better conclusions and articles useful to the industry. There is need to improve the catchment of research in these developing countries through the various research institutions, collaboration between institutions and organizations and encouragement from local government to the researchers.

(iii) Need for implementation of six sigma in other Industry sectors:

While considering the industry focus of the research articles, it was found that most of the articles are addressing issues from manufacturing sector. One of the reasons is six sigma principles were invented from the manufacturing sector initially. However, at present there is a need of six sigma implementation in other sectors like service, infrastructure, finance, healthcare and agriculture sector. Moreover there is need to carry out the research in other conventional and non-conventional industries in order to improve their productivity, flexibility and to fulfill customer needs.

(iv) Need for development of six sigma implementation framework:

From the literature review of six sigma articles, it is clear that only few researchers have talked about framework of six sigma and no framework has discussed the relation between the elements and effect of one over other element. The study also observed that articles have talked about limited number of six sigma elements instead of considering a complete set of six sigma elements in the organization. To encourage the professionals to implement a set of six sigma elements, the researchers need to develop more numbers of six sigma frameworks, which acts as guiding torch to the professionals. This shows the urgent need for the six sigma implementation framework, describing important elements of six sigma, relationships between these elements and which will guide the professionals for effective implementation of six sigma.

2.4.1 Significant observations

Apart from the abovementioned various research gaps, certain prominent observations were made during the literature review are discussed below,

- **Increase in the number of articles:**

The importance of six sigma philosophy is growing day by day due to its positive impact on productivity of organizations and fulfillment of customer requirements. All this adds

to significant growth in published articles in various journals. It is evident from analysis of papers published during period (i.e., 2005-2011) that there is a large increase in the number of published articles, which is 76.53 % of the total articles considered for the present review.

- **Integration of six sigma with other philosophies:**

As evident from the integration with the other philosophies section, there is a need to integrate six sigma philosophies with other manufacturing philosophies to achieve manufacturing excellence. The study reports that research community should investigate integrating six sigma philosophies with other manufacturing philosophies in order to exhibit all the benefits of this process.

- **Status of six sigma in India:**

Six sigma has evolved into a powerful business improvement methodology in many Indian industries and its importance is growing. Very little research has been carried out relating to the status of six sigma implementation in the Indian industry. In order to gain a better insight into the six sigma initiative within the Indian industry, there is need to carry out a large-scale survey in the immediate future for greater validity of the findings from this research.

2.5 Research plan

The flow chart of research plan followed is as shown in Figure 2.6. The research problem is chosen as per the gaps identified through literature review. The state of existing six sigma frameworks is investigated and subsequently the need for new framework for six sigma is proposed. To accomplish this, existing models/frameworks of six sigma are identified through thorough literature search. In the next step, the empirical investigation of existing six sigma frameworks was carried out. The objective of this investigation is to find the validity and reliability of the existing frameworks in Indian scenario. Next phase is to develop a new framework suitable for Indian industries. Then empirical investigation of proposed framework is carried out. This phase includes validity & reliability of proposed six sigma framework followed by path analysis & structural equation modeling of proposed six sigma framework to find out suitability in Indian Industry. Finally, based on the results obtained through various analysis conducted in this

phase, the study concludes the proposed six sigma framework is suitable to implement in Indian manufacturing industries.

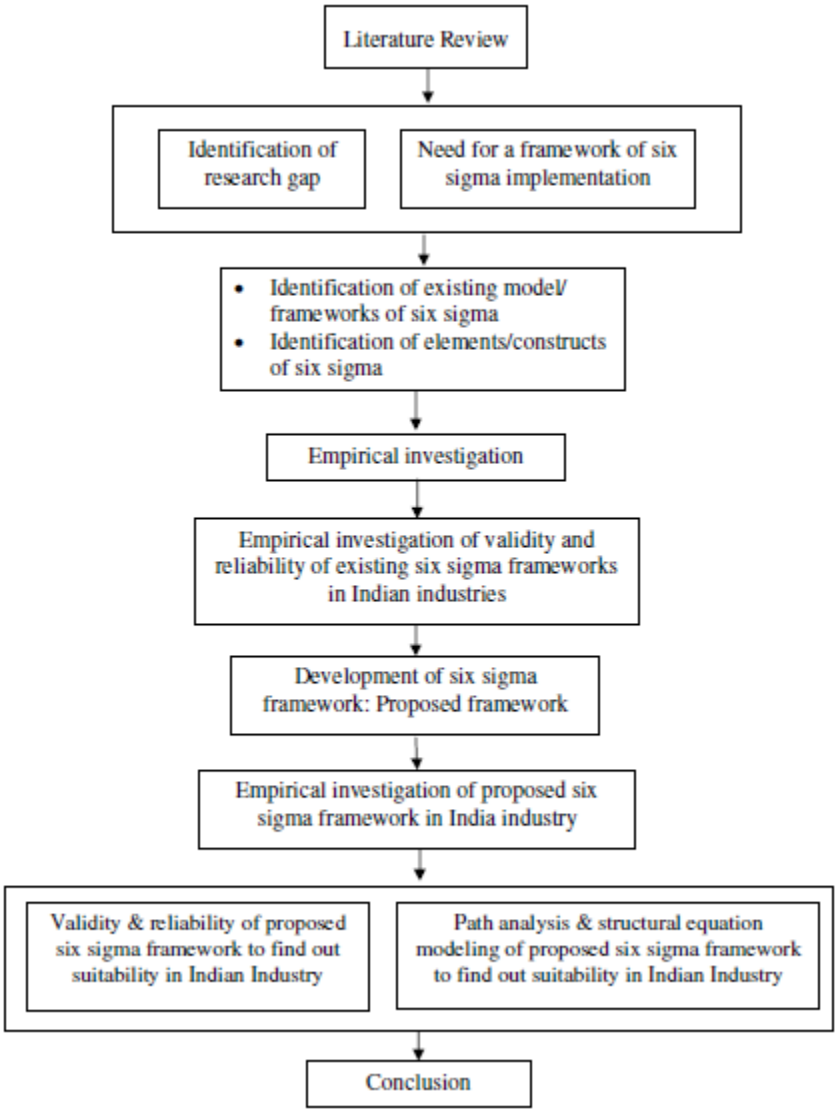

Figure 10: Research plan

2.6 Conclusion

A tremendous growth of literature related to six sigma has been observed in the last two decades. After looking at the wide range of research articles in various journals it can be easily concluded that the concept of six sigma has a big impact on academicians, industries and researchers worldwide. The detailed examination of literature shows that there is good information available about six sigma principles, tools and techniques, its applications, system and metrics. But in the opinion of the authors, it is the first attempt

to critically review the articles in this explicating field. The authors have provided an in-depth and integrated review of articles. Through this literature review many issues are addressed which have not been covered adequately in the past. The authors hope this study will trigger an impulse to promote further research and exploration.

The limitation of this study is that only three publishing houses were used for articles collection. It is possible to execute research at even larger scale as six sigma literature has become very vast. Secondly, there is subjectivity involved in the categorization of articles as it depends on the author and his perceptive. Although the article categorization process is carried out with due care but still probability of unintentional faults cannot be ruled out. Thus in order to strengthen these outcomes, future attempts may be directed to validate the outcomes of this study with larger sample size.

Overall this review of literature shows that there is substantial advancement in this field. However, there is still need to carry out further research in this direction and to throw light on certain dark and unexplored areas of six sigma implementation. Future studies may cover these issues by promoting the topics and effective exploration. All these advancements will make it more assorted and useful tool across various domains and global recognition/application.

In this chapter extensive literature review was undertaken firstly to gain an insight into the concept of six sigma and secondly to identify work done by the researches in this field. The various gaps in the existing literature were found regarding the state of various models/frameworks proposed by researches and need for development of six sigma implementation framework, describing important elements/construct of six sigma, relationships between these elements and which will guide the professionals for effective implementation of the six sigma. Based on the gaps identified, the objectives of the proposed research were framed.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The main purpose of this study is to present the benefits and to discover the various trends of six sigma. The research strategy was made by selecting the research paper in which successful implementation of six sigma was presented and documented. First phase of this chapter discuss about importance of empirical research and research methodology followed. Questionnaire design and data collection process used for the study is explained in the subsequent section. In next phase selection of industry, brief information about the typical products that are manufactured in the selected industry and importance and need of six sigma in the selected company sector is explained.

3.2 Empirical research

Empirical research methods are a class of research methods wherein empirical observations or data are collected in order to answer particular research questions. While this methods are primarily used in academic research, it can also be useful in answering practical questions. Minor et al., (1994) defined "empirical studies as those involving the gathering and analysis of data, and subsequent reporting of findings and conclusions." The importance of empirical research in applied business studies has been highlighted by various It cannot be denied that the most effective method of conducting a research is to follow a proven systematic empirical research approach. By following an existing approach, more time can be spent on content of the research rather than on the method. The empirical research methodology proposed by Approach given by Flynn for systematic empirical research consists of following six stages:

- Establish the theoretical foundation
- Select research design
- Select data collection method
- Implementation

- Data analysis
- Findings and conclusions

This approach has been widely followed by the practitioners and researcher in the empirical study. The reason for choosing this approach is due to its simplicity, straightforward nature and a systematic approach for conducting empirical research and it is shown in the Figure 3.

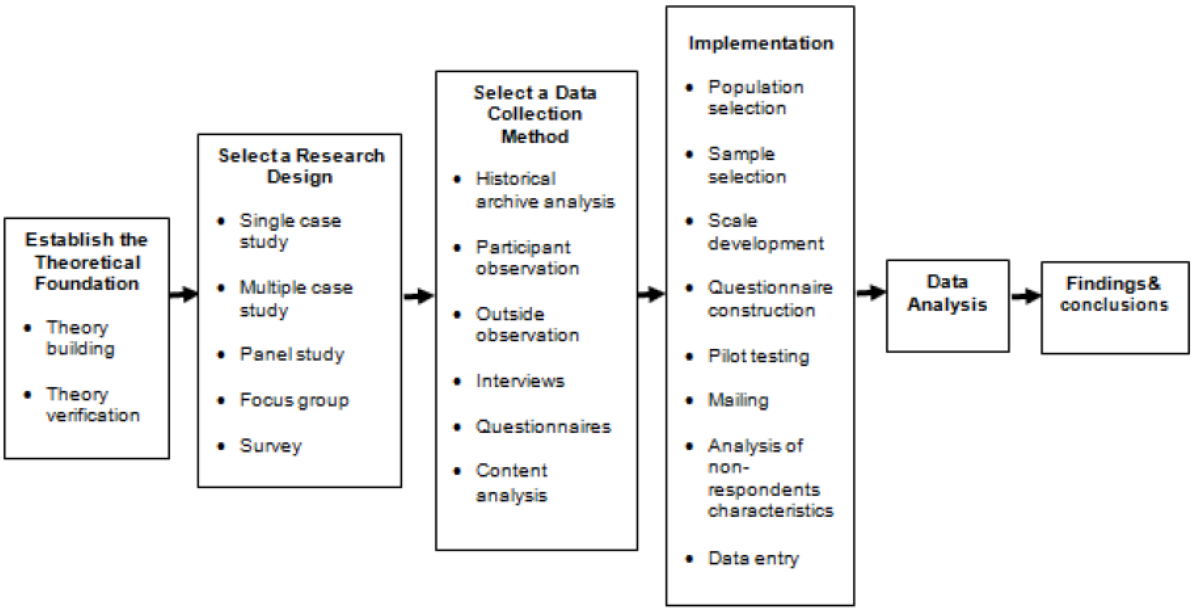

Figure 11: A systematic approach for empirical research

The systematic approach of empirical research proposed was followed step by step. In the stage of establishing the theoretical foundation the researcher either builds a theory or verifies a prior theory. Empirical research can have one of the two purposes either theory building i.e. to propose one's own theory based on empirical data or theory verification i.e. to verify an already existing or newly proposed theory on the basis of empirical data. The focus of theory verification is on testing the hypothesis within specified confidence levels, instead of the origin of the hypotheses. However the origin for a theory building study is not hypothesis, rather some assumptions, frameworks, a perceived problem or perhaps, very tentative hypotheses. The second stage in the systematic approach is selecting a research design and various methods are prescribed which are given in the Figure 3.1. The survey is the most frequently used research design.

The reason for this is that cross-sectional survey design involves selecting different organizations over a large industry space. This design has the ability to describe features of large number of people and organizations.

Proposed that "when the focus of the research is generalizability to an entire population of firms, administrating a survey to a large sample is a more appropriate approach". Once the research design is selected a data collection method needs to be selected. Researchers have given various methods of data collection and sometimes a combination of data collection methods can also be used. Questionnaire is the most widely used method of data collection, as it gives inference about a large group of people/ organizations from data drawn on a relatively small number of individuals/ organizations. In the next step the implementation of the selected data collection method is discussed. The first step involves selection of the population and then from that population a random sample is generated, to help control against bias. If the sample is drawn from a specific group, such as a given industry the actual sample should be drawn randomly once the master set of names have been obtained. The next step in implementation involves scale development.

The most widely used is the Liker scale which is an example of interval scale. After the scale development the questionnaire is constructed, and then its pilot testing is done before sending it to the full random sample taken out of the population. If possible the non-respondents can be identified and then they can be contacted again through some other means of correspondence like telephone, e-mails etc. The last stage of implementation stage is the data entry stage. Prior to data entry, careful examination of completed questionnaire is required to prevent subsequent data analysis problems. The data entry should be done very carefully to keep the vital integrity of the data. The last stage of systematic empirical research is the data analysis. Several data analysis methods are prescribed in the literature. Finally the research report is prepared for publication.

3.3 Methodology of the proposed empirical research

The methodology of the proposed empirical research to achieve the objectives is discussed in the following sub-sections.

3.3.1 Theory verification

Through the detailed literature review the concept of six sigma was studied and the theoretical foundation for the research on six sigma in Indian scenario was identified at the onset of research. The various initiatives taken in this regard were identified through the search of different six sigma models /frameworks suggested by various authors around the globe. The validity and reliability of existing frameworks of six sigma was investigated. The present status of six sigma implementation in Indian manufacturing companies was studied in depth and need for a six sigma framework was identified. Subsequently, a framework for the six sigma implementation was proposed.

3.3.2 Selecting a research design

When planning any form of research one of the most important factors is establishing the method and design of the empirical research. The research design depends on the kind of information required, the nature of changes observed and the status of industry to be observed. Decision is needed to be made whether to go for a longitudinal survey i.e. to focus on a small group or number of organizations and attempt to investigate them over a period of time. The second option is to go for a cross sectional survey i.e. selecting different organizations. This design has an ability to describe a large number of organizations and its people. Cross-sectional survey was preferred since our need was to identify the requirements of six sigma in the Indian scenario.

Secondly the complexity of data in the longitudinal survey and the time constraint required, also suggest following cross-sectional survey. The method of survey was cross-sectional and hence to extract relevant information survey methodology was chosen. The survey is the most commonly used method of research design in operations management, as survey gives self-reports of the industry as well as their opinions.

In this case the term empirical is used to describe the real world observations using field research (gathering data from naturally occurring situations) not simulations where the researcher has control over the events being studied. As stated earlier Empirical research has been used to collect the data across various manufacturing sectors in the Indian industry. Surveys are fairly common in empirical research. Survey research involves collection of data from a large group of population.

3.3.3 Selecting a data collection method

Questionnaire survey was used as data collection method. The method of questionnaire administration was chosen as mail-survey in the first phase of the exploratory study and subsequently the second questionnaire was launched on the same samples selected in the first study, but in this case the questionnaires were sent through e-mails. The questionnaire was prepared separately for the two surveys conducted on the same population. The first questionnaire was for evaluation of the validity and reliability of existing six sigma frameworks. The second phase of the exploratory search is to do the empirical investigation of proposed framework for six sigma implementation.

3.3.4 Selection of industry

A database of manufacturing industries was obtained from the CII (Confederation of Indian Industry) directory. Next, to select the sample manufacturing companies a brief literature review was done and it was found that from the Indian perspective, the major manufacturing sectors are automobile, electronics, engineering, and process industries

In addition to above four sectors, Textile is considered as a separate sector. Certain sectors have emerged in the forefront regarding growth and employment because of unique opportunities they enjoy at the present time: Textile & Garments, Automobiles & Components, Steels, Minerals, Fertilizers, IT hardware and Electronics, Chemical & Petrochemicals, Telecom equipment etc. Hence the lists of large companies from the above sectors were chosen from the CII industrial directory. In India manufacturing industry is consist of many different sectors, each of which is influenced by the overall manufacturing environment, but each of which also has its own ups and downs. A database of 208 companies was generated from the directory to which the questionnaires were sent. Table 3.1 shows the typical products that are manufactured in the sample sectors.

Table 3.1: Typical products that are manufactured in the sample sectors

Sector	**Product**
Automobile	• Two wheelers includes scooter and motorbikes

	• Four wheelers including cars, trucks, tractors, and buses • Automotive components includes axles, shock absorber, head lights, battery, bearings, clutches, brakes, steering and suspension systems, speedometers, mileage meters, piston and piston rings, engine assembly etc.
Machines & Equipment's	• Generators, inverters rotors, stators, electric motors etc. • Diesel engines • Construction machinery • Agriculture machinery ➢ Material handling equipment such as forklift trucks, cranes, etc. ➢ Sewing machines ➢ Refrigerators, fans
Electricals and Electronics	• Electronic consumer items, TV tubes, cables • Measuring instruments like electronic energy meters, optical pyrometers, stabilizers, etc. • Industrial electronics including, microcircuits, electronic panels, fuse gears, telephone exchange chambers, cables, transformers, etc. • Semiconductors, capacitors, HMC's, etc. • Switchgears etc.
Process Industries	• Paper • Paint • Tyres • Packaging products • Cement • Petroleum and products

	• Medicines • Fertilizers
Textiles	• Fabrics • Cotton Yarn • Textile Products • Yarn

Questionnaires were sent to top management of the companies i.e. CEO's/ Chairman's/ Managing Directors in five industrial sectors:

- Automobile
- Machines and equipment's
- Electricals and Electronics
- Process Industries
- Textiles

The detailed list of companies to which the questionnaire was sent is given as appendix F at the end. The relevance, importance and brief overview of each of the above five sectors are discussed as below:

3.3.4.1 Automobile sector

India has made a mark in the global automobile industry; the salient aspects below make for India featuring on every leading automobile player's roadmap.

- India is the second largest two-wheeler market in the world
- Fourth largest commercial vehicle market in the world
- 11th largest passenger car market in the world
- Fifth-largest bus and truck market in the world (by volume)
- Envisaged to be the 7th largest automobile market by 2016, and world's 3rd largest by 2030 (behind only China and the US)

The Indian automotive industry has witnessed an unprecedented boom in recent years, owing to the improvement in living standards of the middle class, and a significant increase in their incomes. The industry is expected to touch the 10 million mark, to which the Commercial Vehicle Segment will be a major contributor. Industry experts peg the

Indian Automobile sales growth at a compounded annual growth rate (CAGR) of 9.5 per cent - 13008 million vehicles - by 2015. Hence the growing commitment of international auto manufacturers to India as a source of high value, high quality engineering products and services cannot be denied. India seems set to emerge not only as a very large domestic auto market, but also as a powerful link in the global auto chain.2" In terms of auto components, the world's top car makers turn to India for various auto components like crankshafts (Bharat Forge Ltd. is world leader in supplying crankshafts to all the countries) and other components for their vehicles. Riding this success, and capitalizing on the spiraling demand of domestic auto industries, the Indian automobile components companies have emerged as one of India's fastest growing manufacturing sector, and a globally competitive one. According to the Auto Component Manufacturers Association (ACMA), the apex body of component makers in India, global sourcing of components from the country will double from US$ 5.9 billion to US$ 12.9 billion in 2013-14, and is slated to hit US$ 20 billion in seven years. India is estimated to have the potential to become one of the top five auto component economies by 2025. India's component industry now has the capability to manufacture the entire range of auto-components, such as engine parts, drive, transmission parts, suspension and braking parts, electrical parts, and body and chassis parts. The Indian automobile market is estimated to become the third largest in the world by 2016 and will account for more than 5 per cent of the global vehicle sales;

India is expected to become the fourth largest automobiles producer globally by 2020 after China, US and Japan3. In automobile sector, there is a huge scope for six sigma in terms of improving the quality of automotive parts, reducing the defects in the final product and so on. Large automobile companies like Ford, GM have reported significant benefits from the application of six sigma and this made other automobile companies to adopt this philosophy for the similar benefits. Have advocated the application of six-sigma and has mentioned that it is a successful mode for achieving improvement across the individual activities in the automobile industry.

3.3.4.2 Machines and equipment's sector

This sector in India comprises of heavy engineering Industry, machine tool industry, electrical industry, industrial machinery and auto-industry. These industries provide

goods and services for almost all sectors of the economy, including power, rail and road transport. Heavy engineering industries are engaged in the production of heavy engineering goods and mainly produce high-value products using high-end technology.

The major end customer industries for heavy engineering goods are power, infrastructure, steel, cement, petrochemicals, oil & gas, refineries, fertilizers, mining, railways, automobiles, textiles, etc. The machine building industry caters the requirements of equipment for basic industries such as steel, non-ferrous metals, fertilizers, refineries, petrochemicals, shipping, paper, cement, sugar, etc. Heavy electrical industry covers power generation, transmission, and distribution and utilization equipment's. These include turbo generators, boilers, various types of turbines, transformers, switchgears and other allied items. Majority of the products manufactured by heavy electrical industry in the country, which includes items like transformers, switchgears etc. are used by all sectors of the Indian economy. Some major areas where these are used are the multi core projects for power generation including nuclear power stations, petrochemical complexes, chemical plants, integrated steel plants, non-ferrous metal units, etc. India is the only other developing country besides China, which produces a full range of electric power generation and transmission equipment4.

In machines and equipment sector, six sigma approaches has been increasingly adopted worldwide in order to enhance productivity and quality performance and to make the process robust to quality variations. Have applied six sigma in machine industry and mentioned it as a viable option to the shop floor problems. They have also reported the there was substantial improvement in the efficiency and performance of manufacturing operations.

3.3.4.3 Electricals and electronics sector

The highlights of the Indian Electronics Industry are5:

- Industry size – US$ 25 billion
- Ranked 26th in the world in sales, 29th in production
- Growing at over 25 % CAGR
- Expected to reach US$ 158 billion by 2015
- Low penetration levels

- The industry is one of the fastest growing in India, driven by growth in key sectors such as IT, Consumer Electronics and Telecom

The total electronic equipment production in India had reached $52 billion in 2013, compared with $14 billion in 2006, a compound annual growth rate (CAGR) of 18 per cent. Semiconductor consumption in India will be more than double from $2.8 billion in 2006 to $7.2 billion in 20136. The growth in electronic equipment production is being bolstered by the rapid growing demand for electronics equipment's in India. Gartner classifies electronic equipment's across six broad categories: communications electronics, data-processing electronics equipment, consumer electronics, industrial electronics, automotive electronics and military/civil aerospace electronics. In 2013, the consumer electronics equipment segment led to the growth with 42 per cent share of the overall electronic equipment production in India. The segment is primarily driven by analog TVs and other audio and video equipment, including CD players. It also includes electronic appliances such as microwave ovens, washing machines, air-conditioners and calculators.

GE one of the leading electrical company initiated six sigma in 1996 and reported saving of more than US$2 billion of revenue in 1999. Black & Decker's power tool manufacturing company reported savings of approximately US$75 million in 2000. The challenge for electrical and electronics manufacturing facilities is to manufacture item having no quality defects with least cost. In consumer electronics there is a cut throat competition with regard to price. All manufacturers try to curtail manufacturing cost. So there is a great stress in the process of manufacturing electrical and electronics goods. In order to address various types of challenges faced by electrical and electronics companies, these sectors are also trying adopt the six sigma practices.

3.3.4.4 Process industries sector

Process industries sector includes cement, paper, paint, types, petroleum and its products, pharmaceuticals, fertilizers etc. Globally, India is the second largest producer of cement. Cement production grew at the rate of 10.1 per cent during 2012-13 over the previous fiscal's total production of 147.8 MT. Of this, 9.3 MT of cement was exported. Continuing the growth momentum, cement production increased by 8.4 per cent to 80.85 MT. during the period April-September from 74.58 MT during the corresponding period

last year. The Indian cement industry is on a roll. Driven by a booming housing sector, global demand and increased activity in infrastructure development such as state and national highways, the cement industry has outpaced itself, ramping up production capacity, attracting the top cement companies in the world, and sparking off a spate of mergers and acquisitions to spur growth7.

India's rapid economic growth is being built on a frame of steel. Soaring demand by sectors like infrastructure, real estate and automobiles, at home and abroad, has put India's steel industry on the world steel map. The rapid rise in the production has resulted in India becoming the fifth largest producer of steel in the world, up by two places. The Indian pharmaceutical sector is witnessing tremendous growth with the contract research and clinical trials businesses taking wing, and the new patent regime opening new avenues for players in the country. The Indian pharmaceutical industry ranks 4th in terms of volume (with an 8 per cent share in global sales) globally. In terms of value it ranks 13th (with a share of 1 per cent in global sales) and produces 20-24 per cent of the world's generic drugs (in terms of value).

The oil and gas industry has been instrumental in fuelling the rapid growth of the Indian economy. It contributes about 45 per cent of the total energy consumption of the country, which is the fifth largest energy consumer in the world. In the last few years, the paper industry in the country grew by 6 per cent. In the future, it is forecast to grow at 10 per cent because of huge spurt in demand for writing and printing paper. In sharp contrast to it, the Industry in the US and Europe is growing at a mere 2 per cent, while in other Asian countries, it is growing at 4.5 per cent. Riding on the back of a real estate boom, paint companies are extremely bullish on India, which is among the fastest growing markets across the globe. Among the international companies that are increasing their investments is the Japanese paint major, Nippon, which is planning to invest about Rs 350-400 crore in India for its various expansion projects over the next few years.

Type production in the country registered a growth of 10 per cent in April-December 2012-13 compared with the corresponding period last financial year. On the exports front, passenger car types registered a whopping growth of 54 per cent, while growth in the truck and bus segment was 9 per cent. Hence it can be seen that the process industry is also matching the growth of the other sectors.

Have explained the importance of six sigma in process industry. They have explained about implementation of six sigma in power plant and reported huge savings. have mentioned the role of six sigma to address the major challenges in process industries in the highly competitive global market i.e. requirement to produce high quality products with less energy and resources consumed.

3.3.4.5 Textile sector

The Indian textiles industry has significantly contributed to the economic life of the country. Liberalization in India and the scrapping of quotas in world trade of textiles and clothing has bolstered growth for the sector. In the post quota period, the industry size has expanded from US$ 49 billion in 2006-07 to US$ 62 billion in 2012-13. In this period, while the domestic market increased from US$ 23 billion to US$ 30 billion, exports increased from around US$ 14 billion to US$ 19 billion. India has overtaken the US to become the world's 2nd largest cotton producing country, after China. According to the Confederation of Indian Industry– Ernst & Young Textiles and Apparel Report 2013, the Indian sourcing market is estimated to grow at an annual average rate of 12 per cent from an expected market size of US$ 35-37 billion in 2011 to US$ 47-49 billion by 2013. Kumar M et al., (2006) have emphasized use of six sigma in textile industry. Also many authors have indicated the importance of six sigma in addressing the problems in textile industries.

3.3.5 Data collection and analysis

As the next step in implementation of the questionnaire survey the scale selection was done and as stated earlier Liker scale was used. The details of the same shall be provided in chapters four and six respectively. The questionnaires in the first stage were mailed to the 208 companies and in the second stage the developed questionnaire was sent as an attachment through e-mail. The data entry was done for respective surveys. In order to get that relevant and required information, data is analyzed. Data analysis can be defined as “a systematic and orderly approach taken towards the collection of the data so that information can be obtained from the data” It is difficult to draw conclusions from empirical data and to generalize them, without the help of statistical evidence. The Statistical Package of Social Science (SPSS) version 18 and AMOS were used to analyze the data. This software provides complete range of statistical methods and good range of

editing and labeling facilities. It produces output in an easily decipherable manner. Various data analysis techniques like descriptive statistics, correlations analysis, factor analysis etc. were used.

3.4 Conclusion

This chapter reported the systematic approach followed for conducting empirical research for a cross sectional survey. The step by step systematic research methodology followed was explained. The methodology followed to fulfill the research plan was explained in detail. A brief overview of various sectors to which the questionnaire was sent and importance and need of six sigma in these sectors is explained. In last section data collection and analysis techniques are discussed.

CHAPTER 4

EMPIRICAL INVESTIGATION OF VALIDITY AND RELIABILITY OF EXISTING SIX SIGMA FRAMEWORKS IN INDIAN INDUSTRY

4.1 Introduction

For global competitiveness, Indian industries need overall operational and service excellence. Indian industries have experienced periodic impacts of transformation, both, before and after industrial reforms. Initially, the focus has been on large-scale public and private sectors, mainly in core infrastructural production organizations. After globalization and liberalization, quality surfaced as one of the major areas of concern along with productivity. With the reduction of geographical barriers and the pressure of competing in the global market, overall operational and service excellence has become a necessity for the Indian industries to remain globally competitive. Six sigma has evolved into a powerful business improvement methodology in many Indian industries and its importance is growing. According to Antony, J. and Desai, D.A. (2009),

"Although many Indian industries have successfully embraced the six sigma business improvement strategy, the adoption of six sigma in Indian industries is not as

encouraging as it should be. It appears that six sigma is not fully explored by Indian industries".

Presently many Indian companies such as Bharat Forge, Tata Motors, Mahindra and Mahindra, Maruti and their ancillaries, are taking right steps in the direction for implementation of six sigma business improvement strategies. However, a comprehensive six sigma framework/path/roadmap for the Indian scenario is needed, which can be used to establish a mechanism to assess the competitiveness of the Indian manufacturing firms and to encourage the adoption of global best practices. A review of literature in Chapter 2 has reported that there is a need for the six sigma implementation framework, describing important elements/construct of six sigma, relationships between these elements and which will guide the professionals for effective implementation.

4.2 Identification of existing six sigma frameworks

The term framework doesn't have clear cut definition from the research world. But there seems to be a lack of consensus about what really a framework is. Very often, the terms model and frameworks have been used interchangeably. It is all happening due to lack of clarity about what is framework or model. The present study investigated what is a framework. Few researchers tried to give proper definition of the framework and model.

stated that a model can answer the question of "what is" with the overall perception or elements put down together, whereas a framework attempts to answer "how to" questions and presents an overall relationships and method forward. "a framework is a device that used to define the whole blue print of the management business objectives and also tries to present the methodology to reach the organization business goals". Reported that the strong framework help to build up fundamental relationship among the theory and practice of the organizations. The mathematical model is just a model but it should not be considered as a framework. These models are generally useful to take a decision based on value calculated. A framework consists of a set of fundamental tools, techniques, principles with complete discussion on the actions to be performed discussed that a framework projects the complete action plan and ensure each individual step builds up methodology also. A framework can be useful to the managers of the organization as a guiding torch, which can assist and shows the required path during implementation of the new advanced manufacturing philosophies in an organization. After reviewing entire

exiting literature on the frame work, concluded that the framework should satisfy the following conditions:

- A framework is not only a recommended bunch of elements to be considered in that system, but it should give information about the complete relationships amongst the elements of system under study.
- A framework should discuss the important steps and stages of activities and how these are vital for the required purpose.
- A framework should give information about what all activities are involved and connection of various elements of frameworks with those activities.

Hence the focus of the present research is to propose a six sigma framework which will talk about various elements important to achieve six sigma and also give information about the complete relationships amongst the elements. It will also describe the important steps and stages for the implementation of the framework. The framework will consist of definitive set of pillars and its elements which in totality present the overall picture of six sigma and which overcomes the deficiency that exists in existing framework of six sigma. The proposed six sigma framework will be useful for the organization willing to implement six sigma.

From the literature review of six sigma articles, it is clear that few researchers have proposed framework of six sigma. However all the frameworks suggested by various researchers talk about elements of six sigma implementation and do not discuss complete relationships between the elements suggested, steps and stages of activities and its implementation. The study found 67 six sigma frameworks from the literature review.

The comprehensive list of frameworks identified from literature review and considered for the study is given in Table 4.1. Apart from this, a brief overview about the existing frameworks and comments are also shown in Table 4.1

Table 4.1: The complete list of six sigma frameworks considered in the present study Frameworks Comments on frameworks

Frameworks	**Comments on frameworks**
Vijay Shanmugam (2007)	The author has discussed about success of a six sigma program relies mainly on some of

	the key ingredient and identified few elements for six sigma implementation in US manufacturing firm.
Roger Hiltona, Margaret Ballab and Amrik S. Sohal (2008)	The authors emphasized on, there is limited empirical evidence demonstrating the relationship between factors associated with a six sigma quality program and the performance of organizations and discussed about six sigma elements for implementation.
Forrest B. Green (2006)	The author suggests that Total Quality Management is undergoing a revival under a new name, six sigma. Author also discussed about five elements for six sigma implementation.
Navin Shamji Dedhia (2005)	The author discussed about six sigma basics and four necessary elements for implementation.

In all the frameworks listed in Table 4.1 above, various authors have suggested key elements/critical success factors for six sigma implementation. However no one has discussed about relationship between the suggested elements and its validation. It should be clearly understood here that these researchers listed in the above-mentioned table have not proposed any frameworks; rather they have explained what are the elements or critical success factors for six sigma implementation.

The focus of this work is to evaluate reliability and validity of identified frameworks, develop a new framework suitable to Indian Industries, and evaluates reliability and validity of suggested framework with context to Indian Industries and also to explore the applicability of proposed six sigma implementation framework in Indian industries.

4.3 Research methodology for conducting the empirical investigation

The different stages of the systematic approach for the research methodology described in Chapter 3 are followed to conduct the validity and reliability study. A brief description about the same is presented below:

4.3.1 Theory verification

The first step is to analyze the existing six sigma frameworks for validity and reliability in Indian industry.

4.3.2 Selecting a research design

To accomplish the validity and reliability analysis of the existing six sigma frameworks of in the Indian scenario, a cross-sectional survey was conducted as discussed in Chapter 3.

4.3.3 Selecting a data collection method

A questionnaire survey is selected as the data collection method for the first phase of empirical research which deals with validity and reliability analysis of the exiting six sigma frameworks.

4.3.4 Implementation

A cross-sectional study using questionnaire survey has been decided to perform on selected multi-sectional industries of manufacturing sector.

In order to achieve the objectives of the present research, the study focused on different multi-sectional industries in manufacturing sectors, i.e. the automobile industry, process industry, machinery and equipment, electrical and electronics and textiles industry. database of manufacturing companies to be used for the survey was obtained from the CII (Confederation of Indian Industry) directory for the year 2012.

The respondents involved in the survey were from various levels like Managing Directors/CEO's, production managers, maintenance managers, logistics managers, human resource managers, product managers and quality managers.

A structured questionnaire was developed on five point Linker scale, the details of which are given in appendix B where (1) means Not Important, (2) means Less Important, (3) means Important, (4) means More Important and (5) means Most Important. The respondents were requested to consider each framework as independent entity and rate the critical success factors/ elements in it as a milestone to guide the organization wanting

to implement six sigma. The respondent were asked to rate these elements on the five point response scale.

In initial stage of questionnaire design, the industry experts and academicians were consulted. Comments and feedback of the experts were incorporated and a few minor changes were made especially in questionnaire format. Most of the experts shared the feedback on questionnaire format and finally declared that it was suitable for data collection.

The questionnaire consisted of two parts A and B. The aim of the part A was to collect the information about the respondent and organization profile. Part B was a structured questionnaire developed considering all the frameworks for assessing the level of importance of each element on a five point Liker scale.

A covering letter was also enclosed describing aim of the present study, instructions to fill the questionnaire, email address of the present study authors. The respondents were welcome to share any other information they had regarding the concept of six sigma in the Indian industry. The author performed a pilot study to reinforce the expert's feedback. The study expected that the respondents have basic idea about six sigma practices. The language used in each six sigma framework was simple for easy understanding of the respondents.

Moreover, the authors shared their contact details in covering letter with the participants, in case of any ambiguity or queries related to the questionnaire. Total 725 questionnaires were sent to people selected from population of manufacturing industries. Subsequently the author sent 175 postal reminders and 450 emails to no responding organizations and also contacted personally over telephone. Responses from 188 organizations were received. However, there were 8 questionnaires which were incomplete and were not valid and hence we had 180 valid responses which make the overall response rate of 24.82 percent.

Statistics of sector wise responses received are as shown in the Table 4.2. a response rate of 18 % is considered to be adequate in Indian manufacturing conditions. In order to arrive at sample size the author performed literature review and revealed that different sample sizes such as at least 150-300 cases or around 200 is reasonable reported that a large sample size helps to get more appropriate results.

Table 4.2: Statistics of sector wise responses

Industry	Sample size	No. of responses received by Post	No. of responses received by e-mail	Total No. of responses received	Response Rate (%)
Automobile	188	24	29	53	28.19
Process	145	11	20	31	21.37
Machines And Equipment	140	13	25	38	27.14
Electrical And electronics	174	14	19	33	18.96
Textile	78	9	16	25	32.05
Total	725	71	109	180	24.82

4.3.4.1 Validity and reliability analysis

The objective was to investigate the validity and reliability of various frameworks of six sigma in the Indian industry. The validity and reliability of the frameworks was investigated from the responses received and the collected data was analyzed by using the Statistical Package of Social Science (SPSS) version 18.

4.3.4.2 Reliability analysis

Reliability is the extent to which a variable or set of variables is consistent in what it is intended to measure. Reliability analysis is used to find out whether the survey instrument is producing the repetitive results at any time it is administered to the same respondent under same settings regardless of who administers them. Reliability can be measured by test-retest reliability, alternate forms reliability, split-half reliability, and internal consistency reliability. Many researchers have preferred to use internal consistency method due to its various advantages like consistent method and only require a single application to get required results. Cronbach's alpha coefficient is the most commonly used coefficient to measure internal consistency of any framework. It can be calculated using standard commercial package SPSS 18v, which is a user-friendly software package.

4.3.4.3 Validity analysis

Validity is defined as the extent to which any measuring instrument measures what it is intended to measure. Normally validity analysis is done using three measures: (1) content validity, (2) criterion related validity and (3) construct validity. Reliability is a necessary condition for validity, but reliability is not sufficient to determine validity alone.

1. Content validity is determined by judgment made by panel of experts and it is qualitative approach. The main objective of content validity is used to check whether all aspects of the attributes are considered in the survey instrument. It can be determined by expert opinions and cannot be determined statistically.
2. Criterion validity is used to determine the extent to which a measuring instrument is related to the objective measured. It is nothing but a simple correlation analysis for testing a scale of constructs for a single outcome. In the current context, criterion related validity is used to investigate the empirical relationship between the frameworks' elements and the objective of achieving six sigma.
3. Construct validity measures whether a scale is an appropriate operational definition of an outcome. Construct validity provides the researcher with confidence that a survey actually measures what it is anticipated to measure. It can be measured through empirical survey and cannot be directly assessed. The most reliable method to perform construct validity is Principle component analysis. Principle component analysis is conducted to check whether all elements are loading on a single factor i.e., Unidimensionality of the scales towards a single construct. In the present study, the principle component analysis has been used to check unidimensionality of each framework.

4.4 Results and discussion of empirical study

The validity analysis was performed on each six sigma framework to find eligible six sigma frameworks that can be used for further investigation.

The content validity of the questionnaire was performed in two stages: initial stage, the questionnaire was administered to eight practitioners in industry and four academicians. The feedback received from them was incorporated in the final questionnaire. In final stage, the questionnaires were sent to academicians in other prestigious institutions and also pilot study was conducted in one of the reputed automotive industry. The sample

size of the pilot study is 30 samples in middle and top level management, who have complete knowledge about six sigma. The comments and feedback of the experts were taken into consideration and a few minor enhancements were made especially in questionnaire draft format on the basis of the feedback received. Finally, the questionnaires were sent to the various Indian manufacturing organizations.

Criterion-related validity is used to check whether a framework's measures are positively related to the proposed objective or not in the respective context of study. However, in the present study at this juncture the criterion-related validity is not tested for the chosen frameworks. But it has been carried out while validating the proposed framework in their research on manufacturing excellence frameworks. Finally, the construct validity of each framework was checked. The objective of the construct validity is to check whether it measures the concept or the theoretical construct it was anticipated or designed to measure.

In order to perform validity analysis on any scale, the scale should satisfy two conditions: one is unidimensionality of the scale and secondly, the scale should fulfill the reliability conditions as well. Unidimensionality is used to check whether all elements are concentrated towards the main target of the measurement. Hence, for all the considered frameworks, the unidimensionality checks as well as the reliability analysis was performed. The principle component analysis was used to conduct construct validity on all 67 six sigma frameworks.

Table 4.3 shows an example of a component matrix for the framework suggested by Rodney Mcadam and Alison Evans, which is result of the principal component analysis for the factor extraction.

Table 4.3: A component matrix for the framework of Rodney Mcadam and Alison Evans

Elements	**Components**
Role of management	0.711
Empowerment, reward and co-operation	0.721
Process performance issues	0.761

Cultural transformation	0.796
Customer satisfaction	0.771
Methods of communicating to all employees	0.785

Internal consistency or reliability of the frameworks can be checked by inter-item analysis. One of the most commonly used indicators of internal consistency is Cronbach's alpha coefficient. Preferably, the framework Cronbach alpha coefficient of a scale should be above 0.7, which is considered to be good. Cronbach alpha coefficients of selected twenty nine frameworks were more than 0.7 and a mean of more than 3.5. Table 4.5 shows the mean and reliability analysis results for the selected frameworks.

Table 4.4: Reliability analysis for the framework of Rodney Mcadam and Alison Evans

(a) Summary item statistics

Number of cases:180	Mean	Minimum	Maximum	Range	Maximum /Minimum	Variance	N of Items
Item Means	3.739	3.617	3.800	.183	1.051	.004	6
Inter-Item Correlations	.488	.291	.703	.412	2.416	.011	6

(b) Item-total statistics

Elements	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item- Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Role of management	18.6500	12.128	.575	.438	.835
Empowerment, reward and	18.6667	11.888	.597	.511	.832

cooperation					
Process performance issues	18.8167	11.011	.643	.497	.824
Cultural transformation	18.7000	11.842	.681	.510	.818
Customer satisfaction	18.7000	11.206	.645	.600	.823
Methods of communicating to all employees	18.6333	11.463	.672	.552	.818

(c) Reliability statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.850	.851	6

From these selected frameworks, the main elements were identified through frequency distribution analysis. The criteria for chosen elements were generally having a mode (most frequently occurring value) of four or more and mean of more than 3.5. The sample frequency distribution analysis statistics performed on the framework of Rodney Mcadam and Alison Evans shown in Table 4.7. Most of the constructs/ elements in each framework were identified. Finally total 159 elements were identified from these twenty nine frameworks.

Table 4.7: The sample frequency distribution analysis performed on the framework of Rodney Mcadam and Alison Evans

	Role of Manage	Empowerment, reward and	Process performance	Cultural Transformation	Customer satisfaction	Methods of communicating

		ment	cooperation	issues			to all employees
N	Valid	180	180	180	180	180	180
	Missing	0	0	0	0	0	0
Mean		3.7833	3.7667	3.6167	3.7333	3.7333	3.8000
Median		4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
Mode		4.00	3.00	3.00	4.00	3.00	4.00

4.5 Conclusion

The objective of the chapter was to perform the validity and reliability analysis of the existing frameworks of six sigma in Indian scenario. This study has identified that although majority of the frameworks are displaying high level of reliability but only 29 frameworks displayed Unidimensionality with respect to the construct i.e. six sigma it measures. It was found through the frequency analysis that majority of the constructs have a high mean and mode score. Various frameworks displayed different constructs with a certain amount of overlap between them. On further investigating the selected frameworks, many important constructs/ critical success factors were not found like standardization. Very few frameworks reported importance of use of quality tools, role of effective communication and focus on suppliers in their frameworks.

Hence, it clearly shows that none of the existing frameworks can be used in its present form due to various limitations and there is a need for development of a new framework which will suite and fulfill the requirements of Indian industry. Six sigma is an important imperative for Indian manufacturing sector to compete with global as well as Indian competition. Hence, there is need to develop a comprehensive six sigma framework considering all the aspects of Indian manufacturing companies to sustain globally and which will provide strategic directions for the industry. The development of a new framework shall be discussed in the next chapter.

CHAPTER 5

DEVELOPMENT OF SIX SIGMA FRAMEWORK: PROPOSED FRAMEWORK

5.1 Introduction

As seen in previous chapter, many researchers have proposed various frameworks and suggested corresponding elements of six sigma. Also, it was found that none of the existing frameworks were useful in the present form to implement in Indian manufacturing industries. The study also revealed that the elements suggested are not sufficient and there is need to identify comprehensive set of elements and subsequently comprehensive structural framework to fulfill the changing requirements of the Indian manufacturing as well as the global manufacturing scenario. The present study has

considered only those frameworks which successfully validated in Indian manufacturing industries.

5.2 Need of a framework for Indian scenario

Global manufacturing scenario is changing fast and India is well on its way to becoming the premier manufacturing location for companies around the world. "today Indian companies are facing competition from their multinational counterparts. To compete in the global scenario Indian firms need to develop the competence for global manufacturing". As understood so far it can be seen that six sigma is an imperative for competing in the global market and moreover Indian industries have been found wanting in their efforts to survive the changed scenario. In the present Indian market scenario there is a requirement for an appropriate framework for providing direction and guidance to an organization in six sigma implementation. A framework that shall suit the Indian milieu as well as provide strategic directions for the Indian Industry. Hence, the present study is attempting to critically review the six sigma literature to find out the inconsistencies in a sample of existing six sigma frameworks and the study also tried to fulfill this gap with the help of developing a new framework for six sigma implementation. At present some of the Indian industries are also trying to implement six sigma and are competing in the world market without proper guidelines and directions. To achieve the potential benefits of excellence within manufacturing, practitioners require practical and detailed guidance. The absence of a practical and detailed model to follow is an issue of concern to those interested in the pursuit of excellence within manufacturing. In addition to this, to recommend any form of action to improve manufacturing's ability to contribute strategically to the business, it is necessary to consider the key initiatives. These initiatives can be mobilized to effectively pursue the manufacturing performance objectives and provide the business with a sustainable advantage over the competition. Also, it is necessary to describe the means or process, which could make explicit what needs to be done at the operations level in order to sustain the competition. These issues can be resolved using the new framework of six sigma.

In the frameworks which have been reviewed and discussed in the previous chapter, there exists a significant difference in each framework and some framework addresses only

very few issues. Therefore the proposed research will focus on addressing all issues and attempt to develop a comprehensive six sigma framework, which will be suitable for the domestic as well as non- domestic industries.

The reliability and validity of the existing six sigma in the Indian Industry was investigated in the previous chapter. This study identified that although majority of the frameworks are displaying high level of reliability but very few frameworks displayed unidimensionality with respect to the construct i.e. six sigma it measures.

None of the existing frameworks considered some important elements like standardization, quality control tools and techniques etc. Hence none of the existing framework can be used in their present form.

To promote the development of technological and managerial capabilities, it is necessary that the industries should be provided with proper guidelines and directions especially regarding the best practices in manufacturing like six sigma These guidelines or directions are addressed in a framework or model, which paves the way for the Indian industries to achieve manufacturing excellence and help them compete at the global level.

5.3 Comparison of various six sigma frameworks

To develop a new framework, a better understanding of existing frameworks is required. It is necessary to understand, which areas are well-addressed in the six sigma literature and which areas are yet to be addressed. In order to suggest elements for new six sigma framework, it is important to find out:

- What type of elements is used by various researchers to develop the sample six sigma frameworks?
- What are the standard elements that are used to formulate the selected six sigma framework?

Similar to identify the best practices and to develop world class maintenance and supply chain management frameworks respectively. The present study also followed similar approach to identify best practices in the field of six sigma to develop a new framework. The frequency analysis of selected 29 six sigma frameworks in the sample of existing six sigma frameworks has been done and given Appendix-D.

Appendix-D revealed that around, total 159 elements are identified from a sample of 29 six sigma frameworks. Some elements were utilized by various researchers with different

phrases or words, but the meaning of those elements was the same. These kinds of elements were clubbed to find out the exact number of unique elements in the sample of six sigma frameworks. For instance, top management commitment / management support/ executive commitment. All these elements represent top management commitment.

The present study identified 159 elements; however, they are not independent of each other. Majority of the elements can fall in a particular domain. If a suitable principle component analysis is performed, all these elements fall under a few independent elements. These few independent elements are very broad in nature. For example, strong customer focus/ a genuine focus on the customer/ Customer management/ Customer relationship etc. Hence these elements representing very specific area are clubbed together and brought under the common tile e.g. customer relationship management. The purpose of the present study is not to compare six sigma frameworks based on its strengths and weakness. The main purpose of this section is to find out availability of standard elements in the existing literature.

The present study tries to find out a set of standard elements that are critical for six sigma implementation; the study separated the elements that are repeated more than once.

Another objective of the comparative analysis in the study is to identify the pillar or main elements of six sigma framework. Through frequency analysis of selected six sigma frameworks, it was found that some elements have relatively high frequency than other elements. Hence the study identified elements that were repeated with frequency of 0.2 or more i.e. 20% or more frameworks were considered important for six sigma implementation. These repetitive elements were considered as pivotal points to develop a new six sigma framework. These repetitive parameters / elements in the comparative analysis can be called as “pillars” as they become pivotal for implementation of six sigma.

The study found that around 6 elements were repeated with frequency of 0.2 or more. To find the whether these six pillars covers all the necessary elements for implementation, the study formed a twelve member team with six academicians and three each from consultants and practitioners groups. A thorough brainstorming was done and few more elements were added as new pillars through domain knowledge to already identified

pillars identified the comparative analysis. The list of pillars of six sigma is as shown in Table 5.1.

Table 5.1: Pillars of six sigma

Sr. No.	Pillars
1	Top management commitment and leadership (TMCL)
2	Project selection and execution methodology (PSE)
3	Training and education (TRE)
4	Customer relationship management (CRM)
5	Effective Information technology and communication System (ECS)
6	Quality improvement tools and techniques (QIT)
7	Supply chain management (SCM)
8	Human resource management (HRM)
9	Standardization (STD)

5.4 Development of a framework for six sigma

Using frequency analysis, literature review, domain knowledge etc. framework for six sigma was developed. The step by step method of development of the framework is discussed as given below:

5.4.1 Pillars of framework for six sigma

After doing frequency analysis some unique elements were identified, elements having same meaning or broad area are clubbed together which represent the pillars of six sigma and through domain knowledge and expert's suggestion some more pillars were added to already identified pillars through the comparative analysis. Along with this extensive literature search, discussion with practitioner, was done to identify the various elements for the effective implementation of various pillars of six sigma. The list of pillars/elements of six sigma is as shown in Table 5.1. A brief discussion about these pillars is given below:

1 Top management commitment and leadership (TMCL)

This refers to the top management role and behavior in driving the organization towards six sigma. It was covered by 80% of the frameworks / studies and hence it was

considered to be an important element in the proposed framework. the main focus of TMCL is about guiding and influencing employees of the organization to attain the organization's aspirations, developing a vision and mission of the organization, and ensuring that the organizational stakeholders including employees, customers and suppliers understand the values and vision. The effective leadership includes developing strategies required to implement changes, creating a trusting environment, creating an enthusiasm and motivation in the employees, initiate the vision across the organization, conducting training programmers and also encouraging continuous learning and development. The present research also proposed TMCL as a foundation of the framework. Based on the literature various elements were identified as given below:

1. Six sigma vision and mission
2. Strong Leadership
3. Participative Management
4. Long term strategy development
5. Continuous learning and development culturing
6. Policy deployment
7. Appropriate resource allocation
8. Holistic strategy for integrating system

2 Project selection and execution methodology (PSE)

As per project selection and execution (PSE) is one of the important element to make the six sigma implementation really worthwhile. PSE has been recognized by practitioners and researchers as one of the major factors for achieving successful implementation. Organizations try to implement a six sigma approach in anticipation of market penetration and organizational speed, while simultaneously reducing the cost of doing business. In other words, the projects must be selected in line with the organization's goals and objectives. During the project selection, the organization needs to ensure that all the projects are selected in line with the goals and objectives and within a manageable scope. Many researchers have recognized PSE as an important element of six sigma. The selection of suitable projects in a six sigma program is a major factor in the early success and long-term acceptance of six sigma within any organization. The various elements identified under this pillar are given below:

1. Brainstorming
2. Benchmarking
3. Risk management
4. Project review teams
5. Process capability
6. Project Management skills
7. Project prioritization and selection
8. Project orientation with clear & defined goals

3 Training and education (TRE)

Training and education is the most fundamental element in six sigma. It refers to learning activities in organizational levels for sustainable application of six sigma activity. Stresses that six sigma management activities do not just end with implementation, and indicates the need for a monitoring tool that can maintain and develop improvements through sustainable education/training. Many researchers have identified training and education as key success factor for six sigma implementation.

Without organizational learning there can be no continuous improvement. One of the most important stages in the quality planning process is the implementation stage, and so also in six sigma. Education and training give a clear sense for people to better understand the fundamentals, and techniques of six sigma. Training is required to make sure those managers and employees apply and implement the complex six sigma techniques effectively. Based on the literature various elements were identified as given below:

1. Comprehensive six sigma training programmer
2. Investment and training framework for trainers and mentors
3. Rigorous and structured training deployment plan
4. Education of management in the philosophy, methods, applications, and their roles
5. Training scheme

4 Customer relationship management (CRM)

It refers to strong customer focus. Six sigma places extraordinary emphasis on customer needs, both internal and external, seeking to determine what consumer's desire in

products and services. Six sigma formalizes this approach by specifically identifying critical-to-quality requirements, which are characteristics that customers consider to have the most impact on quality. Such characteristics could be a key dimension in a part or product, the time to process a transaction, the ability to deliver a service, or the response to an internal process. The main objective of six sigma, like most of other management strategies on quality initiatives, is focused around meeting the customer requirements. With customer focus as an anchoring guide, an organization is equipped to begin the six sigma process. Many researchers have pointed out that the success of six sigma and its implementation is determined by its impact on customer satisfaction. Hence it is considered as one of the pillar for six sigma implementation and various elements were identified as given below:

1. Business strategy based on customer demand
2. Delivery performance improvement
3. Continuous evaluation of customer feedback
4. Customer enrichment
5. Post sale service to customer
6. Linking six sigma to customer
7. Customer involvement in design process

5 Effective information technology and communication system (ECS)

This refers to communication system, information sharing system for effective communication between employees of the organization as well as outside. Team communication is one of critical success factors for implementation of six sigma in the Indian industries. In the present scenario, the information flow plays vital role to fulfill complex manufacturing systems as well as supply chain activities. Have revealed the importance of information technology tools to control information flow within organization as well as across supply chain activities. To survive in the present dynamic markets conditions, the firms have started to work as group instead of single independent entity. The information technology helps to provide the essential prerequisite to build and control multi-level networks as well as to improve communication effectiveness in supply chain activities. Hence it is included as one of the important pillars to implement

six sigma frameworks in the organization and various elements were identified as given below:

1. Effective communication systems with customers and suppliers
2. Use of EDI(Electronic Data Interchange) to communicate between departments
3. Use of barcoding and scanners in logistic systems
4. Information technology employed at customer base
5. Enterprise resource planning system
6. Centralize database for documentation
7. Methods of communicating to all employees

6 Quality improvement tools and techniques (QIT)

This refers to use of quality tools and methods. The complexity of problem solving requires use of quality tools to assist in the organization and analysis of information and data surrounding the concern. The application of quality tools and methods can lead to improved performance, to the degree that improvement teams follow the six sigma tools and method they can make better decisions, which improves project performance. Use of quality tools is one of the critical success factors for six sigma implementation. Many researchers have emphasized the effective use of quality tools & techniques for successful implementation of six sigma and hence it is considered as one of the pillar and main elements are listed below:

1. Understanding tools and techniques within six sigma
2. Understanding the DMAIC methodology
3. Link quality initiatives to business
4. Use of statistical tools and the statistical design of experiments (DoE)

7 Supply chain management (SCM)

It refers to Supplier involvement, long-term relationships with suppliers, fewer dependable suppliers, reliance on supplier process control. In the 1990s, companies started discovering that the impact of suppliers was of enormous significance to customers. Rather than producing only high quality products, delivering products to customers at the right time, at the right place, and at the right price has become a new challenge. The supply chain management (SCM) approach has thus been increasingly identified by many organizations as an opportunity to achieve these goals. Many

organizations are focusing on SCM to improve their organizational performance and enhance competitiveness in the marketplace. The important aspect of six sigma methodology, such as supplier management could also serve as an orientation for continuing in-depth analysis of the real reasons for the success of six sigma. Many researchers have considered supplier management as one of the critical success factor for six sigma implementation.

In today's businesses scenario, the interdependence of buyers and suppliers has increased significantly. Hence organizations are looking for establishing long term relationship with suppliers. Furthermore, companies have realized, vendors' knowledge and experience can be valuable during the design of new products and in achieving higher quality and faster response to market needs. With the increase of global competition, increased emphasis on supply chain performance has become a critical source of sustainable advantage in many industries. Various elements identified from literature are given below:

1. Linking six sigma to suppliers
2. Long term supplier relationship
3. Supplier feedback
4. Supplier training and development activities
5. Supplier evaluation and certification
6. Supplier proximity
7. Supplier involvement in design process

8 Human resource management (HRM)

It refers to employee involvement/ employee participation, support from every employee of the organization in making any initiative towards achieving goal of that organization successful. Human Resource (HR) is the back bone of any company. Success or failure of any company is mainly depending on the employee's i.e. human resource of that company. The organizational employee commitment is one of the major factors to implement any change management concept in the organization. The employee relationship and management is based on change implementation, with all the employees acting as team to make the change process as any kind of success. Before anticipating contribution from the employees, the organization management should invest a

considerable capital budget in all steps of the planning and execution of employee development. It includes job design, knowledge training programmers, financial benefits and recognition initiatives that encourage employees to contribute effectively to attain the organizational vision and mission. Hence many researchers have considered human resource as important element in six sigma implementation in organization. Hence the study proposed HRM as a one of the pillar in six sigma framework. Various elements identified under HR are listed below:

1. Linking six sigma to employees
2. Availability of well-trained full-time team leaders (Champions, Master Black Belts)
3. Multi skilled employees
4. Employee involvement in every stage of organization
5. Suggestion scheme
6. Stable or long term employment
7. Fair rewards and recognition

9 Standardization (STD)

The main purpose of standardization is the use of common products, processes and components to fulfill the heterogeneous requirements. Simplified design and standardization is encouraged for manufacturability. Standardization aims to institutionalize the improvement results from six sigma through documentation and standardization of the new procedures.

The real challenge of six sigma methodology is not in making improvements to the process but in providing a sustained improvement to the optimization. This requires standardization and constant monitoring and control of the optimized process.

While discussing the role of standardization in context of other quality initiative, discussed that the process of standardization helps to improve the productivity, reduce the number of managing reference points, decrease the stock level, and drastically reduce the complexity of a manufacturing system. Any optimal standardization of internal products will not create any change in characteristics of the end product from the customer's point of view. After discussion, many practitioners & researchers have suggested to include standardization as one of pillars of six sigma. Along with this extensive literature search

was done to identify the various other elements under standardization. Hence the present study also proposed standardization as one of the key pillars in six sigma framework. Based on the literature various elements were identified as given below:

1. Standardized work procedures
2. Standardized products
3. Standardized tools and equipment
4. Standardize materials for specific products families
5. Group technology
6. Visual control boards
7. Standardize the quality check methods

5.4.2 Pillars and elements of six sigma

The various pillars identify and their respective elements are shown in Table 5.2.

Table 5.2: Identified pillar of six sigma and respective elements

Sr. No	Pillars
1	Top management commitment and leadership (TMCL)
2	Project selection and execution methodology (PSE)
3	Training and education (TRE)
4	Customer relationship management (CRM)
5	Effective Information technology and communication System (ECS)
6	Quality improvement tools and techniques (QIT)
7	Supply chain management (SCM)
8	Human resource management (HRM)
9	Standardization (STD)

5.5 Proposed framework for six sigma

The identification of mail pillars and its elements important for six sigma framework have been discussed in previous section. All the suggested pillars with elements were

wetted by eight member's team consisting of academicians and practitioners in order to make sure that suggested pillars and elements are appropriate to form a six sigma framework. Figure 5.1 presents a framework for six sigma.

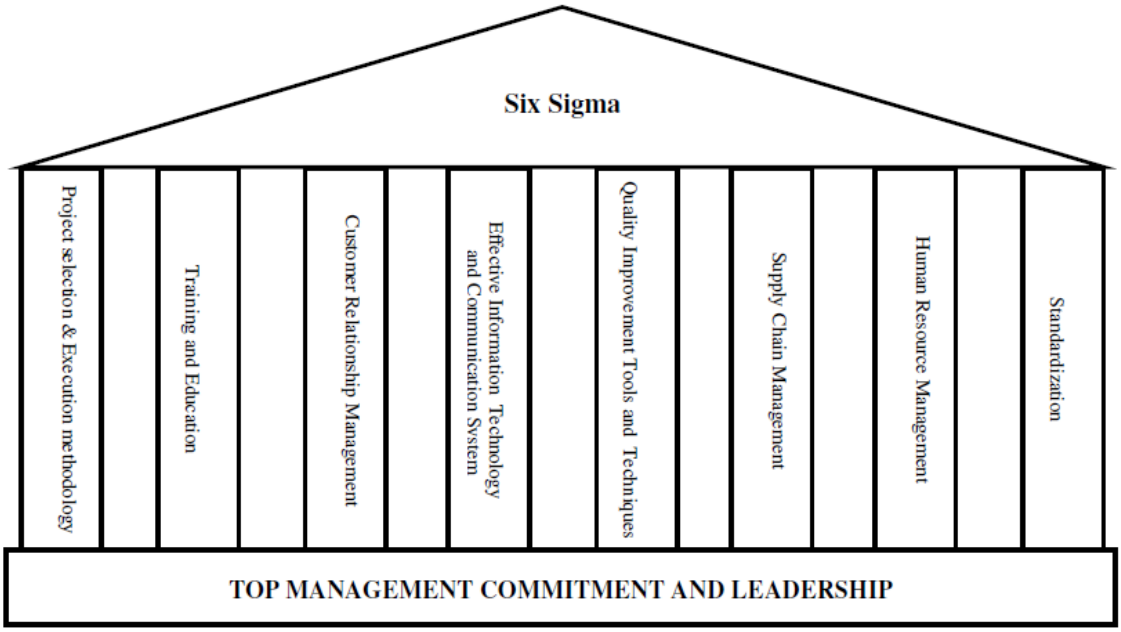

Figure 12: A framework for six sigma

The salient features of the proposed framework are discussed below:

- The proposed framework of six sigma consists of 60 elements and 9 pillars or broad areas that were identified through empirical survey and a thorough literature survey respectively.
- The proposed framework was constructed after consultations with academicians, practitioners and consultants, which overcomes the shortcomings of the existing frameworks in the field of six sigma.
- The framework stands on strong foundation of top management commitment and leadership towards. The pillars that support the roof of six sigma are the nine initiatives a company takes for achievement of six sigma viz.: Top management commitment and leadership, Project selection and execution methodology, Training and education, Customer relationship management, Effective information technology and communication system, Quality improvement tools and techniques, Supply chain

management, Human resource management and Standardization. A detailed discussion about each was done in the previous section.

- The proposed framework was consisted number of pillars and elements as compared with the sample frameworks considered in the study. It clearly indicated its comprehensive nature compared with other existing frameworks in the field of six sigma. However the study is accepting that there is a possibility of missing some of the elements in the proposed framework. frameworks generally consist of inadequacy because it is not possible to generate a framework with the characteristics being general, simple and accurate at the same time.
- Any framework generally undergoes the process of evaluating reliability and validity of the constructs. The proposed framework also generates a requirement to evaluate reliability and validity of elements. Hence, the framework verification and validation is indispensable.

5.6 Conclusion

Many researchers/ authors and practitioners have proposed important elements for six sigma across the world in the form of framework. However, the present study did not find any review article existing in the literature reviewing various frameworks proposed by authors/ researchers and practitioners. Different frameworks as proposed by authors/ researchers and practitioners were reviewed to find out the standard elements. As a result total 159 elements obtained through the various frameworks and were grouped under major initiatives like Top management commitment and leadership, Project selection and execution methodology, Training and education, Customer relationship management, Effective information technology and communication system, Supply chain management, Human resource management. Along with the same some more initiative like Quality improvement tools and techniques, Standardization were proposed to take into account the changing manufacturing scenario.

Many researchers proposed six sigma frameworks to utilize in a specific environment of the organization, which made it difficult to find the standard elements in the field of six sigma. Hence the present study has proposed a six sigma framework to give a coherent set of elements with the help of empirical study as well as comparative analysis.

The study has proposed six sigma framework with the help of academicians, professionals and consultant's team. Hence, it is believed that the proposed six sigma framework will overcome all the limitation of existing six sigma frameworks and will be useful for the organization wanting to implement six sigma. The study requires validating the proposed six sigma framework in Indian manufacturing industries.

CHAPTER 6

AN EMPIRICAL INVESTIGATION OF PROPOSED SIX SIGMA FRAMEWORK IN INDIAN INDUSTRY

6.1 Introduction

A framework for six sigma was developed in the fifth chapter. The study has proposed nine main pillars, along with the various elements identified with the help of empirical study under each pillar. An exploratory study was conducted to check the reliability, validity and applicability of the proposed six sigma framework. To fulfill requirements, the study performs a nationwide survey in the second phase of the empirical study. The study also attempted to establish the directional relationships among nine pillars of six sigma, i.e. dependencies and inter-dependencies by using Interpretive structural modeling (ISM), which was subjected to statistical testing for model fit by using SEM. Details regarding the same are presented in the subsequent sections.

6.2 Methodology for empirical investigation

The different stages of the systematic approach for the empirical research are described in Chapter 3. Same methodology was followed to conduct the second phase of empirical study. A brief description about the same is presented below:

6.2.1 Theory verification

The first step in the systematic approach is theory verification. Accordingly, the second exploratory study was aimed at conducting an empirical investigation of proposed six sigma framework in Indian manufacturing industries.

6.2.2 Selecting a research design

To do the empirical investigation of proposed six sigma framework in Indian industry, a cross sectional survey was conducted as discussed in Chapter 3.

6.2.3 Selecting a data collection method

A questionnaire survey was used as data collection method, as per the research methodology discussed in detail in Chapter 3. The questionnaire was prepared and it was also sent to the same 725 industry professionals to whom the first questionnaire was sent.

6.2.4 Implementation

Although this exploratory study was conducted on the same population of 725 industry professionals identified in the previous exploratory survey, the questionnaires were sent as a soft copy attachment through e-mails and also through post to various industries.

The survey instrument was developed with pillars and identified elements under these pillars. The questionnaire was developed for assessing the implementation, level of involvement related to various elements under each pillar. In addition to this, general questions were also incorporated to identify the industry profile in terms of employee strength, growth, customer strength, etc. The questionnaire consisted of two sections part A and B. The aim of the section A is to build a profile of the respondent and the manufacturing company based on the experience of the respondent and the mission, vision of the company etc. section B deals with structured questionnaire developed on a five point Liker scale for assessing the level of importance of each element under nine pillars of six sigma identified (the details of which are given in Appendix-E). A covering letter was also drafted which gives general information about the research work, purpose of the study and how to use the instrument and confidentiality of the information. Respondents were welcome to share any other information they had, regarding the concept of six sigma in the Indian industry.

Respondents were asked to consider each pillar as a means for implementing six sigma with each element in it as a milestone to guide the organization wanting to assess the status of that particular pillar in their organization. The respondents were requested to rate the element based on “how important is each element under various pillars of the proposed framework are to the organization?” In the questionnaire was prepared in very simple language and can easily be understood. In case of any discrepancy in understanding, the respondents were requested to revert to the researchers through e-mail, postal mail or phone. In totality, 725 questionnaires were sent by e-mail and post.

Subsequently, more than 200 e-mail reminders were sent. Apart from this, some people were contacted personally over telephone. The questionnaire is developed using five

point Liker scale where (1) means not important, (2) means less important, (3) means important, (4) means more important, and (5) means most important. Respondents were requested to rate the degree or extent of practice of each element with reference to the five point response scale. The details of the questionnaire are given in Appendix-E. This time the response rate was slightly improved and out of the 725 questionnaires, 206 responses were received. Eight questionnaire were incomplete and hence total 198 valid responses were received which include 74 from the automobile sector, 31 from the process industry, 34 from the machines and equipment industry, 36 from electronics and components, and 23 from the textile units. The overall response rate was 27.31 % which can be considered good in Indian conditions. Details of sector wise responses received are shown in the Table 6.1. On an average experience the respondents were eleven years. Majority of the respondents were from the top management having designation such as general manager, associate vice president etc.

Table 6.1: Statistics of sector wise responses

Industry	**Sample size**	**No. of responses received by post**	**No. of responses received by e-mail**	**Total No. of responses received**	**Response Rate (%)**
Automobile	188	29	45	74	39.36
Process	145	10	22	32	22.06
Machines and Equipment	140	8	26	34	24.28
Electrical and Electronics	174	15	21	36	20.68
Textile	78	7	15	22	28.20
Total	725	69	129	198	27.31

6.2.5 Overview of data analysis techniques used

Brief about various data analysis techniques used are given below:

- **Descriptive statistics:** Descriptive statistics are designed to give information about the distribution of variables. It gives idea about measures of central tendency (Mean, Median, and Mode), measures of variability around the mean (standard deviation and variance), information concerning the spread of distribution (maximum, minimum and range) and information about the stability or sampling error of certain measures. This is used for computing sector wise and overall statistics for various issues. The overall statistics for various measures is as shown in various tables in Appendix-C.
- **Correlation analysis:** Correlation analysis is performed to assess, association between two constructs/variables. It is designated as "r" and varies between +1 to – 1. It measures the strength of relationship between interrelated variables. It gives the strength of relationship through identification of variance which lies between 0 to 1. Correlation analysis was performed to estimate relationship among various elements within the pillars. The Pearson correlation coefficient (r) is calculated, which describes the extent to which an increase or decrease in one variable is accompanied by a corresponding increase and decrease in the other (Sharma, 1996). The results are shown in Appendix-C.
- **Reliability analysis:** Reliability analysis addresses the issue that whether the survey instrument shall produce the same result every time it is administered to the same person under same settings regardless of who administers them. Reliability analysis is performed for each element considered in the questionnaire to check the scale reliability of each pillar. Inter-item analysis is used to check the scales for internal consistency or reliability. Several measures of reliability can be evaluated in order to establish the reliability of a measuring instrument. These include test retest method; equivalent forms, split-halves methods and internal consistence method. Of all the above methods, the internal consistence method requires only one administration and consequently is supposed to be the most general and effective method. In this method reliability is operationalized as internal consistency, which is the degree of inter-correlation amongst the items that constitute a scale. Internal consistency is estimated using a reliability coefficient called Cronbach's alpha. Hence Cronbach's alpha is calculated for each pillar as recommended for empirical research in operations management. The minimum generally acceptable value of Cronbach's Alpha is 0.70.

- **Factor Analysis:** Factor analysis is used to identify a small number of factors that might be used to represent relationship among sets of interrelated variables. Its primary usefulness is to take a large number of observable instances to measure an unobservable construct or constructs. The purpose of factor extraction is to extract factors i.e. the underlying constructs that describe a set of variables. It is used to uncover the latent structure (dimensions) of a set of variables. It reduces attribute space from a larger number of variables to a smaller number of factors. The results are shown in Appendix-C. The details of the data analysis discussed from the next section onwards.

6.3 Reliability analysis

Prior to evaluating the internal consistency of the measures (Cronbach's alpha, α), an inter item correlation matrix was prepared for each measure to examine the extent to which some common trait was present in the items. Low inter item correlations designate that the associated items are probably should avoid from the group elements. Even an item correlation of 0.2 is considered enough to be incorporated in the list for further principle component analysis. None of the elements has shown correlation value less than 0.2. The mean item correlation of these pillars came as more than 0.4.

Hence, they were considered satisfactory. Table 6.2 shows the Reliability analysis for six sigma pillars. For all the pillars the alpha value is quite high and hence all the elements within various pillars can be considered for further analysis. Although, dropping some items from scales would improve some alpha values, no items were deleted to improve the alpha values, as they were already high and meet the criterion of exceeding 0.7 for all the scales. Also, this was done in order to ensure the content validity of each measurement scale. The reliability analysis for all constructs showed α value of more than 0.82. As already said α value of 0.70 or above is considered to be the criterion for demonstrating internal consistency of established scales. The range of α value from 0.837 to 0.917 indicates that some pillars are more reliable than the others. It is noted that usually more number of items in a scale tended to show higher reliability and it is yet to be seen if validity of the constructs demonstrates such robustness too. Since the measurements used in this study are developed, based on extensive literature review and practitioner/expert inputs, the values found are considered to be highly adequate.

Table 6.2: Reliability analysis for six sigma pillars

S.No.	Pillar	No. of Items *	Item means for scale	Means of inter item correlation	Cronbach alpha (α)	Standardized Item alpha (α)
1	**Top management commitment and leadership**	8 (1-8)	4.075	0.555	0.908	0.856
2	Project selection and execution methodology	8 (9-16)	3.75	0.495	0.889	0.876
3	Training and education	5 (17-21)	3.85	0.502	0.89	0.889
4	Customer relationship management	7 (22-28)	4.071	0.486	0.866	0.871
5	Effective Information Technology and communication system	7 (29-35)	4.1509	0.4701	0.837	0.838
6	Quality improvement tools and technique	4 (36-39)	3.882	0.474	0.875	0.854

7	Supply chain management	7 (40-46)	4.1829	0.6300	0.917	0.916
8	Human resource management	7 (47-53)	3.689	0.528	0.909	0.870
9	Standardization	7 (54-60)	3.527	0.491	0.870	0.921

6.4 Validity analysis

Prior to performing the principal component analysis, the data matrix was examined to ensure that it had sufficient correlations to justify the application of factor analysis. One of the measures to quantify the degree of inter-correlations among the variables and the appropriateness of factor analysis is the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. A small value of KMO means each variable cannot be predicted or explained by the other variables without significant error; hence factor analysis may not be appropriate.

As a guideline, KMO values in the 0.90s are considered as marvelous; 0.80s are meritorious; 0.70s are middling; 0.60s are ordinary; 0.50s are miserable; and below 0.50s are undesirable (Hair et al.,1996). Individual variables that have KMO values lower than 0.50 should not be considered. Table 6.3 shows the overall KMO measure of sampling adequacy for six sigma pillars. From Table 6.3 it is clear that for all the pillars KMO value is more than 0.7. A large number of constructs like Top management commitment and leadership, Project selection and execution methodology, Training and education, Effective Information technology and communication system, Quality improvement tools and techniques, Supply chain management and Human resource management were considered meritorious, while the pillars Customer relationship management and Standardization are middling, which has values above the suggested minimum standard of 0.7 required for performing factor analysis. Hence, based on the above tests, it concluded that all nine pillars were suitable for applying principle component analysis. In addition to this, the methodologies were followed to find out the Factor analysis statistics.

The percent of variance explained by the first principal component of each measurement scale was considered as vital. One criterion is that the first component of each scale explains more than 40% of the variance in the items. The second criteria is that the factor loadings for items should be greater than 0.30. Hence this study considered items whose factor loadings are greater than 0.40. The two remaining criteria considered were: a large Eigen-value for the first component and small, fairly equal Eigen-values for subsequent components for subsequent components. The values are verified with the parallel analysis.

Table 6.3: Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for six sigma Pillars

Pillars	**No.of Items***	**Items deleted (by number)**	**KMO**
Top management commitment and leadership	8 (1-8)	None	0.826
Project selection and execution methodology	8 (9-16)	None	0.811
Training and education	5 (17-21)	None	0.811
Customer relationship management	7 (22-28)	None	0.727
Effective information technology and communication system	7 (29-35)	None	0.858
Quality improvement tools and techniques	4 (36-39)	None	0.821
Supply chain management	7 (40-46)	None	0.891
Human resource management	7 (47-53)	None	0.852
Standardization	7 (54-60)	None	0.769

Validity analysis measures that the item or scale measure what it has been designed to measure and nothing else. Normally validity analysis is done using three measures:

- **Content validity:** It is judgment by experts, of the extent to which a summated scale truly measures the concept that it intended to measure, based on the content of the items. It can be determined using qualitative technique. It is not possible to measure by using any quantitative techniques. It can be determined by the help of experts. To assess the content validity of the questionnaire, the initial draft of the

questionnaire was administered to the same group of fourteen members to whom the previous questionnaire was administered. At the same time the questionnaire was also sent to two senior level executives in reputed automotive manufacturing organizations. The questionnaire was also administered to eight PS students of mechanical engineering group of Birla Institute of Technology and Sciences, Pilani, undergoing their practice school (industry Internship) in various organizations and hence the opinions from these individual students were also considered. Finally, the questionnaire has modified as per feedback received from the experts and the final version of the questionnaire was sent to the top management i.e. to CEO's and managers of the same group of 725 companies identified earlier.

- **Criterion-related validity:** Criterion-related validity is concerned with the extent to which a measuring instrument is related to an independent measure of the relevant criterion. Traditionally, it is evaluated by examining the correlations of the different constructs with one or the more measures of business or manufacturing performance. This investigates the empirical relationship between the scores on a test instrument (predictor) i.e. framework elements and an objective outcome (the criterion) i.e. the various pillars. The most important of measure for checking the criterion related validity is simple correlation, for testing a scale or elements for a single outcome. The bivariate correlation matrices between various six sigma pillars are shown in Table 6.4 and it can be seen that for both the relevant criterion the correlation is high for all the pillars.

Table 6.4: Bivariate correlation matrices

	Mean	**Std. D**	**TMCL**	**PSE**	**TRE**	**CRM**	**ECS**	**QIT**	**SCM**	**HRM**	**STD**
TMCL	4.075	0.882	1	.596**	.495**	.449**	.545**	.430**	.523**	.504**	.546**
PSE	3.75	0.935	.596**	1	.436**	.459**	.430**	.514**	.462**	.432**	.406

											**
TRE	3.85	0.889	.495**	.436**	1	.612**	.338**	.476**	.448**	.504**	.493**
CRM	4.071	0.871	.449**	.459**	.612**	1	.521**	.606**	.491**	.537**	.510**
ECS	4.1509	0.876	.545**	.430**	.338**	.521**	1	.367**	.348**	.497**	.428**
QIT	3.882	0.854	.430**	.514**	.476**	.606**	.367**	1	.600**	.577**	.377**
SCM	4.1829	0.821	.523**	.462**	.448**	.491**	.348**	.600**	1	.694**	.692**
HRM	3.689	0.870	.504**	.432**	.504**	.537**	.497**	.577**	.694**	1	.681**
STD	3.527	0.921	.546**	.406**	.493**	.510**	.428**	.377**	.692**	.681**	1

Legend

TMCL: Top management commitment and leadership; PSE: Project selection and execution methodology; TRE: Training and education; CRM: Customer relationship management; ECS: Effective information technology and communication system; QIT: Quality improvement tools and techniques; SCM: Supply chain management, HRM: Human resource management, STD: Standardization.

- **Construct validity:** It measures whether a scale is an appropriate operational definition of an outcome i.e. six sigma. Since the construct cannot be directly assessed, indirect inference about the construct validity can be made through empirical investigations. Principle component analysis conducted on a single scale will show whether all the dimensions (elements) within a summated scale will load a single or same construct or whether the summated scale measure more than one construct i.e. it checks the unidimensionality of the scales towards a single construct. The principle component analysis was conducted within each main pillar with the means of all elements taken as the loading on each pillar. The results of validity analysis have clearly showed that the complete pillars were loaded on single pillar. The complete sets of elements under each pillar were also loaded on single element or construct. Hence, the proposed six sigma framework has fulfilled the requirements of validity and reliability analysis and also is suitable to fulfill the requirements of Indian manufacturing industries.

6.5 Path analysis for six sigma framework

The relationships among pillars were not established while checking the validity of the constructs. The importance of establishing relationship among pillars is very significant from implementation point of view. Successful deployment of first level of pillars is needed for successful implementation of second level of pillars and so on. Hence the study made an attempt to create a mental model derived from these nine pillars to establish the directional relationships among the pillars of six sigma. It also includes dependencies and interdependencies by using interpretive structural modeling (ISM). Later, it is subjected to statistical testing for model fit by using structural equation modeling (SEM).

6.6 Research methodology applied for path analysis

The objective of the present section of study is to develop and validate the proposed framework of six sigma in Indian manufacturing industry using ISM and SEM.

6.6.1 Interpretive structural modeling (ISM) method

Good understanding of the pillars and its elements as well as their inter-relationship is vital to develop any framework. This following section deals with the recognition of underlying relationships between cause and effect that can lead to new conclusions and

empirical verification. ISM methodology has the ability to draw the order and direction on the complexity of relationships among factors/drivers of a system. It is used to reduce complex system interactions to a logically oriented graph. ISM methodology essentially analyses the drivers, the inter-relationship between pillars, and hierarchy of their importance and classification of intervention levels. In the present section ISM is developed for six sigma model. In various research fields ISM has been applied to find out the relationship among the elements like energy management, information technology , manufacturing strategy, organization behavior, performance management, project management, risk management, supply chain management , strategic management., total quality management , vendor selection and waste management. In the present research work, a structural relationship between the pillars was established using ISM. The study has considered two cases: One case of small and medium scale automotive industry (SMSAI) and another one are of large scale automotive industry (LSAI) for developing the ISM models. These two organizations are practicing six sigma for more than five years. Also both the organizations had shown keen interest in finding the association between pillars of six sigma.

Case 1: Small and medium scale automotive industry (SMSAI)

SMSAI organization considered for the study is a leading global supplier of automotive components and systems like transfer case and gear box. The organization provides customers with incomparable manufacturing reach and ability. The organization claims that their approach in implementation of six sigma principles is exceptional.

Case 2: Large scale automotive industry (LSAI)

LSAI considered for study is manufacturing different automobile components like crank shaft and forged components and is actively participating in implementation of six sigma projects across organizational activities. The LSAI organization has continuous rigorous training programmer in place within the company.

6.6.2 Development of interpretive structural modeling (ISM) for proposed cases

In following section ISM methodology is explained as it is applied to both the proposed cases. The various steps involved in ISM technique are as follows:

- **Step 1.** All the nine elements identified from the previous chapter were arranged in a matrix, with the elements arranged so that the experts can give their opinion while the

items in the matrix are being compared. The nine pillars are Top management commitment and leadership (TMCL), Project selection and execution methodology (PSE), Training and education (TRE), Customer relationship management (CRM), Effective information technology and communication system (ECS), Quality improvement tools and techniques (QIT), Supply chain management (SCM), Human resource management (HRM) and Standardization (STD). The letters shown in the parenthesis refers to the pillar legends.

- **Step 2.** Establishing a contextual relationship between pillars with respect to which pairs of elements will be analyzed.
- **Step 3.** Developing a self-interaction matrix (SSIM) of pillars to display pair-wise relationship between pillars under consideration. The data required to fill in the matrix was collected by interacting with the six experts from industry and academics. The six experts from industry were working in the capacity of managers, general managers and vice presidents. The six academic experts belong to leading institutions from India. All the experts were requested to identify the relationships among nine pillars of six sigma under the light of their elements and general understanding. Each expert was given a worksheet which had structural self-interaction matrix (SSIM) to fill. To develop contextual relationship among pillars of six sigma model and their elements, the experts were asked to respond on a worksheet by indicating 'V', 'A', 'X' and 'O' in each cell of the matrix, where:
    - V: pillar or construct i will affect pillar or sub-construct j;
    - A: pillar or construct j will affect pillar or sub-construct i;
    - X: pillar or construct i and j affect each other equally;
    - O: pillar or construct i and j will have no relationship.

Each expert was briefed about the pillars and elements of six sigma model in the worksheet provided to record their responses. The research objectives and the queries of experts were clarified first and then each expert was requested to respond on the worksheet. All the responses were collected and a check was performed. If the relationship between ith and jth element is unanimous then corresponding letter was allocated in the respective cell. However if the responses in a particular cell were of varied opinions among the experts, all the experts were again consulted for that particular

relationship and requested to rethink on the relationship to probably enhances the concurrency of the responses. In this manner after several interactions the final SSIM of six sigma model pillars was formed. The SSIM for SMSIM and LSAI are shown in Table 6.5 and Table 6.6.

Table 6.5: Structure self-interaction matrix (SSIM) of SMSAI

Drivers	**SCM**	**STD**	**HRM**	**QIT**	**TRE**	**CRM**	**ECS**	**PSE**	**TMCL**
TMCL	V	V	V	V	V	V	V	V	*
PSE	A	O	A	A	A	O	X	*	
ECS	A	A	A	O	O	X	*		
CRM	A	A	A	A	X	*			
TRE	V	X	O	V	*				
QIT	A	A	A	*					
HRM	X	A	*						
STD	O	*							
SCM	*								

Table 6.6: SSIM of LSAI

Drivers	**SCM**	**STD**	**HRM**	**QIT**	**TRE**	**CRM**	**ECS**	**PSE**	**TMCL**
TMCL	A	A	A	A	V	X	A	O	*
PSE	A	O	O	V	V	V	V	*	
ECS	A	O	A	V	V	V	*		
CRM	A	A	A	X	V	*			
TRE	A	A	O	O	*				
QIT	A	A	A	*					
HRM	A	A	*						
STD	A	*							
SCM	*								

- **Step 4.** The SSIM has to be changed into a binary matrix, called the reachability matrix by replacement X, A, V and O by 1 and 0. The rules for substituting 1‟ s and 0‟ s are given as follows:
    a) If the entry in cell (i,j) of SSIM is V then entry in the (i,j) cell of reachability matrix must be replaced with 1 and in cell (j,i) must be replaced with 0.
    b) If the entry in cell (i,j) of SSIM is A then entry in the (i,j) cell of reachability matrix must be replaced with 0 and in cell (j,i) must be replaced with 0.
    c) If the entry in cell (i,j) of SSIM is X then entry in the (i,j) cell of reachability matrix must be replaced with 1 and in cell (j,i) must also be replaced with 1.
    d) If the entry in cell (i,j) of SSIM is O then entry in the (i,j) cell of reachability matrix must be replaced with 0 and in cell (j,i) must also be replaced with 0.
    e) After making the reachability matrix its transitivity is checked. If element i lead to element j and element j leads to element k, then element i should lead to element k. By transitivity embedding, the modified reachability matrix is obtained. Table 6.7 and Table 6.7 shows final reachability matrix for SMSIM and LSAI organization considered for study.
- **Step 5.** Table 6.7 and Table 6.8 display the driving power and dependence of each six sigma pillar. The driving power of a particular six sigma pillar is the total numbers of pillars (including it) which may help to achieve or establish. These driving power and dependencies will be used further in MICMAC analysis, which involves classification of elements into four groups of autonomous, dependent, linkage, and independent (driver) six sigma model elements.

Table 6.7: Final reachability matrix of SMSAI organization

Element	**TMCL**	**PSE**	**ECS**	**CRM**	**TRE**	**QIT**	**HRM**	**STD**	**SCM**	**Driver**
TMCL	1	1	1	1	1	1	1	1	1	9
PSE	0	1	1	0	0	0	0	0	0	2
ECS	0	1	1	1	0	0	0	0	0	3
CRM	0	0	1	1	1	0	0	0	0	3
TRE	0	1	0	1	1	1	0	1	1	6

QIT	0	1	0	1	0	1	0	0	0	3
HRM	0	1	1	1	0	1	1	0	1	6
STD	0	0	1	1	1	1	1	1	0	6
SCM	0	1	1	1	0	1	1	0	1	6
Dependence	1	7	7	8	4	6	4	3	4	

Table 6.8: Final reachability matrix of LSAI organization

Element	**TMCL**	**PSE**	**ECS**	**CRM**	**TRE**	**QIT**	**HRM**	**STD**	**SCM**	**Driver**
TMCL										
PSE										
ECS										
CRM										
TRE										
QIT										
HRM										
STD										
SCM										
Dependence										

- **Step 6.** From the reachability matrix, the reachability set and antecedent set for each criterion is found. The reachability set consists of the pillar itself and other pillar to which it may reach, whereas the antecedent set consists of the pillar itself and the other pillar which may reach to it. Then the intersection of these sets is derived for all pillars. The pillar for which the reachability and intersection sets are the same is the top-level pillar. Physically, the top pillars of the hierarchy will not reach to any other pillar above their own level. Once the top-level pillar is identified, it is separated out from the other pillar. Then, by the same process, the next level of pillars is found. The

levels of partition of the pillars for SMSIM and LSAI are shown in Table 6.9 and Table 6.10.

Table 6.9: Levels of partition of the pillars for SMSAI organization

Pillars	Reachability set	Antecedent set	Intersection set	Level
1	1	1	1	5
2	2, 3, 5, 6, 7, 8	1, 2, 3, 5, 6, 7, 8	2, 3, 5, 6, 7, 8	2
3	3	1,2,3,7	3	3
4	4, 9	1, 2, 3, 4, 5, 6, 7, 8, 9	4, 9	1
5	5,7	1,2,5,7	5,7	3
6	2, 6, 8	1, 2, 3, 5, 6, 7, 8	2, 6, 8	2
7	7	1,2,7	7	4
8	2, 3, 5, 6, 7, 8	1, 2, 3, 5, 6, 7, 8	2, 3, 5, 6, 7, 8	2
9	4, 9	1, 2, 3, 4, 5, 6, 7, 8, 9	4, 9	1

Table 6.10: Levels of partition of the pillars for LSAI organization

Pillar	Reachability set	Antecedent set	Intersection set	Level
1	1,	1,	1,	6
2	2,	2, 7, 1,	2,	4
3	8, 9, 3,	8, 5, 6, 9, 3, 2, 7, 1,	8, 9, 3,	2
4	4,	8, 5, 6, 9, 4, 3, 2, 7, 1,	4,	1
5	5,	5, 1,	5,	4
6	6,	5, 6, 2, 7, 1,	6,	3
7	7,	7, 1,	7,	5
8	8, 9, 3,	8, 5, 6, 9, 3, 2, 7, 1,	8, 9, 3,	2

9	8, 9, 3,	8, 5, 6, 9, 3, 2, 7, 1,	8, 9, 3,	2

According to Tables 6.7, 6.8, 6.9 and 6.10, if there is an existence of relationship between the pillars j and i, an arrow directed from i to j is drawn. The resulting figure is called diagraph. Next the elements descriptions are written in the digraph to call it the ISM. The developed ISM has no cycles or feedbacks. Elements are related in a pure hierarchical pattern.

- **Step 7.** Once all the transitivity's are removed, the diagraph is finally converted into ISM model. The ISM model of SMSIM and LASI organization is as shown in Figure 6.1 and Figure 6.2.

The structural linkages between six sigma pillars are shown in Figure 6.1 and Figure 6.2 represents which helps to explain the role of different pillars in the context of six sigma process. Finally the ISM's are checked for conceptual inconsistency and necessary modifications are carried out in case of any inconsistency.

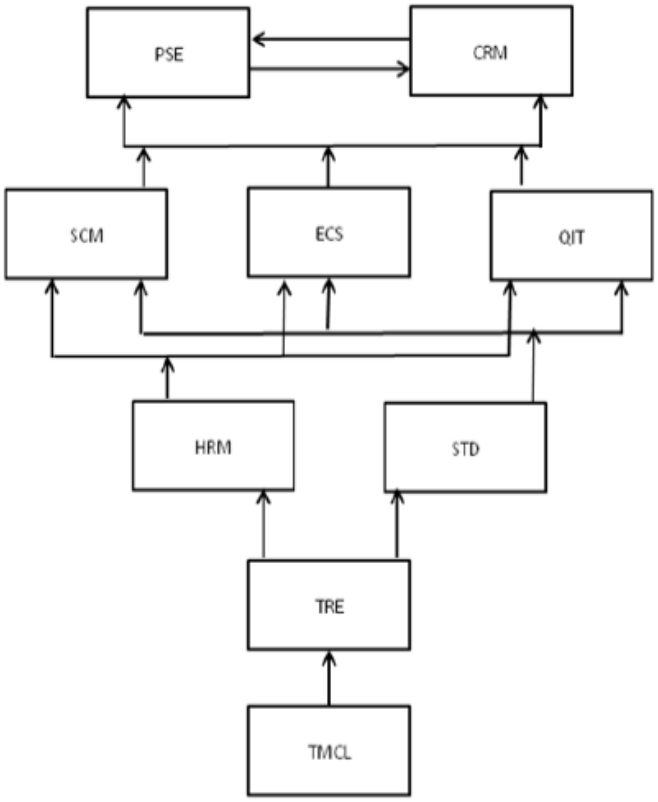

Figure 13 : ISM of SMSAI

Legend:

TMCL: Top management commitment and leadership; PSE: Project selection and execution methodology; TRE: Training and education; CRM: Customer relationship management; ECS: Effective information technology and communication system; QIT: Quality improvement tools and Techniques; SCM: Supply chain Management, HRM: Human resource management, STD: Standardization.

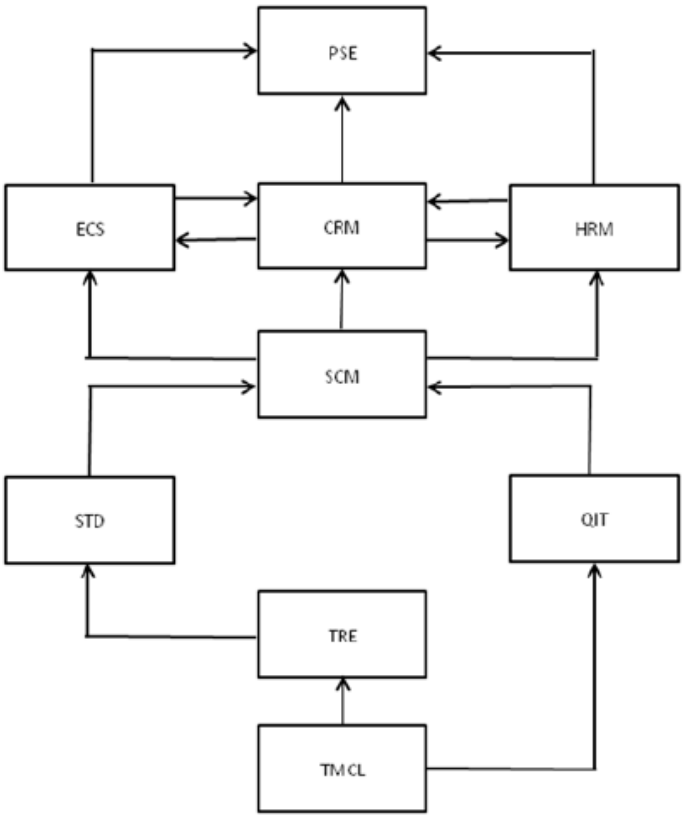

Figure 14: ISM of LSAI

Legend:

TMCL: Top Management commitment and leadership; PSE: Project selection and execution methodology; TRE: Training and education; CRM: Customer relationship management;

ECS: Effective information technology and communication system; QIT: Quality improvement tools and techniques; SCM: Supply chain management, HRM: Human resource management, STD: Standardization.

6.6.3 Analysis of ISM models

ISM model developed shows different pillar appearing at a particular level in the model. While there are similarities across both the ISM model diagrams, there is conspicuous difference in terms of a particular element appearing at a particular level in the respective six sigma model. ISM model of SMSAI (Figure 6.1) and ISM model of LSAI (Figure 6.2) diagrams are both similar in a way that both have the element, top management commitment and leadership (TMCL) influencing all the other variables. It was found that elements like top management commitment and leadership, training, standardization pillars are at the same hierarchical in both the models. This shows that both the organizations are following some kind of sequential process to implement six sigma in terms of organizational activities.

Top management commitment and leadership is having direct influence on training and education in both models. The roles of other seven elements (Project selection and Execution, Customer relationship Management, Effective information technology and communication system, Quality improvement tools and techniques, Supply chain management, Human relationship management, Standardization) show significant difference in both the models. In the case of SMSAI model, top management commitment and leadership is the Driver variable. It directly influences the element training. Element training has a direct influence on element human resource management and standardization. Again, these 2 elements, i.e. human resource management and standardization co-determines the level of the elements supply chain management, Effective information technology and communication system and Quality improvement tools and techniques which is the penultimate element in the hierarchy of the elements. Finally, these elements SCM, ECS and QIT have a direct influence on the dependent variables, namely Project selection and execution and Customer relationship Management. These 2 variables have a direct influence on each other at the same level.

In LSAI case, element top management commitment and leadership is the driver variable. It influences the element training and education and quality improvement tools and techniques. Element training directly affects standardization, which is at the same level of element quality improvement tools and techniques. Element standardization and element quality improvement tools and techniques directly influence element supply chain management. Element supply chain management in turn directly affects the elements

effective information technology and communication system, Customer relationship management and Human relationship management. All these three elements also affect each other at same level. Finally the element project selection and execution is directly affected by these three elements i.e. ECS, CRM and HRM. While there are similarities in both the interpretive structural models of SMSAI and LSAI, there are structural differences as well. Firstly, there are only 5 levels in SMSAI ISM while LSAI's ISM exhibits 6 levels. However, in both the diagrams ultimate and penultimate level elements are same i.e. top management commitment and leadership and training but quality improvement tools and techniques is at higher level in SMSAI as compared to LSAI. Supply chain management is driven by quality improvement tools and techniques and issues of standardization, and it drives effective information technology and communication system, customer relationship and human relationship management. While in SMSAI, supply chain management was at higher level and was driven by human relationship management and standardization and it drove only project selection and execution and customer relationship management.

After developing ISM's for SMSAI and LSAI it was observed that the mental model that emerges out are different from each other which signify variation in the way pillars and constructs of six sigma excellence interact with each other in the case organizations. Hence it requires further analysis and discussion on this issue.

6.6.4 SEM development for statistical testing

Structural equation modeling (SEM) using AMOS 18.0v was performed to check the statistical fit of the proposed ISM models. The inputs for this analysis are respondents data (200 responses) collected from the previous section of study. The averages of responses for the elements under each pillar were used and the directional relationships among pillars established using ISM method so as to check the goodness of fit.

The model fit parameter values of SEM for SMSAI and LSAI considered for study is given in Table 6.11. It is clearly visible from Table 6.11 that SMSAI's ISM complies to range of model fit parameters while LSAI's ISM fit is very much under permissible range of model fit parameter values. It can thus be proposed here that LSAI's ISM, presents a statistically valid six sigma model in Indian manufacturing sector.

Table 6.11: Model fit parameter values of SEM for SMSAI ISM and LSAI ISM

Model parameters	**SMSAI ISM**	**LSAI ISM**	**Permissible range**
χ^2	29996.5	586.254	-
Df	632	572	-
χ^2/df	42.53	1.31	≤3
GFI	0.846	0.902	≥0.90
AGFI	0.837	0.833	≥0.80
RMSEA	0.018	0.019	≤0.10
CFI	0.657	0.921	≥0.90
RMR	0.141	0.132	≤0.14

6.6.5 MICMAC analysis

The driver power and the dependence power of the developed ISM can be analyzed by using MICMAC analysis. In this, the pillars are classified into four groups based on the driving power and dependence power. The MICMAC analysis principle is based on the multiplication properties of matrices. If element ‘i' directly influences element ‘k’ and if element ‘k’ directly influences element ‘j’, any change affecting element ‘i’ have repercussions on element ‘j’. This is because there is an indirect connection between elements ‘i’ and ‘k’.

Table 6.7 and 6.8 show the final reachability matrix with an additional row and a column. The names of pillars are listed in the first column while the first row contains pillar numbers only. The last column is labeled as “driver” and the last row is labeled as “dependence”. The number under the driver column indicates the number of nodes (or pillars) that pillar can reach (directly and indirectly). The dependence metric tells us how many nodes can reach a particular node (or pillars). For example, in table 6.8 which shows final reachability matrix for in LSAI organization considered for study element training, the driver value is 7 and the dependence value is 5. This means that this element reaches seven other elements (in this context “influences” seven other elements) and is reached (or “influenced”) by only five elements.

6.7 Discussion

Validity and reliability analysis on a proposed six sigma framework in Indian manufacturing industries has been performed in initial part of this chapter. The sample data collected from two hundred Indian manufacturing industries. The study performed correlation analysis to find out the relationship among pillars and elements within the pillars also. The study revealed high inters item correlation mean value among elements and pillars also. It clearly indicated that all the pillars and elements were played major role in the implementation of six sigma principles in the organizations. The study also revealed overall mean of each pillar was more than 3.5, which indicated all the elements under each pillar plays very important role in successful implementation of six sigma principles in the organizations and all the pillars have high Cronbach's alpha value, which was more than 0.8. From the above values it is clearly demonstrated the high internal consistency shown among the elements and pillars also. Hence, the study clearly shows that proposed six sigma framework fulfills the requirement of reliability analysis.

Validity analysis on the proposed six sigma framework was also performed with the same sample data in the first phase of this chapter. The study has performed content, criterion-related as well as constructs validity analysis. For the content validity analysis twelve team members were consulted. They were suggested minor corrections to improve questionnaire and to improve the format of the questionnaire. The criterion related validity analysis revealed bivariate correlation among pillars were high, which was 0.3 and above. It clearly indicates all the elements in the proposed six sigma framework plays important role. The study also performed construct validity analysis.

The objective of the construct validity is to check whether it measures the concept or the theoretical construct it was anticipated or designed to measure. The validity analysis can be performed on any scale, but the scale should satisfy two conditions: One is unidimensionality of the scale. Secondly, the scale should fulfill the reliability conditions as well.

Unidimensionality is used to check whether all elements are concentrated towards the main target of the measurement. The study revealed all elements were shown

Unidimensionality towards pillars of the framework. Similarly, all the pillars were shown Unidimensionality towards six sigma.

The study has also performed reliability analysis the result shown high cronbach's alpha value. The proposed six sigma frameworks have fulfilled the validity and reliability analysis requirements. Hence, the study concluded the proposed six sigma framework can useful to implement in Indian manufacturing industry. The chapter also includes research methodology to perform ISM methodology for proposed framework of six sigma in Indian manufacturing industry by considering two automotive organization cases. The ISM was performed on two exemplary cases of six sigma organizations in Indian manufacturing industry: one is small and medium scale automotive industry (SMSAI) and other is large scale automotive industry (LSAI). These cases (LSAI and SMSAI) were selected on the basis of capital scale of the organization.

From the discussion presented in the research work, it is focused as to how the framework for six sigma practices in Indian manufacturing industry works. So far as managerial implications of this framework are concerned, the study provides guidelines for achieving standardization in all the functions involved and also helps a manager to understand cause and affect relationship among various important pillars in developing a six sigma organization.

Such relationships can be used to diagnose any form of malfunctioning that may exist in six sigma practices. From researcher's point of view, the framework provides a definitive set of pillars which in totality present the overall picture of six sigma and which overcomes the deficiency that exists in standard theory of integrating various field of six sigma practices together.

The proposed framework highlights the importance of various relationships and interrelationships between pillars of six sigma practices in Indian manufacturing industry. However, there are some shortcomings of the present study. Firstly, the case study focused only on the automotive sector. However, in India, several other sectors of manufacturing like process, machinery, apparel sectors are also fast growing and six sigma practices are very prevalent in them.

Therefore in order to test the applicability of the proposed six sigma framework in these sectors too, several more studies should be conducted. Secondly, the pillars of six sigma

practices are solely based on existing literature (although respondents in the survey are practitioners), hence in order to increase the robustness and comprehensiveness of proposed six sigma framework, more pillars in consultation with practitioners and consultants can be added. In the end, authors would like to suggest to the researchers to deliberate on the proposed framework and make efforts to enhance the applicability of this framework in other manufacturing sectors so that all the sectors of manufacturing industry not only in India but in other countries too, can be also benefited from adopting the proposed six sigma practices.

6.8 Conclusion

In this chapter various statistical tools like the descriptive statistics; reliability analysis, principle component analysis, structure evaluation modeling, and correlation analysis are used and the data was analyzed using SPSS (version 18.0 V).

Based on the 200 responses received from Indian manufacturing industries, the proposed six sigma framework was tested. The study found Pearson's one tailed correlation coefficient value. It is revealed that a strong correlation exists among pillars and elements under pillars also in the proposed framework. The study also performed reliability analysis to find out the reliability of the pillars and its respective elements, which revealed all pillars and its elements have high cronbach's alpha value. The study also performed Unidimensionality of the pillars as well as elements under the pillars, which revealed that all the pillars were Unidimensionality towards six sigma and all the elements were Unidimensionality towards respective pillars of the framework.

The ISM model based on expert opinions were formed which enabled comparison of the structural model from the different pillars of six sigma practices. The ISM was developed for two automobile component manufacturing organizations as test cases.

The two manufacturing organizations selected from the automobile sector, which were SMSAI and LSAI. The relationships among pillars of six sigma frameworks were obtained from ISM, and later were subjected to statistical testing for model fit by using SEM. The input to SEM was the respondent's (200 responses) data used in previous study in the present chapter. The major findings revealed that ISM of LSAI organization statistically fits for six sigma framework, and finally MICMAC analysis was conducted to find the driving and dependency power of each element of the statistically fit six sigma

framework. Finally, based on the results obtained through various analysis conducted in this chapter, the study concludes the proposed six sigma framework is suitable to implement in Indian manufacturing industries.

CHAPTER 7
CONCLUSIONS

Global competition, rapidly changing technologies imposes a great deal of competition from global market to manufacturing industries in India. In order to be competitive globally, Indian manufacturing industries have to work most efficiently and improve their productivity. Moreover shorter product life cycles have contributed in making the current manufacturing environment extremely competitive. Under such circumstances, traditional quality improvements approaches which were used by the industries are no longer provide edge over the competitors.

Hence many industries are implementing various change management programmers such as Total productive maintenance (TPM), Total quality management (TQM), six sigma (SS), Lean enterprise (LE) systems, etc. Among such programmers, six sigma has attracted the attention of many industry professional significantly, which is reflected in the number of case studies and participating organization in the surveys that are reported in the literature related to six sigma.

However, many organizations are not successful in their attempts to implement six sigma effectively. Although many publications and books are available that discusses about six sigma, it is ironical to hear about such failures. It is due to there is an improper understanding of six sigma among the professionals. Many researchers has discussed that implementation of six sigma requires a thorough understanding about the ‘six sigma elements’, ‘steps to implement six sigma’, and ‘relationship between six sigma elements’.

Although there is a good literature available about six sigma but it seems to be highly incoherent with respect to use of elements and inconsistent in strategy formulation. Hence, there is a need to study the six sigma practices in Indian manufacturing industry and also find out a definitive set of pillars (or practices) of six sigma that can lead to six sigma excellence framework. The present research is focused on examining some of fundamental concerns in field of six sigma. Hence, the present study has focused on addressing all these concerns while making efforts to present an empirical investigation of six sigma practices in Indian industry.

In Chapter 2, in depth review of six sigma literature is presented. It provides a comprehensive assessment of research methodology and content of six sigma research articles published from 1995 to 2011 in 52 journals having focus towards six sigma. A systematic classification and a critical analysis was performed to identify research gaps in content of six sigma as well as to recommend directions for future research. Using research approach given by Nakata and Huang, this chapter reviewed total 179 research articles related to six sigma researches with respect to research methodology and its related aspects

The research reveals that most of the articles are conceptual in nature and empirical articles are increasing aggressive than the past. The study has found a rise in empirical approach over the years but still it is in minority as compared to conceptual approach and hence there is further need for more empirical research to get better benefits to the organizations. The review also indicated that researchers should start focusing on various sphere of theory verification as well rather than only theory building.

The literature review carried out in Chapter 2 has found that the contribution of research articles is mainly from academicians with very few professional being involved. To overcome this issue, the academicians have to collaborate with the professionals to get better conclusions and articles useful to the industry. There is need to improve the catchment of research in these developing countries through the various research institutions, collaboration between institutions and organizations and encouragement from local government to the researchers.

The various gaps in the existing literature were found regarding the status of six sigma implementation in Indian manufacturing sector and applicability of existing frameworks in the Indian industry.

The third Chapter discusses about the research approach which has been widely followed by the practitioners and researcher for carrying out an extensive survey in the manufacturing scenario. The justification for using empirical research for the study and the detailed description of the research methodology followed is given. The type of empirical survey that is to be done has been explained and the justification for selecting for questionnaire survey is also explained. At the end of this chapter, the method of collecting the industry database is explained and finally a brief overview about the five sample sectors namely automobile, machines and equipment's, electrical and electronics, process industries and textiles which were chosen for conducting the survey research are provided.

Chapter 4 describes about the various steps undertaken by researchers and consultants related to the concept of six sigma have been studied and certain frameworks as suggested by various academicians / researchers / consultants were identified. Reliability and validity analysis of these existing frameworks of six sigma has been done through extensive survey of Indian manufacturing industry. The results of this survey have been discussed in this chapter, and the results show that although majority of the frameworks are displaying high level of reliability, very few frameworks displayed Unidimensionality with respect to the construct i.e. six sigma it measures.

Apart from this, many important constructs were not found in the existing frameworks like, quality control tools and techniques, standardization etc. Very few frameworks reported importance of training and education in their frameworks. Hence, it has been concluded that none of the existing frameworks can be used in their present form and therefore there is a need for development of a new framework to address all these gaps.

Hence there is a need for development of a new framework which will suite and fulfill the requirements of Indian industry which suits the Indian milieu and provide strategic directions for the Indian industry

In the fifth Chapter, a critical review of six sigma frameworks is discussed and an attempt is made to highlight the inconsistencies present in existing frameworks. Various

frameworks proposed by authors, researchers and practitioners were compared to find out the commonalities. Subsequently the total 159 elements obtained through the various frameworks and were clubbed under major initiatives referred as pillars like Top management commitment and leadership, Project selection and Execution methodology, Training and Education, Customer Relationship Management, Effective Information technology and communication System, Quality Improvement Tools and Techniques, Supply Chain Management, Human resource management (HRM). Along with the same some more initiative like standardization were proposed to take into account the changing manufacturing scenario. Finally a six sigma framework was proposed to give a coherent set of elements with the help of empirical study as well as comparative analysis.

The proposed framework will help researchers to overcome the limitation of existing six sigma frameworks and help reducing the inconsistencies that may occur in future six sigma frameworks.

In the sixth Chapter, firstly, extensive survey of Indian industries has been done for empirical investigation for the usefulness and comprehensiveness of the proposed six sigma framework for the Indian Industry. This chapter discusses about the observations and analysis of the second questionnaire which was sent to the same industries as discussed in fourth Chapter. The second questionnaire was developed to check the reliability and validity of the developed framework. The developed framework of six sigma was validated. Secondly, a path analysis for proposed framework of six sigma in Indian manufacturing industry using interpretive structural modeling (ISM) and structural equation modeling (SEM) was performed. The ISM is done using two six sigma principles practicing Indian manufacturing industry. The study has identified two organizations, one of the organizations is practicing six sigma principles aggressively and another organization has also implemented six sigma, but lacking in six sigma implementation as compared with first organization due to its limitations. Based two organizations practices, ISM model were developed. The relationships among pillars of six sigma frameworks were obtained from ISM, and later were subjected to statistical testing of model fit by using SEM. The input to SEM was the respondent's (200 responses) data used in previous study. The major findings revealed that ISM based on organization, is statistically fit for six sigma framework.

7.1 Summary of contributions of the research

The contribution of this research may be summarized in the following manner:

1. Extensive review of six sigma literatures was carried out to identify various research gaps and existing six sigma frameworks.
2. Validity and reliability of the existing six sigma frameworks were carried out using an exploratory survey. In addition, it was found none of the frameworks were suitable in existing form for Indian manufacturing scenario.
3. A structured framework of six sigma was proposed. The proposed framework can be helpful to organizations to identify the various initiatives towards implementation of six sigma for manufacturing excellence.
4. The managerial implications of six sigma framework can be vastly felt. In India many companies are new to six sigma implementations. The present study thus provides managers an insight as to what are the pillars of six sigma and what are the elements under these pillars. These nine pillars also span across all the crucial areas of business right from project selection and execution to customer relationship management. This can guide managers about the use these pillars within a framework to achieve successful six sigma implementation. The main benefit of the study is that the nine pillars proposed with the help of conceptual analysis as well as group of experts belonging to academics, professionals and consultants. The elements of the

framework are derived with the help of empirical study from Indian manufacturing sector.

5. The proposed framework was validated using one more exploratory survey and path analysis. Various statistical analyses were used, which confirmed that the developed framework is legitimate in the Indian scenario. Finally, the applicability of the proposed framework of six sigma is verified in two manufacturing organizations with the help of ISM model.
6. The research contribution of the study is far reaching as huge literature on six sigma lacks standardization. The identified pillars of six sigma can be used as standard and important set of elements for future research since these pillars and elements are derived from literature and empirical study from Indian manufacturing industry.
7. The proposed framework of six sigma provides a definitive set of elements which present overall picture of six sigma and overcomes the deficiency that exists in the literature with respect to frameworks.
8. It was found that there exists a huge gap between theory building and theory verification. Theory building is progressing at faster rate than theory verification. Hence researchers must concentrate on theory verification as well to bring the discipline to maturity phase.
9. It is observed that sample size used by various researchers especially in survey research is very much restricted. Hence researcher should try to go for larger sample sizes and try to achieve higher response rates in survey research.
10. In the also felt researchers working on empirical studies should report several characteristics of respondents like industry, work experience of respondents, designation etc. Such characteristics are helpful to judge the quality and reliability of the reported facts and theories. However getting complete demographic data is not an easy task but researchers can take help of survey professionals in this context.

7.2 Recommendations for future work

The work presented in thesis addresses several issues related to six sigma in empirical research literature, Indian manufacturing industry and theory. However there are few issues that remained unaddressed due to limitation on the scope of work. Hence avenues for further research are suggested, which are given as follows:

1. In the present study, only five sectors across the Indian manufacturing domain were considered and the response rate was reasonable good as compared to present empirical research works. However, this study can further be extended to various other sectors and the reliability / validity of the proposed framework in other sectors can also be analyzed.
2. The five sectors considered for study can further be refined to various sub classification within each sector like for process industries cement, pharmacy, chemical, etc. and their level of six sigma identified.
3. Each pillar of six sigma framework can be developed further by identifying their implementation elements individually.
4. Further development of this questionnaire can be done so that it can be used for a global survey also. By doing this it will be possible to compare the Indian companies and their global counterparts.

5. In the present study relationships amongst various pillars of proposed six sigma pillars were identified using bivariate correlation (Pearson's Correlation) which indicated positive correlations among the nine pillars. This relationship can be further analyzed using other methods.

REFERENCES

1. Antony, J., Banuelas, R., 2002. Key ingredients for the effective implementation of six sigma program. Measuring Business Excellence 6, 20-27.
2. Antony, J., 2002. Design for six sigma: a breakthrough business improvement strategy for achieving competitive advantage. Work Study 51, 6-8.
3. Antony, J., Desai, D.A., 2009. Assessing the status of six sigma implementation in the Indian industry: results from an exploratory empirical study. Management Research News 32, 413-423.
4. Banuelas, R., Antony, J., 2003. Going from six sigma to design for six sigma: an exploratory study using analytic hierarchy process. The TQM Magazine 15, 334-344.
5. Bendell, T., 2006. A review and comparison of six sigma and the lean organizations. The TQM Magazine 18, 255-62.
6. Black, K. and Revere, L.2006. Six sigma arises from the ashes of TQM with a twist. International Journal of Health Care Quality Assurance 19, 259-66.
7. Chakrabarty, A., Tan, K.C., 2007. The current state of six sigma application in services. Managing Service Quality 17, 194-208.
8. Gowen III, C.R., Tallon, W.J., 2005. Effect of technological intensity on the relationships among six sigma design, electronic-business, and competitive

advantage: A dynamic capabilities model study. The Journal of High Technology Management Research 16, 59-87.

9. Guo, L.,2008, "PERSPECTIVE: an analysis of 22 years of research in JPIM", Journal of Product Innovation Management, 25, 249-260
10. Jin, T., Janamanchi, B., Feng, Q., 2011. Reliability deployment in distributed manufacturing chains via closed-loop six sigma methodology. International
11. Journal of Production Economics 130, 96–103. Kwak, Y.H., Anbari, F.T., 2006. Benefits, obstacles, and future of six sigma approach. Technovation 26, 708-715.
12. Mohamed Gamal Aboelmaged, 2010. Six sigma quality: a structured review and implications for future research. International Journal of Quality and Reliability Management 27,268-317
13. Nonthaleerak, P. and Hendry, L.C., 2006. Six sigma: literature review and key future research areas. Int. J. Six Sigma and Competitive Advantage 2, 105-161.
14. Pulakanam, V., Voges, K.E.,2010. Adoption of six sigma: Review of empirical research. International Review of Business Research Papers 6, 149-163.
15. Schroeder, R.G., Linderman, K., Liedtke, C., Choo, A.S.,2008. Six sigma: definition and underlying theory. Journal of operations Management 26, 536-554.
16. Tjahjono, B., Ball, P., Vitanov, V.I.,2010. Six sigma: a literature review. International Journal of Lean six sigma 1, 216-233.
17. Andersson, R., Eriksson, H. and Torstensson, H.,2006. Similarities and differences between TQM, six sigma and lean. The TQM Magazine 18, 282-296.
18. Amar, K., Davis, D., 2008. A review of six sigma implementation frameworks and related literature, in: Proceedings of the International Multi Conference of Engineering and Computer Scientist,19-21 March, Hong kong
19. Chen, M., Lyu, J., 2009. A Lean Six-Sigma approach to touch panel quality improvement. Production Planning and Control 20, 445-454.
20. Flynn, B. B., Sakakibara, S., Schroeder, R. G., Bates, K. A., and Flynn, E. J.,1990. Empirical research methods in operations management. Journal of Operations Management 9, 250-284.

21. Furterer, S., Elshennawy, A.K., 2005. Implementation of TQM and lean six sigma tools in local government: a framework and a case study. Total Quality Management and Business Excellence 16, 1179-1191.
22. Gowen III, C.R., Stock, G.N., Mcfadden, K.L., 2008. Simultaneous implementation of six sigma and knowledge management in hospitals. International Journal of Production Research 46, 6781-6795.
23. Harry, Mikel J., and Schroeder, Richard, 2000. Six Sigma: The Breakthrough Management Strategy Revolutionalizing the World's Top Corporations, Doubleday, New York.
24. Kevin Burgess, Prakash J. Singh, Rana Koroglu, 2006. Supply chain management: a structured literature review and implications for future research. International Journal of Operations and Production Management 26, 703-729.
25. Kumar, M., Antony, J., Singh, R.K., Tiwari, M.K., Perry, D., 2006. Implementing the Lean Sigma framework in an Indian SME: a case study. Production Planning and Control 17, 407-423 Nakata Cheryl and Huang Yili, 2005. Progress and promise: the last decade of international marketing research. Journal of Business Research, 58, 611-618.
26. Pannirselvam, G.P., Ferguson, L.A., Ash, R.C. and Siferd, S.P., 1999. Operations management research: an update for the 1990's. Journal of Operations Management 18, 95-112.
27. Sekaran, U., 1983, "Methodological and theoretical issues and advancements in cross-cultural research", Journal of International Business Studies, 14, 61-73.
28. Shah, R., Chandrasekaran, A., Linderman, K., 2008. In pursuit of implementation patterns: the context of Lean and six sigma. International Journal of Production Research 46, 6679-6699.
29. Sin, L.Y.M., Cheung, G.W.H. and Lee, R., 1999, Methodology in cross-cultural consumer research: a review and critical assessment. Journal of International Consumer Marketing, 11, 75-96.
30. Snee, R., 1999. Why Should Statisticians Pay Attention to Six Sigma?: An Examination for Their Role in the Six Sigma Methodology, Quality Progress 32, 100-103.

31. Swamidass, P.M., 1991. Empirical science: new frontier in operations management research. Academy of Management Review 16, 793-814.
32. Su, C.T., Chiang, T.L., Chang, C. M., 2006. Improving service quality by capitalizing on an integrated Lean six sigma methodology. International Journal of six sigma and Competitive Advantage 2, 1-22.
33. Yeh, D.Y., Cheng, C.H., Chi, M.L., 2007. A modified two-tuple FLC model for evaluating the performance of SCM: By the six sigma DMAIC process. Applied Soft Computing 7, 1027-1034.
34. Yusuf, S.M. and Aspinwall, E., 2000. Total quality management implementation frameworks: comparison and review. Total Quality Management, 11, 281-294.