Development of an integrated quality management Framework for manufacturing organisations

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List of abbreviations:

AHP: Analytic Hierarchy Process

ASQ: American Society for Quality

ARMI model: (Approve, Resources, Member, Interested, Interested party)

COPQ: Cost of Poor Quality

CP: Process Capability Potential

CPk: Process Capability Actual

CSFs: Critical Success Factors

CTC: Critical To Cost

CTQ: Critical, To, Quality

CTS: Critical To Schedule

DFSS: Design for Six-Sigma

DMAIC: Define, Measure, Analyse, Improve and Control

DMDIV: Define, Measure, Design, Improve and Verify

DOE: Design of Experiment

DPMO: Defect per Million Opportunity

DPU: Defect per Unit

EFA: Exploratory Factor Analysis

FA: Factor Analysis

FMEA: Failure Mode Effect and Analysis

GRPI checklist: (Group, Resources, Process, Interpersonal Relations)

IQM: Integration Quality Management

IQM-FW: Integrated Quality Management Framework

ISO: International Organisation for Standardization

KIP: Key Indicator Performance

LSS: Lean Six-Sigma

LSS-M: Lean Six-Sigma Integrated Model

OEE: Overall Evaluation Effectiveness

PCA: Process Capability Analysis

PDCA: Plan, Do, Check and Act

QCC: Quality Control Circle

QFD: Quality Function Deployment

QIT: Quality Improvement Team

ROI: Return on Investment

RPN: Risk Priority Number

RTY: Rolled Throughput Yield

SIPOC: Supplier Input Process Output Customer

SPC: Statistical Process Control

SPSS: Statistical Package for Social Science

SS: Six-Sigma

SS-TQM: Six-Sigma TQM integrated Model

SUF: Single Unite Flow

TPM: Total Productive Maintenance

TQM: Total Quality Management

VOB: Voice of Business

VOC: Voce of Customer

VOP: Voice of Process

VSM: Value Stream Mapping

QMMs: Quality Management Methods

Publications from the Thesis

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Abstract

During the last couple of decade's operation management methods such as Six-Sigma, Lean Manufacturing and TQM have been implemented by many organizations to facilitate the production lines and to improving the operation performance. However, none of these models able to solve all organisation problems when implemented alone, whereas integrated management models such as Lean Six-Sigma, have been empowered organisations to exceed the improvement rates and achieves competitive advantage. The aim of this research study is to develop *an integrated quality management framework, consists of two models which are; Lean Six-Sigma integrated model and Six-Sigma TQM integrated model,* to help manufacturing organisations to eliminate the quality issues and to improve and modernize quality system.

The study explores the literature pertinent to the topic, in order to identify the key drivers that are required to develop the proposed models and the framework. The study adopted a quantitative approach method for developing and validating the proposed models and the framework. Initially, Questionnaire surveys were conducted for the validation of the proposed models, the models were endorsed by a significant number of industrialists, quality professionals and academics from various manufacturing organisations. The models were integrated together and, therefore, the key drivers for developing the framework were identified. Furthermore, a multi-criteria decision-making method (AHP) was applied to evaluate and prioritise the key components of the framework. Based on an (AHP) evaluation the framework is designed and its implementation procedures were developed. The questionnaire survey was designed and conducted for the purpose of validating the framework and its implementation procedures.

The key findings of this study clearly demonstrated that the development of the proposed models and the framework should enable manufacturing organisations to achieve their desired objectives effectively.

Finally, the proposed framework and the integrated models were designed to provide impetus and guidance for manufacturing organisations in order to achieve significant improvement in the manufacturing organisations' performance and, as such, make a key contribution to academic knowledge.

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Chapter One:

Introduction

1.1. Introduction

The thesis in this introductory chapter presents the context for this research; it starts with a brief background to the research and then states the aim and the objectives of the research. In the final section, there is an outline of the structure of the theses.

1.2. Background

Quality managers nowadays are usually overstrained to identify the proper method for achieving the quality goals in their organisations. However, many manufacturing organisations, particularly in the developing countries, are facing many challenges with respect to improving the level of quality compared with competitors Porter and Yegin (2006). In this regard, (Triki et al., 2006) stated that such organisations often suffer from a lack of quality experience and absence of a systematic approach towards organisation management.

Therefore, quality managers have been involved recently to determine the most effective methodology for achieving goals concerning quality (Harmon, 2010) also, Johannes (2013) stated that organisations can combine quality methods and use it in parallel since synergies between quality management methods exist. However, Johannsen (2011) clarified that integration becomes a means for employing different quality methods and, therefore, can lead to value-creating synergies. (Andersson et al., 2006) said integrated quality management method is a method used to overcome weaknesses from the quality system. Thus, in response to those challenges that quality managers are facing, integration quality management concept can bridge this gap and overcome quality management problems and put the quality system of manufacturing organisation in place more effectively**.** (Johannes, 2013) argued that integrated quality management methods would be the key development in today's business environment. Therefore, the most effective quality methods for an integrated approach according to Antony (2009) stated that many academics and practitioners agreed that Six-Sigma is one of the superior quality initiatives in terms of decreasing the defects and variations of the system. Demast (2004) declares that Six-Sigma is the greatest complete strategy. Yang (2012) argues that TQM is also classified as one of the best initiatives in terms of continuous improvement and quality commitment with Cheng (2008) confirming that TQM is the prime component of Six-Sigma.

Reichhart and Holweg, (2007) suggested that Lean manufacturing is another effective method for simplifying the production lines and achieving the process performance, though, Lean is also focused on achieving cost reduction through the elimination of waste and fully utilise the workers' capabilities.

Finally, many critical factors of Six-Sigma, Lean and TQM can lead to the formulation of a successful quality management framework (Andersson, 2006). Therefore, this research focuses to develop an integrated quality management framework to provide inputs and guides for the manufacturing organisation in order to achieve effective improvement performance and sustainable improvement

1.3. Research questions

The general question:

How can manufacturing organisations develop and implement a quality management framework which reaches its full potential through the use of a manufacturing philosophy and quality management initiatives?

The sub-questions are all connected to the overall question:

- *What are the successful production methods and quality management initiatives that can lead to developing an effective integrated quality management framework? And how can be used together?*
- *What is a powerful model that can be used to improve the manufacturing processes and how it can be developed and validated?*
- *What is the superior model that can be used for enhancing and unifying the quality management system of manufacturing organisations? And how can be developed and validated?*
- *What are the main factors that can lead to combining the models selected above in order to develop the integrated framework and how can be implemented and validated?*

1.4. Research aim

The research programme aims to develop an integrated quality management framework for manufacturing organisations in order to eliminate the quality critical issues and make the quality system in place more effective for the organisations.

1.5. Research objectives

1. To carry out a comprehensive literature review to establish current knowledge and identify research gaps.

2. To identify the key drivers that can lead to a successful development of a quality management framework, which consists of two models namely; Lean and Six-Sigma integrated model and TQM and Six-Sigma integrated model.

3. To develop and validate Lean and Six-Sigma integrated model to improve the processes in manufacturing organisations.

4. To develop and validate TQM and Six-Sigma integrated model to unify the management system and achieve business excellence in a manufacturing organisation.

5. To identify the key drivers that can lead to a successful integration between Lean Six-Sigma model and Six-Sigma TQM model developed above to produce a robust quality management system for manufacturing organisations.

6. To develop and validate an appropriate framework by integrating Lean Six-Sigma model and Six-Sigma TQM model for the manufacturing companies to improve and modernise the quality system.

7. To identify the critical success factors that lead to a successful implementation of the tools and techniques of TQM, Lean manufacturing and Six-Sigma Methods in an integrated fashion.

8. To develop and validate an implementation procedure for the proposed framework.

1.6. Overview of the thesis

The thesis is organised into nine chapters relating to various research objectives and the adopted research design as follows:

Chapter One: Introduction

This chapter provides an introduction to the research study, research questions, aims and objectives, and an overview of the thesis structure and summary of the chapter.

Chapter Two: Literature review

The chapter provides a comprehensive review of the literature on the following topics;

1. Introduction to quality management;
2. Quality management methods tools and techniques and the differences between them;
3. The Six-Sigma initiative;
4. Lean manufacturing;
5. The differences and similarities between Six-Sigma and Lean;
6. The TQM method;
7. The differences and similarity between Six-Sigma and TQM;
8. The integrated approach in quality management, existing integration approaches, methods and techniques often being integrated and how methods and techniques are being integrated;
9. The project motivation for integrating Six-Sigma and Lean
10. The project motivation for integrating Six-sigma and TQM;
11. The critical success factors for the usage of each method mentioned above and
12. The relationship between the proposed methods.

Chapter Three: This chapter provides an introduction to the research methodology, then it presents an overview of the research philosophy, research approach and research techniques. Additionally, it outlines the common research design and strategy employed in the study, after that it provides, in detail, the selection of the research strategy and the necessary analytical tools and techniques that have been adopted for validating the research. Finally, it concludes with a summary of the chapter.

Chapter Four: Development and validating of LSS integrated model

This chapter illustrates the requirements for integrating Lean and Six-Sigma, then listing the CSFs for successful implementation of LSS. The chapter presents the development of LSS model and identifies the main component of the model and its implementation steps. In addition, it provides the required methodology for validating the model, the results of data analysis and, finally, it concludes with a comprehensive discussion and draws conclusions on the chapter.

Chapter Five: Development and validating SS-TQM integrated model

This chapter illustrates how Six-Sigma and TQM are integrated, then it outlines the critical components of both Six-Sigma and TQM implementations which can assist in identifying the main components of the proposed model, the chapter also provides a brief discussion about business excellence in quality management and provides a strategic plan for developing the proposed model. Moreover, it lists the CSFs for successful implementation of SS-TQM model. The chapter presents the development of SS-TQM model and comprehensively states the main component of the model and the steps for its implementation. In addition, it provides the required procedures undertaken for validating the model, the results of data analysis and the final discussion are included at the end of the chapter. Finally, the study concluded with brief conclusions on the chapter.

Chapter Six: Identifying and evaluating the key drivers for development of the proposed framework

The chapter demonstrated how LSS model can be integrated with SS-TQM model and shows how the key drivers for developing the proposed framework were identified. It also provides brief discussion about AHP as a means for assessing the key drivers of the proposed framework, then it presents the development of AHP model for evaluating and prioritising the key components of the framework, hence the required steps for validating the model which are elaborated on, in detail, at the end of the chapter, concluding with a discussion.

Chapter Seven: Development an integrated quality management framework for manufacturing organisations

The chapter provides in-depth information on the development of the proposed framework, the main components of the framework and procedures for its implementation; it includes the mechanism of the framework for attaining high-quality performance and business excellence within manufacturing organisations.

Chapter Eight: Validation of the proposed framework

This chapter discusses the main procedures that were undertaken for validating the framework, the data collection and the main steps of data analysis which are clarified. The results of data analysis are performed using SPSS-23 and are provided in this chapter, the validity and reliability analysis used for validating the framework and its implementation procedures are provided with an adequacy discussion following.

Chapter Nine: The final chapter includes; overall conclusions about the key research findings, some recommendations with the research limitations for further study highlighted. Finally, the contribution to knowledge is presented.

Chapter two: Literature review

2.1. Introduction to Quality management

Quality is a management philosophy developed over decades based on three interrelated approaches which incorporate; business strategy, methodology, tools and techniques. Many authors contributed to the development of that philosophy including Deming, Juran, Ishikawa, Crosby, Shewhart, and Feigenbaum (Juran, 1999). The key role of quality management is to identify the opportunities for improvement within processes, products, and services in order to accomplish high performance in operations and, thereby, satisfy customer requirements (Vive (2005). As such, quality management has gained considerable attention in the last three decades in order to enable organisations to meet the required demand, satisfy customer needs and achieve competitive advantages.

Therefore, many quality management methods have been developed such as TQM, Six-Sigma and Lean manufacturing to facilitate the operation system and achieve high-quality performance for manufacturing and services organisations (Bhuiyan and Baghel, 2005). However, the literature shows that none of these approaches is able to solve all of the quality issues for organisations when adopted alone, whereas a hybrid model, such as LSS, is able to exceed the improvement rates and achieve an excellence performance (Antony, 2009). Consequently, integrated quality management methods become the new effective quality management system in terms of attaining high-quality performance and sustainable improvements (Antony, 2009; Johannes, 2013)

2.1.1. Definition and concept of Quality management

Quality is a subjective term; each quality authors has own definition; however, all definitions in the literature has the same objectives, the common definitions of quality according to the quality gurus are;

“Non-faulty systems” (Deming, 2000)

“Fitness for use” (Juran, 1988)

And “Conformance to requirements” (Crosby, 1996)

(Deming, 2000; and Crosby, 1992) stated that quality in technical usage can have two meanings; one the attributes, features, functions of product or services that are applicable to satisfy the required needs of the customer, the other is product and services free of errors, defects and any deficiencies. Juran (1999,) further defined the meaning of quality overall as freedom of deficiencies which means that a product, service and the whole processes are required to be free of errors, defects and waste. In this sense, quality is the scope of an organisation to achieve its main goals. In addition (Juran, 1999) stated high quality enables companies to achieve customer satisfaction, meet product scalable and achieve competitive advantage, to increase market share and increase income. In order to achieve high quality, firms must be controlled the following factors;

- Reduce the error rate;
- Decrease the rework;
- Avoid or decrease the field failures;
- Reduce customer dissatisfaction and
- Improve delivery performance.

2.1.2. Quality management methods, tools and techniques

De Mast (2004.pp199) defined quality methods suggesting; "*improvement strategy comprises* a *coherent series of concepts, steps, methodological rules and tools that guide a quality professional in bringing the quality of a process or product to unprecedented levels (breakthrough)*". The most common quality management methods developed and implemented in practice for over decades are; TQM, Six-Sigma and ISO. However, quality management tools and techniques are integrated means used for assessing the quality issues and monitoring the operation performance, the *quality tool is a device that has a clear role and narrow usage*, whereas *quality technique has a wider application* (Mcquater, et, al., 1995; Johannes, 2013)***.*** According to (Mcquater, et, al., 1995) classified the tools and techniques based on its applications and functions as following;

Examples of tools

- Cause and effect diagrams;
- Pareto analysis;
- Control charts;
- Histograms and
- Flowcharts..etc.

Examples of techniques

- Statistical process control(SPC);
- Quality function deployment (QFD);
- Design of experiments and
- Benchmarking.

2.1.3. The importance of quality tools and techniques

Quality tools and techniques play an important role in terms of guiding an organisation in achieving continuous improvement, Mcquater et al., (1995) summarised the importance of quality tools and techniques in the manufacturing process as follows:

- For the evaluation and monitoring the process and product;
- For the Involvement of teamwork in the improvement process;
- To solve problems easily;
- To help for sustaining continuous improvement;
- To reinforce staff through problem-solving and
- To improve the daily activity business process.

2.2. Six-Sigma Initiative

Six-Sigma is a management system based on statistical thinking developed by Motorola in 1986, the main aim of Six-Sigma is to improve the quality output, through reducing the variation in process and eliminating the defects in the products as low as 3.4 parts per Million opportunities (PPMO) (Henderson and Evans, 2000). Six-Sigma is a business improvement approach which focuses on customer satisfaction, cycle time reduction and cost saving, it seeks to eliminate the causes, errors, defects in both services and process (Keller, 2011). In addition, it is a rigorous discipline based on data-driven, focused and highly effective implementation using a set of statistical tools and techniques (Henderson and Evans, J. R., 2000).

2.2.1. What does Six-sigma mean?

Sigma (Ϭ) is a Greek letter used by statisticians for measuring the variability; however, (Ϭ) also refers to the standard deviation measure, Six (6) is a number refers to the number of the standard deviation on either side of the process mean, where, in statistical science, the normal distribution for any sample data comprises six standard deviations (Mehrjerdi, 2004). In addition, Mehrjerdi (2011) stated that a Sigma level indicates the number of defects that are likely to have occurred; however, the higher the Sigma level indicated that the process attained the fewer the defects. Therefore, the Sigma process corresponds with the defects level which must be 3.4 defects per million opportunities (DPMO) or less based on the Six-Sigma target; table (2.1) demonstrates the Sigma level corresponded with the DPMO and the expected yield for each level.

Table 2. 1. Sigma levels, DPMO and Yield of process (Pyzdek et al., 2014)

Yield of process (%)	DPMO	Sigma level
68.26	690 000	1.0
95.46	308 000	2.0
99.74	66 8000	3.0
99.9936	6 210	4.0
99.99994	320	5.0
99.9999996	3.4	6.0

Six-Sigma is several packages of statistic metrics and management strategies integrated as a rigours discipline which can be divided into three parts; Strategy, Methodology and Metrics (tools and techniques) (Snee and Hoerl, 2005).

2.2.2. Six-Sigma strategy

Snee and Hoerl (2005); Henderson and Evans (2000), Yang (2012) stated that the ultimate goal of Six-Sigma is to enable organisations to deliver the greatest value to the customer and employees; therefore, the key strategy of Six-Sigma are:

Customer focus*;* means to understand the customer requirements proactively and to take proper actions to fully meet the customer needs which is defined and determined using CTQ techniques or QFD.

Reduce variation; the manufacturing and services process should be set up to produce no much variation in order to meet customer needs. The set of statistical and quality tools that are employed to control the variation within the process

Reduce defects; the products and services must be produced or delivered free of defects or maximum 3.4 DPMO.

Centred around the target; the focus is to produce superior results and to obtain an unprecedented level of improvement (Six-Sigma breakthrough).

2.2.3. Six-sigma methodology

(Seen and Hoerl, 2005; Andersson et, al., 2006; Henderson and Evans .2000; Kumar and Sosnoski, 2009)stated that Six-Sigma including two main methodologies. DMAIC is the process improvement of Six-Sigma used for improving the existing process, DAMDV is the other Six-Sigma methodology used for developing and design new products or processes, these methodologies are considered the roadmap of Six-Sigma deployment. Both methodologies are integrated with statistical tools and techniques. However, this study is focused more on the DAMIC process.

***DMAIC*;** stand for; Define, Measure, Analysis, Improve and Control.

DMAIC is considered the most powerful process of Six-Sigma in terms of problem-solving, within existing process, where the power of DMAIC comes from the effectiveness of the five phases: define, measure, analyse, improve and control. The function and the mechanism of these steps are described in figure (2.1) below:

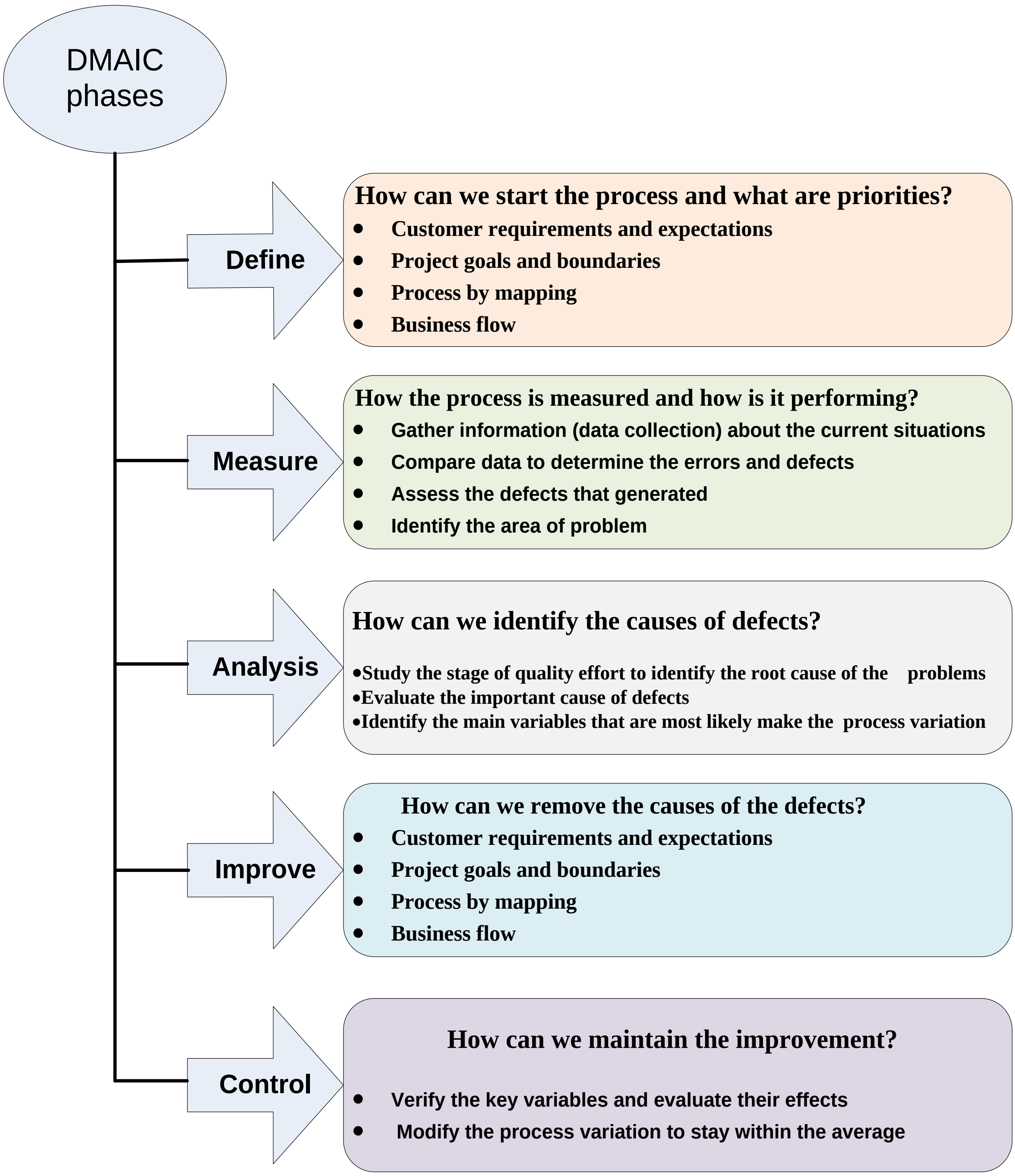

Figure 2. 1. Phases of DMAIC adopted from Henderson and Evans (2000)

DMADV; stand for Define, Measure, Analyse, Design and Verify

DMADV is the second methodology of Six-Sigma focussed on improvement and is similar to the DAMIC phases; however, DMADV includes two different phases: verifying and design. DMADV is an improvement process that is basically used to organise the process, or to develop, or design a new product. It aims to obtain more accurate and effective findings and to achieve high-quality performance free of deficiencies as well as to guarantee the incremental improvement in the system. Seen and Hoerl (2005) stated that General Electric company (GE) corporation developed the DMADV roadmap for the design of projects which is termed Design For Six-Sigma (DFSS) and since that time it has become the second methodology for design new product of Six-Sigma. The DMADV process contains the five steps demonstrated in the table (2. 2) below:

Table 2. 2 The DAMDV methodology adopted from Mehrjerdi (2011)

DMADV Phases	Purpose
Define	Identifying the customer requirements and the project goals
Measure	Determine the characteristics and the specifications to fulfil the customer's needs
Analyse	Evaluate the product design to satisfy the customer needs
Design	Simplify the details of the product or process to fulfil the customer needs
Verify	Validate the system ability and the design performance to verify the design's capability and performance

2.2.4. Six-Sigma tools and techniques

The Six-Sigma initiative focuses on using the quantitative data, along with process thinking to identify the variation in the process through the use of statistical tools and techniques (Markarian, 2004). In response to that (Henderson and Evans, 2000; Pande, et al., 2000) stated that, based on their experience of General Electric company (GE) in Six-Sigma, the projects who intend to implement Six-Sigma should be armed with three group of tools; Team tools, Process tools and Statistics tools. All of these tools can provide the Six-Sigma team and leadership with the required skills to run the projects, these tools support leaders in terms of establishing the project team and sustain it. The following is a comprehensive list of the commonly-used Six-Sigma tools and techniques classified by Henderson and Evans (2000):

Table 2. 3 Six-Sigma Tools and Techniques

Team Tools	Process tools	Statistical tools
Action workouts	Action workouts	One sample t-test
ARMI model (Approve, Resources, Member, Interested, Interested party)	Brainstorming	Two sample t-test
Critical success factors	CTQ	ANOVA
GRPI checklist (Group, Resources, Process, Interpersonal Relations)	Fishbone diagram	Box and whisker plot
In/out frame	Pareto analysis	Chi-square test
Includes/excludes chart	Process mapping	F-test
Responsibility grid	SIPOC (suppliers, inputs, process, outputs, custom)	Normal probability chart; to identify unstable and stable operation
Threat vs opportunity matrix		

Statistical tools

The statistical tools with Six-Sigma method are considered the driving force for process improvement in Six-Sigma; therefore, teamwork is supported by special training, due to which, the process can be improved by using those tools for identifying the potential causes of variation and then reducing variation and defects. Consequently, as it can be seen from the table 2.3 the eight statistical tools are the most frequently applied in practice (Henderson and Evans, 2000).

2.2.5. Six-Sigma and statistical thinking

Seen and Hoerl (2005) and Seow and Antony (2004) stated that the key driver of Six-Sigma is to reduce the negative effects of process variation in two ways: either by shifting the process variation to the desired target level or by reducing the variation to around the process average. The result in both methods is to obtain the minimal variation at the right average level; this is basically the key successful driver for achieving the process performance in Six-Sigma; in short, the best way to deal with the process variation is to use many statistics tools, where the concept of statistical methods is to identify, measure and understand the variation. On the other hand, statistical methods are based on the facts, figures and data analysis, means, and decision-making which is driven by facts and based on data. This is the key mechanism of Six-Sigma for eliminating the defects and improve the process.

2.3. The Lean Manufacturing Approach

Due to the crises that faced the Japanese manufacturing after the Second World War which disabled the Japanese market and significantly damaged Japanese manufacturing. As a result, the increase in the rate of redundancy and the decrease in the size and the value of the Japanese products in the worldwide market forced the Japanese manufacturer to seek a systematic approach to modernise the manufacturing system and to improve the value of products (Drohomeretski et al., 2013). Subsequently, Lean manufacturing emerged as manufacturing philosophy focused on eliminating all kind of wastes and smoothing the production flow, Lean was developed by the Toyota Corporation based on the framework of Ford's mass production and the available contributions to operation strategy made by industrialists of that time. Lean was originally called Toyota production system (TPS) and, over the years, evolved to just-in-time technique and, ultimately, becomes known as Lean manufacturing, this philosophy enables manufacturing organisations to reduce the production lead time and save a number of resources by producing the required products based on the customer demand (Reichhart and Holweg, 2007).

2.3.1. The concept of Lean manufacturing

Lean manufacturing is defined as a manufacturing philosophy aiming to eliminate the waste in the operation process and decreasing the number of resources that are required to perform the manufacturing activities within organisations (Papadopoulou and Ozbayrak, 2005). The technical definition of Lean is the identification and removal of all none value-added activities. Lean manufacturing is based on two concepts; firstly, to achieve cost reduction through the elimination of waste and, secondly, to fully utilise the workers' capabilities (Reichhart and Holweg, 2007). Therefore, the theory presented over the year's shows that the result achieved by Lean includes minimising human efforts, stocks, lead time, production space and its associated cost without compromising on quality (Staatsa et al., 2011). The main focus of lean is to eliminate all types of waste which are specified as anything in the process that does not add value to the process and the product, the waste identified in seven forms:

1. Over process;

2. Over inventory;
3. Overproduction;
4. Rework;
5. Defects;
6. Waiting and
7. Motion.

2.3.2. Principles of Lean Manufacturing

Essentially, the main focus of the Lean manufacturing is to eliminate waste, achieve continuous workflow; ensure better performance and establish a more effective work place employing the exact workforce, taking less time, less equipment and less space. Womack et al., (1990); and Womack et al., (2007) stated that Lean manufacturing can be implemented through five steps:

- Specify value

The first and the most important step in Lean is to focus on the customers and their needs when specifying values because those values can be only defined by the ultimate customer; this is vital step to avoid taking the wrong path when designing or making products for customers.

- Identify the value stream

In this stage, all the steps, process, actions and transaction of the production line are drawn on a map (value stream mapping) from the supplier to the customer, the aim is to evaluate and assess the current performance of the system and identify any non-value added.

- Flow

Once the value specified and the value stream is mapped; at this point the work must give way to the specific products, it is important that employees mentally get used to producing in small lots to ensure the continues flow and to avoid having a high level of inventory in between stations and eliminate time wasted while waiting for the job. This 'one-piece flow' is the quickest way to get from raw materials to finished goods.

- Pull

In this step, the benefits of implementing the previous steps will be evident as, instead of operating according to traditional sales forecasts, production is only what customer requests. In this case, the company should not produce products or services until customers place an order.

- Perfection

The perfection stage is involved in looking back at mistakes while producing and offering products to customers and, mainly, continuing to look for a possible way of reducing the amount of effort, time, space and eliminate wasted.

2.3.3. Lean tools and techniques

Primarily, Lean manufacturing is a method which focuses on achieving significant improvement in the business process through the elimination of all wastes of resources and time across the whole business process, Sharam (2003) stated that various tools and techniques employed by Lean Operation and every tool and technique plays a role in eliminating the waste in order to deliver improvement in a specific area; however, Value stream mapping (VSM) is the key strategy technique of Lean manufacturing since, the key role of this technique is to identify the current state of the system and draw the desired future state of the system, (Furlan, et al., 2011). In this regard, Wilson (2009) stated that in order to implement Lean, the common tools and techniques that the companies must be armed with are.

Problem diagnosis techniques; *Contains the following techniques:*

1. Pareto analysis.
2. Fishbone diagrams.

Quality tools:

1. Poka-Yoke (mistake proofing).
2. Failure Mode and Effective Analysis) (FMEA).
3. Statistics process control (SPC).

Process improvement techniques:

1. 5S (Sort, Sit in order, Shine, Standardise and Sustain).
2. Single Minute Exchange Die (SMED).
3. Visual controls.

2.3.4. DMAIC methodology and Lean manufacturing

DMAIC methodology is considered to be the driving force of Six-Sigma in terms of problem-solving and sustaining the continuous improvement in particular of an existing process, DMAIC is the most popular Six-Sigma methodology based on the Deming cycle (Plan, Do, Check and Act). This cycle is used to improve existing business process (Andersson, et al. 2006). The DMAIC methodology has five phases in its improvement cycle integrated with robust tools and techniques to overcome the quality problems within the system to smooth the operation's performance (Drohomeretski, et al. (2013).

Lean manufacturing is a philosophy and strategy in which the product is based on the customer demand, the philosophy here is that no product needs to be produced unless demanded by the customer and, hence, the most powerful tool associated with the pull system is the signal derived from the Kanban system which controls the flow of the product stream. because of this, Lean manufacturing is called a pull system or process improvement. It aims to improve the process flow and eliminate non-value-added (Snee, 2010). Other Lean tools such as 5S, VSM, TPM and others are related to the elimination of waste and improving the process performance and, in doing so, obtain high-quality output and improve the bottom line performance (Tomas, 2009).

2.3.5. The similarity and differences between Six-Sigma and Lean

In order to evaluate the differences and the similarities between Six-Sigma and Lean, it is necessary to provide definitions and concepts of both approaches. Common definitions for each method are provided by Andersson et al. (2006).

Six-Sigma is a business process that enables the organisation to improve the bottom line through the daily monitoring and controlling the business activities in such a way as to eliminate the defects and minimise resources use by employing statistical methods while increasing the customer satisfaction.

Lean manufacturing is a manufacturing philosophy and business strategy which aims to identify and eliminate the waste and focus on continuous improvement through smoothing the process of production, based on the customer demand in pursuit of perfection. It can be seen that the definitions are different, whereas, the aim and the concept are somewhat similar, where both concepts are aimed at minimizing a number of waste resources and obtaining a continuous improvement, customer satisfaction and the financial results.

Dahlgaard (2006) argued that these approaches have the same origin; both of them are based on the development of the quality management in Japan after the second world war; however, the way of achieving the objectives for each concept are different. Andersson et al. (2006) studied the similarity and differences between Six-Sigma and come up with the comparison as in shown in table 2.4 below.

Table 2. 4 The differences and similarities between Six-Sigma and Lean manufacturing adopted from Andersson et al. (2006)

Concepts	Six-Sigma	Lean manufacturing
Origin	The origin is a quality evaluation by Japanese practitioners. However, developed by Motorola and dispersed by General Electric in the US	The origin is quality evaluation by Japanese practitioners and Toyota
Theory (Aim)	Reducing the defects to less than 3.4 DPMO by decreasing the process variation using effective methodologies	Eliminating the waste in the process through flowing the product based on the customer demand
Process (Concept)	Focusing on reducing the process variation and improve processes	Focusing on improving the flow in the process and removing all kind of waste
Approach	Systematic, based on planning monitoring controlling and improvement (Project management)	Systematic, based on planning monitoring controlling and improvement (Project management)
Methodologies	(DMAIC Phases) Define, measure, analyse, improve, or (DMDIV)	Pull system (based on the customer demand) evaluating by value stream mapping, flow improvement and perfection
Tools	Advanced statistical and analytical tools (The advanced tools integrated with methodologies)	More Analytical tools integrated with quality tools
Primary effects	Increasing the organisation bottom line and high financial orientation	Reducing the lead time in order to improve the flow by removing the waste
Secondary effects	Achieving financial performance	Achieves customer satisfaction by increasing the quality and reducing the cost of products and make the price of the products competitive

2.4. Total Quality Management (TQM)

Total quality management (TQM) is a philosophy and a method of optimisation and integration of all functions of the business, it aims to achieve continuous improvement and satisfy customer needs. 'Word total' refers to everything involved in the organisation, it also covers all the business activities - staff, process, jobs, resources and time (Powell, 1995). TQM was introduced at the beginning of 1980 as a quality management system, particularly in manufacturing field, many writers on quality such as Deming, Ishikawa, Crospy and Juran have made many contributions to its development (Juran, 1995). Mainly, TQM is not limited to manufacturing sectors; it also valid to services sectors. TQM is about changes to management in order to improve the quality output by focusing on three aspects: structural change, technological change and cultural change (Boaden, 1997). In response to that Hellsten and Klefsjö (2000) define TQM as management philosophy based on the core values of customer focus, continuous improvement, process orientation and employees' commitment. Consequently, TQM has become one of the powerful quality initiatives in the field of quality management.

2.4.1. TQM definition

Many authors and researchers have discussed TQM to reach a common definition; a management philosophy that pursues to achieve continuous improvement in the whole process in order to achieve a high quality of product or services that are compatible with the customer requirements (Mehra et al., 2001). Boaden (2007) believed that quality is a degree of excellence and TQM is a management strategy which contains the application of quantitative methods and teamwork to improve the quality of product and services.

2.4.2. Concept of TQM

TQM is a quality management method by which the employees and management involved in the continuous improvement of the manufacturing and /or services process, TQM offers effective strategic tools and techniques to achieve improvement in quality and in the performance of the organisation (Mehra et al., 2001). In this regard, Hellsten and Klefsjö (2000) argued that the techniques in TQM are methods to achieve high-quality output for example self-assessment, process management and product design. These tools are useful for analysing the data to support the decision-making. Therefore, TQM covers all business aspects not only manufacturing; however, every function can be affected and improved on (Lewis and Smith (1994).

2.4.3. Essential elements of TQM

Deming (1994) believed that TQM system aims to increase internal and external customer satisfaction and reducing amount of resources, in this context Hellsten and Klefsjö (2000) pointed out that TQM is a method based on two precepts which are planning and communication; however, Boaden (1997) discussing the principle and practices of TQM, (ibid) declared that TQM consists of seven main elements:

- *Top management involvement and commitment*; everyone involved in the organisation goals and the customer needs; therefore, everyone should be aware of time, process and final product output.
- *Continuous improvemen*t; TQM is not an end state, it never finishes.
- *Customer focus*; All staff should be aware of the core of TQM which satisfy customer needs.

- *Competitive benchmarking*; employees should seek the best and trying to match it or exceed it.
- *Employees Empowerment;* teamwork has wide responsibility and authority to improve the process and production in every aspect of the organisation.
- *Team work;* people in the organisation are incorporated for the purpose of problem-solving and group ownership of the process.
- *Knowledge of TQM tools;* all staff must be trained in quality control and improvement techniques.

2.4.4. TQM strategy and organisation change

Strategy, in general, refers to identifying the vision and defining the organisational goals along with monitoring the implementation of the process which is the key role of the leadership. While Senge (1990) lists the key quality of leadership as the ability to build a shared vision. Bergman and Klefsjö (2002) advise the strategy of TQM must be built on the management's continuous commitment. On the other hand, TQM is considered as a comprehensive organisation-wide change (Bon and Mustafa, 2013), thus the process change is integrated with TQM philosophy into the organisation, and also the process change is based on the training and developing the employees along with changes to organisation structure, values attributes and management style. All of these factors should be taken into consideration once TQM is implemented.

2.4.5. The similarity and differences between Six-Sigma and TQM

Many quality authors have discussed TQM and Six-Sigma, however, Andersson et al., (2006) stated that there are many similarity and differences between Six-Sigma and TQM in many aspects such as origin, theory, process view, approach, methodologies, tools and effects. Table (2.5) shows the author comparisons between Six-Sigma and TQM.

Table 2. 5 The similarity and differences between Six-sigma and TQM adopted

Concepts	Six-sigma	TQM
Origin	Quality evaluation by Japanese practitioners; However, developed by Motorola and dispersed by General Electric in the US	The origin is the evaluation of quality by Japanese practitioners.
Theory	Reducing the defects to less than 3.4 DPMO by decreasing the process variation using effective methodologies.	Focusing on satisfying the internal and external customers by armed the employees with quality management tools and methodologies to achieve customer satisfaction.
Process	Focusing on reducing the process variation and improve processes.	Focusing on the improvement by organising the process to produce the customer satisfaction.
Approach	Project management.	Employees commitment with the target of the organisation.
Methodologies	(DMAIC phases) for process improvement (DMADV) for developing new product and/ or process.	(PDCA cycle) Problem-solving strategy.
Tools	Advanced statistical and analytical tools (The advanced tools integrated with methodologies).	Analytical and statistical tools.
Primary effects	Increasing the organisation bottom line and high financial oriented.	Increase or exceed customer satisfaction.
Secondary effects	Achieving financial performance.	Obtains customer loyalty and improves the whole performance.

from (Andersson et al., 2006)

2.5. Integration approach in quality management

The integration approach in quality management is a method of combining one or more quality management methods or techniques to overcome the difficulties in a quality system and to achieve competitive advantages. Gijo and Rao (2005) defined integration quality management as a means of combining the appropriate quality management methods and techniques to attain improvement in the operation process. Bendell and Tony (2006) said that integration quality management demands discipline when improving the business process to avoid the weaknesses in the quality management methods. The meaning of integration in quality management, according to Johannes (2013), is the parallel the use of the applicable quality management methods in order to achieve significant improvement in the business process while adding value to the quality system.

2.5.1. The essential elements for incorporating the integrated approaches

Johannes (2013) discussed a holistic approach for integration method in quality management, it can be seen from his study that the basic elements for formulating the integration method in quality management comprises of five main elements:

- *The synergy between quality management methods;* a stage of eliminating the weaknesses of certain quality management methods which enables an exchange the results between them which resulted in value added.
- *Procedure model;* the sequences of procedures that are taken as the basis for modification and improvement of the quality system.
- *Consistency*; the consistency refers to compatibility and the harmony in the behaviours of the methods combined and the procedure model used; it is a

logical sequence of the activities in the procedure model which assure that the tasks are performed and contradictions are avoided.

- *Completeness;* that all the component of the proposed methods must be adequate to fulfil the integration between quality management methods which including method elements, procedure model and the consistency in the procedure model.
- *Value adding;* adding value to the quality system means that to develop the activities of the whole process in which to improve the quality of products and services and, hence, to satisfy the customer requirements.

2.5.2. How methods and techniques are being integrated?

Essentially, the possible approaches to integration in quality management are either integrating methods with methods, techniques with techniques or methods with techniques (Johannes, 2011). Therefore, the literature shows that the common mechanism of the integrated method in quality management is based on the possibility of the following motivations; *elimination of the weaknesses in the methods or techniques, the occurrence of synergies between the homogeneity methods and or techniques and the prerequisite of enhancing one method to another in the way to exchange the results* (Pfeifer et al, 2004). This view supported by Johannes (2011) who stated that elimination of the weaknesses and the possibility of occurrence of the synergies among the methods serves as the key trigger for the integrated approach.

2.5.3. The key motivation for the integrated approach to quality management

Johannes (2013) stated that there are four key motivations for integrated approaches in quality management:

- *Eliminating the existing weakness in quality management methods and techniques*. The weaknesses and the failings in the quality management methods and techniques is a critical indication encourage for integrating with other methods to eliminate those weaknesses and failings.
- *The existence of synergies between* Quality Management Methods *and Techniques;* The synergies between quality management methods are considered the backbone of the integration approach when the synergy is the stage of exchanging the results between QMMs and techniques which result in value added.
- One method is *an existing prerequisite enhancing another one;* Whatever the weaknesses in any method are irrepairable or if it can be eliminated by another method in a successive way, then methods or techniques need to be integrated
- *Fear of missing trends in quality management*; This concern that areas of quality management are flawed or absent can be a key factor that plays an important role in the way to improve the process in quality management

2.5.3.1 The key drivers of the integrated approach in quality management

Despite the different ways of combining the methods or techniques; the mechanism of the integrated method is the same Johannsen (2011) stated. That, based on the integrated models discussed by many theories, the integration between quality management methods or techniques can be incorporated by examining three stages;

- Evaluating the quality methods and techniques in terms of homogeneity.
- Deriving the synergies between quality management methods and techniques.
- Ensuring and verifying the requirements of the integrated method are being met (the essential elements of the integration approach).

2.5.3.1.1. Evaluating the methods and techniques for integrated readability

In this stage, quality management methods or techniques are being evaluated based on their concepts and essential elements to identify the similarity and differences through which it can be identified to what extent the methods or techniques are interrelated, this view is supported by De Mast (2004) who stated that the quality management methods can be compared based on the following factors in order to identify its eligibility for integration (*steps, rules, concepts, tools)***.**

2.5.3.1.2. Deriving the synergies between quality management methods

Once quality management methods or techniques are selected the second step is to derive the synergies from the methods, where the synergy is considered the foundation of the integrated approach. Johannes (2011); however, *to address the question of how to derive the synergies between methods or/and techniques,* adopted four factors from the literature which are frequently used to achieve the synergies between the quality methods, these factors are considered the key steps to incorporate the synergies and hence formulating the integrated approach, the four steps focused to derive the synergies which are;

- Evaluate the weaknesses and strengths of quality management methods to derive the synergies.
- Find out the common core concept between quality management methods to derive synergy.
- Use the strategy of (PDCA or DMAIC) cycle to enhance the activities of other method and to generate the procedure model.
- Use the proper quality techniques to enhance one method from another.

2.5.4. What methods and techniques are often being integrated?

According to Johannes (2011) stated that the integration between quality management methods and techniques can be formulated by three ways; Integrating methods with methods, integrating methods with techniques and Integrating techniques with Techniques. Johannes (2013) stated that Lean Six-Sigma is the most frequently integrated model discussed in the literature during the last two decades and the results of those studies demonstrated the validity of the integrated models. The view was supported by (Pfeifer et al., 2004; Sharma, 2003; Shahin, 2004; Revere et al., 2004 and Clegg et al., 2010; Ehie and Sheu, 2005) who discussed the integration of Six-Sigma and ISO 9000 as well as Six-Sigma and Lean management. However, table 2.6 below demonstrated the most integrated quality methods and techniques discussed in the literature, where column one shows integrating methods with methods, two methods with techniques and three techniques with techniques.

Table 2. 6 The methods and techniques are often found to be integrated throughout the literature, adapted from Johannes, (2011)

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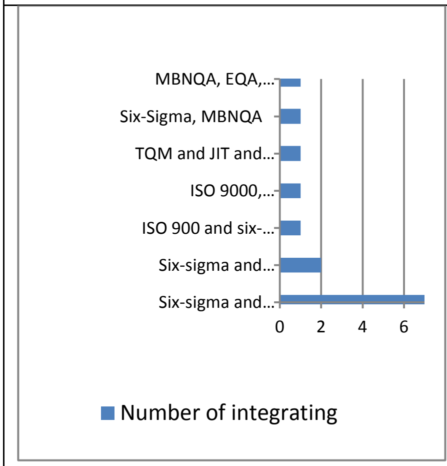

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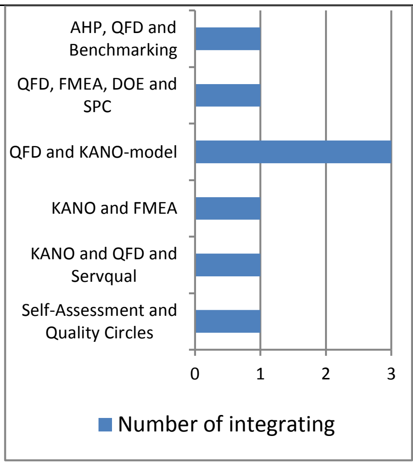

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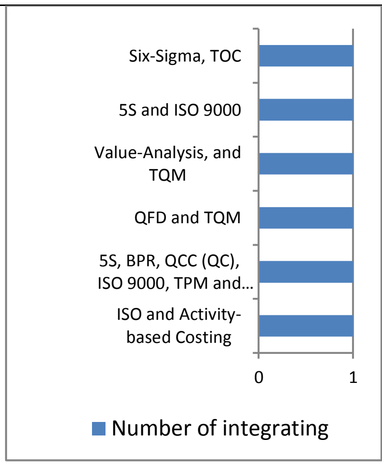

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2.5.5. Project motivation for integrating the selected methods

The study in this section seeks to identify the main project motivations for integrating *Lean and Six-Sigma as an integrated model* and *Six-Sigma and TQM* as another integrated model, the purpose is to explore the importance of integrating the mentioned methods and the key incentive for conducting the integrated approach among the proposed methods. Johansson (2011) stated that the similarity between the quality management methods is the basis of the integration approach, the potential synergy between the proposed methods is the trigger of the integration approach, and, finally, the compatibility to overcome the weakness of the methods is the driving force for the success of the integrated approach to quality management. Therefore, based on the overall motivations for integrating quality management methods that were discussed earlier in this study (see 2.5.3), these motivations are considered the basis of the project motivation for integrating the proposed methods. The comparison studies used to discuss the similarity and differences between Six-Sigma and Lean and Six-Sigma and TQM (see 2.3.5 and 2.4.5) demonstrated the similarity between these approaches. The project motivations for integrating the selected methods are summarised in the following section.

2.5.5.1. The project motivation for integrating Lean and Six-Sigma

As discussed earlier in this research, it is clear from the literature that Lean manufacturing and Six-Sigma are the most frequently integrated methods studied. Johannes (2011) stated that the integration between Lean and Six-Sigma was conducted by 7 studies with the aim to improve the process and eliminate the weaknesses of both methods, most of the studies concluded that Six-Sigma with DMAIC methodology can serve as the key driver for process improvement and weed out the quality issues, a view supported by Chen, Li and Shady, (2010); Bendell (2006) Brett and Queen (2005). Therefore, both methods are similar and each one can complete the other in many respects. However, a number of motivations for integrating Lean and Six-Sigma can be observed based on the similarities and differences study (discussed in 2.3.5.). The key project motivations for integrating Lean and Six-Sigma are as follows.

In terms of the process planning and management strategy: DMAIC technique is the key methodology that offers the opportunity for quality improvement which can draw a robust strategy for improving the business and operation processes using a set of tools and techniques, the view supported by Salah et al. (2010). Andersson et al., (2006) agreed that Lean and Six-Sigma can be used to enhance each other by using DMAIC strategy to achieve the organisation's objectives effectively.

In terms of evaluating the process performance**;** Value stream mapping (VSM) with Lean tools and techniques combined with DMAIC strategy can enhance the operation process and obtain high performance. Andersson et al., (2006); Thomas et al. (2008); Salah, (2010) agreed that value stream mapping

(VSM) with DMAIC methodology might be used as a platform for assessing the operation process and Six-Sigma tools and techniques which can be the right strategy for improving the process performance.

In terms of simplifying the quality problems and sustaining continuous improvement; Integrating Lean tools and techniques with the advanced statistical tools of Six-Sigma can be another motivation for integrating both methods to overcome the fears of complicity and obtaining high performance. Tomas et al. (2008); Andersson et al. (2006) stated that companies intended to implement LSS to develop, what can be termed, the process of quality enhancement which must be armed with specific tools and techniques such as Six-Sigma statistics.

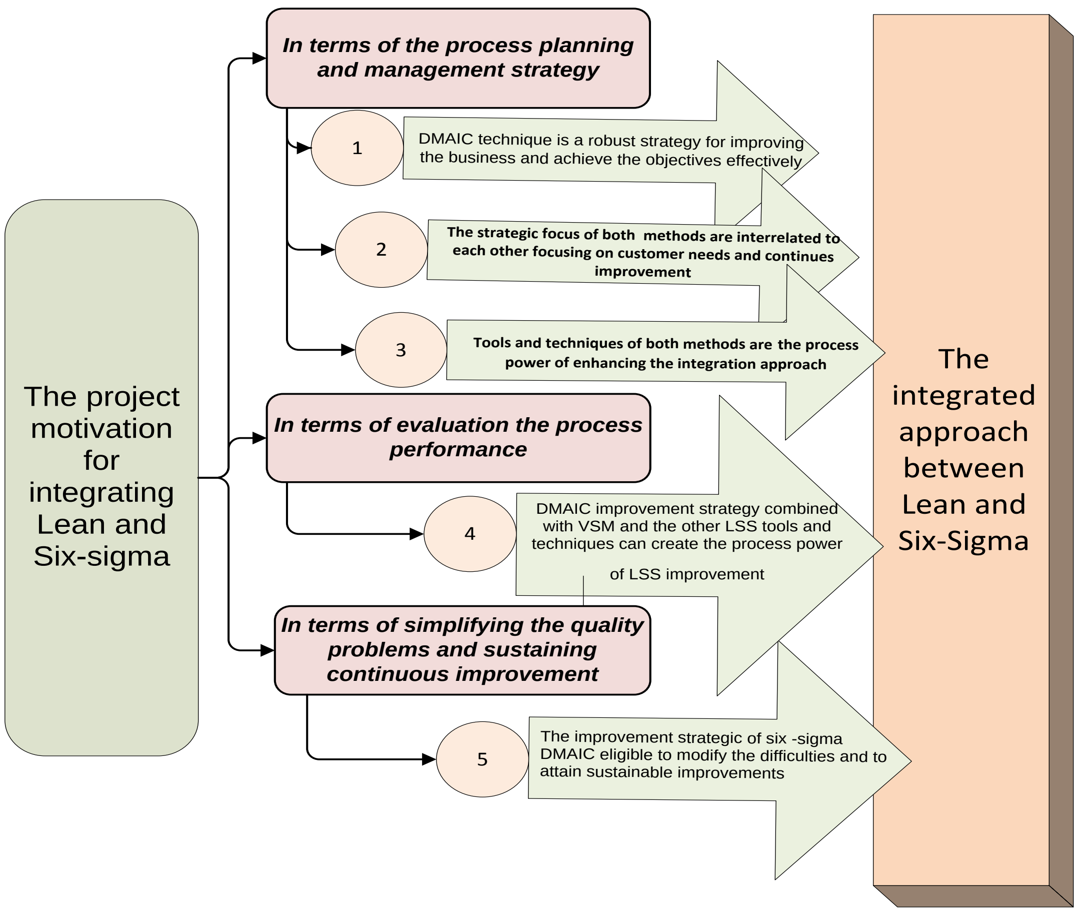


Figure 2. 2. The project motivation for integrating Lean and Six-Sigma

2.5.5.2. The project motivation for integrating Six-Sigma and TQM

Based on the above concept, the key motivation for integrating Six-Sigma and TQM can be surmised into the three main motivations; the existing similarity between Six-Sigma and TQM, the potential synergy between both methods and the applicability of the methods to overcome its weaknesses.

The similarity between Six-Sigma and TQM; *Snee, (2010); Johansson, (2011); Andersson et al., (2006) agreed that* similarities between both methods exist, as the objectives, concept and the methodology of the methods are similar; where the objectives of both methods is to drive out the defects, errors and variation in the products and use the process to satisfy customer requirements and improve ‘the bottom-line’, the concepts of both methods are; focusing on customer needs, focusing on process and are based on premise that the data be used to attain high operation performance and continuous improvement, the methodology of the methods are also same where TQM employs the PDCA technique and Six-Sigma utilises the DMAIC strategy in which DMAIC is already developed based on the PDCA cycle.

The existence synergies between Six-Sigma and TQM; There is a consensus among the quality authors who are concerned with integrating Six-Sigma with TQM that the synergy between both methods exists since the essential elements of both approaches can complement each other and overcome the existing weakness. (Yang, 2010; Bendell, 2006; Yang et al., 2007; Yang et al., 2011) Its methodologies are intermingled in a manner which can provide a robust strategy for the success of the quality system and, finally, the tools and techniques of both methods are relatively similar, which can be worked as key drivers for eliminating the critical issues within the system.

The capability of one method to be prerequisites for another method; Antony (2009) discussed the difference between Six-Sigma and TQM in a panel of Academics, experts and practitioners. The study concluded that TQM is a method that requires enhancement in many aspects during the implementation stage, for example, TQM used, in practice, a less efficient strategic roadmap for obtaining better results when compared with Six-Sigma which employed DMAIC and DMADV. Andersson and Torstensson (2006); and Klefsjo et al. (2001) stated that Six-Sigma can embrace TQM as a way to overcome many difficulties by combining and using strategic tools and techniques; moreover, when Low (2001) and Ho (1996) discussed the implementation of TQM, both studies agreed that TQM required a stepwise implementation of certain methods and techniques to obtain better results. Therefore, Six-Sigma can be used as the baseline when integrating with TQM and this may also be another motivation for success.

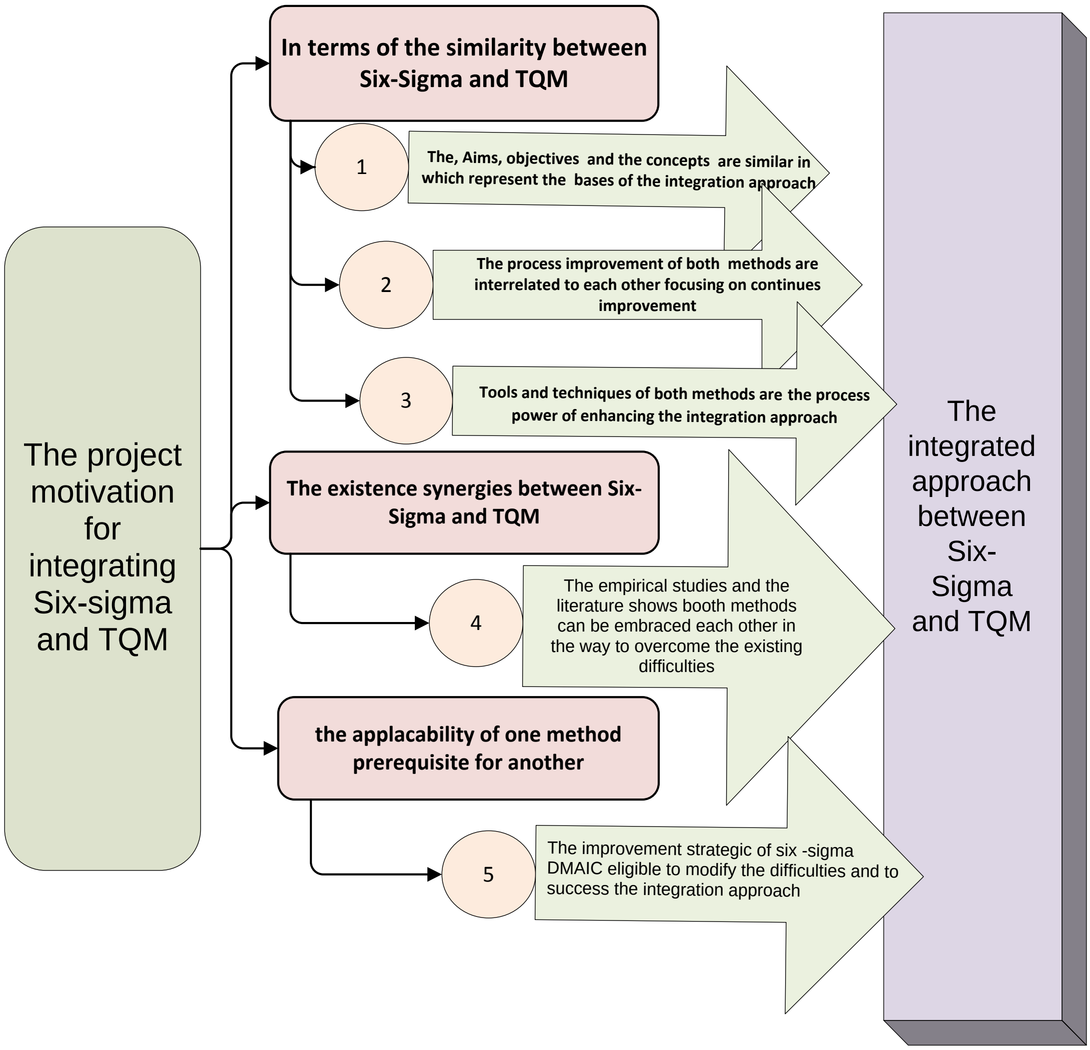


Figure 2. 3. The project motivation between Six-Sigma and TQM

2.6. The relationship between the organization and the methods selected

In this part of the research, the study intends to identify the relationship between Six-Sigma, Lean and TQM and the organisation in practice. A number of studies have provided a clear evidence and confirmed that these methods are related to each other in many aspects and many authors indicated the benefits that can be achieved if the methods are integrated.

2.6.1. The relationship between the organisation and TQM

According to (Miles et al., 1978 pp547) "*the organisation is both an articulated purpose and establishes a mechanism for achieving it*". Additionally, the initial activities and the aim of the organisation are elements defined by the owners of the organisation, whereas the strategic planning includes; a definition of the vision, implementation of the strategy and monitoring and controlling of the process performance are other elements associated with the management method of the organisation. Srinidhi (1998) stated that the organisation is a set of interlinked processes, the change of these processes is considered to be the foundation of the improvement; Accordingly, the efficient organisations must be armed with the effective quality management method in order to achieve competitive advantages. (Srinidhi, 1998). Based on this concept it can be seen that there is a direct link between TQM and the organisation. Prajogo and Sohal (2006) found there is *a positive relation between TQM and the organisation in practice since TQM establishes a system and culture that proves fertile for the organisation and for innovation*. Srinivasu et al. (2010) determined that TQM is integrated program permeating the entire organisation.

2.6.2. The relationship between the organisation and Six-Sigma

Six-Sigma as quality management method offers the organisation an effective organisational culture, where the certified experts (Master Black belts, Black belts and Green belts) lead the improvement projects (Srinivasu et al., 2009). In this context Kumar et al., (2008) stated that Six-Sigma provides a clear change of tangible results in many organisations in practice, moreover, it is a powerful method which provides DMAIC methodology that led the organisations in practice to attain incremental improvements (Srinivasu et al., 2009). In addition, Cronemyr (2007) cited further benefits that Six-Sigma provides; a company-wide strategy, an improvement program and a toolbox to deploy Six-Sigma in the organisation, Hammer (2002, p. 32) warns: "Six-Sigma should be a part of process management not the other way around". Based on this concept it can be said that there is a logical and positive link between Six-Sigma and the organisation, Cronemyr (2007, p. 55) argued that this was always an intrinsic feature; **"**Six Sigma is a methodology for making breakthrough improvements, It was never intended as a system for managing quality in an ongoing manner, nor was it intended to define the proper criteria for world-class quality management".

2.6.3. The relationship between the organisation and Lean manufacturing

Lean manufacturing is another method which has a significant relationship with the organisation in practice and, in particular, in the manufacturing field, which is focused on adding value to the system by eliminating the waste and achieving perfection (Snee, 2010), Lean manufacturing was developed by Toyota as a way of organising manufacturing in order to achieve improvement in most economic ways, this can be seen in the positive relationship between the manufacturing organisation, Lean manufacturing and process performance *(*Thomas et al., 2008). Andersson et al. (2006) support, suggesting there are many reasons for introducing the Lean concept and its tools to the organisation as it makes a substantial contribution to cutting costs and providing competitive advantages.

2.6.4. The relationship between the Six-Sigma and TQM

Concerning the relationship between Six-Sigma and TQM as quality management methods, various authors agreed that TQM is useful philosophy for management if it is planned properly and implemented, whereas Six-Sigma is program that seeks to decrease the defects in every product, process and transaction by using effective tools and techniques focusing on the process output (Black and Porter;1996, Flynn and Saladin;2006; Srinivasu et al., 2019; Snee, 2004). In addition, Hammer (2002) stated that Six-Sigma has its rules in TQM; while, Six-Sigma goes beyond TQM by employing the strategy of DMAIC, on the other hand, Antony (2009) said that Six-Sigma does not depend on TQM structure but it can empower the organisation to implement TQM. Based on this concept, despite the number of differences between these approaches in its strategies and methodologies, there are many related factors due to the significant commonalities, the view can be supported by Antony (2009) that Six-Sigma and TQM are not the same; however, there is no a critical difference between these methods to quality management.

2.6.5. The relationship between Lean manufacturing and Six-Sigma

Finally, it can be seen, from many studies, that Lean manufacturing and Six-Sigma are two methods focusing on process improvement by eliminating the waste and defects in the product and process, the aims of these concepts are the same and the strategy of achieving their objectives are similar (Andersson et al., 2006). Moreover, Snee (2010) stated that both Lean and Six-Sigma have a similar concept providing tools and methodology for changing processes and improve performance, Snee concludes that those programs can be integrated to overcome their limitations and making improvements to a business process. Therefore, it can be said that Lean and Six-Sigma are interrelated with each other due to the similarity in their principles concepts and methodology (Andersson et al., 2006). They (ibid) also identified that the five principles and the aim of Lean production, as well as the principles and tools behind Six-Sigma, are embedded in the principles, concepts and tools of the holistic management philosophy called TQM. This is another indication that Lean Manufacturing has a positive relation with TQM initiative as both methods are focusing on process improvement and continuous improvement.

2.7. Summary of the chapter

The chapter began with an introduction to quality management as the main subject of the research and, then, followed by the definitions and the importance of quality management methods and techniques which are the key components of any quality management system. In the second part, the review conducted above provides details including clarification about definitions, concepts, components and the key tools and techniques of the main quality management methods in the study; Six-Sigma, Lean manufacturing and TQM, moreover, a comparison between the emerging quality methods provides, in detail, the strengths and weakness of each concept and the most common distinctive features are covered in order to clarify to what extent these methods can be compatible with each other. The review of the literature showed that there is a general agreement among the authors and the academics that the proposed methods can be integrated and the synergy between them can occur.

The third part of the literature review, discussed the integrated approaches within quality management, which is the main mechanism of this study - to develop the proposed models and the framework - the study of the integrated approach included; definitions of the key terms, the main elements of the integration method, the requirements of the integration method and the motivations of the integration approach in quality management.

Furthermore, the review of the literature discussed in detail, the important factors that can lead to developing the proposed models and the framework. These included; identifying the existing integrated approach, the methods and techniques which are often integrated, the project motivation for integrating Six-Sigma, TQM and Lean, the CSFs for the usage of each method, in addition, the critical relationships between the Organisation, Six-Sigma, Lean and TQM.

Finally, based on the review conducted above, the study argued that the research intends to apply the concept of the integration of quality management methods providing new means for developing quality management systems in recent years. The context of the section is directly relevant to the research questions of this thesis because it forms the cornerstone for the development of the proposed framework and its components. The next chapter, chapter (3), will focus on the research methodology applied in this study.

Chapter Three:

Research methodology

3.1. Introduction

This chapter presents the research methodology adopted throughout the research study, the chapter starts with an introduction to research methodology, and it provides an overview of the research philosophy, research approach, then the research design and strategy. Accordingly, the study provides the selection of the research methods and techniques employed for conducting the research. Finally, it explains the analytical procedures used for validating the research

3.2. Introduction to research methodology

The Oxford English Dictionary Coed (2004) defines research as "the systemic investigation into and study of materials and sources to establish facts and reach new conclusions". Other authors described research as systematic procedures and organised efforts to investigate a certain problem that needs a solution (Neuman, 2006; McNeill and Chapman, 2005; Sarantakos, 2012). Moreover, research methodology is defined as an art developed through skills of inquiry, experimental design, data collection, analysis and measurements Greenfield (1996). In addition, Arbnor and Bjerke (2008) stated that it is a way to indicate how the methods are constructed and how the framework is being developed. Moreover, Robson and Mccartan (2016) observed that the research strategy methods and techniques must be appropriately selected to address the research questions.

However, research methodology comprises a number of academic procedures that are applied to investigate a particular area of study. Therefore, Remenyi (1998) indicates that, whatever the methods selected, the research should be systematic rigorous, integrated and focuses, Remenyi et al., (1998) stated that the essential drivers of selecting the effective research methodology include; the topic of the research, the research questions and the available resources.

Therefore, in the research methodology model developed by Kagioglou et al., 2000), the research methodology can be divided into three main interrelated schemes which are; research philosophy, research approach and research techniques as in figure 3-1 below.

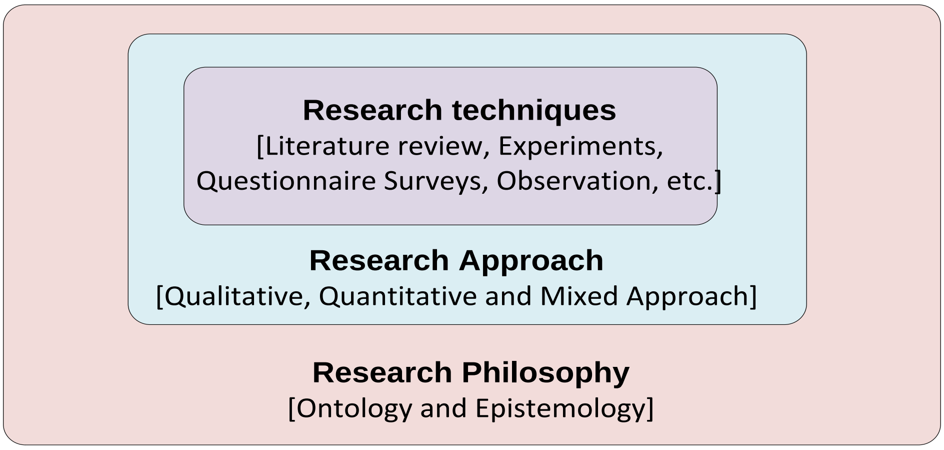


Figure 3. 1. A Nested Research Methodology adopted from Kagiogluo et al. (2000)

The research philosophy constitutes the outer section of the pillar which guide and energise the research approaches and research techniques, where the research approaches comprise qualitative methods, quantitative methods and/ or mixed method. Research techniques including literature review, experiment design, survey questionnaires, interview and observation.

3.2.1. Research philosophy

According to (Saunders., 2009), the research philosophy is a comprehensive term related to the development of the knowledge and the nature of the knowledge, essentially the research philosophy is based on assumptions which the researcher viewing the area of being studied, these assumptions are considered the basis of the research methods and strategy that the researcher selected. The view supported by Flowers (2009) who stated that when research is undertaken the vital point is to consider different paradigms and concerns of the research philosophy, these considerations will influence the way in which the researcher the research is designed until the conclusion of the study. Many authors believe that there are two main philosophical schools in social science and engineering research; *Ontology and Epistemology* (Kagioglou et al., 2000; Bryman,2004; Flowers, 2009). Each one contains different paradigms that influence the way of thinking about the research process including topics selection, questions formulation, methods adopted and research design.

Bryman and Cramer (2005) clarified that Ontological philosophy is concerned with the nature of reality, in other words, it is a way of thinking that reflects an interpretation of an individual about constitutes a fact, the ontology philosophy is divided into realist and relativist paradigms. The Epistemology philosophy is concerned with possibility, nature, sources and the limitations of the knowledge, it seeks to answer the question of how the researcher perceives its aim and gains knowledge about it. The Epistemology philosophy comprises two main approaches; interpretivism and positivism. Table 3.1 below summaries the main philosophy consideration.

Table 3.1. A summary of philosophy considerations (Bryman, 2005; Fizgerald and Howcroft, 1998)

Ontological consideration	
Realist (objectivism)	Relativist (Subjectivism)
External world comprises pre-existing hard and tangible structures. Structures exist independent of individual's ability to acquire knowledge.	The existence of multiple realities is a subjective construction of the mind. Socially-transmitting terms vary across different languages and cultures.
Epistemological considerations	
Positivist	Interpretivist
The application of natural science methods to the study of social reality beyond the world conforms to laws of causation and complex issues can be reduced through reduction.	The absence of universal truth and emphasis on the realism of context. Understanding and interpretation come from researcher's own frame of reference

The most important philosophy paradigm in such study is epistemology; in which one paradigm is interpretivist which focuses on the development of knowledge and the building of knowledge by generating ideas through observation and interpretation using the qualitative approach (Love et al., 2002). The other approach is positivist, which focuses on the development of knowledge by investigating the reality, evaluation and observation the facts using quantitative approach (Blumberg et al., 2005).

3.2.2. Research approaches

In order to provide an effective justification for the methods selected to conduct the research, it is important to discuss the main approaches to managing the research methodology (Saunders et al., 2012). The research approach is concerned with types of methods employed to conduct the research (Blumberg et al., 2005). There are three common research methods; the quantitative research method, qualitative research method and mixed research method (Saunders et al., 2012).

3.2.2.1. Quantitative research method

Quantitative method is defined as; an inquiry into a social or human problem, based on testing a hypothesis or a theory composed of variables, measured with numbers, and analysed with statistical procedures in order to determine whether the hypothesis or theory holds true Creswell (2013). The aim of the quantitative approach is to study the relationship between different concepts or to investigate a certain situation of a specific subject by adopting the techniques of natural science (Saunders et al., 2009). Accordingly, the quantitative approach is based on numerical measurements and analysis using statistical and/or mathematical methods (ibid). The most commonly used quantitative research is experimental research and survey research, the advantage of quantitative methods, particularly the questionnaire survey, is that it is faster and more economical compared with the other methods. However, using the quantitative approach particularly in social science has been described as being rigid and providing less detailed information (Bryman and Bell, 2003).

3.2.2.2. Qualitative research method

Qualitative methods are defined as a study or a research using a data collection process, such as interviews, and data analysis procedures, the categorisation of data, which produces non-numerical data, Saunders et al., (2009) stated that the role of the qualitative method seeks to understand, in depth, the behaviour or action of certain discipline and help to explain the reason for implementing that action. Qualitative research is based on gathering the significant information from a group of people or individual, who are involved in the relevant issue, in which the researcher is investigating (McNiell and Chapman, 2005). Mainly the data obtained through the qualitative research is categorised into two groups of research which are; exploratory and attitudinal (Saunders et al., 2012). Exploration is used when the research is limited in resources in the main area hence, the interview technique is, usually, the most suitable technique to collect the data. Attitudinal research; is used to investigate views and perceptions towards of certain object, where the object refers to a factor, variable or question.

3.2.2.3. Mixed method

Both methods quantitative and qualitative research methods are combined to conduct a research, Saunders et al., (2009) stated that the research method can be either conducted sequentially or concurrently; *concurrently,* means that the research method is included from one phase of data collection and analysis, the point of this design is to enable both of results to be interpreted together to provide more comprehensive responses to the research questions. Furthermore, the methods can also be used equally or un-equally dependant on the purpose of the research; the priority varies between qualitative or quantitative method and also depends on the preferences of the researcher or the expectation of directors of the research or the organisation. *Sequential,* means that the research conducted in more than one phase of data collection and analyses the point that the researcher planned to expand on the findings by following one method with another (Saunders et al., 2012).

3.3. Research design and strategy

Saunders et al., (2012) defined research design as a plan or action as to how the study is going by answering the research questions. The guide for developing any research methodology is to select the suitable research strategy that should completely address the research questions (Creswell, 2013). Therefore, the research design starts from the research questions and provide an appropriate strategy to deliver the research aim and objectives. Additionally, the research strategy mainly includes; sampling, methods and data collection techniques, additionally, analytical procedure techniques for analysing the data collected in order to find out the research results. The sensible decision for selecting the appropriate methodology must be taken based the purpose of the study and answering the research questions with the available resources (Robson and McCartan, 2016), thereby selecting the appropriate research strategy and effective data collection technique depends on several factors and conditions including; the research situation, the types of the research questions, the types and size of data required, and the available resources (Yin, 2003; Binti Kasim, 2008).

3.3.1. Selection of the research methodology and techniques

The aim of this research is to develop an integrated quality management framework to improve and modernise the quality system within manufacturing organisations, based on the purpose of the research, research questions and the availability of the resource. The research methodology selected include*; the position of the research paradigm for this study is epistemological philosophy and the research tends more to positivism (favouring the quantitative approach)*. The nature of this study is to explore the insight and notion of manufacturing organisations towards the quality management system and to identify the effective quality system in practice. Therefore, the approach selected suits the research questions and fulfils the research aim and objectives, Hair et al., (2008) stated that the key strategy of the survey is to enable the research study to obtain quantitative and/or qualitative data with full description and inferential statistics provided, moreover Saunders et al., (2009) argue that quantitative research method is considered a highly effective approach that can lead to obtaining reliable and valid results. (Figure 3.2)

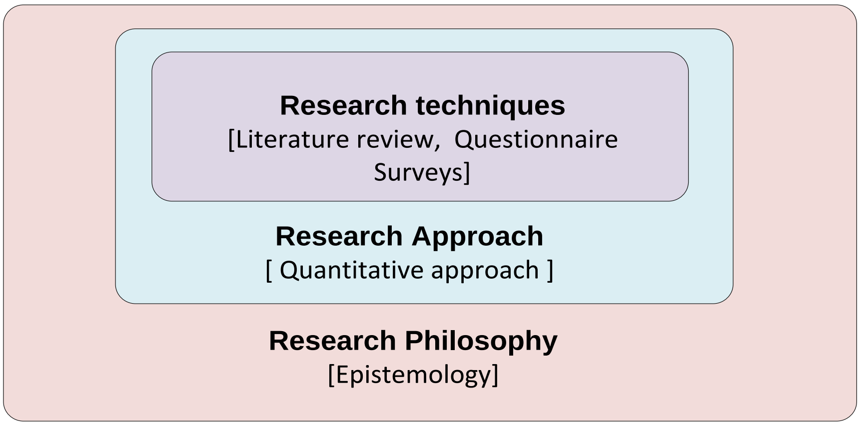


Figure 3. 2 Selection of the research methodology

The research techniques employed in this study comprise of the literature review and three different functions of questionnaire surveys as well as a multi-criteria decision making technique (Analytical Hierarchy Process), (Farrell, 2011) assures the questionnaire can be considered an efficient and reliable technique to collect the required data, which enables the researchers to gather data from many respondents within a relatively short timeframe. Three different questionnaires have been developed and applied to gain the practitioners and academics insight and information to validate the proposed models and the framework. Another questionnaire was used to collect the required data for applying a Multi-Criteria decision-making technique (AHP) in order to evaluate and prioritise the main components of the framework.

3.3.1.1. Literature review

Lewis and Ritchie (2003) said that term ‘literature’ refers to any sources of published data; these are called, in research methodology, secondary data, the key role of the literature is to explore the required items of secondary data which is necessary to address the research questions, Lewis and Ritchie (2003) listed some sources of secondary data; articles in journals, magazine, newspaper books, reports, conference papers, located on internet. The literature review is undertaken to address the main research questions that are required to identify the key drivers developing the proposed models and the framework, the main methods deeply covered in the literature review are quality management methods, tools and techniques, Six-Sigma, Lean manufacturing, TQM and the Integrated approach in quality management methods as well as the CSFs of the aforementioned methods.

3.3.1.2. Questionnaire survey

Meadows (2003) stated that the key role of the questionnaire survey is that the questions, methods and the data collected must be able to reflect the objectives of the investigation, the purpose of the questionnaire is to translate the research objectives into particular questions, the responses to these questions must provide data for answering some of the research questions. Based on this concept this study included three different questionnaires, each one designed, with some consideration, to cover all the issues that are required to attain the research investigations in order to achieve the research objectives, the questionnaires in this study have been sent through a Google survey to a host of management employees spread across different manufacturing organisations around the globe.

What makes the questionnaire efficient and reliable?

The good questionnaire design is critical to the success of a survey. Meadows (2003) stated that selecting the appropriate questions, design the questions in a coherent order, selecting the correct scales and using the right questionnaire format are all critical points to success the survey and obtaining reliable data. Thereby, Robson, et al. (2016) stated the key characteristic of questionnaire design are:

- Questions should be clear, specific, short and easy to fill in.
- Questions must be aimed, coherent and motivated to provide information.
- Questions should be free of ambiguity.
- The questionnaire must have good design and layout.
- The questionnaire should respect the privacy of the respondents.
- The questionnaire must use clear and reliable scales and instruments.

3.3.1.2.1. Questionnaire 1

This questionnaire is designed and sent to the participants to collect the data in order to verify, validate and develop the first Lean Six-Sigma integrated model proposed for manufacturing organisation, the aim of the questionnaire is to validate the proposed model, its suitability for manufacture within an organisation and identifying the CSFs and barriers to successful implementation of LSS in those organisations. The target population was selected, and the sample size was identified to conduct the survey.

3.3.1.2.2. Questionnaire 2

This questionnaire is designed to collect data in order to verify, validate and develop the proposed Six-Sigma TQM integrated model for manufacturing organisations, the aim is to investigate the suitability of the proposed integrated Six-Sigma TQM model for achieving business excellence within manufacturing organisations. This questionnaire was designed for a different purpose; to collect the required data from professionals and experienced employees in the available manufacturing organisations and from academics related to the topic. The sample size was identified, and the survey was conducted and sent to the respondents through electronic emails.

3.3.1.2.3. Questionnaire3

This questionnaire was designed to collect the primary data in order to verify, validate and develop the proposed framework, the aim is to investigate the suitability of the proposed integrated quality management framework to improve and modernise the quality system within manufacturing organisation, the questionnaire was designed in the form of Google survey and distributed through emails, the participants' selection and the target population was conducted in the same way of the previous models.

3.4. Samples selection

Sampling is a procedure or process of selecting units (managers, academics, employees and larger organisations) from a population of interest, a sample size essentially should be large enough to provide an appropriate number of participants from the population in order to positively affect the results (Patton, 2005). Saunders et al., (2012) clarified that there are two types of sampling techniques which is; probability sampling and non-probability sampling. In general, the probability sampling is required to include a random selection, for example, elements in the population. Non-probability does not; however, non-probability does select the participants and their characteristics are based on the purpose of the research, furthermore, it does not require a statistical estimate.

The characteristics of the population selected are based on the concept above, the sampling selection of this research is non-probability sampling and purposive sampling; therefore, the target population that has been chosen for all questionnaires are quality professionals, practitioners, experts, and academics from various manufacturing organisations and academic education. The numbers of participants involved in this study were fair-enough to provide adequate feedback to develop and validate the proposed models and the framework, where the percentage of the participants in each questionnaire was relatively high and acceptable (Saunders et al., 2009). See the research methodology for each model and the framework.

3.5. Data collection and analysis

The data collected from each questionnaire were conducted at a different period of time; however, the data collected in each questionnaire was reviewed for completeness and accuracy and underwent several pre-analyses checks on the quality of data through visual checks and data screening, see data collection and analysis in each model and the framework, subsequently, the data was coded and entered into SPSS for producing descriptive and inferential analysis. Therefore, in order to provide a robust and structured analysis, the collected data in each questionnaire was organised into three steps summarised in Table 3.2 below.

Table 3. 2. The main steps of data analysis

Steps no	Type of analysis	Analysis description
1	Integrity data analysis	Measures the collected data in terms of reliability, validity and validating the proposed model
2	Descriptive analysis	Measures the tendency of the collected data based on Likert scales: frequency tables, figures and charts
3	Evaluating the CSFs	Measures the construct validity of the CSFs and identify the underline factors using factor analysis

3.5.1. Integrity data analysis

Integrity data analysis concerns the most important procedures for any research to ensure that the data used is reliable and valid (Flick, 2009). Integrity analysis measures the collected data in terms of reliability, validity and validating the contents of the proposed model. Reliability is to evaluate the accuracy of the results in terms of consistency, stability and how easily the study can be duplicated by another individual (Field, 2009). Validity, on the other hand, is concerned with the truthfulness or correctness of the research findings (Afifi et al., 2014).

3.5.2. Descriptive analysis

Descriptive statistics are used to make the data collected easier and more readily comprehensible, tables, charts, graphs and a calculation of various descriptive measures such as the measures of central tendency (mean, mode, median), and measures of variability (variance, standard deviation) are provided (Field, 2009). In this study mean, percentage and the standard deviation were used to analyse the results on the date it was collected as shown in the following sub-sections.

3.6. Analytical procedures and validity of the research

This research, as mentioned above, is designed for being conducted through three stages, the first stage is to develop and validate the first proposed model, the LSS integrated model; the second stage is to develop and validate the SS-TQM integrated model. The final stage includes two sub-stages; one applying Multi-Criteria decision making (AHP) to prioritise and evaluate the main components of the framework, the second sub-stage is to develop and validate the proposed framework which is based on the integration of both models.

Therefore, the two data analysis techniques used as analytical procedures for analysing the primary data in this study are; SPSS software and AHP technique using Expert Choice software version 11. These techniques are, generally, considered to be efficient and suitable techniques for interpreting and analysing the quantitative data in the research (Saunders et al., 2012) and (Saaty,1980). The techniques are:

3.6.1. Statistical Packages for Social science (SPSS)

SPSS is analytical and predictive software package used to analyse the quantitative data, SPSS is one of the most utilised software for the analysis of quantitative data, it provides various types of statistical analysis and how to interpret data, Field (2013) stated that SPSS is a technique designed to assess and analyse numerical data which is mostly collected through a series of questions in form of questionnaire. Therefore, this software is selected as a reliable and an effective technique for analysing the quantitative data from this research collected in questionnaire1, questionnaire2 and questionnaire3.

3.6.2. Analytical Hierarchy Process (AHP)

AHP is selected as an analytical procedure to evaluate and prioritise the components of the proposed framework. The Analytical hierarchy process is a multiple-criteria decision-making technique used for organising and analysing complex decision-making (Vaidya and Kumar 2006). AHP is based on mathematics and psychological procedures which enables the users to categorise the priorities and make the best decision by minimising the complex decisions, the technique relies on computing a series of pair-wise comparisons and then analysing the results. In order to apply AHP, the questionnaire survey is designed for the purpose of AHP to collect the required data form professionals and academics related to the topic, the aim is to evaluate and decide upon the strategic quality management elements that should form the integrated quality management performance.

3.7. Pilot study

According to Collis et al. (2013) pilot studies are a crucial means to pre-test and evaluate the questionnaire survey or the interview in terms of the contents, clarity and the design of the questions. The aim of the pilot study is to provide feedback to the researcher which enable detection of any ambiguity and provide the opportunity to refine the survey, assisting in establishing the content validity (Sauders et al., 2009), the main purpose of the pilot test is to:

- Identify whether the questionnaire is easily understood.
- Ensure that all the questions are completely clear and understandable.

- Ensure that the rating scales are understandable.
- Determine how long it would take to complete the survey.
- Make an initial reliability and validity assessment regarding the measurement scales.

Therefore, a pilot study had been done for each questionnaire before distribution to ensure that the questions are free from the ambiguity and raise the validity of the questionnaires. Three procedures have been completed to successfully conduct the pilot study in this research; the questioners were discussed with number of PhD students related to the topic in terms of the clarity of questions, question contents, questionnaire layout and design, some modifications have been made including corrections to some questions, a shortening of the survey and a refinement to the questionnaires layout. Second, the questionnaires were sent to some PhD and MSc students related to the topic to assess the reaction of the participants and to estimate the time required to complete the survey. Finally, the questionnaires were discussed and reviewed by the director of the study in the aforementioned aspects; the feedback received from the supervision meant the questionnaires were further redesigned and modified.

3.8. Research validation

In order to validate and verify the framework and the findings of the research study, a number of steps and procedures have been conducted to obtain reliable and valid information and the knowledge to confirm the validity of the research. According to AERA, APA, and NCME, (1999) validation refers to the process of systematically collecting evidence to provide justification for the set of inferences that are intended to be drawn from scores yielded by an instrument. Thereby, the most common measures that can provide evidence for validating any research study are reliability and validity analysis (Flick, 2009), Reliability is used to evaluate the accuracy of the results in the categories of consistency, stability and how easily the study they can be duplicated by another individual, whereas validity is concerned with the truthfulness or correctness of the research findings (Feld and William, 2002; Afifi et al., 2014;)

3.8.1. Reliability analysis

The reliability test of an instrument is to examine its ability to obtain consistent measurements; the internal consistencies for a set of measurements indicates the extent to which the items are identical Field (2009). Therefore, the most common measure of reliability for quantitative data is the Cronbach alpha index; the test used to find the internal consistency among the instruments used in the research, ideally Cronbach alpha should be greater than 0.7 to consider the items being measured are consistent and reliable (Field, 2013). Therefore, this test is used to measure whether the items and scales are free of measurement errors Field (2009). The mathematical formula for calculating Cronbach alpha is:

$$\alpha = \frac{K.\bar{c}}{\bar{v}+(K-1).\bar{c}} \qquad (3.1)$$

Where;

K= Number of items

$\bar{c}$ = The average of all covariance between the items and

$\bar{v}$ = The average variance of each item

Cronbach alpha test is undertaken to check the reliability of the measures used to the evaluate LSS integrated model, SS-TQM integrated model and the framework.

3.8.2. Validity analysis

The validity test is basically used to evaluate two main issues: to what extent the instruments used are accurate and the extent to which they are measuring what is supposed to measure (Flick, 2009), In general, validity testing comprises of content, construct and criterion validity (related validity). Content validity is not numerically evaluated but based on judgments and normally established in the literature review; criterion validity refers to the degree a measure is related to the outcome and construct validity refers to whether the instruments measure what supposed be measured. (Thompson and Daniel, 1996; Yusof and Aspinwall, 2000). The most important type of validity in such research is construct validity, where the CSF's for each model and the framework are evaluated based on measuring the construct validity for each factor as illustrated in the next section.

3.8.2.1. Construct validity

Thompson and Daniel (1996) stated that construct validity is a measurement approach to test whether the instrument's scales act like the attributes being measured. Therefore, in order to assess whether the instrument scales measures what they are supposed to and to identify the construct validity, the CSFs for each model and the framework must be analysed by factor analysis. This test is the most common test used to measure the construct validity and to determine the appropriateness of instruments (Pallant, 2010). Moreover, Thompson and Daniel (1996) stated that factor analysis and construct validity are associated with each other and in published literature considered to be "factorial validity".

To facilitate the thesis for the reader and to avoid repetition, the statistical measures used to examine the validity of the research instruments and the results would be covered in this chapter.

3.8.2.2. Selection the measures of validity analysis

Two types of statistical analysis are employed in this research to evaluate the instruments of the questionnaires and validating the finding of the research. Chi-square Goodness of fit is employed to examine the instruments used for evaluating the models and the framework and, hence, confirm the validation. Factor analysis is undertaken to measure the instruments used to evaluate the CSFs of each model and the framework. The reasons why these tools are selected to confirm the validity of the research are discussed in the following sections.

3.8.2.2.1. Chi-Square Goodness-of-Fit

According to Pallant (2010), the Chi-Square Goodness of fit is a non-parametric test used to measure the validity of the statistical assessment, one common application of this tool is to find out how the observed data of the given phenomenon is significantly different from the expected data. Chi-Square Goodness of fit is one of the best statistical tools used to answer the question of how well do experimental or survey data fit expectations (Field, 2002). Additionally, (Field, 2002) stated that Chi-square goodness of fit is used to measure the extent to which the observed values are, statistically, significantly different from the expected values. Chi-Square Goodness of fit with corresponding P value is considered to be significant if the P value ≤ 0.05

(Bryman and Cramer, 2005), which in turn indicates that the probability that happened by chance should be equal or less than 0.05 in order to confirm the validity of the proposition items; this also can be an indication of the possibility of publishing the results and generalising from the current research sample to the entire publication (Balck, 2011). The mathematical formula for calculating Chi-square goodness of fit is:

$$X^2 = \sum \frac{(obs - \exp)^2}{exp} \quad (3.2)$$

Where X^2 = Chi square goodness of fit,

obs. = Observed data

exp. = Expected data.

3.8.2.2.2. Factor analysis

Factor analysis is a powerful and crucial tool to determine the construct validity, Field (2013) *stated that one of the main usages of factor analysis is to measure and understand the structure of the latent variables* (factors). Additionally, Williams et al. (2012) stated that factor analysis is a statistical method which describes the variability among observed correlated variables to explore and verify a set of correlation coefficient in three steps; namely, reducing large number of variables into small number of factors, establishing underlying dimensions between the measured variables and latent construct and, hence, providing construct validity evidence for self-reporting scales. In this study, Exploratory Factor Analysis (EFA) was used to validate the CSFs in which EFA is the suitable procedure to calculate the latent variables and explore the construct validity (Williams et al,. 2012).

Based on the concept presented above, the purpose of this test is to measure the validity of the instruments and to understand the structure of the latent variables (factors). Furthermore, the author would go beyond that and intended to interpret the relationship between the latent variables and the contents of models in each data analysis.

Exploratory factor analysis (EFA)

The exploratory factor analysis was carried out using SPSS 23 through the data-reduction factor analysis method, to check the construct validity of each critical factor. In this analysis, the raised variation is explained by the factors resulting from factor analysis, the more powerful the instrument's measure of what supposed to be measured (Mallak et al.,1997). Furthermore, Principle Component Analysis (PCA) technique with direct Oblimin rotation method is used for extracting the factors. (Williams et al., 2012) stated that principal component analysis is one of the most commonly-used extraction method used in the literature in order to produce a scale unidimensionally or unifactorial and direct Oblimin is an appropriate rotation procedure to produce factors that are more correlated and easy to interpret.

The criteria for assessing factor extraction

The purpose of extraction is to reduce a large number of items into factors (Williams et al., 2012). In order to obtain scale dimensionality and simplify the factor solution, typically multi-criteria should be used to analyse factor analysis (Thompson and Danial, 1996). In this respect, the most common criteria used by the researchers to produce unidimensionality are;

- *Factorability test:* To check the suitability of data for obtaining factor analysis, the Kaiser-Meyer-Olkin test (KMO) is used to assess the appropriateness of data set for factor analysis, this test is basically calculated based on the correlation matrix, where the higher correlation among the variable the more suitable of data for conducting factor analysis test (Field, 2009), KMO can be calculated mathematically using the following formula (Kaiser, 1981):

$$KMO = \frac{\sum_j \sum_{j\neq i} r_{ij}^2}{\sum_j \sum_{j\neq i} r_{ij}^2 + \sum_j \sum_{j\neq i} a_{ij}^2} \tag{3.3}$$

Where: *r* =Correlation matrix.

a =Partial matrix.

i and j= are the elements of the matrix.

Also, Barlett's test of sphericity; is used to check if the data presents equal variation among the variables to ensure if there is a redundancy between the observed variables, it can be determined by testing if the correlation matrix (R) diverges significantly from the identity matrix. This can be calculated by employing the determinate of the correlation matrix$|R|$, where the variables are highly correlated if $|R| = 1$, therefore Barlett's test of sphericity indicates the extent to which there is deviation from$|R| = 1$. This basically calculated by the following formula quoted from Field (2013):

$$X^2 = \left[1 + \frac{(2p+5)}{6} - N\right] ln(1 - |R|) \tag{3.4}$$

Where.

N = number of observations.

P = number of variables.

X^2 = Chi-square.

Therefore, KMO with a value greater than 0.6 is adequate for factor analysis, whereas the Barlett's test of sphericity should be significant and P value ≤ 0.05 (Williams et al., 2012).

- *Factor extraction*: The principle component analysis (PCA) method with Eigen value technique is the most common way to identify the retained factors; the mathematical formula for calculating factors from covariance matrix is taken from Anton and Rorres (2011).

$$Ax = \lambda x \quad (3.5)$$

Where; λ = Eigen value.

A = the covariance matrix.

Any Eigenvalue with value greater than (1.00) is considered to be acceptable and can be returned (Williams et al., 2012).

- *Factor rotation:* Oblimin technique is the most prevelant technique for producing more correlated factors; the test provides patterns of loading in a manner that is easier to interpret (Williams et al., 2012). In this respect, Hair et al. (2006) stated that factor loading ≥ 0.3 is considered to be minimal level, ≥0.4 moderate and ≥ 0.5 highly significant level, in this study, the author decided to eliminate any item less than 0.5 which is highly significant when avoiding any bi-dimensionality (Habibah et al., 2014). Figure 3.3 below shows the main steps explained above and provide a clear flow chart for conducting the exploratory factor analysis in this study.

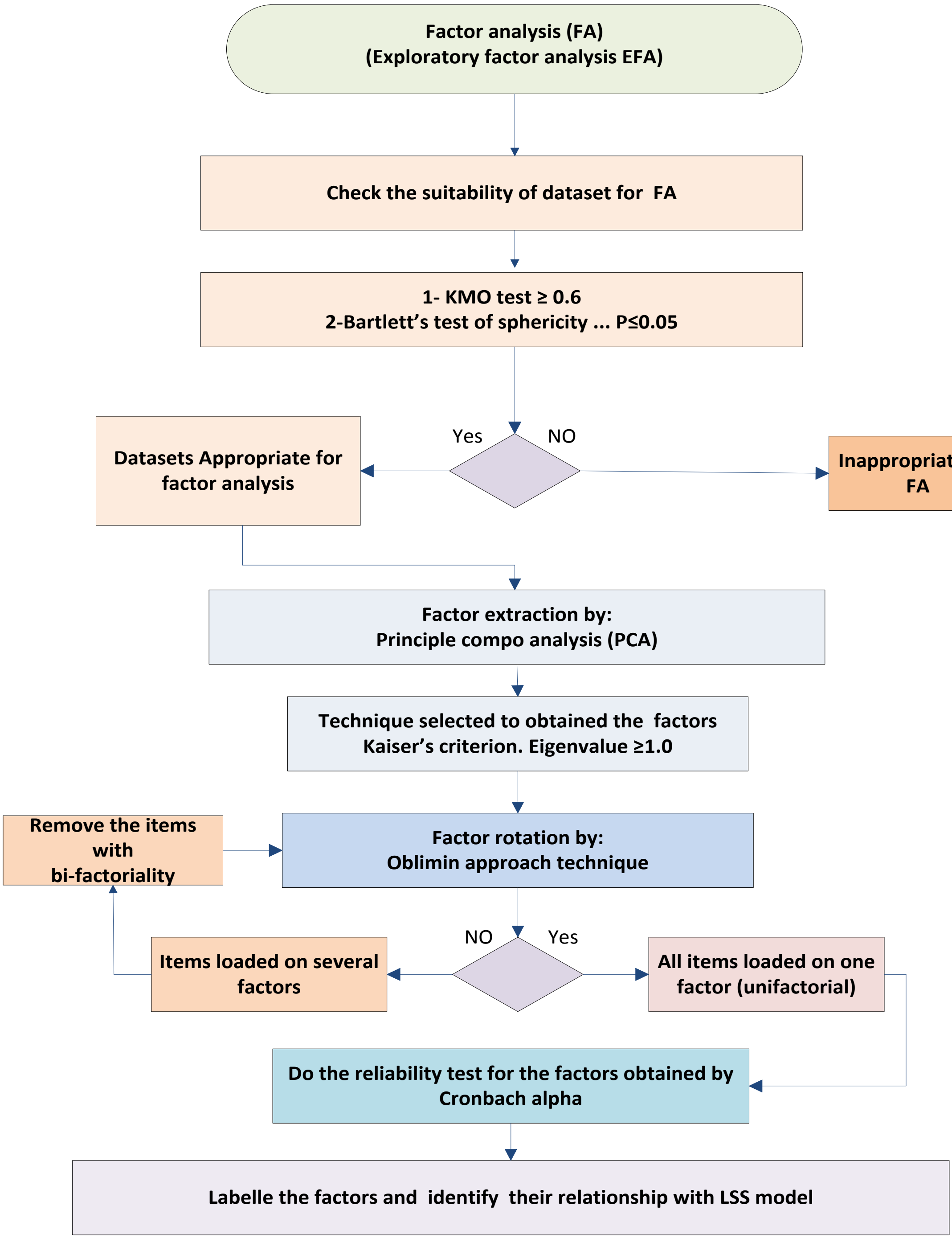


Figure 3. 3. The main steps for calculating factor analysis in this study

3.9. Summary of the research methodology

This part of the research has outlined the main role of the research methodology and how the research methodology can employ certain tools and techniques to achieve the research aims and objectives, the author in this section focused on the main methodology that can be used in quality management research. The main aspects of research methodology that were discussed are research philosophy, research approach and research techniques; known in research method as Methodological choice (Saunders et al., 2013).

Accordingly, the research design and strategy section provided the research methodology selected for conducting the research and achieving the research objectives. The selection of the research methodology adopted provided through the three sections of this chapter: 1) The literature review for collecting the secondary data and developing the proposed models and the framework. 2) the main investigations, the two different questionnaires used to collect the primary data for validating the proposed models and a multicriteria decision making applied to evaluating and prioritising the components of the framework. In addition, another questionnaire was conducted to collect data for validating and verifying the framework and its implementation procedures. 3) Analytical procedures were undertaken to verify and validating the results of the data collected for the models and the framework and, hence, confirming the validity of the research. The chapter also highlighted the sample selection and demonstrated the pilot study that was conducted in the research. The next chapter focuses on the development and validation of LSS integrated model, it discusses how the proposed model developed and outlined the main steps and procedures used for validating the mode.

Chapter Four:

Development and validation of Lean Six-Sigma integrated model

4.1. Introduction

Contemporary manufacturing organisations are facing a relatively dramatic change in the external environment driven by superfast competition, increasing demand from the consumers and the non-stable economic climate in many countries has forced manufacturing managers to expand their strategic thinking to the long-term in order to attain a competitive advantage. Thus, operation management models such as Lean, Six-Sigma and TQM have been implemented to simplify the production lines and to improve the quality performance. However, none of these approaches is able to deal with the manufacturing problems when implemented alone, therefore, there is the need for integrated models like Lean Six-Sigma (Bhuiyan and Baghel, 2005).

This chapter presents the development and validation of Lean Six-Sigma integrated model for manufacturing organisations to help them to embed the strategic thinking into long-term planning and achieve a high quality result. The chapter starts by discussing how LSS is different than the other strategic approaches and then presents the main requirements for integrating this model and the main drivers that lead to success when integrating these methods. The review of the literature pertinent to the topic enables the study to identify the main components and the strategy of the model, subsequently, the questionnaires and methodological tools were applied to verify and validate the model; therefore, the validation steps were carried out and led to the desired result, which is that the LSS integrated model is workable and can help manufacturing organisation to achieve competitive advantage.

4.2. What makes Lean Six-Sigma different?

Lean Six-Sigma is a successful approach due to the inclusion of a disciplined and DMAIC methodology which is a systematic strategy for improvement which leads to rapid project completion within reasonable time periods. Juran et al., (1999) stated that in order to create a tangible improvement methodology the best way is to create an integrated system for managing projects rather than separate system for Lean or Six-Sigma projects. Therefore, Lean and Six-Sigma are both formulated into one system including a business strategy and methodology that increase the process performance and, hence, enhance customer satisfaction and the bottom line results in terms of cost saving, improving the organisation's profitability, cycle time reduction, improving yield rate, elimination of rework and reduction of the variation (Harry, 1998 and Snee 2010). Also, LSS provides the concepts, strategy and tools that enable the organisation to change from one way of working to a better way.

This integration between Lean and Six-Sigma can lead to the elimination of all types of waste in operation process, reducing process variability and defects which results in business process improvements (Bendell, 2006). In addition, (Chen Li and Shady, 2010) add that Lean Six-Sigma in its capacity as a hybrid model leads to a smoothing in the production flow by reducing the inventory level between work stations, making the operation more flexible by applying Lean tools and the Six-Sigma improvement strategy. Moreover, Brett and Queen (2005) clarified that the LSS application, for instance, can enhance the management of information by improving on the shortcomings of one with the other. Consequently, it can be argued that Lean Six-Sigma is different to the other approaches due to the key factor of the critical success factors generated by the disciplined system.

4.3. The requirements for Lean Six-Sigma implementation

Basically, business organisations are always looking for ways to improve their bottom line; this, generally, can be realised only by obtaining the high-quality output of product or services necessary to attain competitive advantages. Therefore, the strategic programs and management methods have been significantly developed over the last three decades, for instance, Six-Sigma, TQM, Lean management. This variety of methods frequently puts strained the organisation's managers in selecting the proper method for dealing with certain problems (Johannes, 2013). Organisations are now required to operate at the lowest cost, with greater speed and reliability, develop a superior ability to change and continuously improve in order to gain competitive advantage (Datta and Roy, 2011). Repetitive.

The general requirements of the integration approach have been much studied, for instance, Brinkkemper (1996) stated that the main requirements of the integration approach are; completeness, consistency and intended purpose. Johannes (2011) studied these requirements and linked them to the integrated method in quality management, Johannes (ibid) concluded these requirements are considered the key factors that are required to obtain the synergies between methods and hence success in the integration approach. Based on this context (Salah et al., 2010) stated that Six-Sigma and Lean mutually reinforce and enhance each other, where DMAIC strategy can be worked as a strategic driver for process improvement and value stream mapping (VSM) might be used as platform for Lean and Six-Sigma tools. Moreover, Salah (ibid) advised that combining Lean techniques into DMAIC and the future state of VSM is a right way to change the structure of the process.

4.4. Critical Success Factors of Lean Six-Sigma

According to (Johnson and Scholes, 2002; Schon, 2006; Youssef, 2006) the CSFs are important to success any business and considerable attention should be paid to them and used as a means of benchmarking. The use of CSFs for the successful implementation of LSS is identified in chapter 2 section (2.6.2) and based on (Anthony et al., 2002; Hendorson and Evan, 2000; Manville et al., 2012; Sandholm and Sörqvist, 2002; Goldstein, 2001; Timanset al., 2012). These CSFs (listed below) are selected for the successful implementation of the proposed LSS model:

1. Organisational structure;
2. Business plan and Vision;
3. Linking LSS to the customer;
4. Changes in management and organisation culture;
5. Education and training;
6. Top management involvement and participation;
7. Effective communication;
8. Linking LSS to organisation's business strategy;
9. Project selection, prioritisation, reviews and tracking;
10. Linking to Suppliers;
11. Project management and
12. The monitoring and evaluation of performance.

4.5. The proposed LSS integrated model

The aim of the proposed model is to simplify LSS implementation to enable manufacturing organisations to overcome the fear of high cost and the complexity associated with LSS implementation. The model seeks to utilise the knowledge within the organisation and breaks down the barriers hindering individuals from using statistical problem-solving methods by following a step-by-step guide. The proposed model is based on DMAIC approach which, as the main strategy, enables the implementation processes to identify opportunities for quality improvement, increases process performance and reduces variability and waste in a product or process using statistical tools. However, DMAIC phases in this model are integrated with each other to draw the implementation processes and streamline the operating system.

Therefore, the proposed model in figure 4.1 consists of two main components: *Strategic elements,* that comprise the key drivers required for successful implementation of business process. *Operation elements,* including the key factors for the successful implementation of the operation system and obtaining high quality performance, the implementation process of the model is summarised into four sub processes as follows:

i. Planning and Organisation stage. In this process, the model employs the strategic tools for organising and planning the implementation process, which includes four steps: (1) Analyse the market to capture the Voice of Customer (VOC), evaluate the business process to identify Voice of Business (VOB), and translate VOC and VOB to Critical to Quality (CTQ) in order to improve the quality of products: (2) formulate a high-level functional team and identify the final vision; (3) Establish the overall improvements including process improvement using Supplier Input Process Output Customer (SIPOC); (4) Create the baseline of LSS metrics and analyse the cost benefits associated with the strategic planning using CTQ, CTC and CTS.

ii. Enhancement and Stimulation stage. This stage aims to enhance the process and prepare the work environment for improvement. This can be conducted through collecting the required data to identify the process behaviour, determination of the bottle neck and identifying area of waste via VSM, Identifying the current performance using process capability metric and Sigma measures, in the end of this stage evaluate the measurement system by applying the Six-Sigma Gauge RR technique (Repeatability and Reproducibility) which is a statistical tool that measures the amount of variation in the measurement system.

iii. Evaluation and Activation stage. The purpose of this step is to apply the proper statistical tools to eliminate the quality problems, identify the gap between the current and desired performance and analyse the root causes to identify the potential improvements by conducting Design of Experiment (DOE).

iv. Improvement and Verification stage. Once the results of DOE are confirmed, then, the whole operation process is monitored through a controlled plan using the appropriate LSS tools to attain sustainable improvement for the operating practice. Finally, the whole process performance is verified via a balanced scorecard and KPI to assure whether the organisation meets the business objectives.

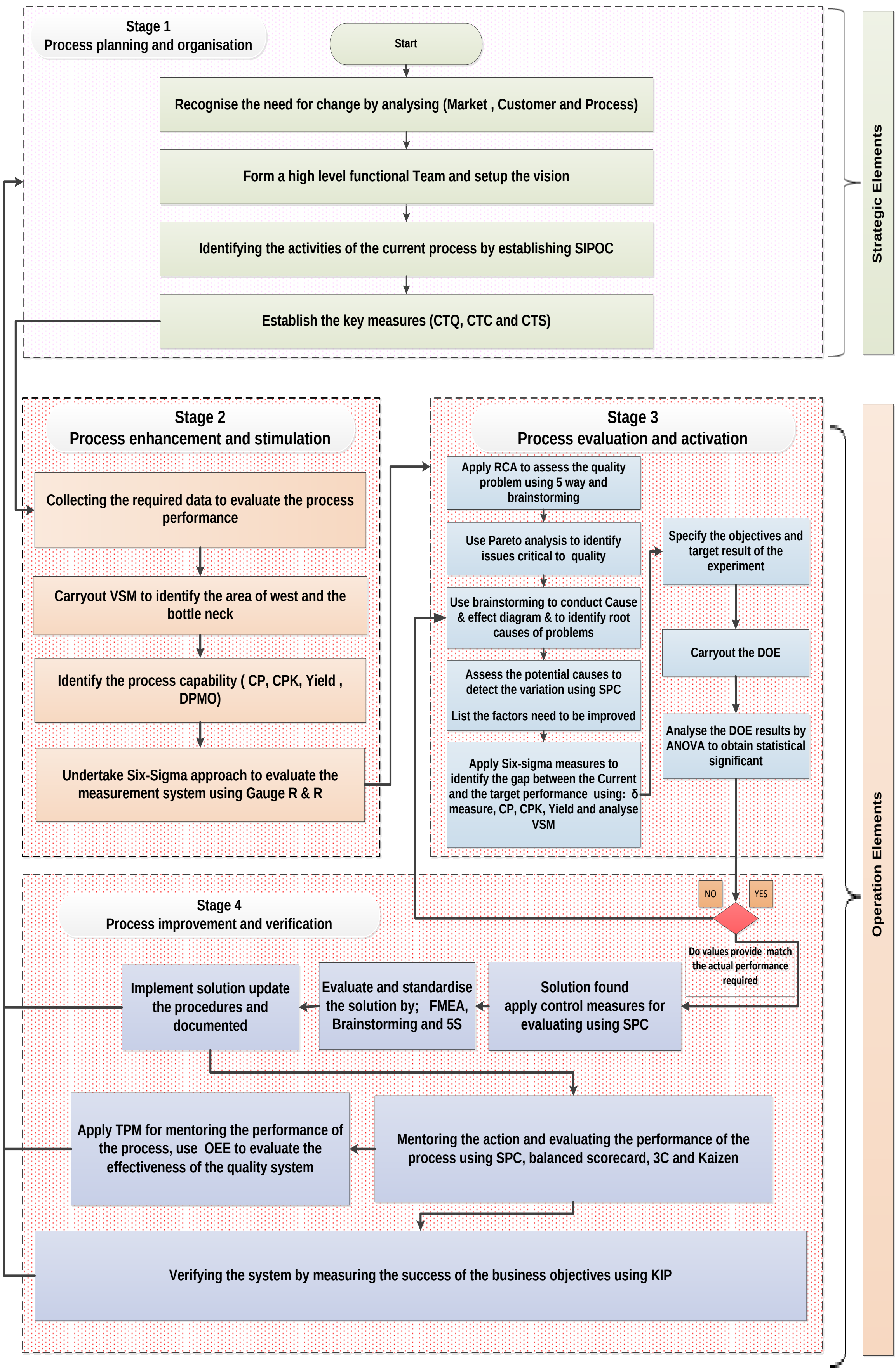


Figure 4. 1. LSS conceptual model for manufacturing organisations

4.6. Validation of the LSS integrated Model

4.6.1 Research methodology

A questionnaire survey was developed for this study based on the findings obtained from the existing literature, a copy of the questionnaire is attached in appendix (A-1); the questionnaire was divided into five main sections with 22 main questions. The main aim was to investigate the suitability of the proposed model for manufacturing organisations. The key point of the survey is to analyse the current trend in LSS implementation in manufacturing organisation, its methodologies, perceived benefits, critical success factors and the barriers to successful implementation.

The first section of the questionnaire was about the background information to gather a clear picture about the respondent's background and to understand their awareness of the LSS approach. The second section examined the suitability of LSS for manufacturing organisations and determined the potential benefits that might be achieved through its implementation, this part attempted to investigate the extent to which Lean-Six Sigma would be appropriate to the respondent's organisation in terms of long term strategic thinking. It will also give an indication of the top management and other employees perception about the LSS approach. The third section investigated the awareness and usefulness of the LSS tools and techniques to Manufacturing organisations. The fourth section focused on the evaluation of the proposed model, it was intended to assess the proposed model based on Six criteria: model contents, Suitability and capability for manufacturing organisations, the ability of the model to improve competitiveness, overcome natural LSS implementation difficulties, foresee any difficulty in implementing the proposed model and evaluate the completeness of the model.

Finally, section five, is the major part of the questionnaire aimed at evaluating the importance of the CSFs for the successful implementation of the LSS model and the potential barriers that can impede the implementation process. The CSFs were identified from the existing literature related to the Lean and Six-Sigma approach as stated earlier in this study; basically, the CSFs gathered comprise 12 major factors believed to be crucial for LSS implementation. the impeding factors including the common causes that hindering the effective implementation of the LSS approach which comprises 11 factors drawn from the existing literature (Johannes, 2013; Antony, 2009).

4.6.2. Data collection and analysis

A total of 70 research surveys were sent out to a host of management employees spread across different manufacturing organisations around the global, 56 questionnaires were completed and returned within a given time frame, a percentage considered to be relatively high and acceptable (Saunders et al., 2009). Statistical software package employed to analyse the data was collected which is an appropriate method to provide robust and structured analysis. Bryman (2005) stated that the Statistical Package for Social Science is the most appropriate statistical software used for social science and engineering research (see chapter 3 section (3.4.1)). Therefore, SPSS 23 was used to analyse the data collected in this study, 56 useable questionnaires were coded and entered into the (SPSS 23) software program, basic statistical analysis was carried out for the observation of frequencies, percentage, mean and standard deviation to assess the data.

4.6.2.1. Integrity data analysis

4.6.2.1.1. Reliability test

As discussed in chapter 3 the procedure used to ensure the reliability of the data used for validating LSS model is Cronbach alpha (α) see section (3.6.1). However, the Cronbach alpha result must be greater than 0.7 to consider the items being measured are reliable (Field, 2013). As such, a Cronbach alpha test was undertaken to check the reliability of the measures used to evaluate the LSS conceptual model, the results in table (4.1) shows that coefficient alpha is 0.804 and the standardized item alpha is 0.720, this slight variation among the alpha values refers to the variation between the scores of participants and the overall scores of the questionnaire, however, both are higher than 0.7.

Table4. 1. Reliability statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.804	.720	6

Table (4.2) showed the internal correlation of the item measures, it can be seen that there are a positive correlation between most of the items except for item five (*Is any difficulty foreseen in Implementing the LSS-Model?*) which has negative correlation with the all the items, also item six (*Is any content missing from the LSS-Model?*) has low correlation with all the items.

Table4. 2. The internal correlation of the items measured

	LSS-M Contents rating	Suitability /capability of LSS-M	Ability of LSS-M Boost Competitiveness	Overcome Nature LSS Implementation Difficulty	Foresee any difficulty in Implementing LSS-M	Any content missing in LSS-M
LSS-M Contents rating	1.000	.745	.680	.741	-.056	.179
Suitability /capability of LSS-M	.745	1.000	.738	.814	-.143	.068
Ability of LSS-M to Boost Competitiveness.	.680	.738	1.000	.735	-.180	.017
Overcome Natural Difficulties implementing LSS.	.741	.814	.735	1.000	-.058	.282
Any difficulty foreseen in Implementing LSS-M.	-.056	-.143	-.180	-.058	1.000	-.062
Any content missing from LSS-M	.179	.068	.017	.282	-.062	1.000

The effect can be seen in table (4.3) *Item-total statistics.* According to Field, (2009) and Pallant, (2010), the values in the column labelled 'Corrected Item-Total Correlation', covers the correlation between the item and the total score of the questionnaire, in reliable cases, all the items should be correlated with the total scores and all the values must be above 0.3. The column labelled 'Cronbach's Alpha if Item Deleted' represents the values of overall alpha if the item is deleted in the calculation, all items in that column should be roughly around the same value, in other words, alpha can be improved on by deleting any item that does not match the other values in the column (Pallant, 2010). Based on the above propositions, the results were shown in table (4.3), column three *'Corrected Item-Total Correlation'*, item five on the left-hand side of the table (*Is any difficulty foreseen in Implementing the LSS-Model?*) has a negative correlation with overall score -0.128. Also, item six (*Is any content missing from the LSS-Model?*), in the same column, has low correlation score with value 0.141.

In addition, in column five "Cronbach's Alpha if the Item were Deleted", the mentioned items have the highest alpha values, 0.863 and 0.835, which do not match the other values within the column. Therefore, if those items, number Five and Six, were deleted from the calculation, then the Cronbach alpha would be improved.

Table4. 3 Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
LSS-M Contents rating	15.45	6.711	.788	.631	.713
Suitability /capability of LSS-M	15.69	6.759	.813	.749	.707
Ability of LSS-M to Boost Competitiveness.	15.51	6.380	.728	.648	.732
Overcome Nature LSS Implementation Difficulty.	15.65	6.440	.864	.775	.690
Any difficulty foreseen in Implementing LSS-M.	17.76	11.355	-.128	.081	.863
Any content missing in LSS-M	17.69	10.717	.141	.222	.835

As a result, table (4.4) shows the statistics that Cronbach alpha indicated as reliable, 0.911, and the standardized item 'alpha' is 0.913, also in table (4.5) Item-Total Statistic. In Column three, 'Corrected Item-Total Correlation' reveals that all the items are correlated with a value above 0.3 and, in column five, the values of the Cronbach alpha, if the items deleted ranged between 0.89 to 0.87, is greater than 0.7. Consequently, it can be concluded that these instruments have a high level of internal consistency and increased the authors' confidence in the reliability of the obtained results.

Table4. 4. Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.911	.913	4

Table4. 5. Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
LSS-M Contents rating	11.87	6.002	.758	.581	.898
Suitability /capability of LSS-M	12.09	5.899	.848	.733	.868
Ability of LSS-M to boost Competitiveness.	11.95	5.497	.774	.602	.896
Capability to overcome atural LSS Implementation Difficulty.	12.04	5.813	.822	.701	.876

4.6.2.1.2. Validity test and validation of the proposed LSS conceptual model

The main aim of the validity test is to examine the extent to which the instruments used to evaluate the proposed model measured what they are intended to; therefore, the Chi-Square Goodness of fit (X^2) (see chapter 3 section (3.6.2.2.1)) was undertaken to check the instruments used in order to evaluate the proposed model. However, the Chi-Square Goodness of fit with corresponding P value should be ≤ 0.05 to consider the results are statistically significant and the instruments used are valid (Bryman and Cramer, 2005), which means that the probability, which happened by chance, should be equal to or less than 0.05 in order to confirm the validity of the proposition items; this also can be an indication of the possibility of publishing the results and the abaility to generalise from the current research sample across the entire publication (Black, 2011: Zuabi, 2015).

The results of Chi-Square Goodness of fit in table (4.6) demonstrated that the P values for all measures are less than 0.05, which means that the results are significantly different from the actual observed values and, taking into consideration the expected values of all the statements used to evaluate the proposed model, this confirms that all of the proposition measures considered in the proposed model are valid. Consequently, in summary, the outcomes from the reliability and validity analysis confirm that all the proposed model contents are reliable and valid.

Table4. 6. Test Statistics

	Model Contents rating	Suitability /capability of the model	The Ability of LSS-M to boost competitiveness	Overcoming natural difficulties implementing LSS.	Foresee any difficulty in Implementing the model	Any missing content in the LSS-Model
Chi-Square	42.929[a]	44.909[b]	30.964[a]	42.750[a]	15.680[c]	31.500[d]
df	4	4	4	4	1	1
Asymp. Sig. (P)	.000	.000	.000	.000	.000	.000

4.6.2.2. Descriptive analysis

This part of the study outlines the descriptive analysis of the data collected using SPSS 23, statistical analysis applied to the output of the data collected by measures of the central tendency including; mean, percentage and standard deviation; thereby, the results of the data were collected and presented in the following sections in forms of tables, charts and different statistic figures.

4.6.2.2.1. Section A: background information

This section outlines the results of the questionnaires received from the respondents. The authors believe that the management employees involved in the survey belong to a trustable target population that can provide reliable responses to the survey questionnaire. The respondents comprised of mostly operational managers and quality managers from selected manufacturing organisations around the world.

1*. Respondent's position*

The respondents were asked to state their position within their organisation. The results in the table (4.7) demonstrated that 25% of the respondents are quality managers, 17.9% are operational managers, also 17.9% are academics, including quality professionals, who work in the higher education and research students who are related to industrial engineering. 12.5% directors, 8.9 % quality engineer, 7.1% belt functions, including; Master Black belt, Black belt, Green belt and Yellow belt. Working in the same capacity for an organisation, another 5.4% including project leaders and heads of department. Finally, 5.4% are coordinators.

Table4. 7. Respondent's positions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Director	7	12.5	12.5	12.5
	Quality Manager	14	25.0	25.0	37.5
	Operation manager	10	17.9	17.9	55.4
	Project leader or head department	3	5.4	5.4	60.7
	Belt function	4	7.1	7.1	67.9
	Coordinator	3	5.4	5.4	73.2
	Academics	10	17.9	17.9	91.1
	Quality engineer	5	8.9	8.9	100.0
	Total	56	100.0	100.0	

2. Area of industry

The respondents were asked to identify the industrial sector to which their organisations belong. The results are presented in a chart (4.2) below as follows. 64.2% of the respondents belong to the manufacturing sector, 14.3% are from the Oil and Gas sector, and 3.6% are from the automotive industry. The remaining 17.9% are academics including quality professionals and research students belonging to the higher education.

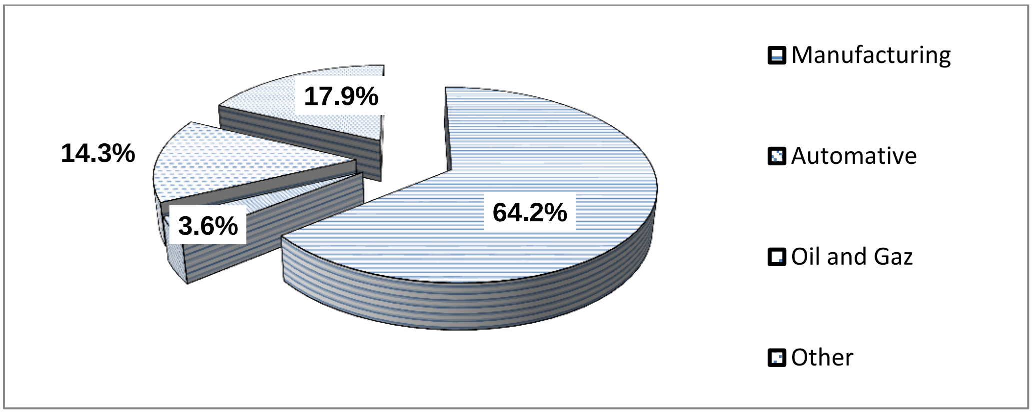


Figure 4. 2. Aria of industry of respondent's organisation

3. Country organisation location

The respondents were asked to state the location of their organisations, the chart (4.3) shows: 20% are from Nigeria, 12% from Libya, 8 % from India, 5% from UK and China, 2 from the UAE and the remaining locations comprise of Russia, Germany, Spain and Greece, Each of them 1%.

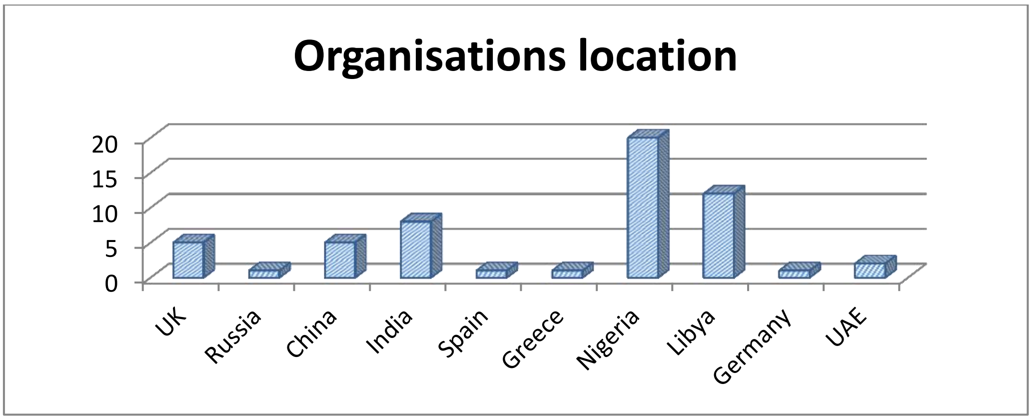


Figure 4. 3. Organisation's location

4. Type of quality management system of the respondent organisations.

The respondents were asked to identify the current quality system used in their organisation. Figure (C-1) in Appendix (C) demonstrated 39.3% of the respondents use the ISO series in their organisations, 33.9% using TQM, 5.4% employ Six-Sigma and the rest 21.4% failed to indicate the type of quality system in their organisation due to using hybrid quality management models which do not belong to any particular quality management initiative.

5. The level of the awareness with the LSS approach

The respondents were asked if they have ever heard or are aware of LSS. Figure (C-2) in Appendix (C) shows that 83.9% of the respondents' are aware of LSS while the remaining 16.1% are not aware or has ever heard of LSS before.

6. The level of awareness with LSS Tools and techniques

LSS tools and techniques were presented to the respondents and were asked to indicate if they were aware of any of the tools listed in the survey questions. The results presented in table (C-1) in the appendix (C) show that the majority of respondents seems to be familiar with most of the tools and indicated that their level of the awareness with these tools was above 50%, a threshold for awareness. However, tools such as; Kaizen events, ANOVA, SIPOC, Force Field Analysis, Poka-Yoke and Run Charts were ranked in the results below 50% by the respondents which means that they are not familiar with these tools in their organisations and their awareness level with those tools is slightly low

7. The major problems facing quality system of respondent's organisations

The respondents were asked to indicate if the quality system in their organisations was capable of dealing with a list of 11 essential factors considered the key problems leading to failure in any quality system; those elements were summarized from the literature (see Antony and Banuela (2008) and Andersson et al., (2006)). Table (C-2) in Appendix (C) demonstrated that the majority of the respondents indicated that their organisations are able to deal with most of the problems and the average of the results was above 50%. However, the results of concerning each element were as follows:

The lack of cost driven priorities: Capable with 51.8%

The failure to track which quality efforts work in a market place: Capable with 55.4%

Employee commitment: Capable with 53.6%

Defects: Capable with 53.6%

Decision-making: Capable with 51.8%

The organising of documentation and paperwork for registration; Capable with 53%

The utilisation of problem-solving techniques or validations of the robustness of the technical solutions - crucial to advance planning: Capable with 55.4%

Risk and uncertainty: Capable with 55.4%

Whereas, with the rest of factors, the organisations were indicated incapable of dealing with them and the average of resulted fell below 50%:

Investment in training: incapable with 41.1%

Certification by independent auditor: incapable with 48.2%

Inability to analyse how good the processes are: incapable with 42.9%

The respondents also were asked if there are other problems facing their quality system. The results showed that other problems related to demand management.

***4.6.2.2.2. Section** B:*

The suitability of LSS for manufacturing organisations and what the potential benefits that can be achieved through its implementation are:

This section of the questionnaire was designed to assess the manager's viewpoint on the suitability of LSS and its benefits to their organisations. This will give an insight into the potential offered by implementing the Lean Six-

Sigma approach by top management and quality professionals within manufacturing organisations.

1. Attendance of any formal training on Lean or Six-Sigma approaches.

The respondents were asked to state if they have received any formal training on Lean, Six-Sigma or both. The results in Chart (C-3) in the appendix (C) showed that 33.9% of the respondents had no formal training on Lean and/or Six-Sigma, 19.6% of them had formal training on Six-Sigma alone, 14.3% have formal training on Lean and 33.9% had formal training on both Lean and Six-Sigma.

2. The duration of using Lean or Six-Sigma approach.

The respondents were asked to state the duration that they have been involved in Lean and /or Six-Sigma training. Chart C-4 in appendix (C) demonstrated that; 46.4% of the respondents have never used Lean and/or Six-Sigma, 30.4% have used it for a period of 1- 2 years, 16.1% have used it for 3 - 5 years, and the remaining percentage, 3.6%, for 5-10 years with the remainder using it for more than 10 years.

3. The role of respondents within Lean or Six-Sigma organisation

The respondents were asked about their role within the Lean and or Six-Sigma organisation. The chart (C-5) in appendix (C) shows that; 41.1% of the respondents had no Lean Six-Sigma role, 19.6% were team members, 7.1% were Master Black Belts, yellow belt and practitioners, 5.4% are champions and trainers each, 3.6% are Black and Green Belt each.

4 The potential motivations with LSS approach

The essential elements of both approaches are listed as the key motivation for adopting the LSS approach, the respondents were asked to indicate the extent to which those motives will influence their decision in adopting the LSS. The Likert scale used is **1**–Strongly Disagree. 2– Disagree. 3– Moderate. 4– Agree. 5 –Strongly Agree

Table (C-3) in appendix (C) showed that the majority of respondents rated the highest percentages in favour of agree and strongly agree on Likert scale, which means that the majority of the respondents are aware that LSS is suitable for manufacturing organisations.

5. The potential benefits that could be gained by adopting the LSS approach

The quality objectives of both approaches are listed as the key benefits for adopting LSS approach. The Likert scale was represented as **1**–Strongly Disagree. 2– Disagree. 3– Moderate. 4– Agree. 5 –Strongly Agree

Table (C-4) in appendix (C) showed that the majority of respondents rated the highest percentage in favour of agree and strongly agree on the Likert scale; however, the respondents ranked the following elements as the most important benefits that can be gained:

Improved delivery;

Cultural benefits;

Improved customer satisfaction;

Reducing quality problems, defects and rework;

Higher awareness of quality among employees (quality commitment)

Improved productivity;

Enhancing the organisation's competitive position;

Improved sales;

Organised working environment;

Increased customer confidence and relations and

New business opportunities.

4.6.2.2.3. Section C:

Investigating the awareness and usefulness of LSS tools and techniques to Manufacturing Organisations.

This section of the questionnaire seeks to provide an understanding of the participant's involvement in those LSS tools and techniques that have been used in their organization or used by them, and how useful these tools are to businesses for manufacturing organization and its procedures for implementation. The aim is to provide an understanding, with the basic of LSS tools and implementation procedures, that are suitable for manufacturing organizations.

1. Utilisation of LSS tools and techniques

The respondents were asked to indicate whether they have ever used or have applied Lean Six-Sigma tools and techniques within their organisation, The Likert scale was used on a scale of 1-5, where; '1' indicates *'never been used'*, '2' indicates *'used only once'*, '3' indicates *'used rarely'*, '4' indicates *'used frequently'* and '5' indicates *'use*d continuously'.

Table (C-5) in appendix (C) shown that the level of familiarity with tools and techniques are diverse among the participants; however, some Lean tools and techniques like SMED, Poka-yoka and Kaizen events have been rated unfamiliar, also 5S, VSM, SMED and Kanban are also slightly unfamiliar to most of the respondents, whereas quality tools and techniques such as SPC, Process mapping, brainstorming and benchmarking are the most familiar among the LSS tools and techniques.

2. The usefulness of LSS tools and techniques to respondents' organisation

The participants were asked to indicate if they consider LSS tools and techniques useful to their organisation, the Likert scale used is; '1' indicates *'not useful'*, '2' indicates *'less useful'*, '3' indicates *'moderate'*, '4' indicates *'useful'*, and '5' indicates *'very useful'*.

Table (C-6) in appendix (C) showed that the level of importance with tools and techniques are very diverse among the participants, in general, the majority of respondents' rated tools like 5S, Benchmarking and Parato analysis as very important tools within their organisations and other tools like VSM and SPC ranked as the most useful tools. However, the majority of the respondents indicated that the rest of the tools are moderate in terms of the usefulness within their organisations.

4.6.2.2.4. Section D: Evaluation of the proposed LSS model:

This section of the questionnaire was designed to validate the proposed model for manufacturing organisations. The aim is to gain an understanding of the LSS implementation procedures suitable for manufacturing organisations, identify possible difficulties in implementing the proposed model and reveal the accuracy level of the contents of the proposed Model in terms of helping manufacturing organisations to gain competitive advantage in the long run. The model was presented to the respondents with the respondents asked to evaluate the model in terms of the following statements about the proposed model based on the ranking below;

1–Strongly Disagree. 2– Disagree. 3– Moderate. 4– Agree. 5 –Strongly Agree

The results are presented as follows;

1. Evaluation - the contents of the proposed model

Table (C-7) in appendix (C) demonstrated that 35% of the respondents strongly agreed with the contents of the LSS model, 45% agreed, 16% were moderate, 2% disagreed while 2% strongly disagreed. Therefore, 80% in total fully support the contents of the proposed model. Taking into consideration the results of the reliability and validity tests shown previously in this chapter, this can be considered a high percentage.

2. Evaluation - The suitability of the proposed LSS model for manufacturing organisations:

Table C-8 in appendix (C) demonstrated that 20% of the respondents strongly agreed with the contents of the LSS model, 51% agreed, 25% were moderate, 2% disagreed while 2% strongly disagreed. Similarly, the suitability of the proposed model is fully supported, at 71%.

3. Evaluation – The ability of the proposed model to boost competitiveness and profit

Table (C-9) in appendix (C) showed that up to 38% of the respondents strongly agreed with the contents of the conceptual LSS model, 31% agreed, 25% were moderate, 4% disagreed while 2% strongly disagreed. Therefore, 69% fully supported the proposed model in terms of their capacity to achieve competitiveness and profit of their organisation.

4. Evaluation - The ability of the model to overcome the complexity of LSS implementation:

Table (C-10) in appendix (C) demonstrated that 25% of the respondents strongly agreed with the contents of the LSS model, 50% agreed, 20% were moderate, 3% disagreed while 2% strongly disagreed. Then in total, 75% were entirely in agreement that the proposed model will overcome the complexity of the implementation.

5. Evaluation – Covering any potential difficulty in implementing the proposed *model*

Table (C-11). In appendix (C) demonstrated that 82% of the respondents indicated that they foresee no difficulty implementing the proposed model. However, 18% listed some difficulties, such as the existence of too many models. Some markets being more subject to the prices of goods and services than quality, process or internal procedures. Organisation's size, the high cost of training and the ability to adopt the model to suit organisation with multiple products or services were other key factors.

6. Evaluation - Identifying anything missing and should be added to the contents of the proposed model.

Table (C-12) in appendix (C) demonstrated that 89% of the respondents indicated that the contents of the model are complete. Only 11% suspected that something was missing from the model. They suggested that adequate training should be included in the conceptual model; ANOVA should be adopted as a method of testing the results from DOE against the actual prediction and incentives that were introduced to encourage team cooperation.

4.6.2.2.5. Section E: Evaluation - the CSFs and factors impeding the successful implementation of LSS:

This section of the survey was intended to understand the CSFs required for a successful implementation of Lean Six-Sigma and also the barriers that can hinder the implementation process in the manufacturing organisation.

1. Evaluating-the importance of the CSFs in the implementation of LSS

The main aim of this part of the study is to assess the CSFs that are required for successful implementation of LSS. The respondents were asked to rate the importance of 12 CSFs in the survey, The Likert scale used in this part are: 1-5, where ***1*** *- Not important 2 – Slightly important 3 – Important 4 – quite Important 5-Very important*

Table (C-13) in appendix (C): demonstrated that most of the CSF’s were considered to be important since the majority of the respondents indicated that the highest percentage level (%) fell between Moderate and very important on the scale. However, certain CSF’s were rated of higher importance with a rate higher than 50%: *Training and education, top management involvement and participation*, *linking to business strategy*, *monitoring and evaluation of performance* and *effective Communication* were classified as very important CSFs and have been rated as 69.1%, 62.5, 58.2%, 51.9% and 50.9%, respectively. These are the most important CSFs for a successful Lean Six-Sigma implementation.

2. Factors impeding LSS implementation

The respondents were asked to rate the extent to which the 11 identified barriers factors can impede the successful implementation of LSS in manufacturing organisations. Eleven barriers factors were identified by the existing literature review (Johannes, 2013), (Antony, 2009) and (Andersson et al., 2006). These barriers factors were rated using the Likert scale of 1-5; where 1- corresponds to very low, 2- Low, 3- Moderate, 4-High and 5-Very high.

Table (C-14) in appendix (C) demonstrated that the majority of the respondents indicated that the greatest percentage level (%) fell on the high side of Likert scale for the most impeding factors. *Poor training and coaching* and *the lack of tangible results* were considered to be the most impeding factors for LSS implementation, whereas the greatest percentage for these two factors fell very high Likert scale with a percentage of 42.9% and 37%, respectively.

4.7. Validation of the critical success factors

In order to validate the CSFs, the questionnaire instruments must be measured in terms of validity to ensure whether the accuracy and truthfulness of the results obtained are valid and to what extent the instruments measure what they are supposed to measure. As discussed in chapter 3 section (3.6.2.2), factor analysis undertaken to assess the instruments was used to evaluate the CSFs and, thereby, to confirm the construct validity.

4.7.1. Results of factor analysis

The first step is a factorability test: This is used to examine the appropriateness of the data for factor analysis. The results in table (4.8). demonstrated that all the requirements are met, where KMO is 0.823 and the sphericity test is significant.

Note; (df) in this test is basically calculated using the following formula (Kaiser, 1981)

df = ((number of items)*(number of items-1))/2

Table 4. 8. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.823
Bartlett's Test of Sphericity	Approx. Chi-Square	353.131
	df	66
	Sig.	.000

Second factor extraction; the results obtained from the first trail were relatively satisfactory, since the results of PCA in table (4.9) extracted only 2 latent factors. With Eigenvalue exceeding 1.00 and accounting for 61.69% of the total variation necessary to meet the requirements in which latent factors are the underlying factors or the variables that are not directly observed. However, the latent factors are typically obtained through statistical calculations taken from the observation of the variables. Additionally, the latent variable relates to the set of observed variables, finally, latent factors in factor analysis are considered to be a measurement for construct validity (Williams et al. 2012). in this study two latent factors extracted, and it will be interpreted and labelled in further step.

Table 4.9. Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Latent factors	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6.290	52.419	52.419	6.290	52.419	52.419	5.510
2	1.113	9.276	61.696	1.113	9.276	61.696	5.331
3	.841	7.012	68.708				
4	.741	6.175	74.883				
5	.687	5.722	80.605				
6	.545	4.539	85.144				
7	.487	4.058	89.202				
8	.394	3.284	92.487				
9	.373	3.109	95.596				
10	.239	1.988	97.584				
11	.175	1.462	99.046				
12	.115	.954	100.000				

Extraction Method: Principal Component Analysis.

Third factor rotation:

However, the factor loading obtained from pattern matrix, as it can be seen in table (4.10), showed that out of the 12 items, which are the 12 CSFs, one item is loaded on the two latent factors (bi-factorial); linkage to business strategy. In addition, another item, project management, had a low factor loading with a value of 0.493. In this case, the linkage to business strategy and project management are candidates for removal and a proposed secondary analysis is required (Pallant, 2010) and (Hair et al., 2006).

Table4. 10. Pattern Matrix

	Latent factors	
	1	2
Monitoring and evaluation of performance (performance measurement)	.900	
Project prioritization and selection.	.798	
Effective Communication.	.788	
Top Management involvement and participation.	.765	
Business plan and Vision.	.641	
Linking to business strategy.	.509	.398
Linking to Suppliers.		.880
Organizational structure.		.795
Linking to customer.		.781
Education and Training.		.626
Organizational culture		.578
Project Management.		.493

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.[a]

Therefore, ten items appeared to be interpretable, the rotation of the secondary run was performed for the rest of items, the results showed that the entire items are unidimensional and loaded on one factor, as shown in pattern matrix in table (4.11). Latent Factor one obtained a high loading for five items ranged from 0.903 to 0.626. Latent Factor two also had a high loading across five items ranged from 0.869 to 0.601. Black and Porter (1996) stated that the unidimensional nature of each factor is a measure of construct validity.

Therefore, the survey instruments for the CSFs are validated since all the items of both factors are unidimensional with high loading, greater than 0.6. Additionally, the internal consistency of each factor was tested and found to be greater than 0.7, hence, the results are, statistically, considered to be significant and reliable as shown in table (4.11).

Table4. 11. Pattern Matrix

	Latent factors	
	1	2
Cronbach alpha test for each factor	0.842	0.844
Monitoring and evaluation of performance (performance measurement)	.903	
Effective Communication.	.808	
Project prioritization and selection.	.768	
Top Management involvement and participation.	.767	
Business plan and Vision.	.626	
Linking to Suppliers.		.869
Organizational structure.		.794
Linking to customer.		.759
Education and Training.		.645
Organizational culture		.601

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Finally, the author interpreted the results of factor analysis by naming the extracted latent factors; this interpretation is based on the structure matrix in table (4.12) which showed the correlation between the variables and the factors. Thereby, the underlying factor are labelled as follow:

Table4. 12. Structure Matrix

	Latent factors	
	1	2
Monitoring and evaluation of performance (performance measurement).	.852	.461
Project prioritization and selection.	.830	.535
Effective Communication.	.798	.491
Business plan and Vision.	.768	.597
Linking to business strategy.	.749	.705
Top Management involvement and participation.	.734	.408
Linking to Suppliers.	.453	.834
Organisational structure.	.502	.809
Education and Training.	.599	.760
organisational culture	.582	.718
Linking to customer.	.356	.712
Project Management.	.585	.667

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization

Latent Factor 1. Operation elements

These elements are highly correlated with latent factor 1, as shown in table (4.12), the elements represent 52.4% of the variance, see table 4.9. The items are related to the operation process of LSS-model and have a significant impact on the process performance; in this study, these elements are considered to be the key successful driver for implementation of the LSS model, the internal consistency of this factor is 0.842. The correlation among the observed items (CSFs) and latent factor are shown in Table 4.12 and Figure 4.4.

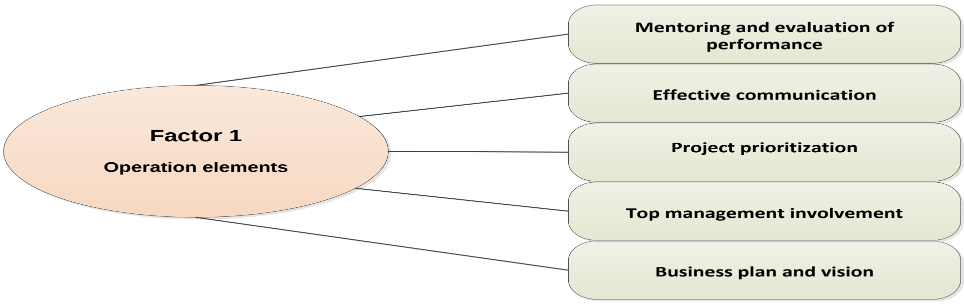


Figure 4. 4. The correlation between Latent factor 1 and CSFs

Latent Factor 2. Strategic elements

These elements, as shown in table (4.12), highly correlated with latent factor 2, the elements represent 9.2 of the variance, see table (4.9). The items are related to the strategic elements of the LSS model and have positive impact on the business performance; therefore, the items are considered key successful strategic elements of LSS model, the internal consistency of this factor is 0.844. The correlation among the observed items and latent factor is shown in Table 4.12 and Figure 4.5.

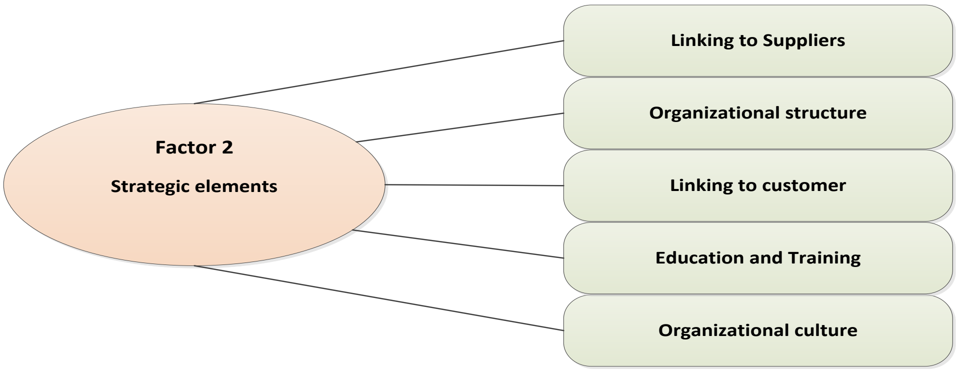


Figure 4. 5. The correlation between latent factor 2 and CSFs

4.8. Discussion

The survey investigated mainly three issues; firstly, the LSS awareness level at different organisations; secondly, the validity of the proposed conceptual LSS model and; lastly, the critical success factors for successful implementation in manufacturing organisations. The results of the survey clearly demonstrated that the awareness level of LSS tools is very high but usage, in an integrated fashion, is still low among manufacturers. Although some of the LSS tools listed in the questionnaire are quite familiar among managers, many of manufacturing organisations have yet to make use of some of them.

The results clearly demonstrate that the proposed LSS model that has been developed is a workable model which can help manufacturing organisations to achieve competitive advantage if embedded into their long-term strategic thinking. This is evident from the obtained results which are presented in figure 4.6. It is very clear that a very high percentage of respondents are strongly or moderately in agreement with the contents, suitability, competitive advantages and implementation complexity of the proposed LSS model.

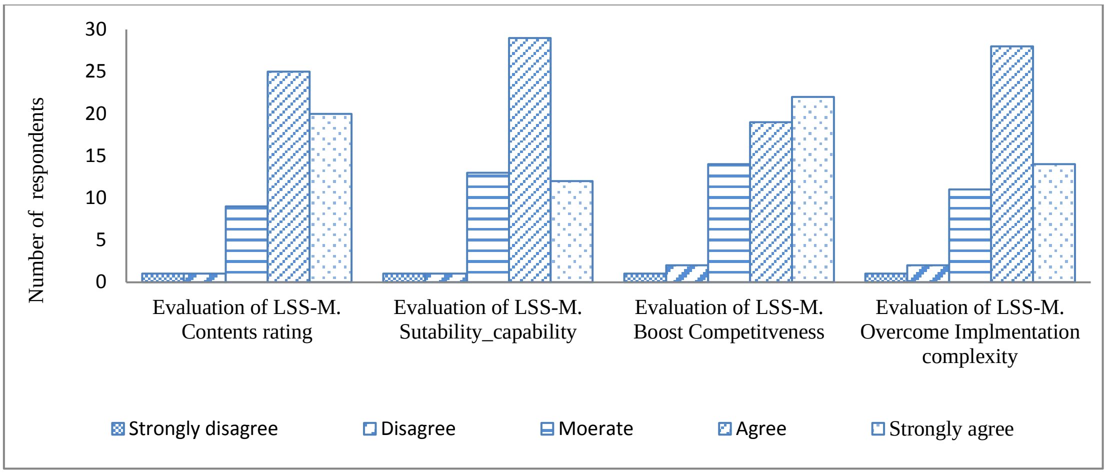


Figure 4. 6. Respondents view on the validity of the proposed conceptual model

4.9. Conclusion

The study in this chapter demonstrated the output of the key question of the research, the development of the Lean Six-Sigma implementation model for manufacturing organisations and the realisation of the main objectives. Lean Six-Sigma implementation requires the full commitment from the top management and the employees involved. To gain competitive advantage for a long term period, Lean Six-Sigma implementation should be integrated into the organisations through long-term strategic thinking. This will shape the management's strategies and vision to which the managers have to be committed and also guide the employees to achieve improved processes, reduce variations, reduce waste and meet or surpass customers' expectations. Although Lean Six-Sigma has been implemented in a good number of manufacturing organisations around the world there are still many others only recently made aware of it and, for them, Lean Six-Sigma implementation is still at an early stage.

Even for those organisations that have used most of the 26 LSS tools and techniques presented in this research, the majority are yet to adopt Lean and Six-Sigma as an integrated approach and embrace this initiative into their strategic planning, hence the need for the proposed developed model. Most of the organisations already have the required culture that will make the implementation process easier but a lot has to be done in terms of training and education so that most managers will fully understand LSS and the potential benefits. It is expected that the proposed model will bridge the gap between the theoretical and practical sides of Lean Six-Sigma implementation in manufacturing organisations and consequently have a positive economic impact on their strategic objectives.

Chapter 5:

Development and validation of Six-Sigma and TQM integrated model

5.1. Introduction

The rapid development of the application of technology in the recent years has caused considerable change in the market environment. Consequently, improving business process has become the major priority for manufacturing and services organisations. This dramatic change has forced businesses to pursue speed, innovation, quality and value (Yang, 2004). This has meant that quality management has gained considerable attention and provided a new approach to management systems such as integrated quality management and business excellence.

This chapter starts by discussing how Six-Sigma and TQM is being integrated, then it provided a comprehensive study regarding the essential elements and implementation procedures of each method in order to understand the strategic and the implementation procedures of the methods, additionally covering the critical success factors for the successful implementation of the proposed conceptual model which is also selected and identified. Furthermore, business excellence in quality management is discussed as well as a clarification as to how to produce performance excellence and obtain sustainable improvement within a quality system. There is a proposal for a strategic plan to achieve business excellence in quality management along with the development of this plan and the way in which the plan guides the study to develop the proposed modal. Finally, a questionnaire survey was applied to verify and validate the model; therefore, the validation steps were carried out in order to lead to the desired result.

5.2. Integrating Six-Sigma and TQM

Based on the previous comparison between Six-Sigma and TQM that clarified the similarity and differences the two methods (see chapter 3 section (2.4.5)) and by referring to the project motivation for both methods (discussed in chapter 3 section (2.5.5.2)) the project motivation provided the research with three key drivers for integrating Six-Sigma and TQM. These are; the similarity between both methods, the existing synergy between both approaches and how Six-Sigma can be incorporated as the core method of the proposed model due to the power provided by the DMAIC improvement strategy as well as the use of its tools and techniques. In addition, the critical relationship between these methods (see chapter two sections (2.7.4)) revealed that both methods can complement each other, with respect to process implementation and achievement of the final results. Finally, how the CSFs identified for implementing the methods can help to facilitate the implementation process of the proposed model.

However, to develop a robust integrated model the essential elements and procedures for implementation of each method must be studied and discussed in order to identify the strategic and the operational components of the proposed model. Additionally, the CSFs for successful implementation and the proposed conceptual model also must be identified. Finally, business excellence in quality management should be discussed and a clarification as to how to achieve performance excellence and obtain sustainable improvement in quality system. In this way, the strategic plan for achieving business excellence in quality management would be developed to guide the study for developing the proposed model.

5.2.1. The critical components of Six-Sigma implementation

Yang (2012), Henderson and Evans (2000), Srinivasu et al. (2009) discussed how to implement Six-Sigma; However, there is a consensus among these studies that the implementation process of Six-Sigma initiative consisting of three main components;

1. Process Improvement of Six-sigma (DMAIC).
2. Staff roles for effective operations.
3. Training program.

1. Improvement process (DMAIC); the improvement methodology of Six-Sigma discussed in chapter two see section (2.2.3).

2. Staff roles; Six-Sigma method is a highly disciplined system. The process management of Six-Sigma and the strategic implementation procedure is based on specific roles and a top-down structure. The responsibility and tasks in Six-Sigma are mainly delivered as follows:

Senior management; is responsible for the success the project through the provision of the following possibilities:

- Providing the resources.
- Selecting strong leadership.
- Providing sufficient support.

The Chief executive (CEO) is considered the key driver of Six-Sigma project with the main responsibilities and tasks as follows:

- Establish the vision.
- Develop the strategy.

- Drive the changes.

The chief executive delivers the above tasks through the team leaders who may be champions, master black belts, black belts, green belts and other workers. Each level has part of the responsibility and tasks, and all of these team leaders who are part of the chief executive, the tasks of each level are as follows:

Champions may to the person or team who is responsible for Six-Sigma projects and Six-Sigma efforts (head of major functional organisation).

Master Black belt (MBB) is a teacher and consultant for the Six-Sigma projects, also working with champions to coordinate project selection and training, and work with or train coach BB and GB and is the individual who communicates the overall progress.

Black belt (BB); is a person with high skills and experience responsible for executing and schedule the Six-Sigma projects. Typically working under MBB and applying Six-Sigma tools and techniques for controlling the products and processes.

Green belt (GB); is the process owner lead by a BB. Their main task is to maintain the successful application of Six-Sigma techniques and lead small-scale improvement projects in their area.

3. Training Program; Six-Sigma invests heavily in the training the employees, the training program is designed for the whole Six-Sigma team from CEO, champion, MBB, BB, GB, YB and extended to all employees, the training covers team leadership skills, qualitative tools, quantitative tools, planning and implementation skills.

5.2.2. The critical components of TQM implementation

According to Hellsten and Klefsjö (2001) the practical definition of TQM is a management system which contain values, methodology and tools, Yang (2004) goes more deeply and defines TQM as an integrated model of management philosophy which contains on quality concepts and set of practice. Yang (2004; Srinivasu et al. (2009) add that the successful implementation of TQM requires the integration of two main components. **The soft side system** is those aspects associated with quality concepts; culture and people factors. (Rahman,2004; Hansson and Klefsjö, 2003) clarifies that the key elements of the soft side of TQM are the behaviour aspects of management, the essential elements of TQM discussed in chapter 2 see section (2.4.3). **The hard side of the system** is a technical system of quality control. Figure (5.1) below shows the main components of TQM implementation.

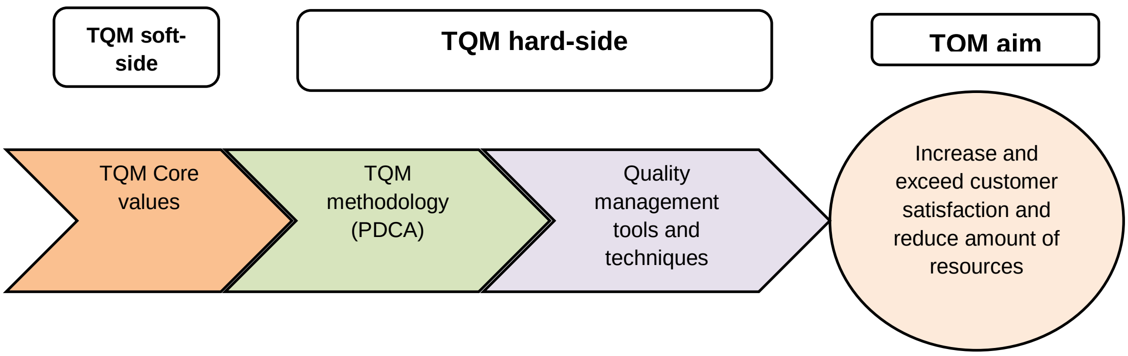


Figure 5. 1. The components of the TQM implementation process

The hard system of TQM mainly consists of;

- Process improvement of TQM (PDCA).
- Tools and techniques.

TQM tools and techniques; are the hard-side components which are considered the key drivers of the process improvement and development, many studies agree on the vital role played by the use of quality management tools and techniques to improve and develop the quality process (Klefsjö et al., 2008). Jafari and Setak (2010) identified that most tools have a statistical basis to facilitate and analyse the products and process and are then used to support the decision. In the implementation of TQM, the strategic technique for process improvement is the **Deming improvement cycle (PDCA*)*** which corresponds with the seven statistics tools and techniques used to determine quality.

5.3. The CSFs for successful implementation of the SS-TQM integrated model

Mainly, there are no clear success factors mentioned in the literature regarding integrating Six-Sigma and TQM; However, the factors that were ranked as an effective success factor for Six-Sigma and TQM implementation by numerous studies (Henderson and Evan, 2000; Ho et al.,2000; Antony and Banuelas, 2002; Yang, 2012). The critical success factors for integrating the above approaches are listed by Antony (2010):

1. Organisation infrastructure.
2. Top management and leadership support.
3. Investment in training.
4. Middle management involvement.
5. Communication.
6. Understanding DMAIC strategy to deal with quality issues.
7. Understanding the usage of Six-Sigma and TQM tools and techniques and how to use in the right action.
8. Investing the adequate resources.
9. Utilization of IT to support implementation.
10. Use of the best talent.

11. Knowledge and competence for the employees.
12. Ability to learn from mistakes and history.

5.4. Business excellence in quality management system

Klefsjo et al. (2008) define excellence as a term describing quality in which Business Excellence or Performance Excellence is an integrated system intending to achieve long-term success, high-quality results and improvement. Vora, (2002) suggested that business excellence can be achieved by understanding the principle of quality management methods and by implementing quality management in practice. To obtain business excellence within manufacturing organisation, the quality management system must be developed to meet the level of sustainable improvement which provides long-term success and customer loyalty (ibid). Those two improvement levels are the critical goals of the business excellence (ibid).

The view supported by Yang (2012) is that business excellence represents a degree of superiority. It is integrated system between quality management methods and based on the pursuit of continuous improvement rooted both in organisation's results and the way of achieving. Moreover, Vora (2002) stated that three major improving elements can lead to the attainment of business excellence: **the concerted effort to delight customers, the streamlining of process** and **the satisfaction of the employees**. These components must be organised in a strategic discipline, working in harmony in order to attain the operational improvement and high financial results found to lead to business excellence. Based on the above concept, the author developed a strategic plan for achieving business excellence model by integrating Six-Sigma and TQM for manufacturing organisations, the strategic plan was designed as a **basis for developing the integrated model,** the strategic plan describes how the integrated model can be implemented to achieve the main goal.

5.5. The strategic plan for developing the SS-TQM integrated model

The strategic plan consists of four stages and each stage includes several elements; the first stage being the primary stage. Here, the key strategic improvement of both methods is integrated to set out the required strategic plan for driving the organisation to meet the final target. The second stage is the essential stage; when the key activities of both concepts are combined together to determine the efforts required to satisfy the customer needs and drive the process to obtain better performance as well as focusing on the employees to achieve high operational performance. The third stage is the outcome; it is the attainment of expected results from previous stages, these are continuous improvement, process improvement and high operational performance. The last stage is the target of the strategic map; long-term success and customer loyalty that, in turn, lead to business excellence, the strategic plan is displayed in figure (5.2) below.

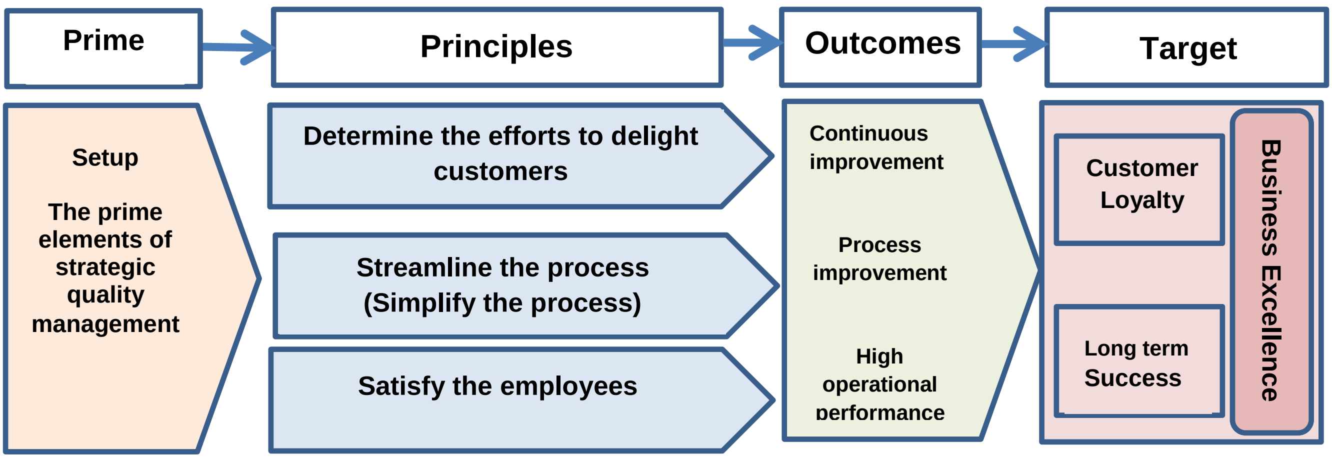


Figure 5. 2. The Strategic Plan for integrating Six-sigma and TQM

5.6. The proposed SS-TQM integrated model for achieving business excellence

Primarily, the study revealed that the **origins, principles, techniques, and goals** of Six-Sigma and TQM are similar; however, the way they achieve their objectives are different. Therefore, the proposed conceptual model seeks to unify the management system by cultivating a culture of quality and a realisation of the environment of innovation, the model developed was based on the improvement methodology of Six-Sigma (DMAIC) and improvement activity of TQM, which are integrated to unify the management system and facilitate the implementation process in order to obtain improved performance. Where DAMAIC is the key strategy of Six-Sigma for achieving process improvement, the process activity of TQM is represented by the Quality Control Circle and Quality Improve Team (QCC and QIT). The purpose is to enable manufacturing organisations to present opportunities for quality improvement by involving everyone in the organisation, streamline the operation process and hence, attaining business excellence.

Therefore, the model developed in figure (5.3) consists of three main elements; **Strategic elements, Implementation elements** and **Performance excellence elements. Strategic elements** are the essential elements of the model to unify the business process and success the implementation procedures ***Implementation elements*** are the key driver of the model for smoothing the operation process, driving out quality problems and attaining high quality operation performance. ***Performance excellence elements*** are the key measures of the model for sustaining continuous improvement and attaining performance excellence. Therefore, the steps towards implementation of the conceptual model are summarized into seven steps as follows:

- Evaluating and assessing the organisation using Six-Sigma strategy combined with TQM concepts in order to set up the key strategic elements; recognizing the mission, determine the vision, identifying the main objectives, provision the required resources and capturing the customer needs which are the main drivers of the process improvement.
- Enhancing the culture of quality by applying Six-Sigma training associated with TQM concepts and, thereby, realise innovation
- Utilising IT system support for digitising the process and enhancing the implementation procedures.
- Emphasizing the involvement of middle management in the system to attain better coordination between the workers and make the organisation more integrated.
- Integrating Six-Sigma DMAIC with improvement activity of TQM (QCC and QIT) to enhance the process improvement by realising of employee's participation and make everyone involved in the organisation.
- Learning from mistakes by taking action to achieve high quality and placing an emphasis on continuous improvement.
- Ensuring the deliverables were met or exceeded customer satisfaction by applying VOC and balanced scored Card in order to fulfil customer delight and achieve performance excellence

All of the above steps are integrated with two critical drivers. One of which is **top management and leadership support** to attain complete participation and team-work, realise the management empowerment and self-control as well as human resource management (HRM) for managing and developing manpower (see the right side part of the proposed model).

The other critical driver is **customer management,** for capturing the customer requirements through high-quality customer services in order to follow-up the value of the products and services with respect to the customer perspective (see the left side part of the proposed model).

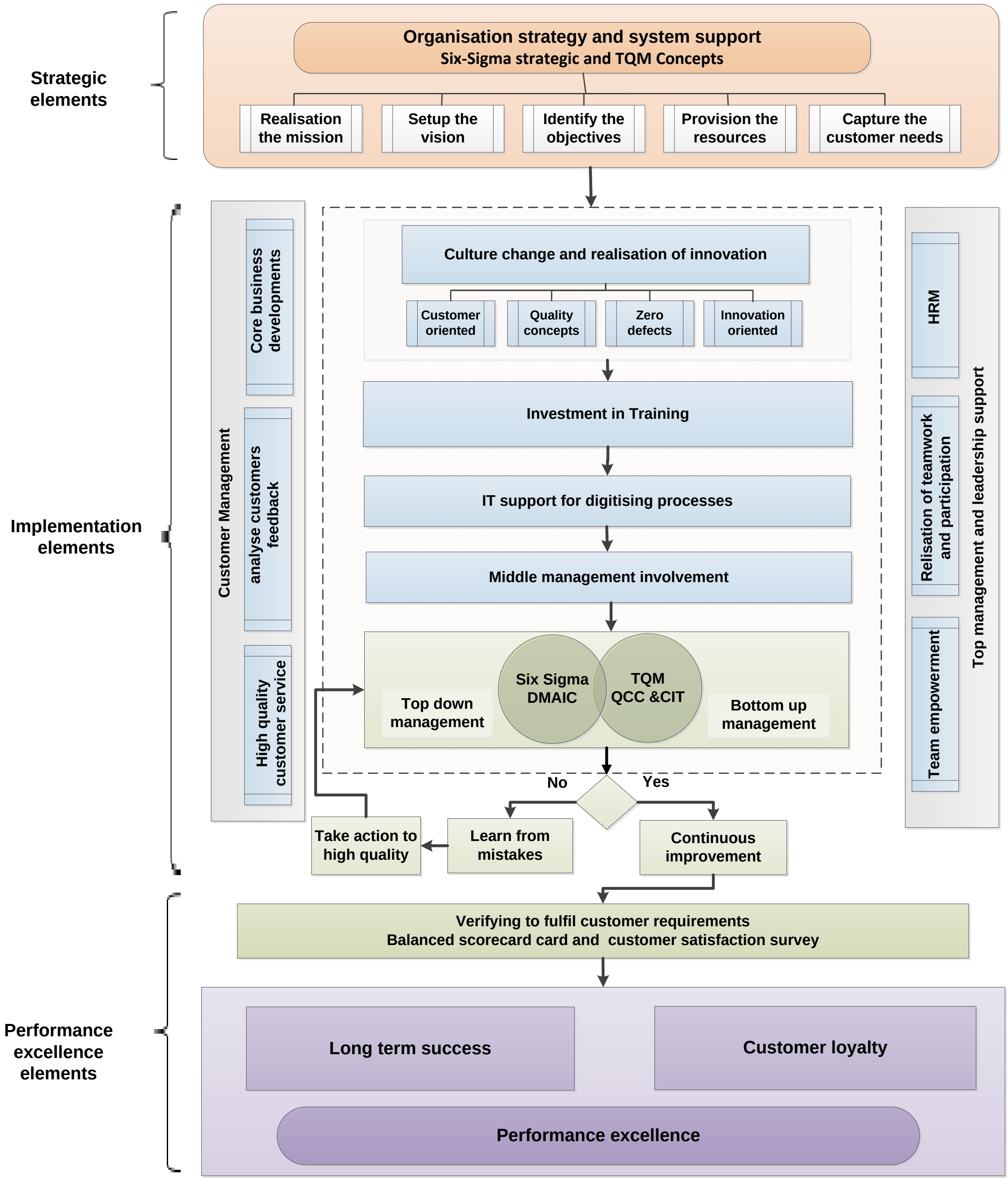


Figure 5. 3. Six-Sigma TQM Integrated conceptual model

5.7. Validation of the SS-TQM integrated Model

5.7.1. Research methodology

The method employed in this study for gathering data was a questionnaire survey; the aim is to investigate the suitability of the proposed integrated SS-TQM integrated model to achieve business excellence in manufacturing organisations. The questionnaire was also designed for another purpose, to collect the required data from professionals and experienced employees in the available manufacturing organisations and academics related to the topic. The first section concerns background information, it was intended to present a clear picture of the respondent's background and understand the level of awareness of Six-Sigma and TQM or any other quality program existing in their organisation in order to determine if the organisation has the right culture for the proposed model. The second section, investigated the awareness and usefulness of Six-Sigma TQM tools and techniques to manufacturing organisations, this part was intended to investigate the extent to which the SS-TQM integrated approach will be appropriate to the manufacturing organisations, It will also give an indication of how the proposed approach will be accepted by top management and other employees in manufacturing organisations.

The third section, validation of the proposed model was intended to evaluate the proposed model based on eight criteria: the contents of the strategic elements, the contents of the implementation elements, the contents of the performance excellence elements, the applicability of the model for manufacturing organisations, the ability of the model to achieve competitiveness, the ability to overcome natural Six-Sigma/TQM implementation difficulties, the ability of the model to help manufacturing organisation to achieve their long-term goals and evaluate the completeness of the model. Finally, the major part of the questionnaire was to evaluate the importance of the CSFs for successful implementation of the proposed model and the potential barriers that can impede the implementation process.

5.7.2. Data collection and analysis

This section outlines the results of the questionnaires received from the respondents and how they can be organised for analysis. A total of 70 research surveys were sent out to a host of management employees spread across different manufacturing organisations. The author believes that the set of management employees selected belong to a trustable target population that can provide reliable responses to the survey questionnaire. A total of 58 questionnaires were completed and returned within a given time frame, a percentage considered to be relatively high above the median (Saunders et al., 2009). The data collected was reviewed for completeness and accuracy, it underwent several stages of pre-analysis such as errors check and data screening, however, no serious errors found, and no responses were found similar to each other. Therefore, the data were coded and fed into SPSS 23 software program, a basic statistical analysis was carried out for the observation of frequencies, and the appropriate statistical analysis was conducted to check the reliability and validity of the instruments.

5.7.2.1. Integrity data analysis

5.7.2.1.1. Reliability analysis

As discussed in chapter three (3.6.1), Cronbach Alpha was undertaken to measure the internal consistency of the instruments used to evaluate the proposed model. Ideally, Cronbach Alpha must be greater than 0.7 to consider the items being measured are consistent and reliable. (Field, 2002). Therefore, the test was carried out for each of the eight statements used to evaluate the proposed model, the results in table (5.1) showed that coefficient alpha is 0.91 and the standardized item alpha is 0.88, which is greater than 0.7, accordingly, that is an indication that all of the items are consistent and reliable.

Table 5. 1. Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.912	.887	8

However, the results in table (5.2), column three labelled ‘corrected item-total correlation’, showed that there is a positive correlation between the whole items except items number eight ‘Evaluating the model in terms of anything missing and can be added to the proposed model’ which has negative correlation with value (-0.37). In addition, in column five labelled ‘Cronbach's Alpha if item deleted’ the same item has the highest alpha value; 0.93. Therefore, if item number eight were deleted from the calculation, then the Cronbach Alpha would be improved.

Table 5. 2. Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Evaluation the contents of the strategic elements.	24.579	22.748	.746	.586	.898
Evaluation of the contents of the implementation elements	24.544	22.145	.880	.795	.885
Evaluation of the contents of the Performance excellence elements	24.719	22.884	.780	.684	.895
Evaluation of the capability of the model for manufacturing organization	24.702	23.070	.722	.608	.900
Evaluation of the effectiveness of the model to boost organization's competitiveness and profit	24.737	22.447	.774	.689	.895
Evaluation of the ability of the model to overcome the complexity of TQM/Six Sigma implementation	24.702	22.856	.789	.682	.894
Evaluation of the model in terms to achieve the organisation goals	24.579	23.034	.811	.683	.892
Evaluation of the model in terms of any missing can be added to the proposed model.	26.509	30.647	-.037	.165	.934

After deleting item eight and running the test again, the results in table (5.3) demonstrated that Cronbach alpha is 0.93 and the standardized item Alpha is 0.93, also table (D-1) in appendix (D) showed that, in column three, all the items are correlated with value above 0.3 and, in column five, the value of Cronbach Alpha, if items were deleted ranged between 0.91 to 0.92, is greater than 0.7 Subsequently, it can be concluded that all the instruments have high internal consistency and reliability.

Table 5. 3. Reliability Statistics

Cronbach Alpha	Cronbach Alpha Based on Standardized Items	N of Items
.934	.934	7

5.7.2.1.2. Validity analysis and validation of the proposed model

Validity tests should be also performed to check the accuracy and the truthfulness of the results, Therefore, the Chi-square goodness of fit (X^2) was undertaken to check the validity of the instruments that were used to evaluate the proposed model (see chapter 3 section (3.6.2.2.1)). However, the Chi square goodness of fit with corresponding P value was considered to be significant if P value ≤ 0.05 (Bryman and Cramer, 2005). Therefore, table (5.4) demonstrated that P values are less than 0.05 for all the items used to evaluate the proposed model. This means that the results are significantly different from the actual observed values and expected values of all the statements used to evaluate the proposed model. That can also be a positive indication of the possibility of publishing the results and generalizing from the current research sample to the entire publication (Balck, 2011; Alzuabi (2015).

Table 5. 4. Test Statistics

	strategic elements	Implementation elements	Performance excellence elements	Applicability for manufacturing organization	Ability for competitiveness and profit	Overcome the implementation issues	Sustainability and Success	Completeness and missing of the contents
Chi-Square	26.772[a]	35.544[a]	32.386[a]	32.211[a]	38.877[a]	40.982[a]	36.246[a]	42.123[b]
Df	4	4	4	4	4	4	4	1
Asymp. Sig.	.000	.000	.000	.000	.000	.000	.000	.000

5.7.2.2. Descriptive analysis

The same steps that have been taken for descriptive analysis in chapter 4 (section 4.6.2.2) the results of the data collected are demonstrated in the following sections in form of tables, charts, graphs using SPSS 23.

5.7.2.2.1. Section A: Background information.

The aim of this part of the survey is to present a clear picture about the respondent's background and understand the awareness level of the existing quality program in manufacturing organisations. This is necessary to determine if organisations have the right culture for the integrated SS-TQM proposed model.

1. Respondent's position

The respondents were asked to state their position within their organisation. The results in the table (5.5) demonstrated that 14% of the respondents are quality managers, 21.1% are operational managers, 24.6% academics comprised postgraduate students and research students who are related to industrial engineering and manufacturing management, 3.5% are directors, 10.5 % quality engineers, 10.5% fulfil belt functions, including the LSS trained professionals like master Black belt, Black belt, Green belt and Yellow belt. Working in the same capacity for an organisation, 7.0% including project leaders and heads of department and, finally, 5.0% are coordinators.

Table 5. 5. Position within the organisation.

	Frequency	Percent	Valid Percent	Cumulative Percent
Director	2	3.5	3.5	3.5
Quality manager	8	14.0	14.0	17.5
Operation manager	12	21.1	21.1	38.6
Quality Engineer	6	10.5	10.5	49.1
Belt function	6	10.5	10.5	59.6
Project leader or head Department	4	7.0	7.0	66.7
Coordinator	5	8.8	8.8	75.4
Academics	14	24.6	24.6	100.0
Total	57	100.0	100.0	

2. Area of industry

The respondents were asked to indicate the industrial sector in their organisations, table (5.6) below demonstrated that 43.9% of the respondents belonging the manufacturing sector, 17.5% were from the Oil and Gas sector, and 5.3% from automotive industry. The remaining 33.3% were others including academics and research students affiliated with higher education.

Table 5. 6. Area of industry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Manufacturing	25	43.9	43.9	43.9
	Automotive	3	5.3	5.3	49.1
	Oil and Gas	10	17.5	17.5	66.7
	Other	19	33.3	33.3	100.0
	Total	57	100.0	100.0	

3. Country/organisation/location

The respondents were asked to state the location of their organisations. The results in a table (5.7) shows 19 of the participants come from the UK, 18 from Libya, 7 participants from Nigeria, 3 participants from Portugal, 2 participants from each the following countries: India, Egypt and Iraq. The remaining participants are from Russia, China, Pakistan and Saudi Arabia each of them contributing 1 Participant.

Table 5. 7. Country/organisation/location

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	UK	19	33.3	33.3	33.3
	China	1	1.8	1.8	35.1
	Russia	1	1.8	1.8	36.8
	Portugal	3	5.3	5.3	42.1
	Pakistan	1	1.8	1.8	43.9
	India	2	3.5	3.5	47.4
	Libya	18	31.6	31.6	78.9
	Egypt	2	3.5	3.5	82.5
	Iraq	2	3.5	3.5	86.0
	Nigeria	7	12.3	12.3	98.2
	Saudi Arabia	1	1.8	1.8	100.0
	Total	57	100.0	100.0	

4. Type of quality management system in the respondent's organisation

The respondents were asked to indicate the Current quality system within the organisation, the results in table (D-2) in appendix (D) showed that used 14.0% Six-Sigma, 19.33 %TQM, 40.4% ISO series and 26.3% used other quality systems.

5. The level of awareness of Six-Sigma TQM tools and techniques

Six-Sigma TQM tools and techniques were presented to the respondents and were asked to indicate if they were aware of any of the tools listed in the survey questions. The results presented in table (D-3) in appendix (D) showed that the majority of respondents seems to be familiar with most of the tools and indicated that the level of the awareness with these tools was above 50%, regarded as slightly high. However, tools such as; PERT chart and Project charter were ranked below 50% which means that they are not familiar with these tools in their organisations and that their awareness level with those tools is slightly low.

6. The major problems facing the quality system of respondents organisations

The respondents were asked to indicate if the quality system in their organisations corresponded to the list of 19 essential problems shown in table (D-4) in appendix (D); considered to be the key problems that lead to failures in any quality system. The major problems summarized from the literature see (Antony (2008) and Andersson et al., 2006). Table (D-4) in appendix (D) demonstrated that the majority of the respondents indicated that their organisations face most of the problems. The results of each element are:

Decision Making; capable with 54.4%

Risk analysis and Uncertainty; capable with 66.7%

Failure to track which quality efforts work in a marketplace; capable with 56.1%

Employee commitment; capable with 57.9%

Follow up on the documentation process; capable with 57.9 %

The right selection of raw material; capable with 77.2%

Defects; capable with 61.4%

Planning and following maintenance programs; capable with 50.9%

Taking action for continuous improvement; capable with 66.7%

Market and sales management; capable with 61.4%

Scheduling and organisation; capable with 50.9%

Utilisation of problem-solving techniques or validating the robustness of the technical solutions (crucial to advance planning); capable with 55.4%.

However, the majority of respondents indicated their organisations are incapable of dealing with the rest of the problems and the average of results were below 50%:

Lack of cost-driven and priorities: incapable with 52.6%

Investment in training: incapable with 59.6%

Resources management: incapable with 52.6%

Appropriate organisation of storage space: incapable with 64.9%

Involvement of top management and support: incapable with 50.9%

Middle management involvement and participation: incapable with 52.6%

Machine setup and control: incapable with 64.9%

The respondents also were asked if there are other problems facing their quality system. The results showed that no other problems were added.

5.7.2.2.2. Results of Section B; the level of awareness and perceived usefulness of SS-TQM tools and techniques among participants

This section of the survey seeks to provide an understanding of the respondents' involvement in SS-TQM tools and the techniques that have been used in their organisation or used by the respondents themselves and how useful these tools are to businesses for the purposes of manufacturing organisation. It aims to provide an understanding of basic Six Sigma and TQM tools and the procedures for implementation that are suitable for manufacturing organisations. To identify the possible difficulty in implementing the proposed model and show the level of accuracy of the contents of the model as they are applied to business in manufacturing organisations.

1. Attendance of any formal training on Six-Sigma or on TQM approaches.

The respondents were asked to state if they have received any formal training on Six-Sigma or TQM, (figure (D-1) in appendix (D)). 14.0% of the respondents had formal training on Six-Sigma, 33.3% had formal training on TQM, 22.8% of them have formal training on both approaches and 29.8% have no formal training.

2. The duration of using Six-Sigma or/ and TQM approach.

The respondents were asked to state for how long they have been using Six-Sigma and/or TQM approaches. Figure (D-2) in appendix (D) showed that 21 of the respondents have never used them, 6 respondents for a period of one year or less, 21 of the respondents for 2 - 5 years and 8 respondents for 5-10 years with only one of them has used it for more than 10 years.

3. The role of respondents within Six-Sigma/TQM organisation.

The respondents were asked about their role within Six Sigma and/or TQM organisation. Figure (D-3) in appendix (D) showed that 18 of the respondents have no Six Sigma/TQM role, 10 of them are managers and team members, 6 Green Belt, 4 of the respondents are heads of department, 3 of them are champions (2 of which are trainers and a yellow belt), and 1 respondent is each master black belt another a black belt.

4. Utilisation of Six Sigma and TQM tools and techniques.

The respondents were asked to indicate whether they have ever used or have applied SS-TQM tools and techniques in their organisation, the respondents were also asked to rate the application of these tools in their organisation on a Likert scale of 1-5, where '1' indicates *'never been used'*, '2' indicates *'used only* *once'*, '3' indicates *'used rarely'*, '4' indicates *'used frequently'* and '5' *'used very often'*.

The results in table (D-5) in appendix (D) showed the level of familiarity with tools and techniques is very diverse among respondents, especially within the group of statistical tools and techniques. In general, the percentage (%) level of familiarity with the more sophisticated statistical tools and techniques were rated 'moderate'. Some advanced statistical tools and techniques like Regression Analysis, PERT, Force Field Analysis, Taguchi, and SIPOC, QFD, FMEA are slightly unfamiliar to most of the respondents. While quality tools and techniques such as SPC, Process Mapping, brainstorming, run chart and benchmarking are the most familiar with the Six-Sigma and TQM tools and techniques.

5. The usefulness of LSS tools and techniques to the respondents' organisation.

The respondents were asked to indicate whether Six-Sigma and/or TQM tools and techniques are considered useful to their organisation, in the Likert scale used; '1' indicates *'not useful'*, '2' indicates *'less useful'*, '3' indicates *'moderate'*, '4' indicates *'useful'*, and '5' indicates *'very useful'*.

Table (D-6) in appendix (D) showed that the level of importance with tools and techniques to the respondents produced a range of answers among the tools and techniques. In general, the majority of respondents' suggested that causes and effect chart, benchmarking, DOE, run charts and process flowcharts are very important tools within their organisations with other tools brainstorming and PDCA being ranked as the most useful tools. However, the majority of the respondents indicated that the rest of the tools are moderate in terms of their usefulness within organisations.

5.7.2.2.3. Section (C): Validation of the proposed integrated SS-TQM model

This section of the survey seeks to validate the proposed model for manufacturing organisations. It aims to provide an understanding of Six-Sigma and TQM implementation procedures, identify the difficulties in implementing the proposed model and reveal the accuracy level within its contents in terms of helping business to gain competitive advantages in the long run. The model was presented to the respondents, the respondents were then asked to evaluate the model in terms of the following criteria; strategic contents of the model, the applicability of the model to manufacturing organizations, the effectiveness of the model to achieve competitiveness, the ability of the model to overcome the nature implementation complexity, the ability of the model to assist manufacturing organizations in achieving long-term goals and, finally, to evaluate the completeness and accuracy of the model in terms of respondents insight. The Likert scale used is **1**–Strongly Disagree. 2– Disagree. 3– Moderate. 4– Agree. 5 –Strongly Agree

1. *Evaluation - of the contents of the strategic elements of the proposed model*

Table (D-7) in appendix (D) demonstrated that 29.8% of the respondents strongly agreed with the contents of the strategic elements of the proposed model, 35.1% agreed, 28.1% were moderate, 5.3% disagreed while 1.8% strongly disagreed.

2. Evaluation - of the contents of the implementation elements of the proposed Model.

Table (D-8) in appendix (D) showed that 26.3% of the respondents strongly agreed with the contents of the elements connected with implementation, 45.6% agreed, 21.1% were moderate, 5.3% disagreed while 1.8% strongly disagreed.

3. Evaluation- of the contents of the elements affecting an excellent performance in the proposed model

Table (D-9) in appendix (D) displayed that, 22.8% of the respondents strongly agreed with the contents of the elements which affect the excellence of the performance, 33.3% agreed, 38.6% were moderate, 3.5% disagreed while1.8% strongly disagreed.

4. Evaluation - of the proposed model in terms of the suitability for manufacturing organisations.

Table (D-10) in appendix (D) revealed that 21.1% of the respondents strongly agreed with the contents of the proposed model in terms of the suitability for manufacturing organisations, 24.1% agreed, 29.8% were moderate, 3.5% disagreed while 3.5% strongly disagreed.

5. Evaluation -of- the effectiveness of the proposed model for manufacturing organisations

Table (D-11) in appendix (D) demonstrated that up to 17.5% of the respondents strongly agreed with the contents of the proposed model in terms of boosting the organisation's competitiveness and profit, 49.1% agreed, 24.6% were moderate, 3.5% disagreed while 5.3% strongly disagreed

6. Evaluation -of- the ability of the model to overcome the complexities of implementation to Six Sigma TQM.

Table (D-12) in appendix (D) illustrated that 17.5% of the respondents strongly agreed with the contents of the proposed model to overcome the complexities of implementation; 49.1% agreed, 26.3% were moderate, 3.5% disagreed while 3.5% strongly disagreed.

7. Evaluation -of- the ability of the proposed model to help the manufacturing organisations meet organisations goals.

Table (D-13) in appendix (D) demonstrated that 24.6% of the respondents indicated that they strongly agree with the contents of the proposed model, in terms of helping manufacturing organisations to achieve organisations goals, 42.1% agree, 29.8% chose moderate, 1.8 disagree and 1.8% strongly disagree.

8. Evaluation -of- the proposed model in terms of anything missing which should be added to the proposed model.

The Likert scale used in this part was 1-Yes and 2-No

Table (D-14) n appendix (D) revealed that 93.0% of the respondents indicated that the contents of the model are complete. 7.0% think something is missing from the model. They suggested that the Lean manufacturing and approach should be included in the conceptual model.

9. Evaluation -of- the potential motivations for the SS-TQM approach

The essential elements of both approaches are listed as the key motivation behind the adoption of Six-Sigma TQM approaches. The respondents were asked to indicate the extent to which the following motives will influence their decision in adopting the Six-Sigma TQM model.

Table (D-15) in appendix (D) showed that the majority of respondents rated the highest percentage for the favour of ‘agree’ and ‘strongly agree’ scales which means that the majority of the respondents are aware that Six-Sigma/TQM approaches are appropriate for manufacturing organisations.

5.7.2.2.4. Section D: Evaluation of the importance of the CSFs for successful implementation of Six-Sigma TQM in manufacturing organizations.

This section of the questionnaire was intended to understand the critical factors necessary for a successful implementation of SS-TQM and, also, the barriers that can hinder the implementation process in manufacturing organisations.

The Likert scale used in this part: 1-5, where **1** - Not important 2 – Slightly important 3 – Important 4 – Quite Important 5- Very important.

1. *Evaluating-of- the importance of* the CSFs of SS-TQM implementation

The aim of this question is to assess the CSFs that are required for the successful implementation of the SS-TQM model. The respondents were asked to rate the importance of the 12 CSFs listed in the survey, the CSFs were rated using the Likert scale of 1-5, with 5 is being very important and 1 is not important.

Table (D-16) in appendix (D) demonstrated that most of the CSFs are considered to be important since the majority of the respondents indicated that the highest percentage level (%) fell between quite important and very important scale. Therefore, it can be concluded from the responses of the survey that 'top management support and communication' are the most important CSFs for a successful Six-Sigma TQM implementation in manufacturing organisations. More than any other factor ranked above 50%

2. Evaluation- of- the factors impeding SS-TQM implementation

In this question, the respondents were asked to rate the extent to which the 11 identified barriers factors impede the successful implementation of Six-Sigma/ TQM in manufacturing organisations. Eleven barriers factors were previously identified by the literature review (Johannes, 2013; Antony, 2008; Andersson et al., 2006). The Likert scale employed is; 1-5 in which 1- corresponds to very low, 2- Low, 3- Moderate, 4-High and 5-Very high.

Table (D-17) in appendix(D), demonstrated that all the barriers factors listed in the survey questionnaire are considered to be quite high since the majority of the respondents indicated that the greatest percentage level (%) fell on High Likert and have a rating greater than 35%. However, a change business focus and change management are considered the greatest barriers to Six-Sigma/TQM implementation in manufacturing organisations.

5.8. Validation of the critical success factors

As illustrated in chapter 3, factor analysis is the most commonly-used approach employed to check the construct validity of each critical success factors and to determine the appropriateness of instruments (Pallant, 2010), the aim is to measure the validity of the instruments and to understand the structure of the latent variables (factors). Therefore, an exploratory factor analysis was undertaken in this model to validate the 12 CSF selected for the successful implementation of the model. The test was carried out using SPSS 23.

5.8.1. Results of factor analysis test

<u>The first step in this test is the factorability test</u> to check the appropriateness of the data for factor analysis. As can be seen in table (5.8), all the requirements are met, where KMO is 0.846 and Sphericity test is significant (Kaiser, 1981).

Table 5. 8. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.846
Bartlett's Test of Sphericity	Approx. Chi-Square	438.057
	df	66
	Sig.	.000

Second, (Factor extraction); Principle component analysis (PCA) method with the Eigen value technique was selected as an extraction method to reduce a large number of items into factors, In order to obtain scale dimensionality and simplify the factor solution. The results in table (5.9) obtained from the first trial were reasonable since the PCA extracted 2 factors with an Eigenvalue which exceeded 1.00 (Williams et al., 2012) it also accounted for 67.85% of total variation which met the requirements.

Table 5. 9. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	4.660	51.782	51.782	4.660	51.782	51.782	4.150
2	1.446	16.070	67.853	1.446	16.070	67.853	3.533
3	.712	7.911	75.764				
4	.630	7.004	82.767				
5	.513	5.695	88.463				
6	.336	3.732	92.194				
7	.295	3.273	95.467				
8	.267	2.970	98.438				
9	.141	1.562	100.000				

Extraction Method: Principal Component Analysis.

***Third, Factor rotation*;** Oblimin technique was selected which is an appropriate rotation procedure to produce factors that are more correlated; it is also used to provide patterns of loading in a manner that is easier to interpret (Williams et al., 2012). Therefore, the factor loading attained by pattern matrix in table (5.10) demonstrated that out of 12 items, three items were loaded on two factors (bi-factorial), those provided candidates for removal and secondary analysis (Costello and Osborne, 2005), (Pallant, 2010) and (Hair et al., 2006).

Table 5. 10 Pattern Matrix

	Latent factors	
	1	2
Middle management involvement.	.908	
Top management and leadership support.	.849	
Investment in training.	.836	
Organisation infrastructure.	.809	
Understanding DMAIC strategy to deal with quality issues.	.804	
Communication.	.661	.270
Understanding the usage of six-sigma and TQM tools and techniques and how to use it in the right action.	.571	.305
Use of the best talent.		.883
Utilise IT to support implementation.		.825
Knowledge and competence the employees.		.758
Ability to learn from mistakes and history.		.755
Investing in the adequate resources.	.324	.586

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Accordingly, nine items appeared to be interpretable, the rotation of the secondary run was performed for the rest of the items. The results showed that all the items are unidimensional and loaded on one factor which is shown in the pattern matrix in table (5.11). Factor one obtained high loading for five items ranged from 0.89 to 0.76. Factor two also had high loading for four items ranged from 0.89 to 0.76. Black and Porter (1996) stated that the unidimensional nature of each factor is a measure of construct validity. Therefore, the survey instruments for the CSFs are validated since all the items of both factors are unidimensional with high loading greater than 0.6 as well as the internal consistency of each factor which were tested and found to be factor1= 0.886 and factor 2= 0.824 as shown in table (5.11), both of them are greater than 0.7, Consequently, statistically, this is considered to be significant and reliable.

Table 5. 11. Pattern Matrix

	Component	
	1	2
Cronbach alpha test	.886	.824
Middle management involvement.	.890	
Investment in training.	.833	
Top management and leadership support.	.830	
Organisation infrastructure.	.826	
Understanding DMAIC strategy to deal with quality issues.	.762	
Use of the best talent.		.898
Utilise IT to support implementation.		.783
Acknowledge and competence the employees.		.773
Ability to learn from mistakes and history.		.767

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.

***Finally, naming the extracted latent factors*;** based on the structure matrix in the table (5.12) which shows the correlation between the variables and the factors. The underlying factor can be labelled as follows:

Factor 1: Strategic elements

These elements are highly correlated with latent factor 1 as shown in table (512), the elements represent 51.782% of the variance (see table (5.9)). The items are considered the key drivers of strategic factors of SS-TQM model and have a significant impact on the operation performance, the internal consistency of this factor is 0.886. as shown in table (5.11) The correlation among the observed items (CSFs) and the latent factor is shown in table 5.12 and Figure 5.4.

Table 5. 12. Structure Matrix

	Component	
	1	2
Top management and leadership support.	.862	.481
Middle management involvement.	.858	.384
Organisation infrastructure.	.831	.425
Investment in training.	.812	.378
Understanding the DMAIC strategy to deal with quality issues.	.798	.454
Use of the best talent.	.432	.888
Knowledge and competence the employees.	.435	.796
Ability to learn from mistakes and history.	.436	.792
Utilisation of IT to support implementation.	.344	.758

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

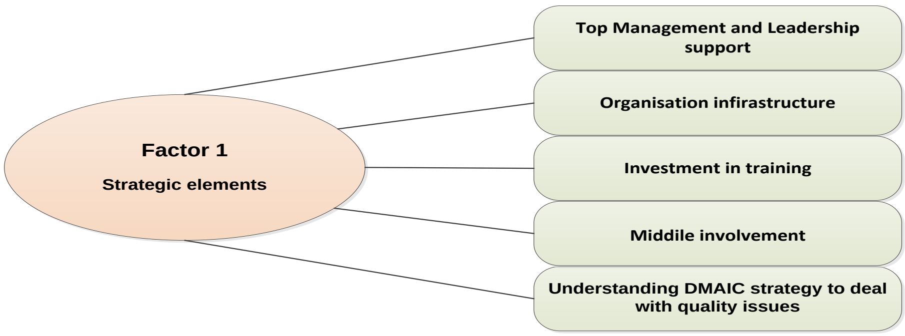


Figure 5. 4. The correlation between Latent factor 1 and CSFs

Latent Factor 2: Elements of implementation

These elements (as shown in table (5.12)) are highly correlated with Latent factor 2, the elements represent 16.070 of the variance, see table 5.9. The items are related to the strategic elements of the SS-TQM model and have a positive impact on the business performance; therefore, the items are considered the key successful strategic elements of SS-TQM model, the internal consistency of this factor is 0.844 as shown in table (5.11). The correlation among the observed items and the latent factor is shown in Table (4.12) and Figure (4.5).

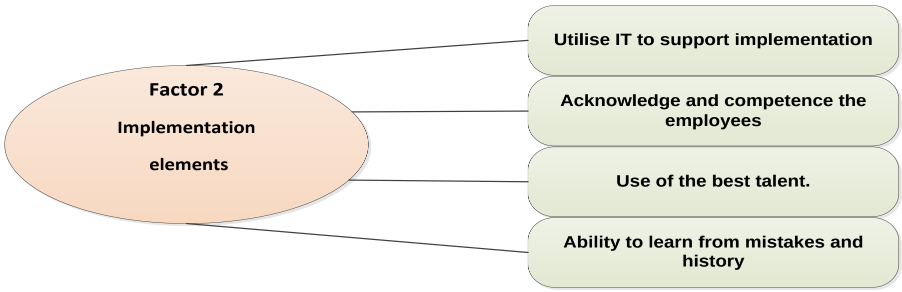


Figure 5. 5. The correlation between latent factor 2 and the CSFs

5.9. Discussion

The survey investigated the awareness level of SS-TQM tools and techniques, the validity of the proposed SS-TQM model and the critical success factors for the successful implementation of Six-Sigma/TQM in manufacturing organisations. The results of the survey verified the awareness level of Six-Sigma/TQM tools and techniques is very high; however, the practical usage, in an integrated manner, is considered somewhat low among manufacturers. Although some of the Six-Sigma TQM tools involved in the questionnaire are quite familiar amongst managers, many manufacturing organisations have yet to utilise them. The results demonstrated that the proposed SS-TQM model developed is validated and verified with respect to assisting manufacturing organisations to achieve business excellence and attaining competitive advantage. This is provided the management tools are unified and operational techniques are implemented effectively. The CSFs of the implementation varies between the organisations; however, in general, the rating for each factor indicted is of considerable importance for the successful implementation of Six-Sigma/TQM integrated approach. Figure (5.6) demonstrated the obtained results; which showed that a very high percentage of respondents are strongly or moderately in agreement with the contents, suitability, the achievement of competitive advantages, the complexity of implementation and the sustainability of the proposed SS-TQM model.

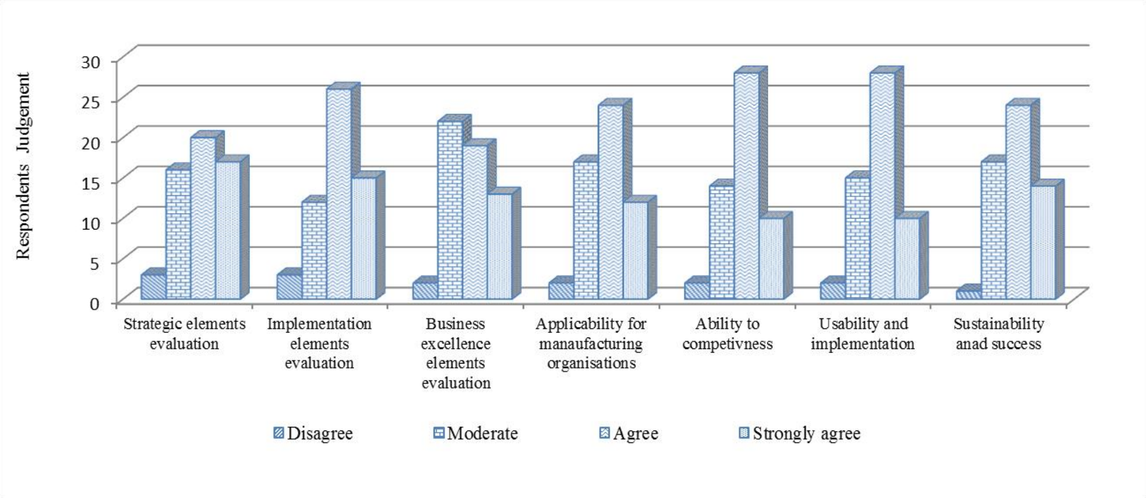


Figure 5. 6. Respondent's judgement with regards to the proposed model

5.10. Conclusions

The chapter focused on the development and validation of the proposed Six-Sigma/TQM integrated model, the study demonstrated that the integration between Six-Sigma metrics and methodology with TQM values and techniques can provide a crucial solution to driving out the quality issues and attaining high-quality performance. It also provides a basis for a standard benchmarking in achieving performance excellence for manufacturing organisations. The research revealed that most organisations are familiar with Six-Sigma TQM's tools and techniques. However, the majority of them are yet to be adopted in an integrated manner. Finally, the study concluded that the model developed is valuable for manufacturing organisations and can help to improve the quality system and attain performance excellence if adopted effectively.

Chapter Six

The AHP model for evaluating and prioritizing the key drivers of the proposed Quality Management Integrated Framework

6.1. Introduction

The increasing variety of quality management methods in recent years has overstrained quality managers to select the effective quality management methods for their organisations. The integration of quality management approaches has become an effective methodology for manufacturing and services organisations (Johannsen, 2013). In this respect, Johannsen (ibid) stated that integrated quality management models enable organisations to exceed the improvement rates and achieve sustainable improvement. Therefore, the study in this chapter is intended to evaluate and prioritise the key drivers of the proposed quality management framework.

The chapter starts by integrating the LSS model with the SS-TQM model then discuss how to identify the strategic drivers required to develop the integrated framework. The way in which the Analytical Hierarchy Process model (AHP) was developed to evaluate the effectiveness of strategic drivers and how quality management factors that have been selected to develop the proposed framework. A questionnaire survey for the purpose of AHP techniques was designed and applied to validate the proposed AHP model and to prioritise the key drivers of the framework, the validation procedures carried out were based on AHP technique and led to the final results.

6.2. Integrating LSS model with SS-TQM model

In order to develop a robust integrated quality management framework for manufacturing organisations, the key strategic elements of the proposed framework must be appropriately selected to formulate an effective quality management system for manufacturing organisations. In this research, the proposed framework will be developed by integrating the *LSS model* developed in chapter 4 and *the SS-TQM model* developed in chapter 5. Accordingly, the strategic drivers of the framework must be identified based on the integrated approach to quality management. As such, two main factors must be obtained in order to integrate the proposed models; one to incorporate the synergy between the models and the other one to identify the procedure model (Johannsen, 2013).

The synergy between both models can be easily attained since the quality methodologies of the models are significantly similar to each other, where each one can complement the other, thereby, identifying the opportunity for quality improvement and eliminating the poor quality performance (see the critical relationship between the methods selected in chapter 2 section (2.7)) (Andersson et al,. 2006; Johannsen, 2013).

The procedure model is also available since Six-Sigma DMAIC improvement is the most appropriate strategy available to guide the framework to achieving effective quality management performance. Thus, the procedure model for integrating the above-mentioned models and for developing the proposed framework in this study is based on Six-Sigma DMAIC. Accordingly, since the required similarity for integrating the models is available, the synergy does exist and the procedure model is identified, the process of integrating the aforementioned models can be summarized in four steps:

- The strategic elements of both models are integrated together to establish an effective platform for the planning process and to facilitating the implementation procedures of the framework.
- The operational elements of the LSS model integrated with both the elements concerned with implementation and the business excellence elements of the

SS-TQM model in order to provide impetus and guidance for quality improvement and for attaining performance excellence for the manufacturing organisations.

- The CSFs of both models are employed and selected based on the literature review to achieve success during the process of implementation of the framework.
- The DMAIC improvement strategy is the key strategic driver that can guide the framework toward attaining effective performance and structuring the strategic elements of the framework.

6.3. Identifying the key driver for developing the proposed management quality framework

The strategic elements of the proposed framework in this study are considered the key driver of the proposed framework for identifying the opportunities for quality improvement, streamlining the operation process and to providing the impetus to attain better performance. Therefore, the author identified five strategic elements for the proposed framework that can be adopted, based on the strategy of DMAIC improvement, to facilitate the procedures for implementation and streamline the operation processes:

1. Strategic planning.
2. Measurement and evaluation.
3. Analysis and activation.
4. Improvement and mentoring.
5. Verification and continuous improvement.

Strategic planning; concerns the strategic drivers that are required for the implementation process to succeed and to achieve the organisational objectives

(Pyzdek, 1996). The aim of these components is to align and coordinate the processes in order to meet the final vision.

Measurement and Evaluation; concerns the key drivers that are required to evaluate the current performance and to enhance the work environment. The main objectives of this stage are to evaluate the current performance of the quality system and determine the area of improvement. Additionally, collecting the required data to investigate the causes of the quality problems and to facilitate the quality system (Six-Sigma Black Belt course, 2015).

Analysis and Activation; concerns the set of statistical tools and techniques that are required to assess the quality problems and identify potential improvement. This stage is concerned with analysing the gap between the current and the desired performance, and also to identify and analyse the root causes of the problems (Six-Sigma Black Belt course, 2015).

Improvement and monitoring; concerns the key quality tools required to implement the improvement plan and monitor the operating performance, the aim is to identify, investigate and confirm the solution to the problems and then implement the plan of improvement (Six-Sigma Black Belt course, 2015).

Verification and continuous improvement; concerns the quality procedures required to sustain continuous improvement, control those actions regarding quality and verify the success of the organisational objectives. The aim is to verify the gains that have been attained and to ensure that the improvements are continued and sustained (Six-Sigma Black Belt course, 2015). All of the key drivers above should correspond with the number of CSFs to ensure that the proposed framework is able to meet the main objectives successfully. Therefore, to identify the CSFs needed for successful implementation of the integrated quality management performance, a number of relevant papers were reviewed to select and identify them (Andersson et al, 2006; Johannsen, 2013; Laureani and Antony, 2012; Dahlgaard and Dahlgaard-Park, 2006). The literature (ibid) recommends focus on corporate culture, the human factors of TQM and the success factors related to the Lean Six-Sigma roadmap in order to combine Lean, Six-Sigma and TQM. Therefore, the CSfs for successful implementation of LSS as well as the CSFs for usage of TQM (see (2.6.2) and (2.6.3)). Additionally, the most important factors that have been ranked in this study for successful implementation of LSS model and SS-TQM model (see (4.4) and (5.5.3)), those factors identified as the CSFs to achieve the integrated quality management performance:

1. Organisational structure.
2. Focus on the customer.
3. Links to the supplier.
4. Training and education.
5. Leadership support.
6. Middle management involvement.
7. Quality commitment.
8. Effective communication.
9. Reviews and tracking quality performance.

6.4. Analytical hierarchy process (AHP)

Analytical hierarchy process is a multiple-criteria decision-making technique used for organising and analysing complex decision-making (Saaty, 1980), AHP is based on principles drawn from mathematics and psychology to enable the users to categorise the priorities and make the best decision by minimising the number of complex decisions. The technique relies on computing a series of pairwise comparisons and, then, analysing the results (ibid). Moreover, AHP is a useful technique for checking the consistency of the decision makers, reducing the unfairness of the decision-making process (Vargas, 1990). In the AHP approach, the decision maker creates a pairwise comparison matrix for every pair item assessed in order to determine the weight of every criterion in relation to the criterion in the higher level (Mendoza and Ventura, 2008). The following is a list of the main steps:

Problem modelling: The first step is to structure the problem in a hierarchical model with different levels, the highest level is the main goal followed by the main criteria, sub-criteria and alternatives. The preference of each criterion is evaluating which should be mutually independent (Saaty, 1980).

Conduct the pair-wise comparison: The next step is to conduct the pairwise compression and to find out the comparative weight among the attributes of elements, in which each pair-wise comparison must be consistent. The result of this step is the ranked priorities based on each criterion (Saaty, 1980).

Priorities derivation: Once the comparisons matrix is completed then the priorities can be calculated. In the AHP Eigen value method, the logarithmic least squares method is used to calculate the priority of each criterion (Saaty, 1994).

Ranking the sub-criteria (global ranking): The final step is to calculate the global ranking of the sub-criteria; which means to determine the relative importance of the sub-criteria within the main goal. This can be obtained by considering all the local priorities obtained from the previous step with the application of a simple weighted sum (Saaty, 1980).

Calculation of the consistency rate: The consistency test must be performed to ensure the results obtained are valid and reliable. The consistency index measures the degree of consistency of each criterion (Saaty, 1980) and it does so by using the following equation:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Where the consistency value of CI must be less than 0.1 to be considered consistent.

λ_{max}= is maximal eigenvalue

The consistency ratio, the ratio of CI and RI, is given by: CR = CI/RI.

RI is the random index (the average CI of 500 randomly filled matrices). If CR is less than 10%, then the matrix can be considered as having an acceptable consistency Saaty (1994).

Sensitivity analysis: The last step of the decision process is the sensitivity analysis in which the input data is examined in order to observe the impact on the results. If the rank is not changed, then the results can be considered robust. This sort of analysis can be performed by Expert Choice software (Bayazit, 2005).

6.5. Development of the proposed AHP model

This section explains the components of AHP proposed model, the model developed based on a review of the relevant literature, the model is classified into three levels for pair-wise comparison; the first level is the overall target of the model which is; *integrated quality management performance*, the second level is the main criteria for achieving the overall goal which includes five strategic quality elements namely; (*strategic planning, measurement and evaluation, analysis and activation, improvement and monitoring and finally verification and continues improvement).* The third level for sub-criteria toward the overall goal is illustrated in figure (6.1) below.

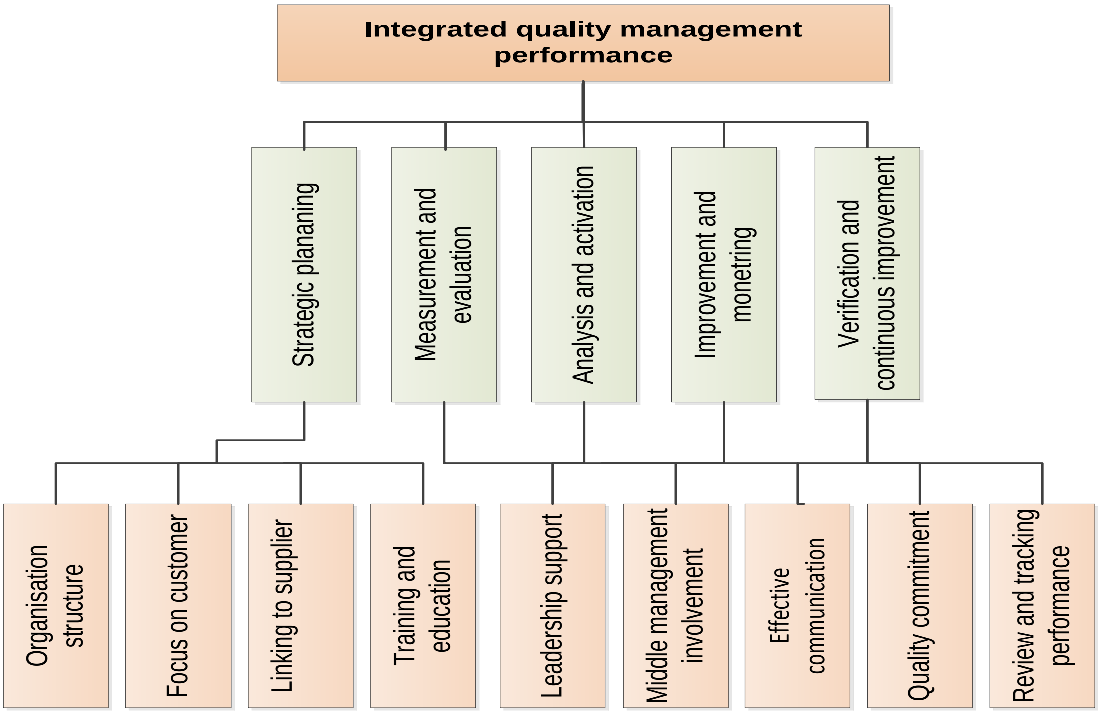


Figure 6. 1. The proposed multi-criteria decision-making model

In this study, all the elements in each level must be compared in pairs to assess its relative importance in relation to the higher level. The purpose is to prioritise and rank every criterion on the second level with the overall target. Next is to determine the local weight of each sub-criteria in the third level with the relative element in the main criteria to assess its relative importance and, also, to establish the global weight of every sub-criteria toward the main goal. This is in order to show the relative importance of each sub-criteria towards the main goal.

6.6. Validation of the proposed AHP Model

In order to validate the AHP model, a questionnaire survey was designed to collect the required data from professionals and academics related to the topic, the aim was to evaluate and decide upon the strategic quality management elements that should form the integrated quality-management performance. The questionnaire was structured into two sections. The first section included one part about the respondent's information to provide background to the participants of the research survey, the other part of this section was to discover which element of the main criteria is most important with respect to the goal of the model. The second section was related to the third level of the AHP model, it was designed to compare the elements in the sub-criteria with respect to the main criteria of the AHP model. The judgement scales used for making the pair-wise comparison were based on the standard scales of AHP (Saaty, 1980) which are shown in table (6.1) below;

Table 6. 1. Likert scale of relative importance

Intensity of importance	Definition and Explanation
1	Equal importance: two activities contribute equally to the objective
3	Moderately important: experience and judgment slightly favour one activity over another
5	Strongly important: Experience and judgment strongly favour one activity over another
7	Very strongly important: an activity is strongly favoured and its dominance demonstrated in practice
9	Absolute importance: the evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments

6.6.1. Data collection and analysis

This section outlines the results of the questionnaire received from the participants and how they were organized for AHP analysis. A total of 70 questionnaires were sent to the relative population across different organisations. The author believes that the set of management employees belong to a trustable target population that can provide reliable responses to the survey questionnaire. 53 questionnaires were completed and returned within the time frame; a percentage considered to be relatively high above the household median (Saunders et al., 2009). The data collected was reviewed for completeness and accuracy; however, no serious errors found and no responses were found to be similar to each other.

6.6.1.1 Respondents background results

Therefore, the results of the first question (respondent's information) figure (6.2) shows years of experience of the respondents, where 20% of the respondents have 1 to 5 years' experience, 12% have 5 to 10 years' experience and 20% of them have more than 10 years' experience.

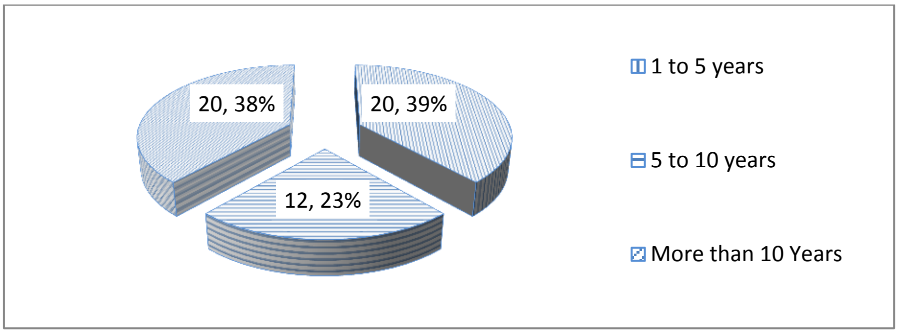


Figure 6. 2. The experience of respondents

Figure (6.3) shows the type of experience of the participants have. The results show; 14% of them are from an industrial background, 21% from an academic background and 11% of them are from both industrial and academics and the rest have other backgrounds, 5%.

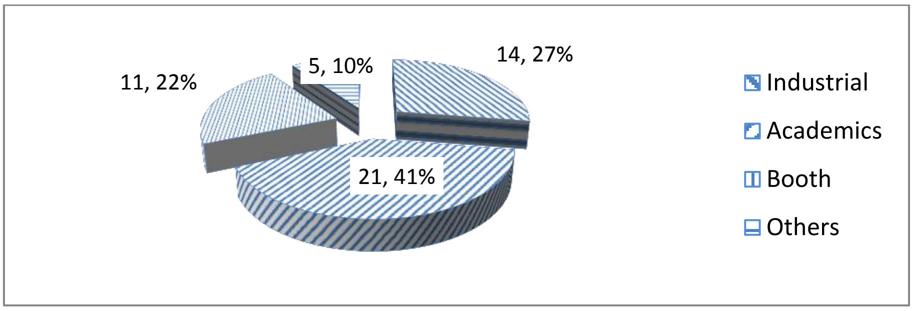


Figure 6. 3. Respondent's information, type of experience

6.6.1.2. Results of data generation

Based on the survey feedback it is apparent that all of the participants agreed about the model. Therefore, the data collected has been converted into a geometric mean to measure pairwise comparison for each criterion through Microsoft Excel, the geometric mean method is the appropriate mathematical technique used to convert the different judgment into one figure for each criterion and sub-criteria (Saaty, 1980). The formula was used to calculate the geometric mean is;

$$\text{Geometric mean} = \boldsymbol{p} = \sqrt[n]{\boldsymbol{a.b.c} \ldots .\boldsymbol{n}}$$

Where:-

$a, .b., c$ are the comparison values for each row and
n is the number of participants

6.6.2. Generating of the comparison matrix

This section outlines how the comparison matrix was generated from the collected data. The comparison matrixes are formulated in each level with respect to the upper level of the model. Thereby, the total number of matrixes generated for this model were 6 matrixes. The elements of the matrices are the values of the geometric mean that were collected by the questionnaire and calculated with Microsoft Excel. The matrixes generated are stated as follows:

The first matrix in table (6.2) compares the main criteria of the model with respect to the main goals: Strategic planning, measurement and evaluation, analysis and activation, improvement and monitoring and verification and continuous improvement as follows:

Table 6. 2. Comparison Matrix of Main Criteria

	Strategic planning	measurement and evaluation	analysis and activation	improvement and monitoring	verification and continuous improvement
Strategic planning	1	4	4	4	4
measurement and evaluation	1/4	1	2	3	3
analysis and activation	1/4	1/2	1	2	3
improvement and monitoring	1/4	1/3	1/2	1	3
verification and continuous improvement	1/4	1/3	1/3	1/3	1

The second matrix in table (6.3) compares the sub-criteria covering: Organisation structure, focus on customer, links to supplier and training and education with respect to strategic planning;

Table 6. 3. Comparison Matrix of sub-Criteria with respect to strategic planning

	Organis ation structure	focus on customer	linking to the supplier	training and education
Organisation structure	1	3	3	3
focus on customer	1/3	1	3	3
links to supplier	1/3	1/2	1	2
training and education	1/3	1/3	1/2	1

The third matrix in table (6.4) is to compare the sub-criteria: leadership support, the involvement of middle management, effective communication, quality commitment and review and tracking performance with respect to measurement and evaluation.

Table 6. 4. Comparison matrix of sub-criteria with respect to measurement and evaluation

	Leadership support	middle management involvement	effective communication	quality commitment	review and tracking performance
Leadership support	1	3	3	3	3
middle management involvement	1/3	1	2	1	3
effective communication	1/3	1/2	1	1/2	2
commitment to quality	1/3	1	2	1	3
review and tracking performance	1/3	1/3	1/2	1/2	1

The fourth matrix in table (6.5) is to compare the sub-criteria; leadership support, middle management involvement, effective communication, commitment to quality and review and tracking performance with respect to analysis and activation.

Table 6. 5. Comparison Matrix of sub-Criteria with respect to analysis and activation

	Leadership support	middle management involvement	effective communication	quality commitment	review and tracking performance
Leadership support	1	3	3	2	3
middle management involvement	1/3	1	3	2	3
effective communication	1/3	1/3	1	1	3
commitment to quality	1/2	1/2	1	1	3
review and tracking performance	1/3	1/3	1/3	1/3	1

The fifth matrix in table (6.6) is to compare the sub-criteria; leadership support, middle management involvement, effective communication, commitment to quality and review and tracking performance with respect to improvement and monitoring.

Table 6. 6. Comparison Matrix of sub-Criteria with respect to improvement and monitoring

	Leadership support	middle management involvement	effective communication	quality commitment	review and tracking performance
Leadership support	1	3	3	2	3
middle management involvement	1/3	1	2	1/2	2
effective communication	1/3	1/3	1	1	3
commitment to quality	1/2	2	1	1	3
review and tracking performance	1/3	1/2	1/3	1/3	1

The final matrix in table (6.7) is to compare the sub-criteria which are; Leadership support, middle management involvement, effective communication, commitment to quality and review and tracking performance with respect to verification and continuous improvement.

Table 6. 7. Comparison Matrix of sub-Criteria with respect to verification and Continuous improvement

	Leadership support	middle management involvement	effective communication	quality commitment	review and tracking performance
Leadership support	1	3	3	3	3
middle management involvement	1/3	1	2	2	3
effective communication	1/3	1/2	1	1	2
commitment to quality	1/3	1/2	1	1	2
review and tracking performance	1/3	1/3	1/2	1/2	1

6.6.3 Pairwise matrix evaluation

The study employed Expert Choice software to evaluate and deriving the priorities between the criteria and sub-criteria of the proposed AHP model. The Expert Choice software applied the Eigenvector method to derive the priorities from the AHP model, the priorities of the proposed model were derived through five steps listed as follows;

6.6.3.1 Problem modelling

In this step, the prioritising model is structured using the Expert Choice software from the goal (Integrated quality management performance) followed by the main criteria and sub-criteria, figure (6.4) shows the hierarchical view of the entire structure of the prioritising model as created by Expert Choice.

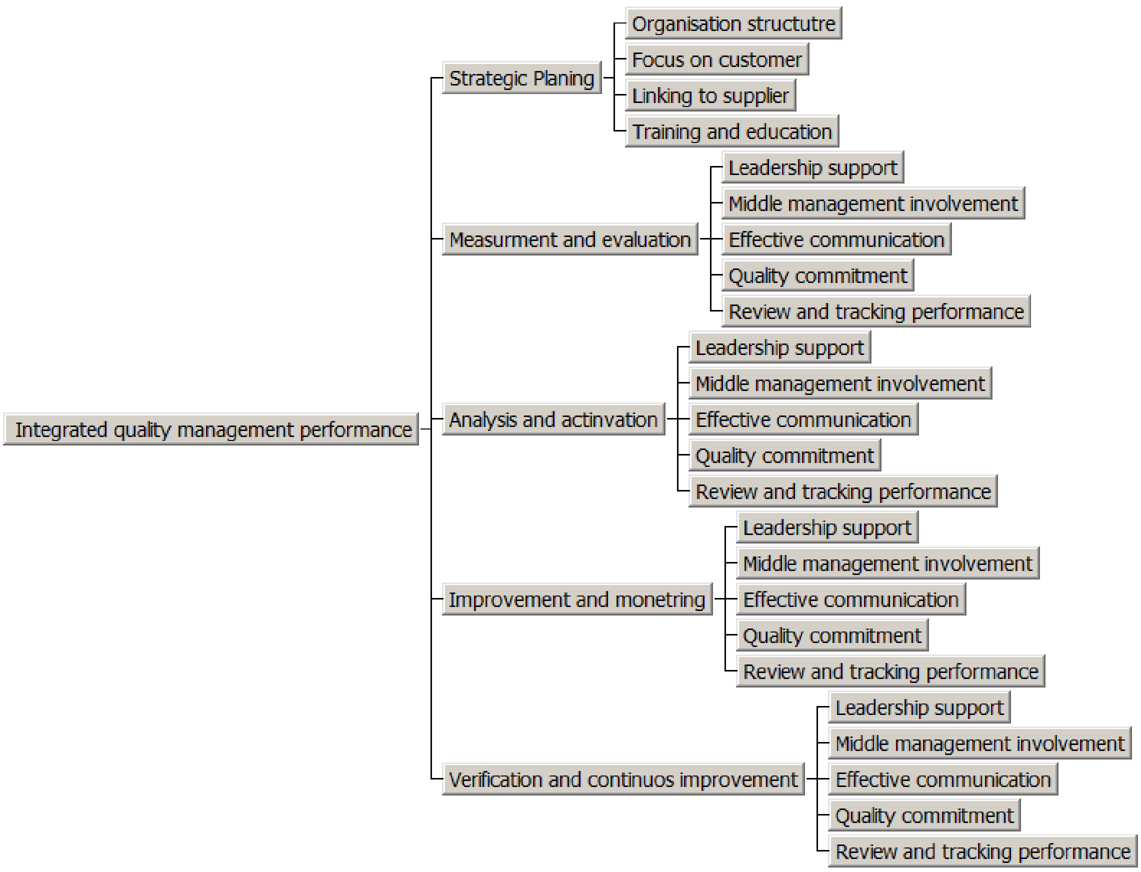


Figure 6. 4. A hierarchal view of the entire structure of the prioritising model

6.6.3.2. Conducting the pairwise comparison

Once the problem was structured, the matrixes at each node of the hierarchy was entered for a pairwise comparison through the use of ratio scale (Kainulainen et al. 2009). Thereby, the data was entered into each pairwise comparison as shown in figure (6.5) and the other comparison matrixes completed in same way.

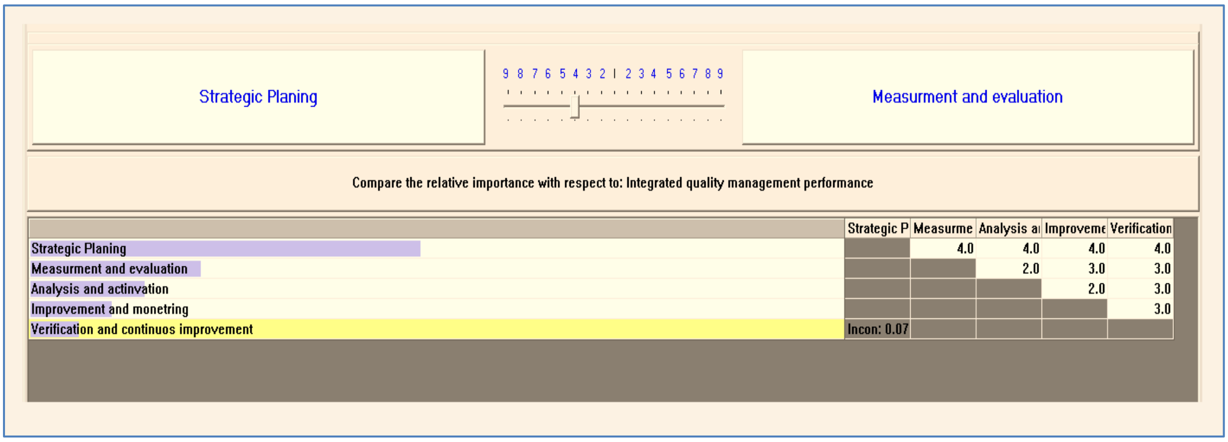


Figure 6. 5. Pairwise comparison

6.6.3.3. Consistency and weight determination

Once the comparison judgement is entered for each matrix, the consistency is automatically calculated by the Expert Choice, it is also possible to assess the highest criteria that contribute to consistency by Expert Choice. Figure (6.6) demonstrated the consistency of the main criteria with respect to the model goal.

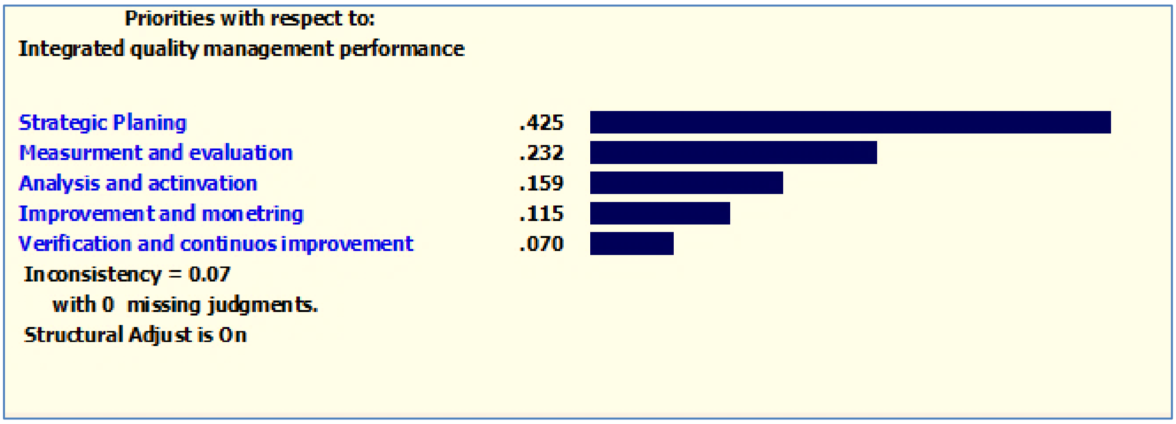
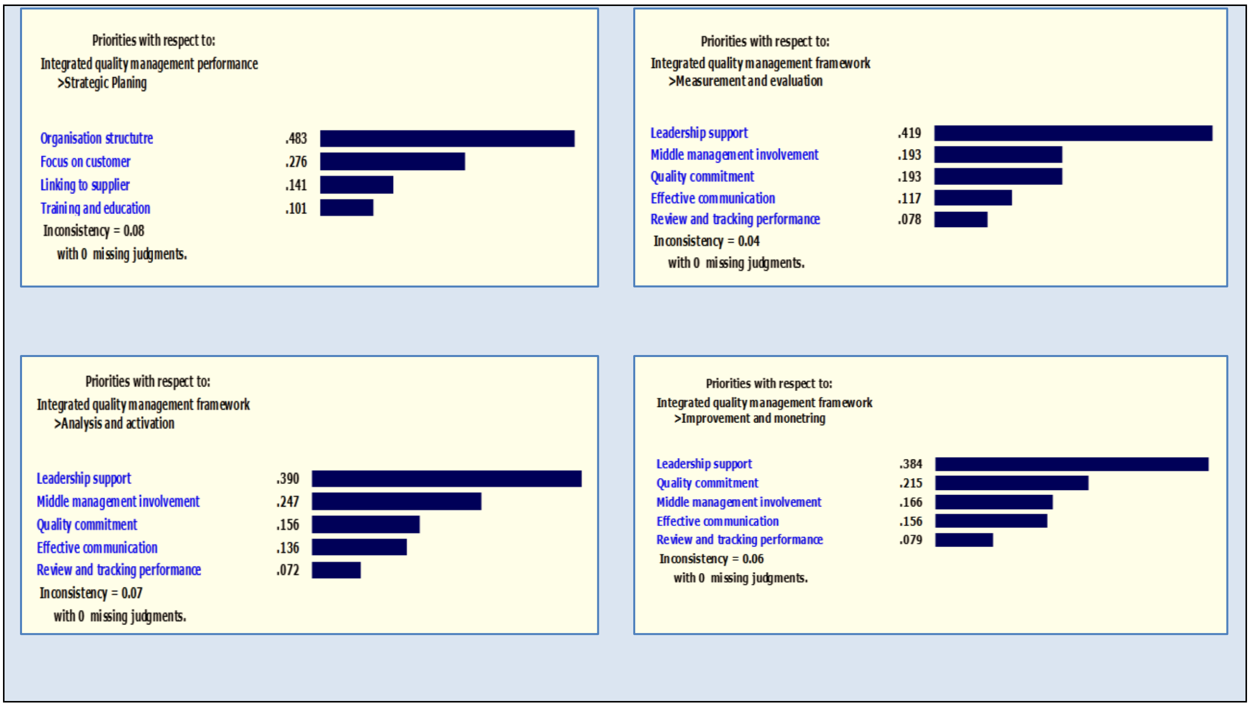


Figure 6. 6. The priority preference of the main criteria

In addition, figure (6.6) (above) demonstrated the priority weights for the main criteria in the first level with respect to the main goal (Integrated quality management performance), in which strategic planning is the most important criteria to the main goal with weight 0.425 followed by measurement and evaluation; 0.322. Next was analysis and activation; 0.159, then, improvement and monitoring; 0.115 and the least important criteria are verification and continuous improvement weighted at 0.070. The overall consistency ratio is 0.07, which is less than 0.1. Therefore; it can be confirmed that the results are valid and reliable.

6.6.3.2. Results of the priority preference of sub-criteria with respect to main criteria

The results of the priority preference of the sub-criteria, with respect to the main criteria, were generated from Expert Choice and organised respectively in figure (6.7) to illustrate the weights of each sub-criteria with respect to its relative to the main criteria.



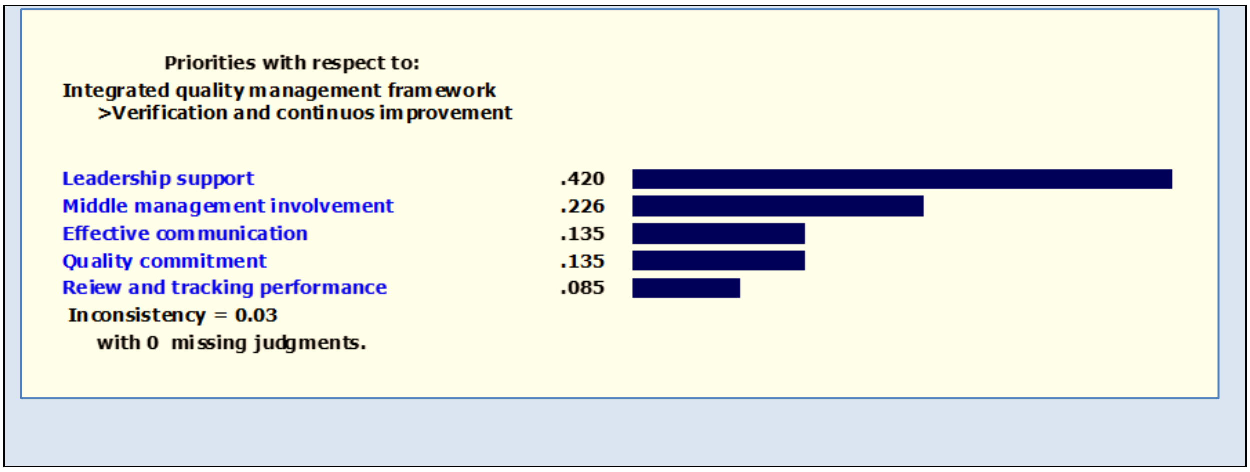


Figure 6. 7. The priority weights of the sub-criteria with respect to Strategic planning

As can be seen in figure (6.7) above the results of weights for each sub-criterion with respect to the relative main criteria are displayed, the overall consistency for each evaluation showed less than 1.0 which indicated that the results are valid and reliable. Therefore, the priority of each sub-criterion towards the main criteria is demonstrated.

6.6.3.3. Synthesizing the results

After determining the local priorities for the criteria and sub-criteria through the pairwise comparisons, a synthesis analysis was performed to determine the global priorities of sub-criteria with respect to the goal. A synthesis analysis shows the relative importance of the sub-criteria with respect to the goal and the overall consistency of the entire model, in which consistency measure is a crucial approach to identify any possible errors in the judgments.

6.6.3.4. Results of the priority preference of the global weights

Based on a synthesis of the results, figure (6.8) shows the results of the global weights for the sub-criteria with respect to the model goal, where the most important sub-criteria, with respect to the main goal, is leadership support with a weight of 0.249 followed by organisational structure, 0.184; next, middle management involvement at 0.128 with the remainder weighted as follows;

Quality commitment 0.111

Focusing on customer 0.105

Effective communication 0.802

Linking to supplier 0.054

Review and tracking performance 0.048

Finally, training and education weighted at 0.038

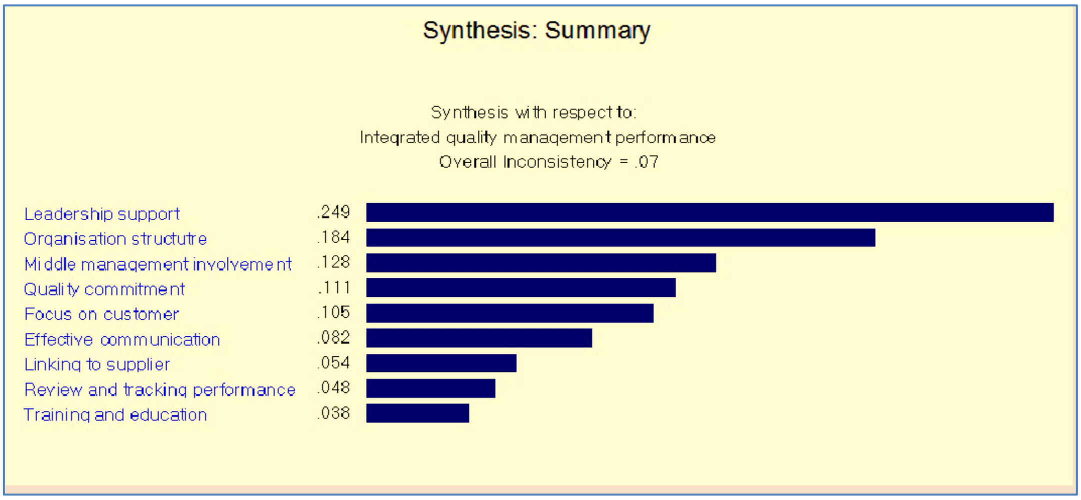


Figure 6. 8. The priority global weights of the sub-criteria

6.6.4. Sensitivity analysis

Sensitivity analysis is essential to approaching the decision-making process as it enables the decision maker to understand the sensitivity of alternatives with respect to all criteria in the table below. (Expert Choice, 2002). Thereby, implementing sensitivity analysis is crucial to ensure the reliability of the final decision through the investigation of different scenarios, and observation of the impact of changing the priority of the criteria on the alternative ranking system (Bayazit, 2005). Therefore, to implement sensitivity analysis the input data is slightly modified to observe the effect on the outcomes and if the ranking does not change then the results considered to be robust (Saad and Gindy, 2007). Expert Choice offers four graphical sensitivity analysis modes; the differences are shown in various graphical representations. In this study, a dynamic sensitivity analysis was selected to discover the impact of the different alternatives.

Figure (6.9) demonstrates the actual results of the sensitivity analysis with respect to the main goal (integrated quality management performance), where strategic planning is the most important main criteria with a priority of 42.5% followed by measurement and evaluation 23% then analysis and activation 15.9%, after that, improvement and monitoring at 11%. The least important criteria are verification and continuous improvement with a weighting of 7%. Whereas, the most important quality management factor in the sub-criteria is leadership support with a priority of 25% followed by organisational structure, 18.4%; then, middle management involvement 12.8%, the rest of factors are ranked, respectively, as follows:

Quality commitment 11.1%

Focus on customer 10.5%

Effective communication 8.2%

Linking to supplier 5.4%

Review and tracking performance 4.8%

However, training and education were ranked as the least preferred quality management factors with a preference weight 3.8%.

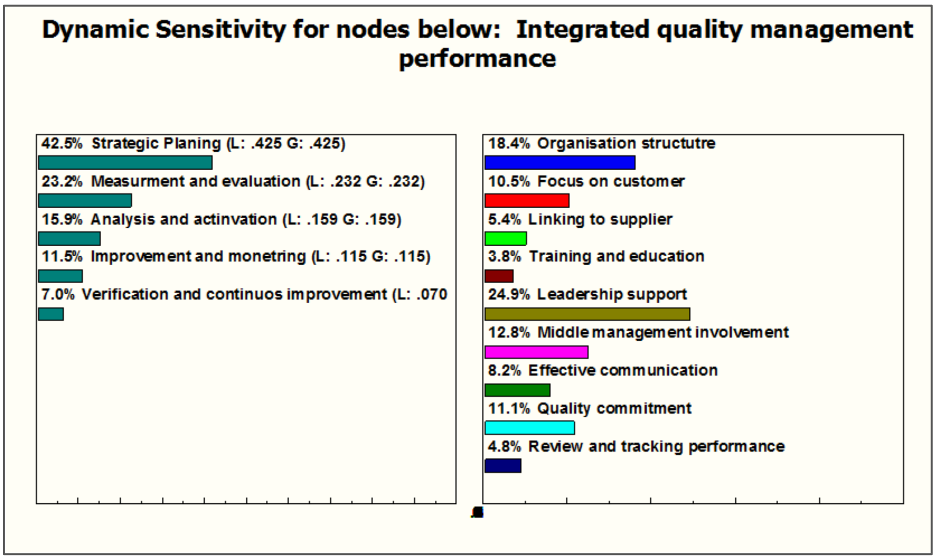


Figure 6. 9. The actual results of the sensitivity study with respect to the goal

Five scenarios of sensitivity analyses were carried out to investigate the impact of changing the priority of the main criteria with the overall results, the results of the sensitivity analysis were generated from the Expert Choice software and organised respectively as shown in figure (6.10).

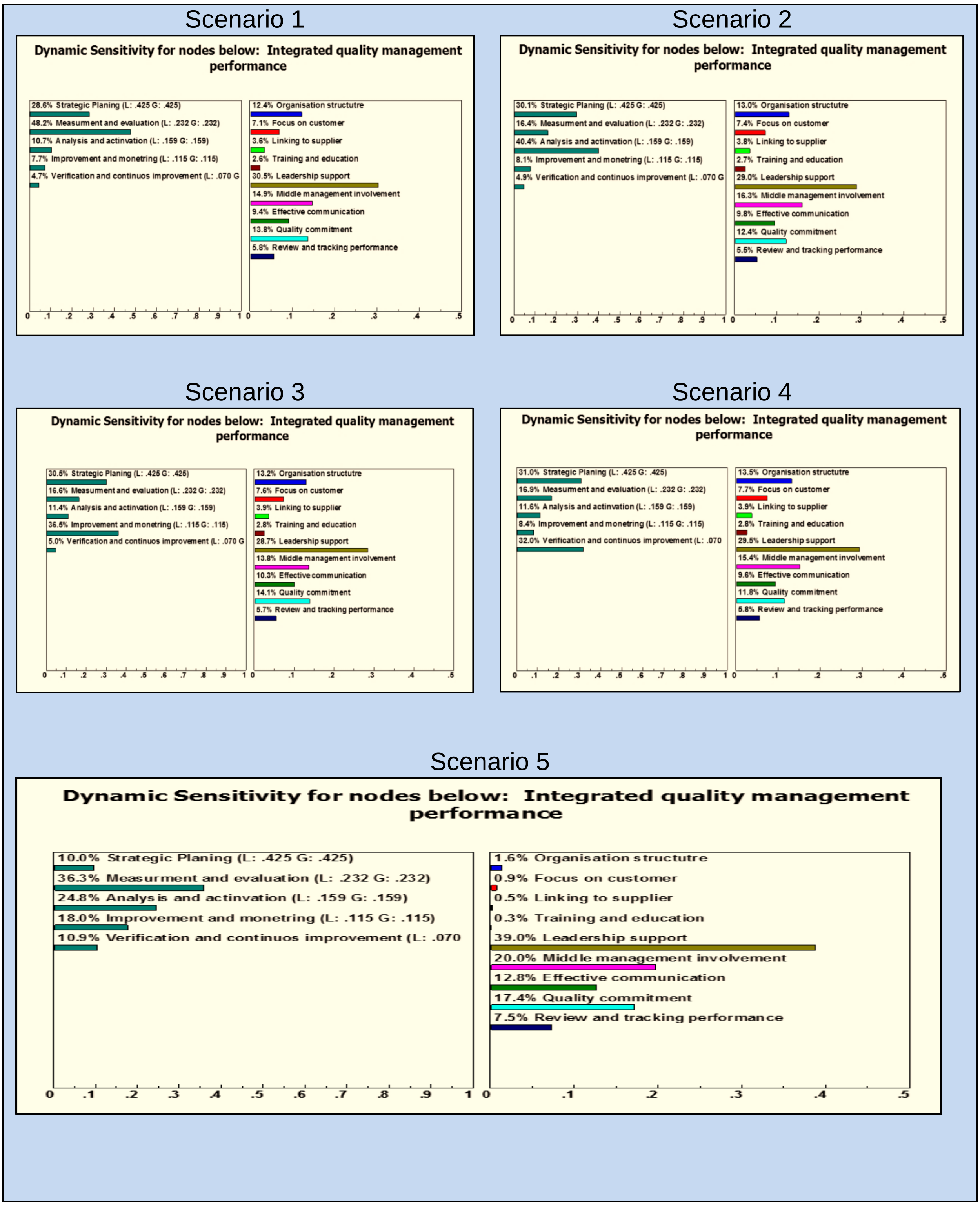


Figure 6. 10. Five scenarios of sensitivity results from the first scenario

The first scenario, in which the importance of measurement & evaluation is recorded, increased by 25%, from 23.2% to 48.2%. The results indicated that leadership support, organisation structure and middle management involvement are still the most preferred quality factors, although the three-factor rated least important changed from (Training & education, Review & tracking performance and Linking to supplier) to (Training & education, Links to supplier and Review & tracking performance) with preferred weights of 2.6%, 3.6% and 5.8%, respectively. However, the alternative priority of the other quality factors remained stable.

The situation in scenarios, 2, 3, and 4, as shown in figure (6.10), was that the important criteria in each scenario increased by 25%, the results showed that the alternative ranks are not sensitive to change and the priorities of the quality factors towards the goal remained the same in all cases, as was the case with the first scenario. However, in scenario number 5 the importance of strategic planning is decreased to 10% and become the least important of the objectives under the main goal. The results in figure (6.10) demonstrated that leadership support, middle management involvement and quality commitment become the most important factors with weightings of 39%, 20% and 17.4%, respectively. While there are other factors related to the importance of strategic planning, organisational structure, customer focus, links to the supplier and training & education are more sensitive to change and were returned as the least important factors with the weights 1.6%, 0.9%, 0.5% and 0.3%, respectively.

In general, the sensitivity analysis indicated that leadership support is prevalent and the other top three preferred factors, middle management involvement, organisation structure and quality commitment, remained at the top throughout the scenarios. As such, they should be selected as the most effective quality management factors for integrated quality management performance.

6.5. Discussion

Analytical Hierarchy process methodology was applied to evaluate the effectiveness of the strategic quality management drivers and the critical quality factors towards integrated quality management performance. The results of AHP in the main criteria demonstrated that strategic planning is the most effective driver towards the integrated quality management performance followed by measurement and evaluation then analysis and activation and, after that, improvement and performance, the least important driver is verification and continuous improvement. The results in this part are considered to be sensible and logical since the elements of the main criteria were built, based on DMAIC strategy of Six-Sigma, in which each phase relies on the previous phase in terms of assessing the process performance and achieving the tasks relating to quality. In addition, the AHP results demonstrated that the most important critical quality factor in sub-criteria, with respect to the main goal, is Leadership support followed by the organisational structure. While the least important factor is training and education. However, the importance of priority weighted for each quality factor, with respect to the relative criteria, can be seen in figure (6.11). Here it is shown that organisational structure is the most important factor with training & education is the least important factor. Whereas, the most important factor for the other criteria is leadership support followed by middle management involvement and quality commitment. In most cases of the analysis, the least important quality factor, with respect to all strategic drivers, is review and tracking performance.

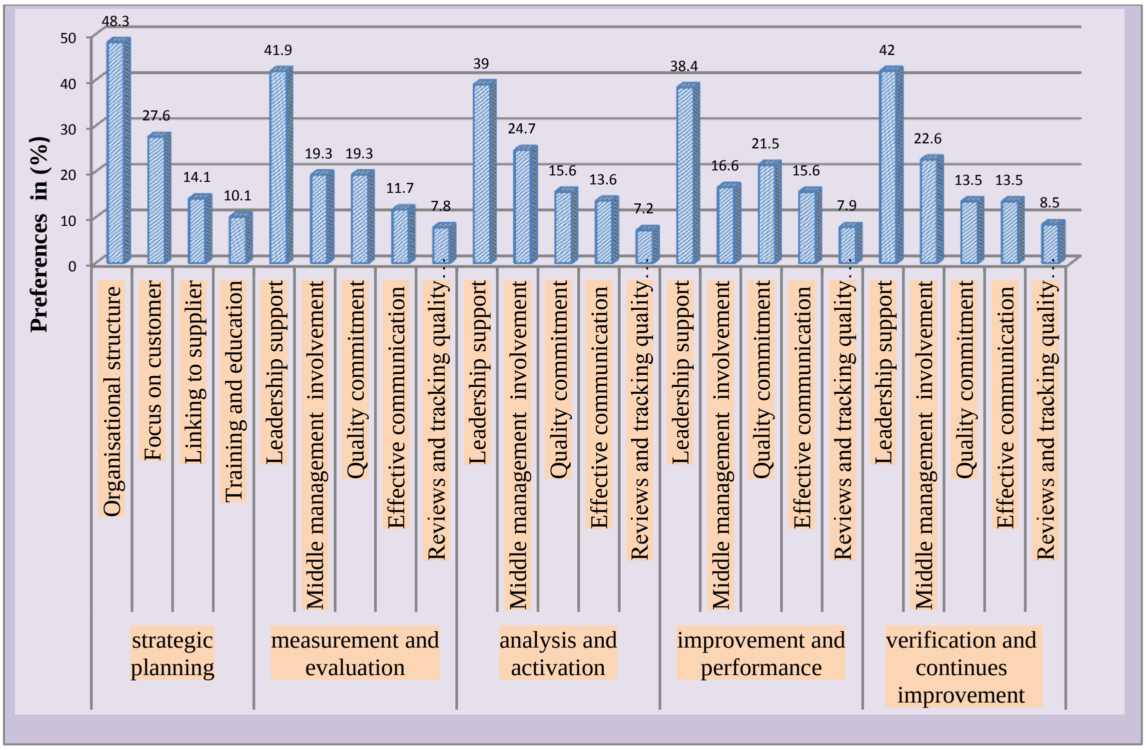


Figure 6. 11. The priority weights of the strategic drivers with respect to the goal

Based on the above results, the AHP demonstrated that the strategic planning driver is more important than the implementation and operation drivers with respect to integrated quality management performance; it revealed that leadership support, organisational structure and middle management involvement are the most important critical quality factors in terms of successful implementation of the strategic drivers and attaining integrated quality management performance. Through sensitivity analysis, a decision maker can observe the best scenario when the importance of the main criteria is changed up and down to arrive at the best combination which suits, or is most effective, to the integrated quality management performance.

6.6. Conclusion

Integrated quality management performance is one of the crucial approaches in today's competitive quality management system. It is reasonable to evaluate the reliable and effective strategy that can lead to the creation of sustainable improvement and achieve a competitive advantage. In this study, the strategic drivers for achieving an effective integrated quality management performance have been selected and evaluated based on the AHP methodology. The proposed model highlighted the relative importance of each criterion with respect to the upper level, through the data collection stage, quality professionals, industrialist and academics who were involved with the model devolved based on their opinion collectively. The local and the global ranking was performed and the validation carried out by the consistency check with AHP.

The study concluded that the strategic planning drivers are more important than the implementation and operating drivers. Additionally, there are critical quality factors which should attract considerable attention for the successful implementation of the strategic drivers and attain integrated quality management; leadership support and organisation structure. The sensitivity study gave a picture about how the changing of priority in one criterion affects the other. Finally, this information is also significant to the decision maker who desires to improve the operation performance and identify quality management.

Chapter Seven

Development of an integrated quality management framework for manufacturing organisations (IQM-FW)

7.1. Introduction

Based on the literature review, the research study was developed and the two models were validated (the LSS integrated model for improving the manufacturing process within manufacturing organisations profoundly discussed in chapter four and SS-TQM integrated model for unifying the management system and achieving business excellence within manufacturing organisations deeply discussed in chapter five). In this chapter, the study presents the development of the proposed framework and provides the main procedures that are necessary for successful implementation the proposed framework.

7.2. The proposed integrated quality management framework

Scheer and Nüttgens (2000) advised that quality management framework should be simple, logical and, yet, comprehensive enough to be successful in the implementation process and attain improvement in the level of performance. Aalbregtse et al. (1991) defined the framework as a conceptual structure intended to guide and supports the practitioners to overcome managerial and operational problems and achieve the desired results. Therefore, the proposed framework will be described as follows. The process of developing the proposed framework is a result of integrating LSS model and SS-TQM model (discussed in chapter 6), in which the strategic element of both models is integrated to formulate an effective platform for planning the operation system and facilitating the implementation procedures of the framework. The operation elements of the LSS model is integrated with both the implementation elements and the business excellence elements of SS-TQM model in order to provide impetus and guidance for quality improvement and for attaining performance excellence in the manufacturing organisations. However, Six-Sigma DMAIC improvement is adopted as the key strategy of the framework for identifying opportunities for improvement and for obtaining the operation performance. Accordingly, the framework consists of three main components which are:

7.2.1. The main body of the framework

The structure of the framework is represented by flowchart diagram in figure (7.1) which displays the framework activities and the integrated functions. The development of the flowchart is mainly based on the literature review and the findings of the AHP model in which the components of the framework were evaluated and prioritised.

7.2.2. The main elements of the framework

The set of quality tools, statistical tools and global tools employed to formulate the stages of the framework are also prioritised and organised based on DMAIC strategy to deliver the tasks step-by-step in order to provide the opportunity for quality improvement and to overcome quality problems. The development of these elements is based on the literature review and according to the strategy of the black belt and green belt of ASQ (Pysdek and Keller, P., 2003).

7.2.3. The operational mechanism of the framework

The work activities and the functions of the framework are organised based on the trend of DMAIC methodology, where the stages, processes and steps of the framework are integrated to gather and to simplify the operation process and to attain an effective quality of performance. This mechanism is designed as an integrated and unified system to operate the framework, the development of these integrated functions and mechanism is based on the literature review and the application of black belt and green belt of ASQ (Pysdek and Keller 2003).

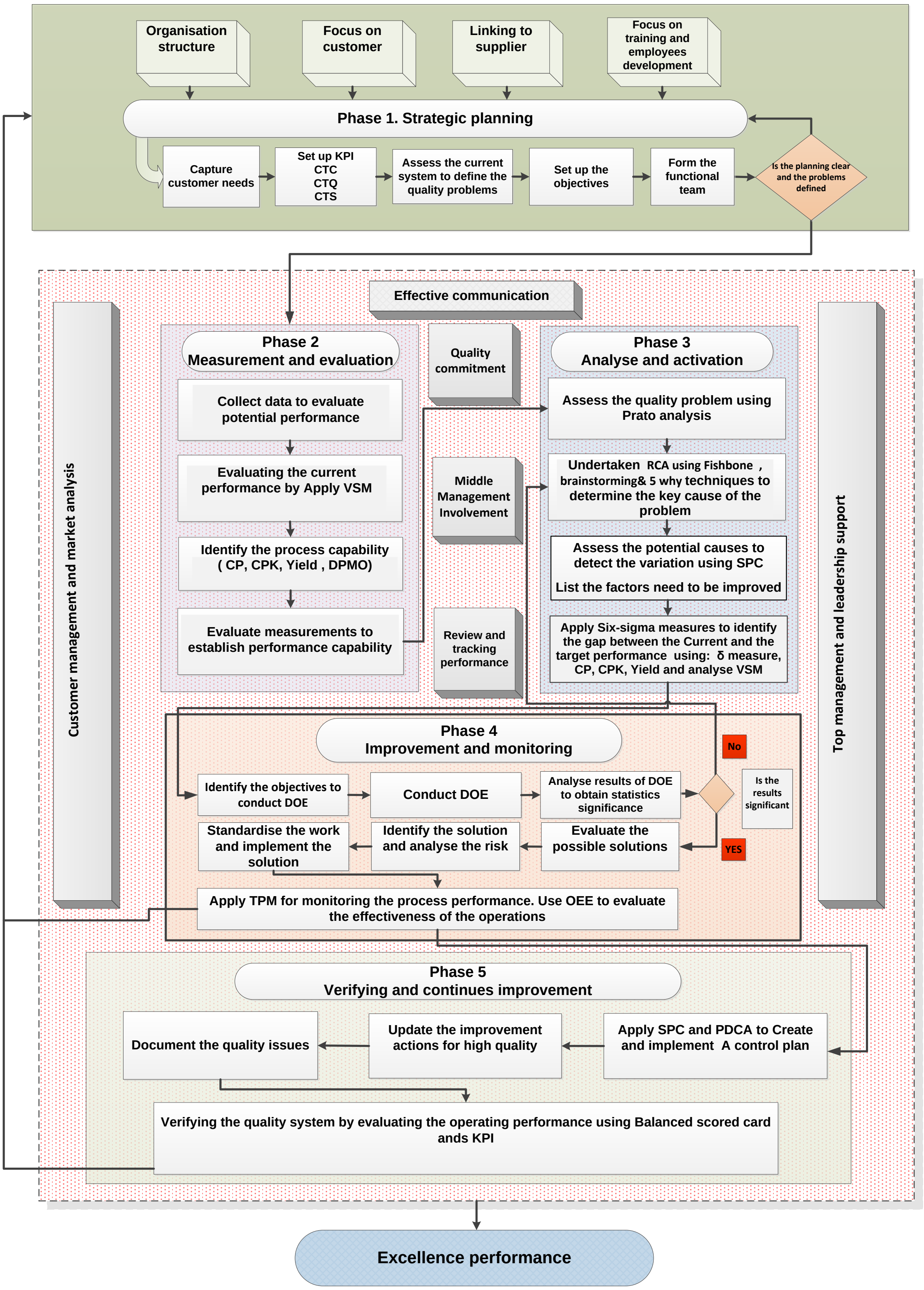


Figure 7. 1. An integrated quality management framework for manufacturing organisations

7.3. The implementation procedures of IQM framework

The components of the IQM framework were developed gradually and were based on the literature review and on what was learned from integrating LSS model and SS-TQM model. It also evaluated and prioritised using AHP in the previous chapter. Accordingly, the implementation processes of the IQM framework have been designed, sequentially, to be implemented in five phases, each phase concerned with the completion of its tasks through a number of stages. The development of the implementation procedures of IQM framework was adopted based on the sequences of DMAIC procedures; in which *Phase1 - Strategic planning*, *Phase 2 - Measurement and evaluation* and *Phase 3 - Analysis and activation* and *Phase 4 - Verification and continuous improvement.*

7.3.1. Phase1: Strategic Planning.

Strategic Planning is an organisational management process for defining its strategy and making decisions in order to allocate its resources, assess the current organisational performance and set up the organisational objectives in which to achieve success in the implementation process and attain the desired goals.

Strategic planning is the first phase of the integrated framework to coordinate and align the ongoing process by determining the mission and identifying the final vision. The strategic planning phase comprises two main elements; strategic soft factors and strategic planning steps:

7.3.1.1. Strategic soft factors

Strategic soft factors are the key factors that are a positively affect on the strategic planning process; therefore, the soft strategic factors must be paid considerable attention before starting in the planning process, soft strategic factors are complemented with the strategic steps to implement effective strategic planning which enable the organisation to succeed with the implementation process and achieve the desired performance. The strategic soft factors cover the key elements including the four main factors*; organisational structure, focusing on the customer, linking to the supplier and focuses on training and education*.

7.3.1.1.1. Organisation structure; is the pattern of the organisation's activities that are divided, organised and coordinated in which supervision is directed toward the achievement of the organisational goals (Antony,2002). Organisations can be structured in a different way depending on its objectives; however, the organisation should start to focus on these factors before starting the planning process.

7.3.1.1.2. Customer focus; Hellsten and Klefsjö (2000) stated customer focus is the driving force of the process improvement and quality development, as such, in the planning process, customer focus should give prior attention to understanding its requirements proactively and, hence, take action to consider its ongoing process.

7.3.1.1.3. Linking to supplier; suppliers are the first stage of delivering quality improvement in which the task of the supplier is to fulfil the requirements of the organisations in terms of delivering quality input (Demirbag et al., 2006), the importance of establishing links to the supplier is to create and sustain a superior relationship with reliable suppliers in order to provide a high-quality input such as providing raw materials and other required services.

7.3.1.1.4. Training and education; Ishikawa (1989) stated that training and education are vital in determining the success of any quality management framework. Oakland (2000) and Porter and Parker (1985) stated that training is a critical factor for the success any quality management programme. Therefore, training and education are the other significant soft strategic factors that must be considered in order to create successful strategic planning.

7.3.1.2. Strategic planning steps

Strategic planning steps are the key steps to formulating quality management planning and defining the current quality problems. This phase including five steps to complete the strategic planning listed below.

7.3.1.2.1. Capture customer needs;

In this step, the customer requirements are determined to obtain the baseline measurement of customer satisfaction, hence, to determine the value of the customer. Voice Of Customer (VOC) is the appropriate tool to employ, where VOC has four steps; identify the customers based on customer segmentation process and SIPOC technique, gather customer information by applying customer information sources, analyse customer information using the two main quality tools; the Affinity diagram and Kano analysis. Finally, determine customer needs using CTQ or QFD techniques to translate customer needs to specific requirements.

7.3.1.2.2. Set up KPIs (Key Performance Indicators)

Based on the information derived from VOC, and according to the products and services specification, the role of KPIs is to establish the *milestone* of the business performance, which includes; product performance metrics, the performance of the business process and the performance of quality improvement. Therefore, KPIs can be defined as the process of establishing the standards and metrics to ensure the strategic planning is being followed.

However, KPIs, in general, are divided into; CTQ (critical to quality), CTC (critical to cost) and CTS (critical to schedule).

CTC; Critical-To-Cost is a metric including the typical cost of tasks and estimation of hidden cost such as are incurred in the cost of poor quality.

CTQ; Critical-To-Quality is the attributes of parts, assembly, sub-assembly and the process which has a direct impact on actual or perceived quality. CTQ enables organisations to identify a valid metrics that are required to be generated from the processes in order to assist the organisation to meet customer satisfaction.

CTS; Critical-To-Schedule is the metrics related to the cycle time and the scheduling of the operation process.

7.3.1.2.3. Assess the current system and define quality problems

In order to set out effective goals for improvement, the whole business and operation process should be evaluated to identify the current quality problems. This step can be obtained by defining the voice of the process (VOP), in which VOP is a quality management term used to describe the ability of the process performance with respect to customer expectation. Evaluating the current performance is mainly taken place in a further phase. However, quality problems must be assessed with respect to the customer requirements to establish effective improvement objectives. The typical quality tools and techniques that can be employed to diagnosis the quality problems in this phase is the ‘5 Why’ tool, where, in most cases, the quality problem is caused by human factors or process variation (Pyzdek, 2014).

7.3.1.2.4. Set up the objectives

The organisational objectives in quality management are the steps which progress towards the achieving of the organisation’s goals. As such, the organisation objectives should be identified, prioritised and organised in order to address the quality problems and achieve the final goals. This task is a team brainstorming session aimed to build up the sequential steps in order to achieve the desired results.

7.3.1.2.5. Formulate a functional team

After the quality management plan is developed, reviewed and approved based on the previous steps, then the leadership, in communication with the chief executive, have to specify the functions and the responsibility of each team based on the organisational objectives. In addition, they have to establish a training program to enable the employees to improve their ability and understanding how to lead their tasks effectively. The team functions in this framework must be planned based on the roles of the LSS and TQM approaches, where the tasks being delivered are based on top-down management. These tasks are integrated with the management activity of TQM (QCC and QIT) to enable the system to establish the opportunity for continuous improvement. They also simplify the implementation process by involving everyone in the organisation under the supervision of middle management and leadership support.

By the end of the strategic planning stage, the planning team should ensure that the strategic planning is clear and that the quality problems are identified. If there is something missing, or not clear, the strategic plan must be reviewed again. If the strategic plan is confirmed, then the tasks of the next phase should be started.

7.3.2. Phase 2; Measurement and evaluation

The main objectives of this phase are to evaluate the current quality system, via collecting the required data in order to assess the process behaviour, determine the bottleneck and the area of waste by studying the current VSM. Then, evaluate the performance of the process using PCA, finally evaluating the measurement system. This phase consists of the following stages:

7.3.2.1. Data collection to evaluate the current process performance

The main objectives of this stage are to evaluate the process behaviour, this can be carried out by collecting data to assess the behaviour of the process and, in doing so, identify the current performance. A set of statistical tools are mainly employed to carry out these tasks; SPC tools including control charts, Proses capability analysis (Cp and Cpk), DPMO and process Sigma level (σ). In which control charts give an indication of the process behaviour, process capability analysis Cp, Cpk work to predict and identify the process performance. However, the desired performance can be identified based on analysing the sigma level or/and DPMO based on CP/Cpk results in next phase.

7.3.2.2. Evaluating the current process by studying the current VSM

The purpose of this process is to evaluate the operation processes by applying the Value Stream Mapping technique. VSM reveals both the flow of product, materials and information from the supplier to the customer. VSM is a technique used to illustrate the flow of the operational processes to identify how the process is working and determine the bottlenecks that are hindering the stream of the process, thereby, identifying the areas that need be improved (Drohomeretski et al., 2013). Therefore, in this phase, VSM is used to identify the bottlenecks, wastage and assess the potential improvements of the quality system. Using the results of VSM, the analysis will be undertaken to study the causes of the poor performance in next step.

7.3.2.3. Evaluating the measurements system to establish the performance capability

The purpose of this step is to evaluate the measurement system in order to ensure its accuracy at all time. This can be achieved by employing Gage R+R (repeatability and reproducibility) which is an effective tool that can standardize and control the variations within the measurement system.

7.3.3. Phase 3; Analysis and activation

This phase is concerned with analyzing the gap between the current and the desired performance, the main role of this phase is to identify and analyze the root causes of the problems. In this phase, the set of statistical tools and techniques is used to identify and analyze the causes of the problems and, finally, to determine a list of factors based on root cause analysis to proceed to the Design of Experiment (DOE) in a further phase. This phase including four main stages as follows.

7.3.3.1. Evaluating the quality system and identifying the significant problems

The aim of this stage is to identify quality problems which would be analyzed step-by-step in later stages. Therefore, Prato chart is a crucial tool for identifying the most significant problems affecting the quality system.

7.3.3.2. Undertaken RCA to analyse the causes of the problems

A set of quality tools is organised sequentially in this stage to quantify, identify and analyse the causes of the problems. This is typically initiated with a cause and effect diagram to classify and quantify the causes overall and define the problems based on brainstorming session by the quality team. The causes and effect matrix is a method which ranks the causes of the problems. FMEA is a vital technique used to rate the causes of the problem based on the severity, likelihood and detecting the possibility of potential causes of problems occurring in the process, determining the risk priority number (RPN) of the potential causes of the problem. Through these steps, the main causes of the problems are qualitatively and quantitatively analysed, in the next stage the key causes will be statistically analysed (Six-Sigma Black Belt Course, 2015; Pyzdek and Keller, 2014).

7.3.3.3. Applying SPC to analyse the potential causes of the problems and detect the variation

Once the behaviour of the process is revealed, then the quality team must be focused on analysing the sources of variation of the problems, this requires the use of sophisticated statistical tools in order to obtain a variation reduction. Therefore, Six-Sigma Black Belt course (2015) recommend the following three steps; one is to develop a graphical representation of data to detect pattern, then, to apply hypothesis testing to detect the sources of the causes and subsequently to reduce the variation. Finally, the lists of factors that need to be improved are identified. This can be achieved successfully using statistical software, such as Minitab, which offers simple ways to conduct this kind of analysis. However, a set of advanced statistical analysis can be used in this stage dependent on the situation and the type of data, in practice, the hypothesis statistical analysis assists by avoiding the high cost of experimental efforts through the use of existing data. It also establishes a degree of confidence that can support team decisions.

7.3.3.4. Identifying the gap between the current and the desired performance

The purpose of this stage is to determine opportunities for the improvements by assessing the value that will be added. This is determined by the causes of the problems that have been identified in the previous stage and, also, based on the results of the data evaluation in the previous phase, the behavior of the process was identified, the variation of the process determined and the defectives and the waste quantified. Subsequently, the gap between the current and the desired performance can be statistically identified. This is based on the Sigma process, where the current sigma level is calculated based on PCA results. The desired sigma level is statistically calculated based on the Six-Sigma target causing the potential improvement to be identified. Finally, the setting up of the actual process capability is based on the variation reduction and value added. In this phase, the most common tools to use are; VSM - to analyse the waste and bottlenecks then redesign the process activities, Rolled Throughput Yield (RTY) - to determine the corrected and non-corrected activities and to find the final process capability PCA.

7.3.4. Phase 4; Improvement and monitoring

The aim of this phase is to identify, investigate and confirm the solution to the problems and, then, implement the improvement plan. The role of this phase is to evaluate the causes of the problems in order to predict its effects on the process output. This phase is based on design of experiment method (DOE) The experiment focuses on assessing the process input (causes of the problems) in order to predict the effects on the output and then optimise that input. However, the input factors are often selected based on statistical analysis obtained in the last phase. DOE is considered an experiment within investigations into those factors. Therefore, the mechanism of DOE is used to set up the required objectives and the conditions to conduct experimentation, then there is an investigation into the relationship between the proposed factors and an effort to identify the type of interaction. Subsequently, this will pinpoint the effects of the proposed factors on the response, ultimately, consolidating and confirming the process of improvement. This phase comprises seven steps which follow:

7.3.4.1. Identification of the objectives needed to conduct DOE

The key objectives of DOE are identified based on causes of the process or product problems and by determining an effective way to eliminate those causes, thereby, solving the problems. Identifying the objectives of DOE is a team brainstorming decision which relies on circumstances of the process; however, the team should identify the requirements preceding the experiment before they set up the objectives. The main requirements of proceeding DOE are:

Identify the factors*;* in which the factors comprise controllable and uncontrollable factors, where the controlled factors are those factors that can be modified. The uncontrolled factors are those parameters that cannot be modified or which cover 'noise' factors such as temperature and humidity.

Identify the Levels; the levels correspond to each factor, the level is the setting of the factor representing the attribute of the factor. Mathematically, the level is termed factor values, wherein each experimental run involves the combination of the levels of investigated factors.

Identify the responses or output measures; In this framework, the overall factors must be identified in the previous phase and classifying in the planning process of DOE in next step. Subsequently, the objectives of DOE can be identified based on the requirements of DOE, the overall objectives of DOE, in process improvement, are intended to achieve the following steps;

- to determine the relationships between cause and effect,
- to understand of interactions among causative factors,
- to determine the levels at which to set the controllable factors (product dimension, alternative material, alternative designs, etc.) in order to optimize reliability,
- to minimize experimental error (noise),
- To improve the robustness of the design or process to variation.

7.3.4.2. Conducting DOE

Design of experiment (DOE) is a systematic procedure which, primarily, carries out in several, particularly in process improvement, to discover the unknown effect on the outcomes (Pochampally and Gupta, 2014). The aim of this technique is to manage the process input in order to optimise the process output. DOE is considered the core value of the process improvement in this framework. As such, it represents reengineering process based on statistical thinking and experimental design intended to achieve dramatic improvement in the business process. DOE is usually carried out in five steps; Planning, Screening, Optimisation, Robustness and verification (Pyzdek and Keller, 2014).

7.3.4.2.1. Planning

The planning step of conducting DOE in this framework is to identify the main objectives based on the requirements of DOE, to prioritise the objectives, to assess the required resources and to determine the time required to complete the experiment. In addition, the factors should be classified in this step, finally identifying the possible factors and the most appropriate response.

7.3.4.2.2. Screening

In this step, the team identifies the most important factors that affect the process from the list of factors, in other words, minimising a number of experimental runs where the greater the number of factors the more time required for the experiment.

7.3.4.2.3. Optimisation

The aim of this step is to determine the setting of the factors needed to achieve the desired objective, which is dependent on the investigation of the process or the product. The goal could increase the yield or reduce the variation or both of them.

7.3.4.2.4. Robustness Testing

Once the optimal factors are determined and the setting is complete, then the robustness test should be carried out to ensure the experiment is working appropriately. Robustness is defined as the degree to which the system is working correctly (De Smith, 2015).

7.3.4.2.5. Verifying

The final step is to validate the experimental and to ensure the process functions and the objectives are met; this can be attained through the following experimental runs.

7.3.4.3. Analyse the results of DOE to obtain statistics significance

In this step, analysis of variation (ANOV) is used to analyse the results of DOE.

If the statistical analysis confirmed that the results are statistically significant, then the quality team should generate innovative solutions for those causes of the problems and develop the plan for improvement. If the results of ANOVA are not significant, then the team should repeat the cycle and go back to the previous phase investigating the root causes of the problems again.

7.3.4.4. Evaluate the possible solutions

Once results of DOE are confirmed and the root causes of the problems are clear, then the team has to generate possible solutions for eliminating the root causes needed for prevention of problems, the process of generating solutions is based on a team brainstorming session. The result of which is that a list of solutions is generated, then, the available solutions must be assessed and evaluated. The appropriate techniques used for evaluating the possible solutions are PDCA technique and 3Cs.

7.3.4.5. Identify the solution and analyse the risk

Based on the results of PDCA, the team have to focus on the easiest and simplest solutions. In this stage, the FMEA technique is an effective tool that can help the quality team to select the efficient solution based on lists and ranking the solutions by risk priority number (RPN) and, then, focus on the most crucial one.

7.3.4.6. Standardising the work and implementing the solution

Once the solution is selected, the next step is applying a pilot experiment to trial the solution or run simulations. If this is possible, this step provides the results of the real-world application of the proposed solution. If the results are confirmed, then, the solution is proven. At that point, the operation and management process should be standardised, organised and sometimes redesigned based on the improvement plan. Basically, in the most cases, the improvement plan includes; eliminating waste, decreasing the number of defectives and cycle time reduction. Thereby, the first tool to apply is formulating the future VSM, after which comes the preparation and standardisation of the work area using 5S and Standardised tools, implementing the improvement plan.

7.3.4.7. Monitoring and enhancing the operation performance

At this stage, total productive maintenance (TPM) is implemented to enhance the effectiveness of the operational performance of machines and equipment. The aim is to increase the efficiency of the system of operation and improve the quality system. A number of tools can be employed to support this methodology; however, Overall Evaluation Effectiveness (OEE) is an effective tool for evaluating and determining the effectiveness of the machines and equipment (see below)

OEE = Availability (A) x Performance efficiency (P) x Rate of Quality (Q) (Ahuja et al., 2008)

Where: *Rate of Quality (R)=* $\frac{processed\ amount - defect\ amount}{processed\ amount}$ *100

Performance efficiency (P)= $\frac{Process\ amount}{operating\ time/theoreticalcycle\ time}$**100*

Availability= (A)$\frac{loading\ time - downtime}{laoding\ time}$ **100*

Based on Six-Sigma black belt course (2015), and in accordance with Nakajima (1988), TPM is a philosophy and a set of tools aimed to eliminate three types of losses; availability loss, performance loss and quality loss. OEE is the key driver which indicates to inefficiencies caused by those losses. Where availability losses may include; breakdown losses and setup/adjustment losses. Performance losses include idling and stoppage losses and speed losses. Quality losses include scrap and rework losses and start-up losses.

7.3.5. Phase 5; Verifying and continuous improvement

The aim of this phase is to verify the gains that have been attained and to ensure that the improvements are continuous and sustained, the main objectives are to confirm that the control plan is created and updated. The documentation process is preceded, and the goals of the quality system are met. This phase comprises four main stages listed below.

7.3.5.1. Creating and implementing a control plan

The variation can be inherited in every process and, hence, the waste and defectives that can occur. Accordingly, an appropriate control plan is required to provide the setup in order to monitor the activities and control the quality system. Thereby, the control plan comprises; SPC which should be applied to track and assess the operating performance and, also, problem-solving techniques such as 3Cs or 8Ds which must be employed to deal with the common problems, moreover the PDCA technique with Kaizen should be used proactively to maintain and control the quality actions.

7.3.5.2. Update the actions aimed at improvement to achieve high quality

The purpose of this stage is to place emphasis on continuous improvement by outlining the lessons learned and updating the recommendation. Another purpose is to support the quality system with facts related to the data analysis, expenditures and cost-saving in the previous performance in order to take action to achieve a high-quality performance. These tasks should be achieved by middle management and a quality team under the supervision of top management.

7.3.5.3. Document the quality issues

This stage is concerned with updating the documentation process including the errors and wrong procedures that have been taking place in the system.

Additionally, the benefits that have been obtained through quality implementation are determined, with ROI analysis used as a tool to outline the benefits. The purpose of the documentation is intended to provide a summary of the framework for the operation and management process, moreover, it provides evidence about organisational capability.

7.3.5.4. Evaluating the operating performance and verifying the quality system

The final stage is the stage of verifying the quality performance and measuring the organisation's level of success, thereby there are different global tools employed at this stage, namely, the KPIs and balanced scrod card. These are used to check whether the organisation has met the desired objectives effectively, KPIs have been already established and set it in the strategic planning phase as standards of quality metrics, However, the role of this stage is to assess the extent to which the quality system is committed to those metrics, in other words, *KPIs measure the operation's performance and a Balanced Scorecard is to measure and monitor the success of the organisation strategy*. The evaluation of KPIs can be broken down into;

7.3.5.4.1. KPIs

Product performance metrics; concerned with the features and functions of the product, where the evaluation is based on measurement system of the organisation.

Performance of Business process metrics; concerned with standards for cycle time, errors, process efficiency and process capability.

Performance of Quality improvement; the quality metric concerned with an aspect of product performance and customer satisfaction which includes speed of transaction and accuracy.

7.3.5.5. Balanced Scorecard

Is a management and measurement technique which enables organisations to set, track and achieve the strategic goals. However, the technique is employed to track and measure the objectives of business performance. The balanced scorecard is concerned with tracking and measuring four aspects; *customer satisfaction, financial requirements, business process* and, finally, *Knowledge, education and growth.* If one of these aspects is missed or ignored in the verification stage, then, the quality system will be unbalanced. Therefore, the aim of the balanced score card is to align the organisational activities to the vision statement (Niven, 2011). Table (7.1) shows how the four pillars of balanced scorecard manage and verify the business performance.

Table 7. 1. The main pillars of Balanced Scorecard

The pillars of balanced scorecard	Tracking and verifying activities
Financial requirements	The Return On Investment The Cash Flow situation Return on Capital Employed The bottom line results (Financial Results)
Business Processes	Following each activity per function Refine each activity across functions Alignment the process (is the process organized right in the correct department) Check if there are bottlenecks in the process Is the process automation adjusted?
Learning and Growth	Are there adequate qualified employees for the job? Are the employees are satisfied? Are the Jobs adequately completed? The opportunities for employees' development (Training/Learning)
Customer *satisfaction*	The rate of customer satisfaction The rate quality performance for customer The value of customer within the market The rate of customer retention

7.4. The CSFs for successful implementation of the proposed framework

As it has been discussed in the literature review there are no clear success factors mentioned for successful implementation of integrated quality management framework; however, apparently the factors that were ranked as an effective success factor for Six-Sigma, Lean and TQM implementation by many studies such as (Schoen, 2006; Henderson and Evan, 2000; Antony and Banuelas, 2002) and others. Some of those factors ranked in the study *as soft factors for the success of the strategic phase*, *others ranked as soft factors for success the implementation phase's as it appeared in the framework, the rest of them are ranked as success factors for an overall of the framework.* However, the critical success factors for the successful implementation of the IQM framework overall are;

1. Organisational structure
2. Focus on customer
3. Linking to Suppliers
4. training and education
5. leadership support
6. Effective communication
7. Quality commitment
8. middle management involvement
9. reviews and tracking of performance

7.5. Conclusions

The chapter focused on the development of an integrated quality management framework for manufacturing organizations, the study showed how the framework is developed and how the synergy between the methods of the framework derived. The main components of the framework and its implementation procedures stated and explained in deep details. Finally, by developing the framework, the study demonstrated that the integration of Six-Sigma, Lean manufacturing and TQM is formulating a platform to manage the quality strategy and vision and how to apply the operational mechanism to attain excellence performance. The next chapter will discuss the validation of the proposed framework and its implementation procedures.

Chapter 8

Validation of the proposed framework

8.1. Introduction

The main focus of this chapter is to discuss the questionnaire survey that has been developed to verify and validate the proposed framework that was presented in the previous chapter and the procedures for implementation along with how the data collected and analysed. This enables the researcher to modify the proposed framework if necessary and can also enhance and increase the confidence level of the researcher with respect to developing the framework and its implementation procedures. The results of the questionnaires are provided for each section and the validation steps were performed using SPSS 23 to confirm the validity and reliability of the framework and its procedures for implementation.

8.2. Research methodology

The findings of this study were obtained by applying a questionnaire survey to gather the required data and to validate the proposed framework, the questionnaire was designed to collect data from different professionals and experienced employees in the available manufacturing organisations and from academics related to the research topic. The questionnaire was structured in three sections with thirty main questions, the aim is to investigate the suitability of the proposed framework and to improve and modernise the quality system within manufacturing organisations.

The first section was about the participant's information; it aimed to present a clear picture of the respondent's background and understand the awareness level of the existing quality programme in the organisation. The second section covered the evaluation the proposed framework and the procedures for implementation. It was aimed to provide an understanding of those implementation procedures suitable for manufacturing organisations, to identify the difficulties in implementing the proposed framework and to reveal the level of accuracy within its contents with regards to helping business to gain a competitive advantage in the long run. The final section was to evaluate the importance of the CSFs for achieving successful implementation the proposed framework and the potential barriers that can impede the implementation process.

8.3. Data collection and analysis

This section outlines the results of the questionnaires received from the respondents and how being organised for analysis. A total of 70 research surveys were sent out to a host of management employees spread across different manufacturing organisations around the global, 62 questionnaires were completed and returned within a given time frame, a percentage considered to be relatively high above average (Saunders et al., 2009). The statistical software package was used to analyse the data collected which is an appropriate method to provide robust and structured analysis (Bryman and Cramer 2005). Statistical Package for Social Science is the most appropriate Statistical software used for social science and engineering research (ibid). Therefore, SPSS 23 was used to analyse the data collected in this study, 62 useable questionnaires were coded and entered to (SPSS 23) software program, basic statistical analysis were carried out for the observation of frequencies, percentage, mean and standard deviation to assess the data.

8.3.1. Integrity data analysis

8.3.1.1. Reliability analysis

A Reliability test is a crucial measure to assess the quality of the instruments used in the questionnaire and to check the reliability of data collected, Cronbach Alpha was also undertaken in this section to measure the internal consistency of the instruments used to evaluate the proposed model. Ideally, Cronbach alpha must be greater than 0.7 to consider the items being measured are consistant and reliable (Field, 2013). Therefore, the test was carried out for each of the six statements used to evaluate the proposed framework, the results (in table (8.1) demonstrated that coefficient alpha is 0.81 and the standardized item alpha is 0.78 which is greater than 0.70, accordingly that is an indication that all of the items are consistent and reliable.

Table 8. 1. Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.819	.763	6

However, the results in table (8.2), column three labelled '*corrected item-total correlation*' showed that there is positive correlation between the whole items except item number six *'Evaluating the FW in terms of anything missing and should be added to the proposed FW'* which has negative correlation with value (-0.098). In addition, in column five labelled *'Cronbach's alpha if item deleted'* the same item has the highest alpha value, 0.865. Accordingly, if item number six were deleted from the calculation, then Cronbach alpha would be improved.

Table 8. 2. Item-Total Statistics

	Scale Mean if Item Deleted	*Scale Variance if Item Deleted*	*Corrected Item-Total Correlation*	*Squared Multiple Correlation*	*Cronbach's Alpha if Item Deleted*
Suitability/ Capability of the proposed Framework	16.81	9.962	.726	.571	.757
The ability of the framework to competitiveness and profit	16.74	10.424	.654	.503	.774
The ability of the framework to deal with quality problems	16.79	10.103	.702	.588	.762
The ability of the framework for implementing in practice	16.92	9.846	.665	.536	.772
The ability of the framework to achieve long term success	16.76	10.613	.665	.502	.772
Evaluation the FW for completeness (any missing should be added to the FW)	18.65	15.544	-.098	.066	.865

After deleting item number six and running the test again, the results in table (8.3) below indicated that Cronbach alpha is 0.865 and that the standardized item alpha is 0.866. Additionally, in table (8.4), in Column three all the items are correlated with value above 0.3 and in column five value of Cronbach alpha if items deleted ranged between (0.82 to 0.84) which is greater than 0.7 Subsequently it can be conclude that the entire instruments have high internal consistency and reliable.

Table 8. 3. Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.865	.866	5

Table 8. 4. Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Suitability/ Capability of the proposed Framework	14.92	10.108	.720	.566	.828
The ability of the framework to competitiveness and profit	14.85	10.454	.671	.484	.840
The ability of the framework to deal with quality problems	14.90	10.220	.703	.588	.833
The ability of the framework for implementing in practice	15.03	9.901	.676	.529	.840
The ability of the framework to achieve long-term success	14.87	10.737	.664	.499	.842

8.3.1.2. Validity test and validation the proposed framework

Validity tests confirm the degree to which the measures used in the study are truthfully measuring what is intended to be measured (Valmohammadi, 2010). As they should be performed to check the accuracy and truthfulness of the results, Chi-square goodness of fit(X^2) was applied to check the validity of the instruments that were used to evaluate the proposed framework. Chi-square goodness of fit is used to find out whether an observed value is statistically, significantly different from the expected value (Field, 2013) (see chapter 3 sections (3.6.2.2.1)). The Chi-square goodness of fit with corresponding P value is considered to be significant if P value ≤ 0.05 (Bryman and Cramer, 2005).

As can be seen in table (8.5), the results of X^2 demonstrated that the P values are less than 0.05, which means that the results are significantly different from the actual observed values and the expected values of all the statements used to evaluate the proposed model. That also can be an indication for the possibility of publishing the results and generalizing from the current research sample to the entire publication Balck (2011) and Alzuabi (2014).

Table 8. 5. Test Statistics

	Suitability/ Capability of the proposed Framework	The ability of the framework to competitiveness and profit	The ability of the framework to deal with quality problems	The ability of the framework for implementing in practice	The ability of the framework to achieve long-term success	Any missing in the contents of the proposed framework
Chi-Square	31.387[a]	33.323[a]	41.387[a]	31.710[a]	34.129[a]	37.161[b]
df	4	4	4	4	4	1
Asymp. Sig.	.000	.000	.000	.000	.000	.000

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 12.4.

b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 31.0.

8.3.2. Descriptive analysis

This section provides the descriptive analysis of the data collected using SPSS 23. Various descriptive measures were used to measure the central tendency (mean, mode, median), allowing the results of data analysis to be provided in the following sections in forms of tables, charts and different statistics and figures.

8.3.2.1 Section A: Background information.

The section provides the results of the questionnaires received from the respondents. The aim of this part of the survey is to present a clear picture of the respondent’s background and to understand the awareness level of the existing quality program in the organisation.

1. Respondent's position

The respondents were asked to state their position within their organisation. The results listed in the table (8.6) showed that 50% of the respondents are academics, 9.7% are quality managers, 8.1% are directors, 6.5% operational managers and belt function. Finally, 3.2% including project leaders and heads of department and coordinators.

Table 8. 6. Position within the organisation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Director	5	8.1	8.1	8.1
	Quality manager	8	12.9	12.9	21.0
	Operation manager	4	6.5	6.5	27.4
	Quality Engineer	6	9.7	9.7	37.1
	Belt function	4	6.5	6.5	43.5
	Project leader or Department head	2	3.2	3.2	46.8
	Coordinator	2	3.2	3.2	50.0
	Academics	31	50.0	50.0	100.0
	Total	62	100.0	100.0	

2. Area of industry

The respondents were asked to indicate the industrial sector in which their organisations functioned, the results were shown in a table (8.7). 29% of the respondents belong to the manufacturing sector, 17.7% belong to the Oil and Gas sector, and 6.5% are from automotive industry. The remaining 46.8% others include academics and research students who belong to the higher education.

Table 8. 7. Area of Industry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Manufacturing	18	29.0	29.0	29.0
	Automotive	11	17.7	17.7	46.8
	Oil and Gas	4	6.5	6.5	53.2
	Other	29	46.8	46.8	100.0
	Total	62	100.0	100.0	

3. The global location of the organisation

The respondents were asked to state the location of their organisations. The results in table (8.8) showed 23 of the participants were from UK, 22 from Libya, 4 from Russia, 3 each from Portugal and Egypt, 2 each from Nigeria and China, with the remaining participants from the USA, Canada and Morocco with1 participant each.

Table 8. 8. Organisations Location

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Libya	22	35.5	35.5	35.5
	UK	23	37.1	37.1	72.6
	Russia	4	6.5	6.5	79.0
	Portugal	3	4.8	4.8	83.9
	Nigeria	2	3.2	3.2	87.1
	China	2	3.2	3.2	90.3
	Egypt	3	4.8	4.8	95.2
	Canada	1	1.6	1.6	96.8
	USA	1	1.6	1.6	98.4
	Morocco	1	1.6	1.6	100.0
	Total	62	100.0	100.0	

4. The type of the quality system currently employed of respondent's organisations

The respondents were asked to indicate the quality system currently used within the organisation, the results in table (E-1) in appendix (E) demonstrated as follows; 4.8% Six-Sigma, 6.5% Lean manufacturing, 8.1 %TQM and 80.6 other quality systems.

5. The level of awareness with Six-Sigma, Lean and TQM tools/ techniques

Six-Sigma, Lean and TQM tools were presented to the respondents and they were asked to indicate if they were aware of any of the tools listed in the survey questions. The results presented in table (E-2) in appendix (E) showed that the majority of respondents seems to be familiar with most of the tools and indicated that the level of the awareness with these tools were above 50% which are slightly above average. However, the only tool ranked below 50% is the PERT chart.

8.3.2.2. Section B: Validation of the proposed framework

This section of the survey seeks to validate the proposed framework for manufacturing organisations, it aims to provide an understanding of the implementation procedures suitable for manufacturing organisations, identify the difficulties in implementing the proposed framework and reveal the accuracy level in its contents in terms of helping manufacturing organisations to gain a competitive advantage in the long run. The framework was presented to the respondents and were asked to evaluate the framework in terms of the suitability for manufacturing organisation and their applicability to achieve competitive advantages, additionally, evaluation the implementation procedures of the framework for manufacturing organisations was based on the ranking below;

1–Strongly Disagree. 2– Disagree. 3– Moderate. 4– Agree. 5 –Strongly Agree.

The results of the evaluation of the proposed framework were as follows;

1. Evaluation -of- The suitability and capability of the framework for manufacturing organisations.

The results in table (8.9) demonstrated that 35% of the respondents answered that the suitability capability of the framework for manufacturing organisations is moderate, 33.9% agree, 24.2% strongly agreed and 3.2% of the respondents either disagree and strongly disagree, respectively. However, the suitability of the proposed framework is fully supported at 58.1%.

Table 8. 9. The suitability/capability Framework

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	3.2	3.2	3.2
	Disagree	2	3.2	3.2	6.5
	Moderate	22	35.5	35.5	41.9
	Agree	21	33.9	33.9	75.8
	Strongly agree	15	24.2	24.2	100.0
	Total	62	100.0	100.0	

2. Evaluation -of- the ability of the framework to generate competitiveness and profit

The results in table (8.10) demonstrated that 40.3% of the respondent agree that the proposed framework is capable of attaining competitive advantage and profit for manufacturing organisations, 24.2% strongly agree, 29% moderate and 3.2% fell in each of the categories, disagree and strongly disagree. As such, 67.7 % supported that the proposed framework will boost competitiveness and profit.

Table 8. 10. The ability of the framework to competitiveness and profit

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	3.2	3.2	3.2
	Disagree	2	3.2	3.2	6.5
	Moderate	18	29.0	29.0	35.5
	Agree	25	40.3	40.3	75.8
	Strongly agree	15	24.2	24.2	100.0
	Total	62	100.0	100.0	

3. Evaluation -of- the ability of the framework to deal with and to overcome quality problems

The results in table (8.11) demonstrated that 48.4% of the respondents agree that the proposed framework can deal and overcome quality problems, 24.2% moderate, 29.4% strongly agree, 4.8% strongly disagree and 3.2% disagree. Therefore, 77.8% were entirely in the agreement that the proposed framework would be able to deal with and to overcome quality problems.

Table 8. 11. The Ability of the framework to deal and overcome quality problems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	4.8	4.8	4.8
	Disagree	2	3.2	3.2	8.1
	Moderate	15	24.2	24.2	32.3
	Agree	30	48.4	48.4	80.6
	Strongly agree	12	19.4	19.4	100.0
	Total	62	100.0	100.0	

4. Evaluation -of- The ability of the framework to be implemented in practice

The results in table (8.12) demonstrated that 45.2% of the respondents agree that the proposed framework is capable of overcoming the complex nature of quality management implementation. 24.2% moderate, 17.7% strongly agree and 6.5% fell into each category; disagree and strongly disagree on the Likert scale. Overall, 62.9% were entirely in agreement with ability of the framework to deal with implementation complexity.

Table 8. 12. The ability of the framework to be implemented in practice

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	6.5	6.5	6.5
	Disagree	4	6.5	6.5	12.9
	Moderate	15	24.2	24.2	37.1
	Agree	28	45.2	45.2	82.3
	Strongly agree	11	17.7	17.7	100.0
	Total	62	100.0	100.0	

5. Evaluation -of- The ability of the framework to achieve long-term success

Table (8.13) demonstrated that 40.3% agreed that the proposed framework can lead the manufacturing organisation achieving its long-term goals. 30.6% moderate, 22.6% strongly agree, 4.3% disagree and 1.6% strongly disagree. The results, overall, supported that 62.9% were in agreement with the ability of the framework to achieve long-term success.

Table 8. 13. The ability of the framework to achieve long-term success

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.6	1.6	1.6
	Disagree	3	4.8	4.8	6.5
	Moderate	19	30.6	30.6	37.1
	Agree	25	40.3	40.3	77.4
	Strongly agree	14	22.6	22.6	100.0
	Total	62	100.0	100.0	

6. Evaluation -of- The level of completeness in the contents of the proposed framework

According to the results in table (8.14) 88.7% of the respondents indicated that the contents proposed framework is complete whereas 11.3% are not confident about the completeness of the model.

Table 8. 14. The completeness of the contents of the proposed framework

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	7	11.3	11.3	11.3
	No	55	88.7	88.7	100.0
	Total	62	100.0	100.0	

8.3.2.3. Evaluation the implementation procedures of the framework

This part of the research seeks to evaluate the procedures concerning implementation of the proposed framework. For the five main implementation procedures (5 phases) designed for implementing the framework see chapter (7) section (7.3). The procedures designed for implementation were presented to the respondents in the framework. The respondents were asked to indicate how the statements related to each phase based on the following ranking;

1–Strongly Disagree 2– Disagree 3– Moderate 4– Agree 5 –Strongly Agree

8.3.2.3.1. Evaluating the strategic planning phase

The strategic planning phase including two main components:

- Strategic soft factors
- Strategic steps

Evaluation - The strategic soft factors

1. Evaluating the contents of strategic soft factors

The results in table (8.15) demonstrated that 51.6 of the respondents agree with the contents of the soft factors in phase one, 43.5% strongly agree and only 4.8% moderate. Overall, 95.1% of the respondents are in agreement with the soft factors in phase one.

Table 8. 15. Evaluating the contents of strategic soft factors

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Moderate	3	4.8	4.8	4.8
	Agree	32	51.6	51.6	56.5
	Strongly agree	27	43.5	43.5	100.0
	Total	62	100.0	100.0	

2. Evaluation the applicability of the soft factors for success in the strategic planning within phase1

The results in table (8.16) demonstrated that 72% of the respondents agree, 12.9%, strongly agree and 14.5% moderate. The results, overall, were that 84.9% of the respondents in agreement with this statement.

Table 8. 16. Evaluation The applicability of the soft factors of the strategic planning in phase one

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Moderate	9	14.5	14.5	14.5
	Agree	45	72.6	72.6	87.1
	Strongly agree	8	12.9	12.9	100.0
	Total	62	100.0	100.0	

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3. Evaluation the soft factors in terms of anything that might be missing and should be added

The results in table (8.17) demonstrated that 98.4% of the respondents agree with the contents of the soft factors.

Table 8. 17. Evaluation of any soft factors missing which should be added to the strategic planning phase

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	1	1.6	1.6	1.6
	NO	61	98.4	98.4	100.0
Total		62	100.0		

Evaluation the strategic steps

1. Evaluation the contents of the strategic planning steps

The results in table (8.18) demonstrated that 64.5% agreed with the contents of the strategic steps in preceding the planning process while 17.7% of the participants fell in each strongly agree and moderate of the Likert scale.

Table 8. 18. Evaluation of the contents of the strategic steps for preceding the planning process in phase one

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Moderate	11	17.7	17.7	17.7
	Agree	40	64.5	64.5	82.3
	Strongly agree	11	17.7	17.7	100.0
	Total	62	100.0	100.0	

2. Evaluation the strategic steps in terms of anything missing which should be added.

The results in table (8.19) indicated that 98.4% or the respondents agreed about the completeness of the strategic steps.

Table 8. 19. Evaluation of anything missing in the strategic steps which should be added to the strategic planning phase

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	1	1.6	1.6	1.6
	No	61	98.4	98.4	100.0
	Total	62	100.0	100.0	

8.3.2.3.2. Evaluation of the measurement and evaluation phase

1. Evaluation the contents of measurement and evaluation in phase 2

The results in table (8.20) shows that 74.2% of the respondents agreed with the contents of phase two, 17.7% moderate and 8.1% strongly agree

Table 8. 20. Evaluation the contents of phase two (Measurement and evaluation)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Moderate	11	17.7	17.7	17.7
	Agree	46	74.2	74.2	91.9
	Strongly agree	5	8.1	8.1	100.0
	Total	62	100.0	100.0	

2. Evaluation -of- the ability of the stages in phase 2 to achieve the key target (evaluation of the current performance and the collection of data for investigating quality problems)

The results in table (8.21) demonstrated that 66.1% of the respondents agree that the stages of phase two are capable of meeting their main target, 21% moderate and 12.9% strongly agree

Table 8. 21. Evaluation of the applicability of the contents in phase two to meet the key target

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Moderate	13	21.0	21.0	21.0
	Agree	41	66.1	66.1	87.1
	Strongly agree	8	12.9	12.9	100.0
	Total	62	100.0	100.0	

3. Evaluation the stages in phase 2 in terms of anything missing that should be added

The results in table (8.22) indicated that the respondents totally agreed with contents of phase two.

Table 8. 22. Evaluation of anything missing that should be added

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	NO	62	100.0	100.0	100.0

8.3.2.334. Evaluation of the phase 3 analysis and activation

1. Evaluation the contents of analysis and activation phase

The results in table (8.23) demonstrated that 71% of the respondents agreed with contents of phase 3 of the proposed framework, with 17.7% moderate, 9.7% strongly agree and only 1.6% disagreeing.

Table 8. 23. Evaluation the contents of phase three (Analysis and activation)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		1	1.6	1.6	1.6
	Moderate	11	17.7	17.7	19.4
	Agree	44	71.0	71.0	90.3
	Strongly agree	6	9.7	9.7	100.0
	Total	62	100.0	100.0	

2. Evaluation the ability of the stages in phase 3 in terms of achieving the key target *(Analysis of the gap between the current and the desired performance and identification of the root causes of the quality problems)*

The results in table (8.24) demonstrated that 69.4% of the respondents agree that the stages of phase three are capable of meet the key target of the phase, 17.7% were moderate and 12.9% strongly agreed.

Table 8. 24. Evaluation of the applicability of the contents in phase three capable of meeting the key target (Analysis and activation)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Moderate	11	17.7	17.7	17.7
	Agree	43	69.4	69.4	87.1
	Strongly agree	8	12.9	12.9	100.0
	Total	62	100.0	100.0	

3. Evaluation of the stages in phase 3 in terms of anything missing which should be added

The results in table (2.25) indicated that the respondents agreed with the contents of this phase.

Table 8. 25. Evaluation of anything missing in the contents of phase four of the proposed framework

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	NO	62	100.0	100.0	100.0

8.3.2.3.4. Evaluation of phase 4 improvement and monitoring

1. Evaluation the contents of improvement and monitoring phase

The results in table (8.26) demonstrated that 66.1 % of the respondents agreed that the stages of phase four are capable of meeting the key target of the phase. 21.0% were moderate and 12.9 strongly agreed.

Table 8. 26. Evaluation the contents of phase four of the proposed framework (Improvement and monitoring)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Moderate	13	21.0	21.0	21.0
	Agree	41	66.1	66.1	87.1
	Strongly agree	8	12.9	12.9	100.0
	Total	62	100.0	100.0	

2. Evaluation -of- the ability of the stages in phase 4 in terms of achieving the key target (developing, implementing and monitoring the improvement plan)

The results in table (8.27.) indicated that 62.9% of the respondents agreed that the stages of phase four are capable of meeting the phase target, 22.6% moderate and 14.5% strongly agreed.

Table 8. 27. Evaluation of the applicability of the contents in phase four's capability to meet the key target (Improvement and monitoring)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Moderate	14	22.6	22.6	22.6
	Agree	39	62.9	62.9	85.5
	Strongly agree	9	14.5	14.5	100.0
	Total	62	100.0	100.0	

3. Evaluation the stages in phase 4 in terms of anything missing which should be added

The results in table (8.28) demonstrated that the respondents totally agreed about the full contents of phase four.

Table 8. 28. Evaluation of anything missing in the contents of phase four of the proposed framework

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	NO	62	100.0	100.0	100.0

8.3.2.3.5. Evaluation of phase 5 (Verifying and continuous improvement)

1. Evaluation the contents of verification and continuous improvement phase

The results in table (8.29) demonstrated that 62.9% of the respondents agreed with the contents of phase five, 21% moderate and 16.1% strongly agree.

Table 8. 29. Evaluation the contents of phase five to meet the key target

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Moderate	13	21.0	21.0	21.0
	Agree	39	62.9	62.9	83.9
	Strongly agree	10	16.1	16.1	100.0
	Total	62	100.0	100.0	

2. Evaluation the ability of the stages in phase five to achieve the key target (to maintain the improvement plan and confirm the organization's success)

The results in table (8.30) demonstrated that 67.7% of the respondents agreed that the stages of phase five was capable of meeting the key target, 21% moderate and 11.3% strongly agree.

Table 8. 30. Evaluation the applicability of the contents in phase five and their capability to meet the key target (verification and continuous improvement)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Moderate	13	21.0	21.0	21.0
	Agree	42	67.7	67.7	88.7
	Strongly agree	7	11.3	11.3	100.0
	Total	62	100.0	100.0	

3. Evaluation the stages in phase 5 in terms of any missing elements which should be added

The results in table (8.31) indicated that the respondents fully agreed that there are no elements missing from the phase.

Table 8. 31. Evaluation of missing elements in the contents of phase five of the proposed framework

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	62	100.0	100.0	100.0

Evaluation the soft implementation factors of the proposed framework.

The soft implementation factors were presented to the respondents via the questionnaire, the participants were asked about the soft implementation factors in terms of helping the implementation of the proposed framework based on the same Likert scale used in the previous sections.

1. Evaluation - The contents of the soft implementation factors

The results in table (8.32) showed that 64.5% of the respondents agreed with the contents of the soft implementation factors of the proposed framework, 19.4% strongly agreed and 16.1% were moderate.

Table 8. 32. Evaluation - The soft implementation factors of the proposed framework

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Moderate	10	16.1	16.1	16.1
	Agree	40	64.5	64.5	80.6
	Strongly agree	12	19.4	19.4	100.0
	Total	62	100.0	100.0	

2. Evaluation of the soft implementation factors in terms of any missing elements which should be added

The results in table (8.33) showed that the respondents were in complete agreement that there was nothing missing with regards to the soft implementation factors.

Table 8. 33. The soft implementation factors in terms of any missing elements which should be added

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	62	100.0	100.0	100.0

Evaluation of the potential motivations within the integrated quality management approach

The essential elements of Six-Sigma, TQM and Lean are listed as the key motivation for adopting an integrated quality management approach. The respondents were asked to indicate the extent to which the following motives would influence their decision to adopt the proposed framework.

The results in table (E-3), appendix (E) indicated that almost the highest percentage of the respondents judgment fell in the favor of ‘agree’ and ‘strongly agree’ on the Likert scale, which means that the majority of the participants agreed that integrated quality management approach were applicable to manufacturing organisations.

8.3.3. Evaluation the importance of the CSFs for the successful implementation of the proposed framework

This part of the survey was aimed at understanding the critical factors necessary for the successful implementation of the proposed framework in manufacturing organisations and the potential barriers that can impede the implementation process.

1. Evaluation -of- The CSFs required for successful implementation of the proposed framework

Nine CSFs were selected and presented to the participants via questionnaires (see appendix A, section C), the respondents were asked to indicate the importance of the CSFs for successful implementation the proposed framework, the Likert scale used was:

1- Not important at all 2- Slightly important 3-Moderate 4- Important 5- very-important

The results in table (E-4) in the appendix (E) demonstrated that the highest percentage of the respondent's judgement fell in the favour of important on the Likert scale for all of the CSFs. Therefore, it can be concluded that the CSFs listed in the survey are the most important factors for successful implementation of proposed framework within manufacturing organisations. However, effective communication is rated as the most important factor for the successful implementation the proposed framework.

2. Evaluation of the impeding factors for the proposed framework.

The respondents were asked to rate the extent to which the 11 barriers factors impede the implementation of the integrated quality management approach in manufacturing organisations, the eleven barriers factors were identified by the review of the literature (Johannes,2013; Antony, 2008; Andersson et al., 2006). These barriers factors were rated using the Likert scale of 1-5;

1- Corresponds to very low 2- Low, 3- Moderate, 4-High and 5-Very high.

The result in table (E-5) in the appendix (E) showed that almost all of the barriers factors listed in the questionnaire were considered high. Where the majority of the respondents indicated that the greatest percentage of the judgement fell in the favour of high importance on the Likert scale with rate of more than 48%. However, ‘lack of leadership’ and ‘unmanaged expectation’ has been rated as the most impeding factors of the proposed framework with rate more than 90% respectively.

8.3.4. Validation of the CSFs for successful implementation the proposed framework

Factor analysis was undertaken to validate the CSFs of the proposed framework, the purpose was to identify the latent factors behind the CSFs and to measure the validity of the instruments used in the questionnaire (Pallant, 20010). The exploratory factor analysis method was also selected to perform the test and to check the construct validity of CSFs of the proposed framework. The test was carried out using SPSS.

8.3.4.1. Results of factor analysis

Factorability test

To check the suitability of the data for conducting factor analysis, a factorability test was performed to check the appropriateness of data for factor analysis.

Table 8. 34. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.838
Bartlett's Test of Sphericity	Approx. Chi-Square	283.545
	df	36
	Sig.	.000

The results in table (8.34) demonstrated that KMO is 0.83 which is greater than 0.6 and that the Sphericity test is significant. Therefore, all the requirements are met and the data is valid to perform the factor analysis test.

***Factor extraction*:** Principle component analysis (PCA) with the Eigen value technique has been selected to extract the latent factors and to identify the dimensionality scales.

Table 8. 35. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	4.765	52.949	52.949	4.765	52.949	52.949	4.075
2	1.206	13.402	66.351	1.206	13.402	66.351	3.674
3	.839	9.321	75.672				
4	.631	7.014	82.687				
5	.483	5.366	88.052				
6	.331	3.682	91.734				
7	.303	3.362	95.097				
8	.254	2.822	97.919				
9	.187	2.081	100.000				

Extraction Method: Principal Component Analysis.

The results obtained from the first trial was satisfactory, thus, the results in table (8.35) demonstrated that PCA extracted 2 latent factors with Eigen value greater than 1.00 which is sufficient to meet the requirements (Williams et al., 2012). Latent factor one accounts for 52.9% of the total variation and latent factor two accounts for 13.4 of the total variation.

Factor rotation: The direct Oblimin method was used to obtain factor loading and to understand the cluster of each latent factor. Williams et al. (2012) stated that factor loading Direct Oblimin provides pattern loading with factors that are more correlated and that are easy to interpret.

Table 8. 36. Pattern Matrix

	Latent factors	
	1	2
Cronbach alpha test	0.88	0.80
Focus on customer	.932	
Training and education	.869	
Organisation infrastructure.	.735	
Linking to supplier	.658	
Top management and leadership support.	.636	
Middle management involvement		.856
Quality commitment		.785
Review and tracking performance		.748
Effective communication		.675

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Table (8.36) demonstrated that the results of factor loading attained with the pattern matrix appeared to be reasonable. Out of 9 items, 5 items were loaded on Latent factor one and 4 items were loaded on Latent factor two, as can be seen all items loaded are unidimensional and loaded onto one factor with a value of more than 0.5 (Costello and Osborne, 2011), (Pallant, 2007), and (Hair et al., 2006). Latent factor one was obtained with high loading for five items ranged from 0.93 to 0.63 and Latent factor two obtained with high loading for four items ranged from 0.85 to 0.67. Accordingly, the questionnaire instruments for CSFs are valid since every item of the latent factors obtained are unidimensional with high loading as well as the internal consistency of each latent factor can be seen in table (8.36) which show they are 0.88 and 0.80 respectively, which is greater than 0.7. Therefore, it considered to be significant and reliable.

Labelling the extracted latent factors

Based on the structure matrix in table 8.37, a correlation is indicated between the latent factors and the CSFs (variables). Therefore, the latent factors can be labelled as follow:

Table 8. 37. Structure Matrix

	Latent factors	
	1	2
Focus on customer	.869	.345
Training and education	.830	.360
Organisation infrastructure.	.805	.623
Linking to supplier	.767	.581
Top management and leadership support.	.763	.427
Middle management involvement	.476	.826
Quality commitment	.579	.795
Review and tracking performance	.309	.795
Effective communication	.393	.756

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Latent Factor 1: Strategic elements

These elements are highly correlated with latent factor 1 (as is shown in table 8.37). The elements represent 52.9% of the variance (see table 8.35). These elements are considered the strategic factors of the FW which has significant impact on the strategic planning process. The internal consistency of these factors is 0.88 (as shown in table 8.36, figure 8.1) and represents a correlation between latent factor 1 with the mentioned elements.

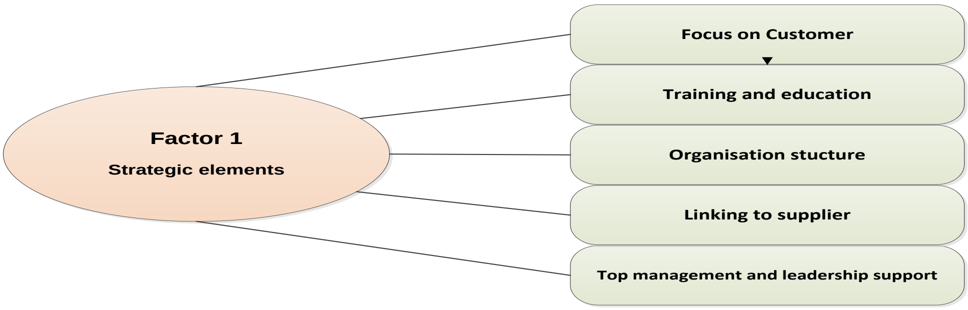

Figure 8. 1. Latent Factor 1; strategic elements

Latent Factor 1: Operational elements

These elements are highly correlated with latent factor 2 (as shown in table 8.38), the elements represent 13.4% of the variance (see table 8.35). These elements are considered the operational factors of the FW which has significant impact on the implementation process. The internal consistency of this factor is 0.88 (as shown in table 8.36), figure 8.2 represents the correlation between latent factor 2 with the previously mentioned element.

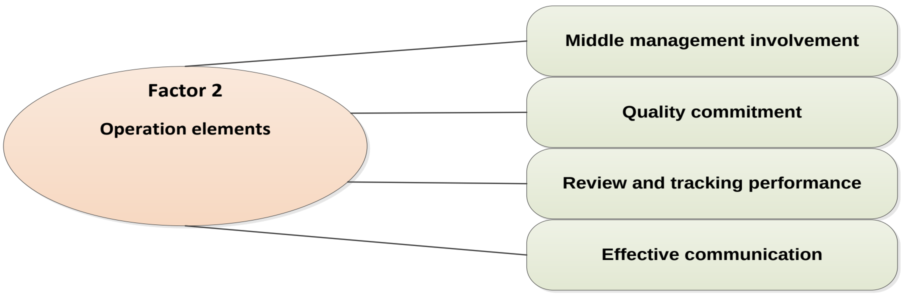

Figure 8. 2. Latent Factor 2; Operational elements

8.4. Discussion

The research study investigated two main issues; one is evaluating and validating the proposed framework and its implementation procedures, the second is evaluation and validating the critical success factors for the successful implementation of the framework in manufacturing organisations. The validation process is undertaken using the quantitative approach represented by the questionnaire survey. It was carried out after the development of the framework; the questionnaire survey involved 62 employees in the industrial sector and academics. It sought to obtain the opinions and ideas of experts in terms of the suitability of the FW for manufacturing organisations. The framework was assessed in terms of; the appropriateness and applicability, the usability and effectiveness, the importance of CSFs for the successful implementation of the FW and the barriers impeding the implementation process.

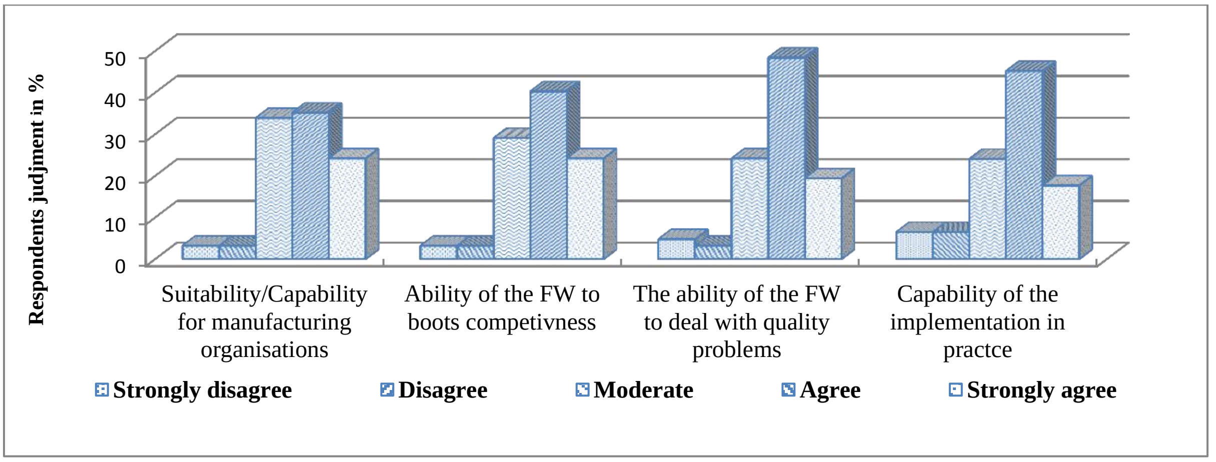

Figure 8. 3. Respondents judgment about the evaluation of the framework

The results confirmed that the proposed framework developed is applicable for manufacturing organisations and can assist in achieving competitive advantages if adopted or applied correctly, figure 8.3 provided evidence from the research outcomes in which it is clearly demonstrated that a very high percentage of respondents agreement with contents, Suitability, competitive advantages, effectiveness and completeness of the framework. Finally, the results demonstrated that the CSFs are very important for implementing the framework. Therefore, considerable attention should be paid if the framework is implemented.

8.5. Conclusion

The chapter focused on validation of the framework and its implementation procedures. The chapter also discussed how the questionnaire survey was designed and how it was conducted, it showed that the questionnaire contains three sections; one provided respondents background, the second for evaluation of the framework and its implementation procedures. The final section covered the evaluation of the CSFs and the impeding factors concerning implementation of the FW. The results of the data analysis were presented and the procedures for validating the FW and CSFs provided using statistics analysis. The study concluded that the proposed framework developed is applicable for manufacturing organisations and can assist in achieving competitive advantages if adopted or applied correctly and also provides guidance towards a successful implementation, the proposed framework in this thesis can be considered a major contribution to both academia and to the industrial sector.

Chapter 9

Conclusions, recommendations, contributions to knowledge, research limitations and future work

9.1. Introduction

This chapter provides the key conclusion drawn from the research; it includes a discussion of the research findings and implications, it also presents the contribution to knowledge in the field of quality management within manufacturing organisations. The chapter concludes with the research limitation, recommendations and suggestions for future work.

9.2. Conclusions

The aim of this research was to develop a quality management framework for manufacturing organisation through the integration of the effectiveness of the quality management initiative. The purpose for conducting the research is that manufacturing organisations are presently required to operate at low cost with great speed and reliability in order to achieve a competitive advantage. To achieve this target and to create the framework, the study involved four main tasks to address the research objectives, the finding and the implications of the research tasks are summarised below.

9.2.1 Literature review

A comprehensive literature review has been carried out to establish the required knowledge for addressing the research objectives in chapter 2. The key methods reviewed comprehensively in chapter 2 are Six-Sigma, Lean manufacturing and TQM. Additionally, a review of the integrated approach in quality management was carried out to identify what methods are typically being integrated and how they are integrated. The purpose of this chapter was to address two main objectives; one, to identify the key drivers that are required for integrating Six-Sigma and Lean to develop the LSS Model, the other one is to identify the key drivers that are required to integrate Six-Sigma and TQM in order to develop the SS-TQM model. The key findings of the literature review showed that there was some consensuses among the majority of the quality authors that the quality methods selected are the most effective quality management methods implemented in practice and led organisations to achieve high quality results. Additionally, due to the similarity between these methods many authors agreed that the synergy does exist and that the potential integration between these approaches can lead to high quality performance.

The review of the integrated approach in quality management highlighted the importance of that approach and showed the way of integrating those methods. In addition, it has been demonstrated that Six-Sigma DMAIC is the most effective improvement strategy and can be used as a key driver for integrating the selected methods. The review of the literature outlines that the key project motivation for integrating Six-Sigma and Lean for improving the operational performance and Six-Sigma with TQM for unifying the management system and achieving performance excellence. Finally, the CSFs for successful implementation of LSS as an integrated model and SS-TQM as integration fashion were identified to ensure the success of the implementation process. Therefore, this part of the study covered and addressed the first two objectives of the research which are *objectives number 1 and 2*.

9.2.2. The proposed integrated LSS model

The development of the proposed LSS model was based on the findings of the literature review, many LSS models were developed and implemented in practice for different purpose, these models make it easier for the author to select the appropriate components of the proposed model, the key drivers for developing the model include the DMAIC improvement strategy for facilitating the implementation process and identifying opportunities for quality improvement. DMAIC is integrated with set of LSS tools and techniques which is organised sequentially to smooth the implementation process and to achieve an improved performance. The elements of the model are involved in two main components; strategic elements and implementation elements. These are structured in five steps based on DMAIC. The author believes that the model can shape the management strategies and vision to which the managers have to be committed and also guide employees to achieve improved processes, reduce variations, reduce waste and meet or exceed customers' expectations (more details presented in chapter 4).

The model was developed and designed, then attached to the questionnaire survey which was designed for the purpose of developing and validating the proposed model. 70 questionnaires were sent to quality professionals, and the senior management of the available manufacturing and academic organisations, 56 questionnaires were returned within the time frame. The key findings of the survey demonstrated that the model is applicable for manufacturing organisations if embedded in long-term strategic thinking. It is also revealed that LSS implementation is still in the early stage; however, most manufacturing organisations involved in the survey have the required culture for adopting LSS and almost all are aware of the common LSS tools and techniques. The task in this stage adequately addressed *the third objective* of the research, related to the development and validation of the proposed LSS model.

9.2.3 The proposed integrated SS-TQM model

Chapter 5 covered the development and validating of the SS-TQM integrated model, the model was also developed based on the findings of the literature review in which the main components of Six-Sigma and TQM implementation and the project motivation of Six-Sigma and TQM assisted in shaping the strategic and the implementation elements of the proposed model. Additional, the key finding of the literature review, with respect to business excellence in quality management, led to developing a strategic plan to employ the proposed model. Furthermore, The CSFs for successful implementation of the model facilitated the implementation process and empowered the key components of the model in terms of orientation to the culture and the streamlining of the operating process. The aim of the model was to unify the management system by utilising the core value of TQM and the improvement strategy of Six-Sigma in order to realise the orientation toward innovation and to achieve performance excellence for manufacturing organisations.

The model was developed, designed and reviewed, then, was attached to questionnaire survey for validation and for final development. As with the previous model, 70 questionnaire surveys sent to available quality professionals, practitioners and academics in different manufacturing and academic organisations with 58 questionnaires returned with in time frame. The findings of the questionnaire concluded that the model is valuable for manufacturing organisations and can enable manufacturing organisations to achieve business excellence if the management tools are unified and operational techniques are implemented effectively. This stage of the research is involved with addressed *objective number 4* of the research and with developing and validating the SS_TQM mode.

9.2.4. Analytical hierarchy process model

The strategic drivers for developing the integrated framework were identified. Based on the integration of the LSS model with the SS-TQM model, the integration process was conducted based on the integrated approach of quality management, in which DMAIC improvement strategy was adopted as the *procedure model* for integrating the models. The similarities and the significant commonalities among the quality approaches of the mentioned models enabled the models to complete the integration process. In addition, the strategic drivers were evaluated and prioritised using Multi-criteria decision-making technique, the modelling of the problem using Multi-criteria decision-making was, then, applied through (AHP). It was designed and structured with the criteria and sub-criteria to evaluate and prioritise the strategic drivers of the proposed framework.

The proposed AHP model was created including the main criteria and comprises of the five strategic drivers selected; the sub-criteria comprise the nine CSFs identified for the successful implementation of the framework (more details presented in chapter 6). The questionnaire survey was designed based on the purpose of the AHP method and sent to the available quality professionals, industry professionals and academics in different manufacturing and academic organisations with 53 questionnaires completed and returned within the time frame. The key findings of the AHP method demonstrated that strategic drivers are more important than the implementation drivers. The critical quality factors in the sub-criteria were ranked and found that Leadership support and organisational structure are the most important factors for implementing the strategic drivers and success in the framework. Additionally, sensitivity analysis confirmed that the changing of the priority does not considerably affect the results obtained.

Since the AHP model, considered the strategic element, affected the quality management performance, these findings are also significant for decision makers who are interested in improving the quality performance and determine the critical quality factors with respect to integrated quality management. The task in this part *sufficiently achieved objective number 5* of the research (to identify the key drivers that can lead to the development of the framework).

9.2.5 The proposed integrated framework

Chapter 7 covered the development of the proposed IQM framework, the aim of the framework is to provide a guide and impetus for manufacturing organisations with respect to improving the operation's performance and facilitating the quality system in order to achieve excellence performance and competitive advantages. The development of the framework was the result of integrating the LSS model and the SS-TQM model and based on the findings of the literature review. The integration of those models provided four key impetuses to create the framework; **Unifying the management system, cultivating the quality culture,** r**ealisation the innovative environment** and, finally, **smoothing and facilitating the operation process.** These motivations are considered the crucial drivers of the framework to enable manufacturing organisations to attain excellence in their performance.

The main components of the framework include; 1) the main body, represented by the flowchart diagram. The flowchart shows all the integrating functions and the work activities involved in the framework. 2) The main elements of the framework, including the sets of different tools and techniques are organised sequentially and based on the DMAIC improvement strategy to guide the framework for identifying opportunities for improvement. 3) The operational mechanism of the framework comprises a number of interrelated steps, stages and process which are integrated and involved in the phases of the framework. These steps formulated the operation system and facilitate the implementation process of the framework. The implementation procedures of the framework were adopted based on DMIAC improvement strategy including the five phases presented in chapter 7. These procedures are considered the key drivers for the organisation and implementation of the framework.

Chapter 8 covered validation and verifying the framework and its implementation procedures. A questionnaire survey was designed for the purpose of validation and verifying the framework. The questionnaire investigated the validity of the framework it was based on; the suitability for manufacturing organisation and evaluation the accuracy level in its contents in terms of helping industry to gain competitive advantage in the long run. Additionally, there was an evaluation and the possible implementation difficulties of the proposed framework. The findings that were derived from the data collected belonged to the 63 responses out of the 70 sent. The findings demonstrated that the framework is valuable if adopted and implemented correctly.

In general, the feedback obtained from the survey confirmed the applicability of the framework to the improvement of the quality system within manufacturing organisations. It also concludes that the framework would be very useful, in practice, due to the functionality of evaluating the operational performance and the ability to achieve an excellence performance. It is the authors belief that the framework can provide the manufacturing mangers impetus for management strategies and vision in which to reform and modernise the quality system within manufacturing organisations, it also can guide the employees attempting to understand the process orientation and to achieve improved processes. Therefore, the study can be considered framework to be a key contribution to both academia and industrialist. In summary, the study in this part addressed and completely achieved the last three objectives of the research which are objectives number 5, 7 and 8.

9.3. Contributions to knowledge

The main contributions of this research study centers around four substantive areas, each provided a foundation for guides and the enhancement of the quality management system in practice within manufacturing industry. The key contribution to the knowledge in this research can be summarized in the following developments:

- *An integrated quality management framework;* to establish a unique quality management strategy and to simplify the implementation process in practice with aim of achieving excellence in performance and competitive advantage within the manufacturing organization.
- *The Lean Six-Sigma integrated model*; provided effective strategic planning and crucial operation features to smooth the manufacturing process and attain sustainable improvement.
- *The S*ix-Sigma TQM integrated model; focusing on unifying the management system by integrating the strategic quality values with the key improvement drivers for orientation towards innovation and business excellence within manufacturing organizations.

- Analytical hierarchy process model; provided a unique means for selecting and evaluating the strategic drivers with respect to integrating quality management performance.

9.4. Research limitation

The main limitations of the research are as follows:

- Due to the lack of related resources and references, the data collected used for validating the models and the framework came from a small number of manufacturing organisations. However, the samples of the data collected were relatively high and involved a trustable target population provided reliable data for validating the research.
- Due to the limitations of time and a lack of the available references, the research study did not manage to collect qualitative data from the required practitioners and experts. This was needed to support the research findings and to examine the impact of the proposed framework on the quality management system within manufacturing organisations.

9.5. Recommendations for further research

The study undertaken the integrated approach in quality management to improve the quality system of manufacturing organisations in practice. Although there were many new features and strategies developed in the framework and the models, there are several recommendations worthwhile which can be suggested for further research within the scope of this thesis:

- Further improvements can be made to the functions and stages of the framework particularly in terms of controlling and sustaining the potential improvements achieved.

- It is important to apply a simulation program alongside a pilot study on the improvement plan to identify the impact of the improvement plan on the quality system.
- Further qualitative investigation is required on the framework involving several manufacturing organisations and an adequate sample size to check the impact of the framework on the quality management system within manufacturing organisations. This could enhance and improve the contents and structure of the framework.
- Further study can be conducted by applying the framework and the integrated models in practice in order to test the effectiveness of its performance within manufacturing organisations.

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Appendixes

Appendix A

Questionnaires for validating the research study

A-1. Questionnaire1; Evaluation the proposed LSS integrated model

Research Survey on investigation the suitability of the proposed conceptual Lean-Six Sigma implementation model for manufacturing organisations

This survey aims to investigate the suitability of the proposed conceptual lean-Six Sigma implementation model for manufacturing organisations. The author's purpose is to analyse the current trend in Lean-Six Sigma implementation in manufacturing organisation, its methodologies, perceived benefits, critical success factors and barriers for success implementation by conducting a survey questionnaire on the senior management of the available manufacturing organisations. The survey is structured in four sections and it is to be filled by managers or management employees.

SECTION A

Background information

The aim of this part of the survey is to present a clear picture of the respondent's background and understand the level of LSS awareness or other quality program existing in the organisation to determine if the organisation has the right culture for LSS implementation.

1) What is your position within your organisation? [ ] Director   [ ] Quality Manager [ ] Operational Manager   [ ] Belt functions [ ] Project Lead   [ ] Other
2) Area of Industry [ ] Manufacturing   [ ] Automotive [ ] Oil and gas   [ ] Other
3) Country organisation Location?

(4) What is the current quality system in your organisation?
TQM [ ]   Six-sigma [ ]   ISO Series [ ]   Others [ ]

5) Have you heard or are you aware of Lean-Six Sigma?
[ ] Yes   [ ] No

6) Have you heard or are you aware of any of these Lean-Six Sigma Tools? Please tick as appropriate.
[ ] 5S methods   [ ] Value Stream Mapping (VSM)
[ ] DMAIC Process   [ ] Pareto Analysis
[ ] Total Productive Maintenance (TPM)   [ ] Brainstorming techniques
[ ] Cause and Effect diagram / Analysis   [ ] Statistical Process Control [ ](SPC)
[ ] Kanban / Line balancing   [ ] Design of Experiments (DOE)
[ ] Single Minute Exchange of Die (SMED)   [ ] Benchmarking
[ ] None of the above   [ ] PDCA (plan, do, check, act)
[ ] Regression analysis   [ ] Force field Analysis
[ ] Quality function deployment (QFD)   [ ] Poka-yoke
[ ] Kaizen events   [ ] Run charts
[ ] ANOVA   [ ] Failure mode analysis
[ ] Process flowchart/mapping   [ ] Histogram
[ ] Taguchi Methods   [ ] Project Charter
[ ] Process capability analysis
[ ] PERT chart (program evaluation and review technique)
[ ] SIPOC (suppliers, input, process, output, customers)

7) What is the major problems facing quality system?

NO	Quality problem	Capable	Incapable
1	Cost driven and priorities	[ ]	[ ]
2	Track which quality efforts work in a market place.	[ ]	[ ]
3	Investment in training	[ ]	[ ]
4	Employee commitment	[ ]	[ ]
5	Defects	[ ]	[ ]
6	Decision Making Technique	[ ]	[ ]
7	Organising of documentation	[ ]	[ ]
8	Quality assurance Auditing	[ ]	[ ]
9	Inability to analyse how good the processes are	[ ]	[ ]
10	Utilizing problem solving techniques	[ ]	[ ]
11	Risk analysis and Uncertainty.	[ ]	[ ]

12 Any other problem facing the current quality system in your organisation not mentioned above, kindly state them below?
……………………………………………………………

SECTION B

How suitable is the Lean-Six Sigma to your organisation and potential benefits that can be achieved through its implementation.

This section of the questionnaire attempts to investigate the extent to which Lean-Six Sigma will be appropriate to your organisation in terms of long term strategic thinking. It will also give an indication of how the approaches to Lean-Six Sigma implementation will be accepted by top management and other employee in your organisation.

(1) Have you had any formal training in Lean and/or Six Sigma? [ ] Lean [ ] Six-Sigma [ ] Both [ ] None
2) How long have you been using the Lean and/or Six-Sigma approaches? [ ] Never used Lean and/or Six-Sigma [ ] 6 months or less [ ] 7-12 months [ ] 1-2 years [ ] 2-5 years [ ] 5-10 years [ ] 10 years +
(3) What is your Lean and or Six-Sigma role? [ ] Team Member [ ] Trainer [ ] Practitioner [ ] Yellow Belt [ ] Green Belt [ ] Black Belt [ ] Master Black Belt [ ] Champion [ ] No Role

(7) Please indicate the extent to which the following motives will influence your decision in adopting the Six Sigma TQM integrated quality management model.

(Rate as you think is appropriate)

Rating scales:
1 - Strongly Disagree 2 – Disagree 3 – Neutral 4 – Agree 5 – Strongly Agree

No.	Factors affecting the organisation’s success	Rating Scales (1-5)
	To meet the customer’s requirement and needs.	
	To improve the organisation’s productivity and overall efficiency.	
	To improve Organisation’s profitability	
	To achieve the organisation’s objectives	
	To reduce production cost / services cost	
	To follow industrial trends	
	To gain competitive advantage	
	To improve product quality / quality of service	
	To expand to overseas market	

	To gain and improve customer's confidence in your product or services	
	To exceed customer satisfaction and fitful customer delight	
	To enhance and support the organisation's reputation	
	To attract more customers	
	To develop the organisation management techniques	
	To achieve sustainable improvement	
Others, please specify:		

(8) Please indicate the extent of the benefits your organisation could gain by adopting Six Sigma TQM as integrated quality management model

(Tick as you consider appropriate)
Rating scales:
1 – Very less 2 – Less 3 – Moderate 4 – Much 5 – Very much

No	Perceived benefits of Lean-Six Sigma to Nigerian Industries	Rating Scales (1-5)
1	Cultivate the quality concepts and awareness of speed and innovation by investment in training	
2	Improved delivery (e.g. reduced customer lead time)	
3	Cultural benefits (e.g. motivated workforce)	
4	Focusing on exceed customer satisfaction and fulfil customer delight	
5	Reducing quality problems (defects and rework)	
6	High awareness of quality among employees	
7	Utilise the IT system support for enhancing the implement process and perform high improvement performance	
8	Improved productivity	
9	Realisation of the employees participation and make everyone involved in the organisation	
10	Learn from mistakes by taking action for high quality (emphasising on continuous improvement)	
11	Increasing profits and reducing the cost of production	
12	Enhancing the organisation's competitive position	
13	Increasing the customers confidence and relations	
14	Reduced warranty claim cost	
16	Improved sales	
17	Organised working environment	
18	Generate new business opportunities	
Others, please specify:		

Section C: Evaluating the awareness and usefulness of the LSS tools and techniques to Manufacturing organisations

This section of the survey seeks to provide an understanding of your involvement in Six- Sigma and Lean tools and techniques that have been used in your organization or used by you and how useful these tools to business for manufacturing organisation. It aims to provide an understanding of basic Six-Sigma and Lean tools and implementation procedure that are suitable for manufacturing organizations, identify possible difficulty in implementing the proposed model and show the level of accuracy of the contents of the model as applied to business in manufacturing organizations.

(9) Which Lean and/ or Six-Sigma tools and techniques have you used or have been applied in your organisation?

(Tick as you consider appropriate)

Rating scales:
1 – Never been used 2 – Used only once 3 – Used rarely 4 – Used frequently 5 – Used continuously

No.	Lean-Six Sigma Tools and Techniques	Rating scale (1-5)
	5 S Methods	
	Kanban / Line balancing	
	Pareto Analysis	
	Brainstorming techniques	
	Value Stream Mapping (VSM)	
	PDCA (plan, do, check, act)	
	Cause and effect diagram / analysis	
	Statistical process control chats (SPC)	
	Quick change over, SMED (single minute exchange of die)	
	Benchmarking	
	Regression analysis	
	Design of experiments (DOE)	
	PERT chart (program evaluation and review technique)	
	Quality function deployment (QFD)	
	Force field Analysis	
	Poka-yoke	
	Kaizen events	
	Run charts	
	ANOVA	
	Failure mode analysis	
	SIPOC (suppliers, input, process, output, customers)	
	Process flowchart/mapping	
	Histogram	
	Taguchi Methods	
	Project Charter	
	Process capability analysis	

(5) Which Lean and/ or Six-Sigma tools and techniques do you consider useful and to your organisation or other M O?

(Tick as you consider appropriate)

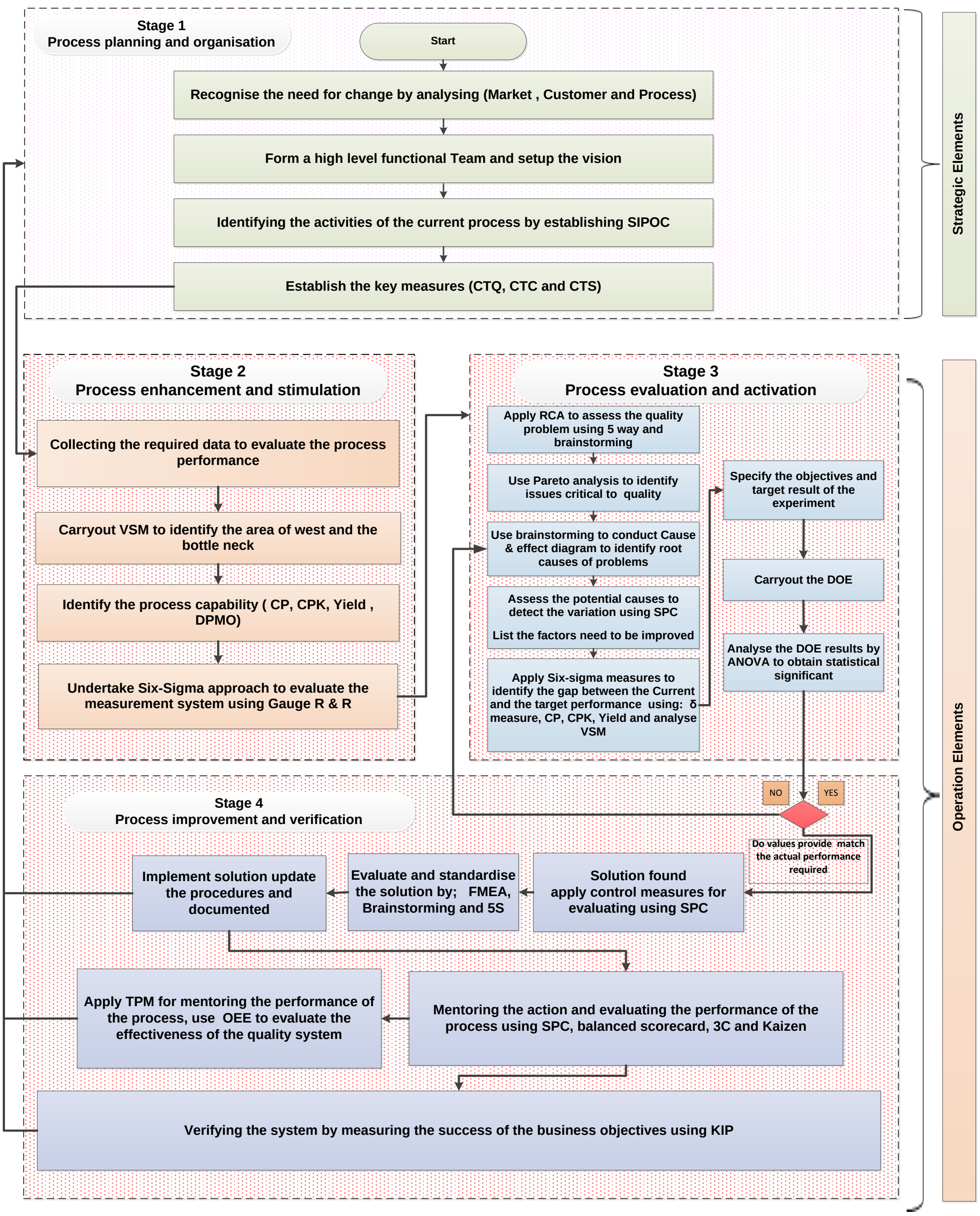
Rating scales:
1 – Not useful 2 – Less useful 3 – Moderate 4 – Useful 5 – Very Useful

No.	Lean-Six Sigma Tools and techniques	Rate Scale (1-5)
	5 S Methods	
	Kanban / Line balancing	
	Pareto Analysis	
	Brainstorming techniques	
	Value Stream Mapping (VSM)	
	PDCA (plan, do, check, act)	
	Cause and effect diagram / analysis	
	Statistical process control chats (SPC)	
	Quick change over, SMED (single minute exchange of die)	
	Benchmarking	
	Regression analysis	
	Design of experiments (DOE)	
	PERT chart (program evaluation and review technique)	
	Quality function deployment (QFD)	
	Force field Analysis	
	Poka-yoke	
	Kaizen events	
	Run charts	
	ANOVA	
	Failure mode analysis	
	SIPOC (suppliers, input, process, output, customers)	
	Process flowchart/mapping	
	Histogram	
	Taguchi Methods	
	Project Charter	
	Process capability analysis	

SECTION D

Evaluation the proposed Lean-Six Sigma integrated Model to your Organization and other manufacturing organization.

This section of the survey seeks to evaluate the proposed Lean-Six Sigma integrated model for manufacturing organizations. It aims to provide an understanding of basic Lean-Six Sigma tools and implementation procedure that are suitable for manufacturing organisations, identify possible difficulty in implementing the proposed model and show the level of accuracy of the contents of the model as applied to business in manufacturing organisations.



The proposed conceptual LSS integrated model for manufacturing organisation

(6) Please indicate the extent of which you agree to the following statements. (Tick as you consider appropriate) Rating scales: 1 – Strongly disagree 2 – Disagree 3 – Moderate 4 – Agree 5 – Strongly agree		
No.	Statements relating to Lean-Six Sigma Implementation Model	Rating Scales (1-5)
1	To what extent do you agree with the contents of the proposed Lean-Six Sigma implementation Model for M O?	
2	To what extent do you agree that this model is suitable and applicable in your Organization?	
3	Do you agree that the contents of this model will boost your Organization's competitiveness and profit?	
4	Do you agree that the proposed Lean-Six Sigma implementation Model will help your organization overcome the complex nature of Lean-Six Sigma implementation?	
5	Do you agree that Lean-Six Sigma will help your organization in reaching its long term goals and business expectations?	
(6) Do you foresee any difficulty in adopting Lean-Six Sigma in your organization using the proposed model? [ ] No [ ] Yes If Yes kindly state it below.		
(7) In your own judgment, do think anything is missing in the content of the model? [ ] No [ ] Yes If yes, kindly state them below?		

SECTION E

Critical Success factors for Lean-Six Sigma Implementation in MO

This part of the survey is aimed at understanding the critical factors necessary for successful implementation of Lean-Six Sigma in manufacturing organisations and potential barriers that can impede the implementation process.

(1) Please rate the importance of these critical factors to the successful implementation of Lean-Six Sigma in M O.

(please tick as you consider appropriate)

Rating Scale:
1 – Not important at all 2 – Slightly important 3 – important 4 – quite important 5- very important

No	Critical success factor for Lean-Six Sigma implementation in M O	Rating Scales (1-5)
1	Organisational structure;	
2	Business plan and Vision;	
3	Liking LSS to customer;	
4	Change management and organisation culture	
5	Education and training;	
6	Top management involvement and participation;	
7	Effective communication;	
8	Linking LSS to organisation's business strategy;	
9	Project selection, prioritisation, reviews and tracking	
10	Linking to Suppliers;	
11	Project management and	
12	Monitoring and evaluation of performance	
Other, please specify and rate:		

(2) Please indicate to what extent these factors will impede the implementation of Lean-Six Sigma in M O.

(please tick as you consider appropriate)

Rating Scale:
1 – Very Low 2 – Low 3 – Moderate 4 – High 5- Very High

Barriers to successful implementation of Lean-Six Sigma in M O	Rating scales (1-5)
Internal resistance	
Poor project selection	
Lack of Leadership	
Lack of Tangible results	
Availability of Resources	
Change management	
Changing business focus	
Competing projects	
Unmanaged expectations	
Poor training and coaching	
Low employee retention	
Others, please specify and rate:	

A-2: Questionnaire 2; Evaluation of the proposed SS_TQM Integrated model

Research Survey on the investigation of the suitability of the proposed integrated Si x-sigma TQM conceptual model for manufacturing organisation

This survey aims to investigate the suitability of the proposed integrated Six-sigma TQM conceptual model for achieving business excellence in manufacturing organisations. The author's purpose is to analyse the current trend in quality management implementation particular Six-sigma and TQM in manufacturing organisation, its methodologies, perceived benefits, critical success factors and barriers for success implementation by conducting a survey questionnaire on the senior management of the available manufacturing organisations. The survey is structured in four sections and it is to be filled by Academics, managers or management employees.

SECTION A

Background information

The aim of this part of the survey is to present a clear picture of the respondent's background and understand the awareness level of the existing quality program in the organisation to determine if the organisation has the right culture for the integrated Six-sigma and TQM proposed model.

What is your position within your organisation? [ ] Director [ ] Quality Manager [ ] Operational Manager [ ] Quality engineer [ ] Belt functions [ ] Project Lead or departmental head [ ] Coordinator [ ] Academics [ ] Others
Area of Industry [ ] Manufacturing [ ] Automotive [ ] Oil and Gas [ ] Other
(3) Country Organisations Location?
(4) What is the current quality system in your organisation? TQM [ ] Six-sigma [ ] ISO Series [ ] Others [ ]
(5) Have you heard or are you aware of the following Quality management approach? Six-Sigma [ ] Yes [ ] No TQM [ ] Yes [ ] No

(6) Have you heard or are you aware of any of these Six-sigma and TQM Tools? Please tick as appropriate.

[ ] PDCA (plan, do, check, act) [ ] DMAIC Process
[ ] Pareto Analysis
[ ] Total Productive Maintenance (TPM) [ ] Brainstorming techniques
[ ] Cause and Effect diagram / Analysis [ ] Statistical Process Control [ ](SPC) [ ] (DOE)
[ ] Benchmarking
[ ] Regression analysis [ ] Force field Analysis
[ ] Quality function deployment (QFD) [ ] Run charts
[ ] ANOVA [ ] Failure mode analysis
[ ] Process flowchart/mapping [ ] Histogram
[ ] Taguchi Methods [ ] Project Charter
[ ] Process capability analysis
[ ] PERT chart (program evaluation and review technique)
[ ] SIPOC (suppliers, input, process, output, customers)

(7) What are the main problems facing the current quality system in your organisation?

	Yes	No
1 Decision Making	[ ]	[ ]
2 Risk analysis and uncertainty	[ ]	[ ]
3 Lacks cost driven priorities	[ ]	[ ]
4 investment in training	[ ]	[ ]
5 Fails to track which quality efforts work in a market place	[ ]	[ ]
6 Employees commitment	[ ]	[ ]
7 Resources Management	[ ]	[ ]
8 Follow up the documentation process	[ ]	[ ]
9 Rescheduling organisation	[ ]	[ ]
10 The right organisation of storage space	[ ]	[ ]
11 The right selection of raw material	[ ]	[ ]
12 Involvement of the top management and support	[ ]	[ ]
13 middle management Involvement and realisation of teamwork	[ ]	[ ]
14 Defects rate	[ ]	[ ]
15 Machine setup control	[ ]	[ ]
16 Planning and following the maintenance program	[ ]	[ ]
17 Taking action for continuous improvement	[ ]	[ ]
18 Marketing and sales management	[ ]	[ ]

(8) Any other problem facing the current quality system in your organisation not mentioned above, kindly state them below?
…………………………………………………………………………………………
…………………………………………………………………………………………
…………

SECTION B

The awareness and usefulness of the Six Sigma and TQM tools and techniques to manufacturing organization

This section of the survey seeks to provide an understanding of your involvement in Six- Sigma and TQM tools and techeques that have been used in your organization or used by you and how useful these tools to business for manufacturing organization. It aims to provide an understanding of basic Six Sigma and TQM tools and implementation procedure that are suitable for manufacturing organizations, identify possible difficulty in implementing the proposed model and show the level of accuracy of the contents of the model as applied to business in manufacturing organizations.

Have you had any formal training in Six Sigma or/and TQM concepts?
[ ] TQM [ ] Six-Sigma
[ ] Both [ ] None

How long have you been using the Six-Sigma or TQM approaches?
[ ] Never used TQM or Six-Sigma [ ] One year or less
[ ] 2-5 years [ ] 5-10 years
[ ] 10 years +

What is your TQM and/or Six-Sigma role?
[ ] Team Member [ ] Trainer
[ ] Practitioner [ ] Yellow Belt
[ ] Green Belt [ ] Black Belt
[ ] Master Black Belt [ ] Champion
[ ] Manager [ ] Head of department
[ ] No Role

(4) Which TQM and/ or Six-Sigma tools and techniques have you used or have been applied in your organisation?

(Tick as you consider appropriate)

Rating scales:
1 – Never been used 2 – Used only once 3 – Used rarely 4 – Used frequently 5 – Used continuously

No.	Lean-Six Sigma Tools and Techniques	Rating scale (1-5)
1	Pareto Analysis	
2	Brainstorming techniques	
3	PDCA (plan, do, check, act)	
4	Cause and effect diagram / analysis	
5	Statistical process control chats (SPC)	
6	Benchmarking	

7	Regression analysis	
8	Design of experiments (DOE)	
9	PERT chart (program evaluation and review technique)	
10	Quality function deployment (QFD)	
11	Force field Analysis	
12	Run charts	
13	ANOVA	
14	Failure mode analysis	
15	SIPOC (suppliers, input, process, output, customers)	
16	Process flowchart/mapping	
17	Histogram	
18	Taguchi Methods	
19	Project Charter	
20	Process capability analysis	

(5) Which TQM and/ or Six-Sigma tools and techniques do you consider useful to your organisation or other manufacturing organisations?

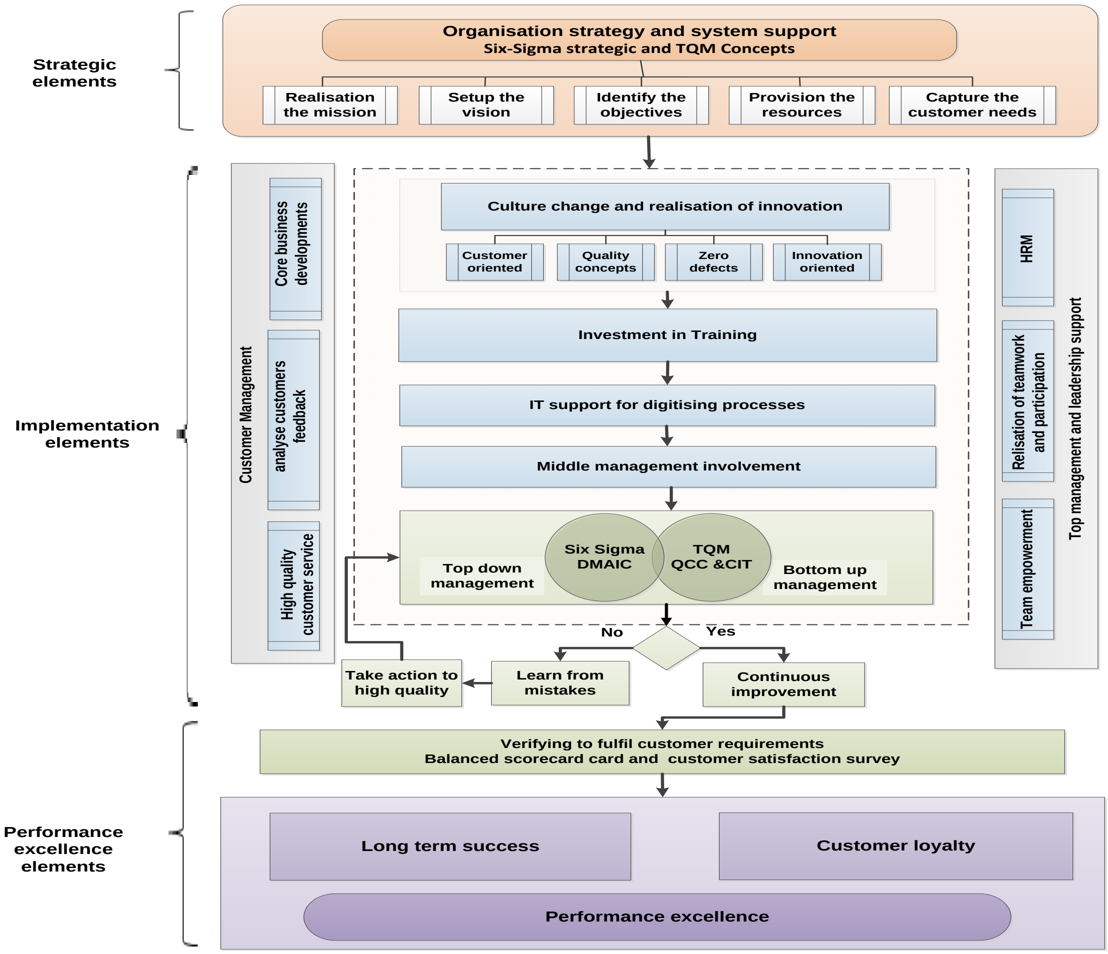
(Tick as you consider appropriate)

Rating scales:
1 – Not useful 2 – Less useful 3 – Moderate 4 – Useful 5 – Very Useful

No.	Lean-Six Sigma Tools and techniques	Rate Scale (1-5)
1	Pareto Analysis	
2	Brainstorming techniques	
3	PDCA (plan, do, check, act)	
4	Cause and effect diagram / analysis	
5	Statistical process control chats (SPC)	
6	Benchmarking	
7	Regression analysis	
8	Design of experiments (DOE)	
9	PERT chart (program evaluation and review technique)	
10	Quality function deployment (QFD)	
11	Force field Analysis	
12	Run charts	
13	ANOVA	
14	Failure mode analysis	
15	SIPOC (suppliers, input, process, output, customers)	
16	Process flowchart/mapping	
17	Histogram	
18	Taguchi Methods	
19	Project Charter	
20	Process capability analysis	

Section C - Validation of the Proposed integrated Six-sigma TQM Conceptual model for manufacturing organizations

This section of the survey seeks to validate the proposed model for manufacturing organizations shown below, it aims to provide an understanding of Six-sigma and TQM implementation procedures suitable for manufacturing organizations, identify the difficulties in implementing the proposed model and reveal the accuracy level in its contents in terms of helping business to gain competitive advantage on the long run, a shown below the model consisting of three main elements which are; Strategic elements including the key elements that can guide the organizations to achieve the main goals. Implementation elements, contains the main drivers that can simplify the operation process and obtain better performance. Performance excellence elements, including the key measures that can attain sustainable improvement and excellence performance. I would like you to consider these elements and indicate to which extent you are agree to the following statements.



The proposed conceptual Six-Sigma TQM integrated model for manufacturing organisations

(6) Please indicate the extent which you agree to the following statements?

(Tick as you consider appropriate)

Rating scales:
1 – Strongly disagree 2 – Disagree 3 – Moderate 4 – Agree 5 – Strongly agree

1	Statement relating to the strategic elements of the proposed model.	Rating Scales (1-5)
	To what extent do you agree with the contents of the strategic elements of the proposed Six- Sigma and TQM integrated Model for Manufacturing Organization?	

2	Statement relating to the implementation elements of the proposed model.	Rating Scales (1-5)
	To what extent do you agree with the contents of the implementation elements of the proposed Six-Sigma and TQM integrated Model for Manufacturing Organization?	

3	Statement relating to the performance excellence elements of the proposed model.	Rating Scales (1-5)
	To what extent do you agree with the contents of the strategic elements of the proposed Six- Sigma and TQM integrated Model for Manufacturing Organization?	

Statements relating to Six-Sigma and TQM integrated Model		Rating Scales (1-5)
4	To what extent do you agree that this model is suitable and applicable in your Organization?	
5	Do you agree that the contents of this model will boost your Organization’s competitiveness and profit?	
6	Do you agree that the proposed Six Sigma TQM integrated Model will help your organization to overcome the complex nature of TQM-Six Sigma implementation?	
7	Do you agree that the proposed model will help your organization in reaching its long term goals and business expectations?	
8	In your own judgment, do you have anything missing and should be added to the proposed model? [ ] No [ ] Yes If yes, kindly state them below? …………………………………………………………………………………… ……………………………………………………………………………………	

Statements relating to Six-Sigma and TQM integrated Model in terms of the extent to which the following motives will influence your decision in adopting the Six Sigma and TQM integrated quality management model.		Rating Scales (1-5)
1	To meet the customer's requirement and needs.	
2	To improve the organisation's productivity and overall efficiency.	
4	To improve Organisation's profitability	
5	To achieve the organisation's objectives	
6	To reduce production cost / services cost	
7	To follow industrial trends	
8	To gain competitive advantage	
9	To improve product quality / quality of service	
10	To expand to overseas market	
11	To gain and improve customer's confidence in your product or services	
12	To exceed customer satisfaction and fitful customer delight	
13	To enhance and support the organisation's reputation	
14	To attract more customers	
15	To develop the organisation management techniques	
16	To achieve sustainable improvement	
Others, please specify:		

Section D- Critical Success factors for Six-Sigma TQM integrated model in manufacturing organizations

This part of the survey is aimed to understanding the critical factors necessary for successful implementation of Six-Sigma TQM integrated mode in manufacturing organizations and potential barriers that can impede the implementation process.

1) Please rate the importance of these critical factors to the successful implementation of Six Sigma in manufacturing organizations?

(please tick as you consider appropriate)

Rating Scale:
1 – Not important at all 2 – Slightly important 3 – important 4 – quite important 5- very important

No	Critical success factor for Lean-Six Sigma implementation in manufacturing organizations	Rating Scales (1-5)
1	Organisation infrastructure	
2	Top management and leadership support	
3	Investment in training	
4	Middle management involvement	
5	Communication	
6	Understanding DMAIC strategy to deal with quality issues	
7	Understanding the usage of six-sigma and TQM tools and techniques and how to use in the right action	
8	Investing in the adequate resources	
9	Utilise IT to support implementation	
10	Use of the best talent	
11	Knowledge and competence the employees	
12	Ability to learn from mistakes and history	
Other, please specify and rate:		

(2) Please indicate to what extent these factors will impede the implementation of Lean-Six Sigma in manufacturing organizations?

(please tick as you consider appropriate)

Rating Scale:
1 – Very Low 2 – Low 3 – Moderate 4 – High 5- Very High

No	Barriers to successful implementation of Lean-Six Sigma in manufacturing organizations	Rating scales (1-5)
1	Internal resistance	
2	Poor project selection	
3	Lack of Leadership	
4	Lack of Tangible results	
5	Availability of Resources	
6	Change management	
7	Changing business focus	
8	Competing projects	
9	Unmanaged expectations	
10	Poor training and coaching	
11	Low employee retention	

A-3: Questionnaire 3; Evaluation the proposed integrated quality management framework

Research Survey on the investigation of the suitability of a proposed integrated quality management framework for manufacturing organisation

This survey aims to investigate the suitability of the proposed integrated quality management framework to improve and modernise the quality system within manufacturing organisations. The proposed framework developed by integrating three powerful methodology which are; Six-Sigma, Lean operation and TQM, the aim is to eliminate the quality critical issues within manufacturing organisation and make the quality system in place more effective. The author's purpose is to analyse the current trend in quality management implementation in particular Six-sigma, Lean operation and TQM in manufacturing organisation, its methodologies, perceived benefits, critical success factors and barriers for successful implementation by conducting this survey questionnaire. The survey is structured in three sections for Academics, managers or management employees to fill in.

SECTION A

Background information

The aim of this part of the survey is to present a clear picture of the respondent's background and understand the awareness level of the existing quality programme in the organisation.

What is your position within your organisation? [ ] Director   [ ] Quality Manager [ ] Operational Manager   [ ] Quality engineer [ ] Belt functions   [ ] Project Lead or departmental head [ ] Coordinator   [ ] Academics [ ] Others
Area of Industry [ ] Manufacturing   [ ] Automotive [ ] Oil and Gas [ ] Other
(3) Country Organisations Location?
(4) What is the current quality system in your organisation? TQM [ ]   Six-sigma [ ]   ISO Series [ ]   Others [ ]
(5) Have you heard or are you aware of the following Quality management approach? Six-Sigma [ ] Yes [ ] No Lean operation [ ] Yes [ ] No TQM [ ] Yes [ ] No
(6) Have you heard or are you aware of any of these Six-sigma, Lean and TQM Tools? Please tick as appropriate.

[ ] PDCA (plan, do, check, act)	[ ] DMAIC Process
[ ] 5S methods	[ ] Value Stream Mapping (VSM)
[ ] Pareto Analysis	[ ] Root causes analysis
[ ] Total Productive Maintenance (TPM)	[ ] Brainstorming techniques
[ ] Cause and Effect diagram / Analysis	[ ] Statistical Process Control (SPC)
[ ] Design of Experiments (DOE)	[ ] Kaizen events
[ ] Kanban / Line balancing	[ ] Poka-yoke
[ ] Single Minute Exchange of Die (SMED)	[ ] Benchmarking
[ ] Regression analysis	[ ] Force field Analysis
[ ] Quality function deployment (QFD)	[ ] Run charts
[ ] ANOVA	[ ] Failure mode analysis
[ ] Process flowchart/mapping	[ ] Histogram
[ ] Taguchi Methods	[ ] Project Charter
[ ] Process capability analysis	[ ] Cost of Poor quality COPQ
[ ] PERT chart (program evaluation and review technique)	
[ ] SIPOC (suppliers, input, process, output, customers)	

Section B - Validation of the Proposed integrated Quality Management framework for manufacturing organizations

This section of the survey seeks to validate the proposed framework for manufacturing organisations shown below; it aims to provide an understanding of the implementation procedures suitable for manufacturing organisations, identify the difficulties in implementing the proposed framework and reveal the accuracy level in its contents in terms of helping business to gain competitive advantage on the long run. As shown below the framework consists of five main stages consolidated with soft factors for successful implementation procedures and achieving the main desired goals, the stages of the framework are;

Phase1 Strategic planning: including the soft factors for successful planning process and strategic planning steps to formulate the quality management planning and facilitate the implementation phases.

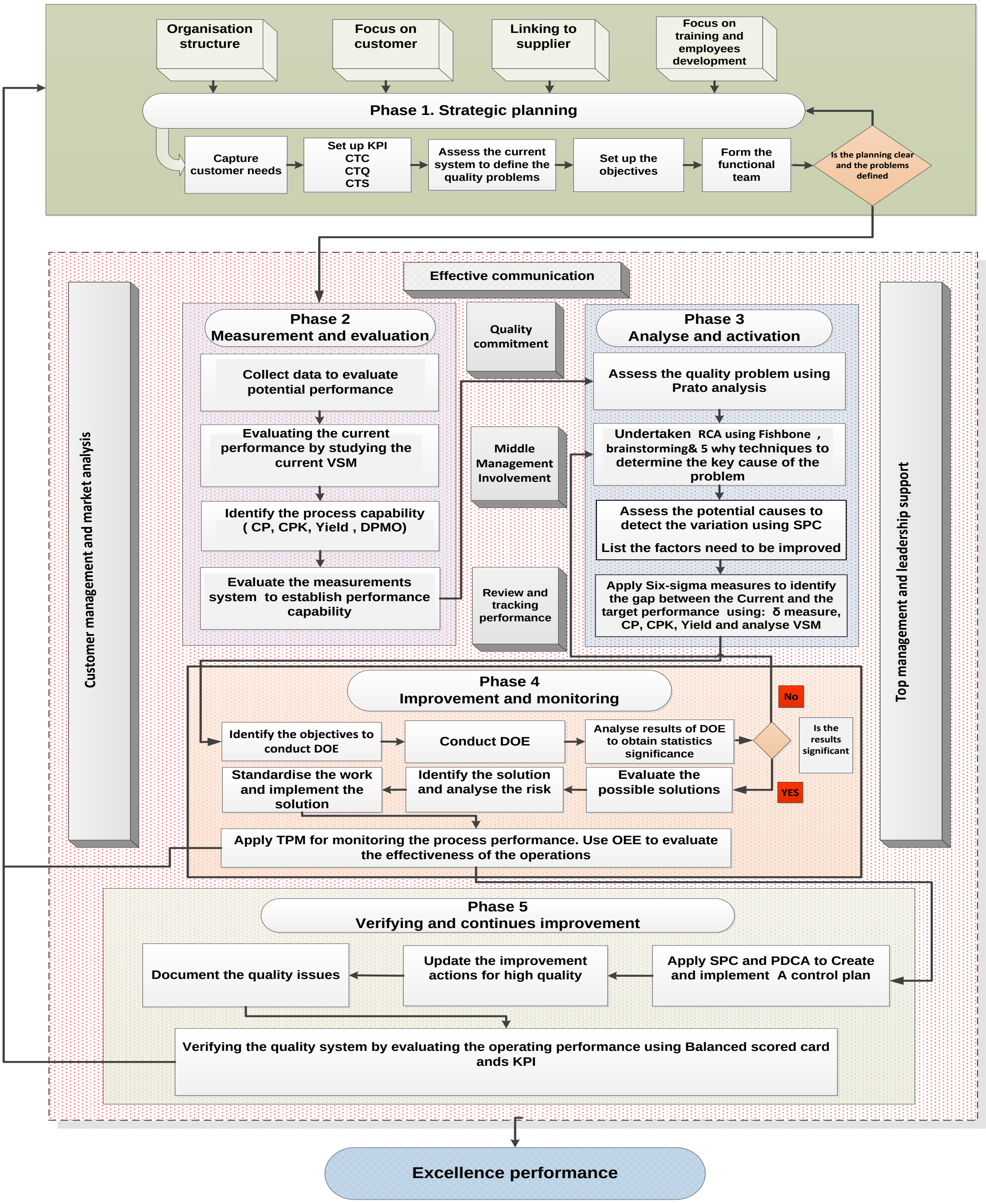
Phase 2 Measurement and evaluation: comprises four stages, each stage equipped with set of tools and techniques to evaluate the current system and to collect the required data for the purpose of inspecting the current performance and investigating the quality problems.

Phase 3 Analysis and activation; consists of four stages each stage employed different quality control tools and techniques to analyse the gap between the current and desired performance and identify the causes of quality problems.

Phase 4 Improvement and monitoring; this phase is concerned with process of developing, implementing and monitoring the improvement plan, Design of Experiments (DOE) technique employed to identify the solution of quality issues and quality control tools used to implement and monitor the improvement plan, this phase includes seven stages.

Phase 5 Verifying and continues improvement; comprise seven stages, set of quality tools used to control and sustain the improvement performance and other global tools employed to evaluate and verify the organisation success.

The whole phases of the framework consolidated by six soft factors to enhance and guarantee the successful implementation process and guide the organisations to achieve the main goals. These factors are: *Top management and leadership support*, *Customer management and market analysis*, *Effective communication, Quality commitment, middle management involvement*, , and *review and tracking performance.*



The proposed integrated quality management framework

I would be grateful if you could consider these components and indicate to what extent you are in agreement with the following statements.

(1) Statements relating to the proposed integrated quality management framework.

Please indicate the extent to which you agree about the following statements?

(Tick as you consider appropriate)

Rating scales:
1 – Strongly disagree 2 – Disagree 3 – Moderate 4 – Agree 5 – Strongly agree

Statements relating to the proposed integrated quality management framework.		Rating Scales (1-5)
1	To what extent do you agree that the integrated framework is suitable and applicable in your Organisation?	
2	Do you agree that the contents of this framework will boost your Organisation's competitiveness and profit?	
3	To what extent do you agree that the integrated framework applicable to deal and overcome the quality problems?	
4	Do you agree that the proposed integrated quality management framework will help your organisation to overcome the complex nature of quality management implementation?	
5	Do you agree that the proposed framework will help your organisation in reaching its long term goals and business expectations?	
6	In your own judgment, do you have anything missing and should be added to the proposed framework? [ ] No [ ] Yes If yes, kindly state them below? ……………………………………………………………………………………… ………………………………………………………………………………………	

(2) Statements relating to the implementation procedures of the proposed integrated quality management framework.

Please indicate the extent to which you agree about the following statements?

(Tick as you consider appropriate)

Rating scales:
1 – Strongly disagree 2 – Disagree 3 – Moderate 4 – Agree 5 – Strongly agree

	Statement relating to phase one of the proposed framework; strategic planning.	Rating Scales (1-5)
1	To what extent do you agree with the soft factors of the strategic planning in phase one?	
2	To what extent do you agree that the soft factors of the strategic planning in phase one will assist and success the planning process.	
3	In your own judgment, do you have any soft factors missing and should be added to the strategic planning phase of the proposed framework? If yes, kindly state them below? ………………………………………………………………………	[ ] Yes [ ] No
4	To what extent do you agree with the contents of the strategic steps for preceding the planning process in phase one?	
	In your own judgment, do you have any strategic steps missing and should be added to the strategic planning phase of the proposed framework? If yes, kindly state them below? ………………………………………………………………………	[ ] Yes [ ] No

	Statement relating to phase two of the proposed framework; Measurement and evaluation.	Rating Scales (1-5)
1	To what extent do you agree with the contents of phase two of the proposed framework (Measurement and evaluation)?	
2	To what extent do you agree that the stages of phase two capable to meet the key target (evaluation the current performance and collecting data for investigating the quality problems)?	
3	In your own judgment, do you have any stages or elements missing and should be added to measurement and evaluation phase of the proposed framework? If yes, kindly state them below? ………………………………………………………………………	[ ] Yes [ ] No

3	Statement relating to phase three of the proposed framework; Analysis and activation.	Rating Scales (1-5)
1	To what extent do you agree with the contents of phase three of the proposed framework (Analysis and activation)?	
2	To what extent do you agree that the stages of phase three capable to meet the key target (Analyse the gap between the current and the desired performance and identify the root causes of the quality problems)?	
3	In your own judgment, do you have any stages or elements missing and should be added to Analysis and activation phase of the proposed framework? If yes, kindly state them below? ………………………………………………………………………	[ ] Yes [ ] No

2	Statement relating to the phase four of the proposed framework; Improvement and monitoring.	Rating Scales (1-5)
1	To what extent do you agree with the contents of phase four of the proposed framework (Improvement and monitoring)?	
2	To what extent do you agree that the stages of phase four capable to meet the key target (Developing, implementing and monitoring the improvement plan)?	
3	In your own judgment, do you have any stages or elements missing and should be added to Improvement and monitoring phase of the proposed framework? If yes, kindly state them below? ………………………………………………………………………	[ ] Yes [ ] No

	Statement relating to the phase five of the proposed framework; Verifying and continuous improvement.	Rating Scales (1-5)
1	To what extent do you agree with the contents of phase five of the proposed framework (Verifying and continuous improvement)?	
2	To what extent do you agree that the stages of phase five capable to meet the key target (To maintain the control plan and confirm the organization success)?	
3	In your own judgment, do you have any stages or elements missing and should be added to Verifying and continuous improvement phase of the proposed framework? If yes, kindly state them below? ………………………………………………………………………	[ ] Yes [ ] No

	Statement relating to the soft factors of the implementation process of the proposed framework.	Ratings Scales (1-5)	Rating Scales (1-5)
1	To what extent do you agree with the soft implementation factors of the proposed framework?		
2	To what extent do you agree that the soft implementation factors will assist and success of the implementation process of the proposed framework?		
3	In your own judgment, do you have any soft implementation factors missing and should be added to the strategic planning phase of the proposed framework? If yes, kindly state them below? ………………………………………………………………………….		[ ] Yes [ ] No

(3) Statements relating to proposed framework in terms of the extent to which the following motives will influence your decision in adopting the integrated quality management framework.		
1	To meet the customer's requirement and needs.	
2	To improve the organisation's productivity and overall efficiency.	
4	To improve Organisation's profitability	
5	To achieve the organisation's objectives	
6	To reduce production cost / services cost	
7	To follow industrial trends	
8	To gain competitive advantage	
9	To improve product quality / quality of service	
10	To expand to overseas market	
11	To gain and improve customer's confidence in your product or services	
12	To exceed customer satisfaction and fitful customer delight	
13	To enhance and support the organisation's reputation	
14	To attract more customers	
15	To develop the organisation management techniques	
16	To achieve sustainable improvement	
Others, please specify:		

(2) Please indicate to what extent these factors will impede the implementation of the proposed framework in manufacturing organisations? (please tick as you consider appropriate) Rating Scale:

Section C- The critical Success factors for the proposed framework in manufacturing organizations

This part of the survey is aimed to understanding the critical factors necessary for successful implementation of proposed integrated quality management framework in manufacturing organisations and potential barriers that can impede the implementation process.

(1) Please rate the importance of these critical factors to the successful implementation of the integrated quality management framework? (please tick as you consider appropriate) Rating Scale: 1 – Not important at all 2 – Slightly important 3 – important 4 – quite important 5- very important		
No	Critical success factor for the integrated quality management framework in manufacturing organizations	Rating Scales (1-5)
1	Organisation infrastructure	
2	Focus on customer	
3	Linking to supplier	
4	Training and education	
5	Top management and leadership support	
6	Effective communication	
7	Middle management involvement	
8	Quality commitment	
9	Review and tracking performance	
10	Project management	
Other, please specify and rate:		

1 – Very Low 2 – Low 3 – Moderate 4 – High 5- Very High		
No	Barriers to successful implementation of the proposed framework.	Rating scales (1-5)
1	Internal resistance	
2	Poor project selection	
3	Lack of Leadership	
4	Lack of Tangible results	
5	Availability of Resources	
6	Change management	
7	Changing business focus	
8	Competing projects	
9	Unmanaged expectations	
10	Poor training and coaching	
11	Low employee retention	

Appendix B

Evaluating and prioritisation the main components of the framework

Development of an integrated quality management performance framework

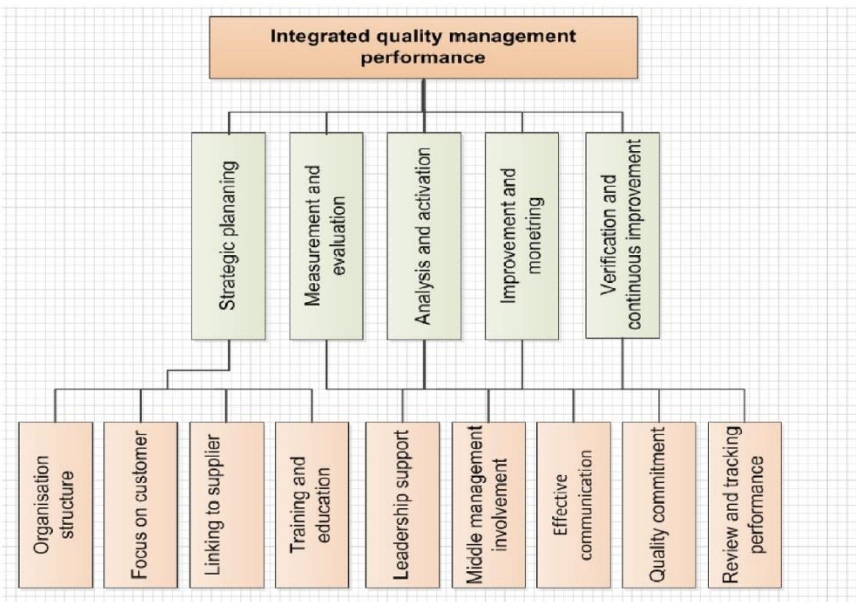
This research focusses on the development of an integrated quality management performance framework in order to evaluate and decide upon the strategic quality management elements that should form this framework. As can be seen in the following proposed strategic elements framework, its criteria and sub-criteria that may have influences are listed and structured in a hierarchy format, this will enable us to formalise the contents of the framework as well as prioritising these elements. Therefore, the aim of this questionnaire is to gather the opinion of the practitioners, researchers and industrialists by carry out a pairwise comparison between these criteria and criteria sub-criteria within the proposed framework. In addition, there is an opportunity at the end to explore your opinion and whether we have missed other criteria which should be added.

Your contribution and partition are highly appreciated and we would like to thank you in advance for your time and answers.

* Required

Top of Form

Figure (1) Proposed hierarchy structure model contains the target, main criteria and sub-criteria



Years of experience

Mark only one oval.

- ( ) 1 to 5 years
- (•) 5 to 10 years
- ( ) More than 10 Years

Sector of experience

Mark only one oval.

- ( ) Academics
- ( ) Industrial
- ( ) Booth
- (•) Others

Comparison between the main criteria

Pairwise comparison between the attributes of the main criteria with respect of effective quality management performance

Compare the relative importance between Strategic planning and (measurement & evaluation) with respect to the main target "integrated quality management performance" Strategic planning means; Is the strategic drivers that are required to success the implementation process and to achieve the organisation objectives. *

Mark only one oval.

- (•) 9 Strategic planning is extremely more important than Measurement and evaluation
- ( ) 7 Strategic planning is very strongly more important than Measurement and evaluation
- ( ) 5 Strategic planning is strongly more important than Measurement and evaluation
- ( ) 3 Strategic planning is moderately more important than Measurement and evaluation
- ( ) 1 Strategic planning and (Measurement & evaluation) are equal important
- ( ) 3 Measurement and evaluation is moderately more important than Strategic planning
- ( ) 5 Measurement and evaluation is strongly more important than Strategic planning
- ( ) 7 Measurement and evaluation is very strongly more important than Strategic planning

9 Measurement and evaluation is extremely more important than strategic planning

Compare the relative importance between Strategic planning and (Analysis & activation) with respect to the main target "integrated quality management performance" *

Mark only one oval.

9 Strategic planning is extremely more important than Analysis and activation

7 Strategic planning is very strongly more important than Analysis and activation

5 Strategic planning is strongly more important than Analysis and activation

3 Strategic planning is moderately more important than Analysis and activation

1 Strategic planning and (Analysis & activation) are equal important

3 Analysis and activation is moderately more important than Strategic planning

5 Analysis and activation is strongly more important than Strategic planning

7 Analysis and activation is very strongly more important than Strategic planning

9 Analysis and activation is extremely more important than Strategic planning

Compare the relative importance between Strategic planning and (Improvement & monitoring) with respect to the main target "integrated quality management performance" *

Mark only one oval.

9 Strategic planning is extremely more important than Improvement and monitoring

7 Strategic planning is very strongly more important than Improvement and monitoring

5 Strategic planning is strongly more important than Improvement and monitoring

3 Strategic planning is moderately more important than Improvement and monitoring

1 Strategic planning and (Improvement & monitoring) are equal important

3 Improvement and monitoring are moderately more important than Strategic planning

5 Improvement and monitoring are strongly more important than Strategic planning

7 Improvement and monitoring are very strongly more important than Strategic planning

9 Improvement and Monitoring are extremely more important than Strategic planning

Compare the relative importance between Strategic planning and (Verification & continuous improvement) with respect to the main target "integrated quality management performance" *

Mark only one oval.

9 Strategic planning is extremely more important than Verification and continuous improvement

7 Strategic planning is very strongly more important than Verification and continuous improvement

5 Strategic planning is strongly important than verification and continuous improvement

3 Strategic planning is moderately more important than Verification and continuous improvement

1 Strategic planning and (Verification & continuous improvement) are equal important

3 Verification and continuous improvement is moderately more important than Strategic planning

5 Verification and continuous improvement is Strongly more important than Strategic planning

7 Verification and continuous improvement is very strongly more important than Strategic planning

9 Verification and continuous improvement is extremely more important than Strategic planning

Compare the relative importance between the (Measurement & evaluation) and (Analysis & activation) with respect to the main target "integrated quality management performance" Measurement and Evaluation means; is the key measures that are required to evaluate the current performance and to enhance the work environment *

Mark only one oval.

9 (Measurement & evaluation) is extremely more important than (Analysis and activation)

7 (Measurement & evaluation) is very strongly more important than (Analysis & activation)

5 (Measurement & evaluation) is strongly more important than (Analysis & activation)

3 (Measurement & evaluation) is moderately more important than (Analysis & activation)

1 (Measurement & evaluation) and (Analysis & activation) are equal important

3 (Analysis & evaluation) is moderately more important the (Measurement & activation)

5 (Analysis & evaluation) is strongly more important than (Measurement & activation)

7 (Analysis & evaluation) is very strongly more important than (Measurement & activation)

9 (Analysis & evaluation) is extremely more important than (Measurement &activation)

Compare the relative importance between (Measurement & evaluation) and (Improvement & monitoring) with respect to the main target "integrated quality management performance" *

Mark only one oval.

9 (Measurement &evaluation) is extremely more important than the (Improvement & monitoring)

7 (Measurement & evaluation) is very strongly more important than (Improvement & monitoring)

5 (Measurement& evaluation) is strongly more important than (Improvement & monitoring)

3 (Measurement & evaluation) is moderately more important than (improvement &monitoring)

1 (Measurement & evaluation) and (Improvement &monitoring) are equal important

3 (Improvement & monitoring) is moderately more important than (Measurement & evaluation)

5 (Improvement & monitoring) is strongly more important than (Measurement &evaluation)

7 (Improvement & monitoring) is very strongly more important than (Measurement &evaluation)

9 (Improvement & monitoring) is extremely more important than (Measurement &evaluation)

Compare the relative importance between (Measurement & evaluation) and (Verification& continuous improvement) with respect to the main target "integrated quality management performance" *

Mark only one oval.

- 9 (Measurement &evaluation) is extremely more important than the (V&C i)
- 7 (Measurement & evaluation) is very strongly more important than (V&C I)
- 5 (Measurement &evaluation) is strongly more important than (V&C I)
- 3 (Measurement & evaluation) is moderately more important than (V&C I)
- 1 (Measurement & evaluation) and (V&C I) are equal important
- 3 (V&C I) is moderately more important than the (Measurement & evaluation)
- 5 (V&C I) is strongly more important than the (Measurement & evaluation)
- 7 (V&C I) is very strongly more important than the (measurement & evaluation)
- 9 (V&C I) is extremely more important than the (Measurement & evaluation)

Compare the relative importance between (Analysis & activation) and (Improvement & monitoring) with respect to the main target "integrated quality management performance". Analysis and Activation means; is a set of statistical tools and techniques that are required to assess the quality problems and identify the potential improvement. *

Mark only one oval.

- 9 (Analysis & activation) is extremely more important than (Improvement & monitoring)
- 7 (Analysis & activation) is very strongly more important than (Improvement & monitoring)
- 5 (Analysis & activation) is strongly more important than(Improvement & monitoring)
- 3 (Analysis &activation) is moderately more important than (Improvement & monitoring)
- 1 (Analysis & activation) and (Improvement & monitoring) are equal important
- 3 (Improvement &monitoring) is moderately more important than the (Analysis & activation)
- 5 (Improvement &monitoring) is strongly more important than (Analysis & activation)

7 (Improvement & monitoring) is very strongly more important than the (Analysis & activation)

9 (Improvement & monitoring) is extremely more important than the (Analysis & activation)

Compare the relative importance between (Analysis & activation) and

(Verification& continuous improvement) with respect to the main target "integrated quality management performance" *

Mark only one oval.

9 (Analysis & activation) is extremely more important than the (V&C I)

7 (Analysis & activation) is very strongly more important than the (V&C I)

5 (Analysis & activation) is strongly more important than the (V&C I)

3 (Analysis & activation) is moderately more important than the (V&C I)

1 (Analysis & activation) and (V&C I) are equal important

3 (V&C I) is moderately more important than the (Analysis & activation)

5 (V&C I) is strongly more important than the (Analysis & activation)

7 ((V&C I) is very strongly more important than the (Analysis & activation)

9(V&C I) is extremely more important than the (Analysis & activation

Compare the relative importance between (Improvement & monitoring) and (Verification& continuous improvement) with respect to achieve the main target "integrated quality management" performance. Improvement and monitoring mean; is the key quality tools that are required to implement the improvement plan and monitoring the operating performance. *

Mark only one oval.

9 (Improvement & monitoring) is extremely more important than (V&C I)

7 (Improvement & monitoring) is very strongly more important than (V&C I)

5 (Improvement & monitoring) is strongly more important than the (V&C I)

3 (Improvement & monitoring) is moderately more important than (V&C I)

1(improvement& monitoring) and (V&C I) are equal important

3 (V&C I) is moderately more important than (Improvement & monitoring)

5 (V&C I) is strongly more important than (Improvement & monitoring)

7 (V&C I) is very strongly more important than the (Improvement & monitoring)

9 (V&C I) is extremely more important than the (Improvement & monitoring)

Skip to question 13.

1. Comparison between the associated sub criteria of strategic planning with respect to Strategic Planning Sub-criteria are the critical success factors that are enable the main criteria to achieve the model goal.

The associated criteria with Strategic planning are; (Organisational structure, Focus on customer, linking to supplier and Training and education)

Compare the relative importance between Organisation structure and focusing on customer with respect to Strategic planning *

Mark only one oval.

9 Organisation structure is extremely more important than focusing on customer

7 Organisation structure is very strongly more important than focusing on customer

5 Organisation structure is strong more important than focusing on customer

3 Organisation structure is moderately more important than focusing on customer

1Organisation structure and focusing on customer are equal important

3 Focusing on customer is moderately more important than organisation structure

5 Focusing on customer is strongly more important than organisation structure

7 Focusing on customer is very strongly more important than organisation structure

9 Focusing on customer is extremely more important than organisation structure

Compare the relative importance between Organisation structure and Linking to supplier with respect to Strategic planning *

Mark only one oval.

9 Organisation structure is extremely more important than Linking to supplier

7 Organisation structure is very strongly more important than linking to supplier

5 Organisation structure is strongly more important than linking to supplier

3 Organisation structure is moderately more important than linking to supplier

1 Organisation structure and linking to supplier are equal important

3 Linking to supplier is moderately more important than Organisation structure

5 Linking to supplier is strongly more important than organisation structure

7 Linking to supplier is very strongly important than organisation structure

9 Linking to supplier is extremely more important than organisation structure

Compare the relative importance between Organisation structure and Training and education with respect to Strategic planning *

Mark only one oval.

9 Organisation structure is extremely more important than training and education

7 Organisation structure is very strongly more important than training and education

5 Organisation structure is strongly more important than training and education

3 Organisation structure is moderately more important than training and education

1 organisation structure and (training & education) are equal important

3 Training and education are moderately more important than organisation structure

5 Training and education are strongly more important than organisation structure

7 Training and education are very strongly more important than organisation structure

9 Training and education are extremely more important than organisation structure

Compare the relative importance between focusing on customer and Linking to supplier with respect to Strategic planning *

Mark only one oval.

9 Focusing on customer is extremely more important than linking to supplier

7 Focusing on customer is very strongly more important than linking to supplier

- 5 Focusing on customer is strongly more important than linking to supplier
- 3 Focusing on customer is moderately more important than linking to supplier
- 1 Focusing on customer and linking to supplier are equal important
- 3 Linking to supplier is moderately more important than focusing on customer
- 5 Linking to supplier is strongly more important than focusing on customer
- 7 Linking to supplier is very strongly more important than focusing on customer
- 9 Linking to supplier is extremely more important than focusing on customer

Compare the relative importance between Focusing on customer and Training and education with respect to Strategic planning *

Mark only one oval.

- 9 Focusing on customer is extremely more important than training and education
- 7 Focusing on customer is very strongly more important than training and education
- 5 Focusing on customer is strongly more important than training and education
- 3 Focusing on customer is moderately more important than training and education
- 1 Focusing on customer and (Training & education) are equal important
- 3 Training and education are moderately more important than focusing on customer
- 5 Training and education are strongly more important than focusing on customer
- 7 Training and education are very strongly more important than focusing on customer
- 9 Training and education are extremely more important than focusing on customer

Compare the relative importance between Linking to supplier and Training and education with respect to Strategic planning *

Mark only one oval.

- 9 Linking to supplier is extremely more important than training and education
- 7 Linking to supplier is very strongly more important than training and education
- 5 Linking to supplier is strongly more important than training and education

3 Linking to supplier is moderately more important than training and education

1 Linking to supplier and (training & education) are equal important

3 Training and education are moderately more important than linking to supplier

5 Training and education are strongly more important than linking to supplier

7 Training and education are very strongly more important than linking to supplier

9 Training and education are extremely more important than linking to supplier

2. Comparison between the associated sub-criteria of Measurement and evaluation with respect to Measurement and evaluation. Compare the relative importance between Leadership support and middle management involvement with respect to Measurement and evaluation. *
Mark only one oval.

9Leadrership support is extremely more important than Middle management involvement

7 Leadership support is very strongly more important than middle management involvement

5 Leadership support is strongly more important than middle management involvement

3 Leadership support is moderately more important than middle management involvement

1 Leadership support and middle management involvement ar equal important

3 Middle management involvement is moderately more important than leadership support

5 Middle management involvement is strongly more important than leadership support

7 Middle management involvement is very strongly more important than

9 Middle management involvement is extremely more important than leadership support

Compare the relative importance between Leadership support and effective communication with respect to measurement and evaluation. *
Mark only one oval.

9 Leadership is extremely more important than effective communication

7 Leadership is very strongly more important than effective communication

- ○ 5 Leadership is strongly more important than effective communication
- ○ 3 Leadership is moderately more important than effective communication
- ○ 1 Leadership and effective communication are equal important
- ○ 3 Effective communication is moderately more important than leadership
- ○ 5 Effective communication is strongly more important than leadership
- ○ 7 Effective communication is very strongly more important than leadership
- ○ 9 Effective communication is extremely more important than leadership

Compare the relative importance between Leadership support and quality commitment with respect to measurement and evaluation. *
Mark only one oval.

- ○ 9 Leadership support is extremely more important than quality commitment
- ○ 7 Leadership support is very strongly more important than quality commitment
- ○ 5 Leadership support is strongly more important than quality commitment
- ○ 3 Leadership support is moderately more important than quality commitment
- ○ 1 Leadership support and Quality commitment are equal important
- ○ 3 Quality commitment is moderately more important than leadership support
- ○ 5 Quality commitment is strongly more important than leadership support
- ○ 7 Quality commitment is very strongly more important than leadership support
- ○ 9 Quality commitment is extremely more important than Leadership support

Compare the relative importance between Leadership support and Reviewing & tracking performance (R & T P) with respect to measurement and evaluation. *
Mark only one oval.

- ○ 9 Leadership support is extremely more important than (R & T P)
- ○ 7 Leadership support is very strongly more important than (R & T P)
- ○ 5 Leadership support is strongly more important than (R & T P)

3 Leadership support is moderately more important than (R & T P)

1 Leadership and R & T P)) are equal important

3 (R & T P) is moderately more important than leadership support

5 (R & T P) is strongly more important than leadership support

7 (R & T P) is very strongly more important than leadership support

9 (R & T P) is extremely more important than leadership

Compare the relative importance between Middle management involvement and Effective communication with respect to measurement and evaluation. *

Mark only one oval.

9 Middle management involvement is extremely more important than effective communication

7 Middle management involvement is very strongly more important than effective communication

5 Middle management involvement is strongly more important than effective communication

3 Middle management involvement is moderately more important than effective communication

1 Middle management involvement and Effective communication are equal important

3 Effective communication is moderately more important than middle management involvement

5 Effective communication is strongly more important than middle management involvement

7 Effective communication is very strongly more important than middle management involvement

9 Effective communication is extremely more important than middle management involvement

Compare the relative importance between Middle management involvement and quality commitment with respect to measurement and evaluation. *

Mark only one oval.

9 Middle management involvement is extremely more important than quality commitment

7 middle management involvement is very strongly more important than quality commitment

5 Middle management involvement is strongly more important than quality commitment

3 Middle management involvements is moderately more important than quality commitment

1 Middle management involvement and quality commitment are equal important

3 Quality commitments is moderately more important than middle management involvement

5 Quality commitments is strongly more important than middle management involvement

7 Quality commitments is very strongly more important than middle management involvement

9 Quality commitments is extremely more important than middle management involvement

Compare the relative importance between Middle management involvement and Review & Tracking Performance (R & T P) with respect to measurement and evaluation. *
Mark only one oval.

9 Middle management involvements is extremely more important than (R &T P)

7 Middle management involvements is very strongly more important than (R &T P)

5 Middle management involvements is strongly more important than (R & T P)

3 Middle management involvements is moderately more important than (R & T P)

1 Middle management involvement and (R & T P) are equal important

3 (R & T P) is moderately more important than Middle management involvement

5 (R & T P) is strongly more important than middle management involvement

7 (R & T P) is very strongly more important than middle management involvement

9 (R &T P) is extremely more important than middle management involvement

Compare the relative importance between Effective communication and quality commitment with respect to measurement and evaluation. *
Mark only one oval.

- ◯ 9 Effective communications is extremely more important than quality commitment
- ◯ 7 Effective communications is very strongly more important than quality commitment
- ◯ 5 effective communications is strongly more important than quality commitment
- ◯ 3 Effective communications is strongly more important than quality commitment
- ◯ 1 Effective communication and quality commitment are equal important
- ◯ 3 Quality commitments is moderately more important than effective communication
- ◯ 5 Quality commitments is strongly more important than effective communication
- ◯ 7 Quality commitments is very strongly more important than effective communication
- ◯ 9 Quality commitments is extremely more important than effective communication

Compare the relative importance between Effective communication and Review & Tracking Performance (R & T P) with respect to measurement and evaluation. *
Mark only one oval.

- ◯ 9 Effective communications is extremely more important than (R & T P)
- ◯ 7 Effective communications is very strongly more important than (R & T P)
- ◯ 5 Effective communications is strongly more important than (R & T P)
- ◯ 3 Effective communications is moderately more important than (R & T P)
- ◯ 1 Effective communication and (R & T P) are equal important
- ◯ 3 (R & T P) is moderately more important than effective communication
- ◯ 5 (R & T P) is strongly more important than effective communication
- ◯ 7 (R & T P) is very strongly more important than effective communication
- ◯ 9 (R & T P) is extremely more important than effective communication

Compare the relative importance between Quality commitment and Review & Tracking Performance (R & T P) with respect to measurement and evaluation. *
Mark only one oval.

- ◯ 9 Quality commitment is extremely more important than (R & T P)

7 Quality commitment is very strongly more important than (R &T P)

5 Quality commitment is strongly more important than (R & T P)

3 Quality commitment is moderately more important than (R & T P)

1 Quality commitment and (R & T P) are equal important

3 (R & T P) is moderately more important than quality commitment

5 (R & T P) is strongly more important than quality commitment

7 (R & T P) is very strongly more important than quality commitment

9 (R & T P) is extremely more important than quality commitment

3 Comparison between the associated sub criteria of Analysis and activation with respect to Analysis and activation. Compare the relative importance between Leadership support and Middle management involvement with respect to Analysis and activation. *

Mark only one oval.

9 Leadership support is extremely more important than Middle management involvement

7 Leadership support is very strongly more important than middle management involvement

5 Leadership support is strongly more important than middle management involvement

3 Leadership support is moderately more important than middle management involvement

1 Leadership support and Middle management involvement are equal important

3 Middle management involvement is moderately more important than Leadership support

5 Middle management involvement is strongly more important than leadership support

7 Middle management involvement is very strongly more important than leadership support

9 Middle management involvement is extremely more important than leadership support

Compare the relative importance between Leadership support and Effective and communication with respect to Analysis and activation. *

Mark only one oval.

- ◯ 9 Leadership support is extremely more important than effective communication
- ◯ 7 Leadership support is very strongly more important than effective communication
- ◯ 5 Leadership support is strongly more important than effective communication
- ◯ 3 Leadership support is moderately more important than effective communication
- ◯ 1 Leadership support and effective and communication are equal important
- ◯ 3 Effective communication is moderately more important than leadership support
- ◯ 5 Effective communication is strongly more important than leadership support
- ◯ 7 Effective communication is very strongly more important than leadership support
- ◯ 9 Effective communication is extremely more important than leadership support

Compare the relative importance between Leadership support and Quality commitment with respect to Analysis and activation. *
Mark only one oval.

- ◯ 9 Leadership support is extremely more important than quality commitment
- ◯ 7 Leadership support is very strongly more important than quality commitment
- ◯ 5 Leadership support is strongly more important than quality commitment
- ◯ 3 Leadership support is moderately more important than quality commitment
- ◯ 1 Leadership support and quality commitment are equal important
- ◯ 3 Quality commitment is moderately more important than leadership support
- ◯ 5 Quality commitment is strongly more important than leadership support
- ◯ 7 Quality commitment is very strongly more important than leadership support
- ◯ 9 Quality commitment is extremely more important than leadership support

Compare the relative importance between Leadership support and Review & Tracking Performance (R & T P) with respect to Analysis and activation. *
Mark only one oval.

- ◯ 9 Leadership support is extremely more important than (R & T P)

7 Leadership support is very strongly more important than (R & T P)

5 Leadership support is strongly more important than (R & T P)

3 Leadership support is moderately more important than (R & T P)

1 Leadership support and (R & T P) are equal important

3 (R & T P) is moderately more important than Leadership support

5 (R & T P) is strongly more important than leadership support

7 (R & T P) is very strongly more important than leadership support

9 (R & T P) is extremely more important than leadership support

Compare the relative importance between Middle management involvement and Effective communication with respect to Analysis and activation. *
Mark only one oval.

9 Middle management involvement is extremely more important than effective communication

7 Middle management involvement is very strongly more important than effective communication

5 Middle management involvement is strongly more important than effective communication

3 Middle management involvement is moderately more important than effective communication

1 Middle management involvement and effective communication are equal important

3 Effective communication is moderately more important than middle management involvement

5 Effective communication is strongly more important than middle management involvement

7 Effective communication is very strongly more important than middle management involvement

9 Effective communication is extremely more important than middle management involvement

Compare the relative importance between Middle management involvement and Quality commitment with respect to Analysis and activation. *

Mark only one oval.

- ◯ 9 Middle management involvement is extremely more important than quality commitment
- ◯ 7 Middle management involvement is very strongly more important than quality commitment
- ◯ 5 Middle management involvement is strongly more important than quality commitment
- ◯ 3 Middle management involvement is moderately more important than quality commitment
- ◯ 1 Middle management involvement and quality commitment are equal important
- ◯ 3 Quality commitment is moderately more important than middle management involvement
- ◯ 5 Quality commitment is strongly more important than middle management involvement
- ◯ 7 Quality commitment is very strongly more important than middle management involvement
- ◯ 9 Quality commitment is extremely more important than middle management involvement

Compare the relative importance between Middle management involvement and Review & Tracking Performance (R & T P) with respect to Analysis and activation. *
Mark only one oval.

- ◯ 9 Middle management involvement is extremely more important than (R & T P)
- ◯ 7 Middle management involvement is very strongly important than (R & T P)
- ◯ 5 Middle management involvement is strongly more important than (R & T P)
- ◯ 3 Middle management involvement is moderately more important than (R & T P)
- ◯ 1 Middle management involvement and (R & T P) are equal important
- ◯ 3 (R & T P) is moderately more important than Middle management involvement
- ◯ 5 (R & T P) is strongly more important than Middle management involvement
- ◯ 7 (R & T P) is very strongly more important than middle management involvement
- ◯ 9 (R & T P) is extremely more important than middle management involvement

Compare the relative importance between Effective communication and Quality commitment with respect to Analysis and activation. *
Mark only one oval.

- ◯ 9 Effective communication is extremely more important than quality commitment
- ◯ 7 Effective communication is very strongly more important than quality commitment
- ◯ 5 Effective communication is strongly more important than quality commitment
- ◯ 3 Effective communication is moderately more important than quality commitment
- ◯ 1 Effective communication and quality commitment are equal important
- ◯ 3 Quality commitment is moderately more important than effective communication
- ◯ 5 Quality commitment is strongly more important than effective communication
- ◯ 7 Quality commitment is very strongly more important than effective communication
- ◯ 9 Quality commitment is extremely more important than effective communication

Compare the relative importance between Effective communication and Review & Tracking Performance (R & T P) with respect to Analysis and activation. *
Mark only one oval.

- ◯ 9 Effective communication is extremely more important than (R & T P)
- ◯ 7 Effective communication is very strongly more important than (R & T P)
- ◯ 5 Effective communication is strongly more important than (R & T P)
- ◯ 3 Effective communication is moderately more important than (R & T P)
- ◯ 1 Effective communication and (R & T P) are equal important
- ◯ 3 (R & T P) is moderately more important than effective communication
- ◯ 5 (R & T P) is strongly more important than effective communication
- ◯ 7 (R & T P) is very strongly more important than effective communication
- ◯ 9 (R & T P) is extremely more important than effective communication

Compare the relative importance between Quality commitment and Review & Tracking Performance (R & T P) with respect to Analysis and activation. *
Mark only one oval.

9 Quality commitment is extremely more important than (R & T P)

7 Quality commitment is very strongly more important than (R & T P)

5 Quality commitment is strongly more important than (R & T P)

3 Quality commitment is moderately more important than (R & T P)

1 Quality commitment and (R & T P) are equal important

3 (R & T P) is moderately more important than quality commitment

5 (R & T P) is strongly more important than quality commitment

7 (R & T P) is very strongly more important than quality commitment

9 (R & T P) is extremely more important than quality commitment

4 Comparison between the associated sub criteria of Improvement and monitoring with respect to Improvement and monitoring. Compare the relative importance between Leadership support and Middle management involvement with respect to Improvement and monitoring. *

Mark only one oval.

9 Leader ship support is extremely more important than Middle management involvement

7 Leadership support is very strongly more important than middle management involvement

5 Leadership support is strongly more important than middle management involvement

3 leadership support id moderately more important than middle management involvement

1 Leadership support and middle management involvement are equal important

3 Middle management involvement is moderately more important than Leadership support

5 Middle management involvement is strongly more important than leadership support

7 Middle management involvement is very strongly more important than leadership support

9 Middle management involvement is extremely more important than leadership support

Compare the relative importance between Leadership support and Effective communication with respect to Improvement and monitoring. *

Mark only one oval.

- ◯ 9 Leadership support is extremely more important than effective communication
- ◯ 7 Leadership support is very strongly more important than effective communication
- ◯ 5 Leadership support is strongly more important than effective communication
- ◯ 3 Leadership support is moderately more important than effective communication
- ◯ 1 Leadership support and effective communication are equal important
- ◯ 3 Effective communication is moderately more important than leadership support
- ◯ 5 Effective communication is strongly more important than leadership support
- ◯ 7 Effective communication is very strongly more important than leadership support
- ◯ 9 Effective communication is extremely more important than leadership support

Compare the relative importance between Leadership support and Quality commitment with respect to Improvement and monitoring. *
Mark only one oval.

- ◯ 9 Leadership support is extremely more important than quality commitment
- ◯ 7 Leadership support is very strongly more important than quality commitment
- ◯ 5 Leadership support is strongly more important than quality commitment
- ◯ 3 Leadership support is moderately more important than quality commitment
- ◯ 1 Leadership support and quality commitment are equal important
- ◯ 3 Quality commitment is moderately more important than leadership support
- ◯ 5 Quality commitment is strongly more important than leadership support
- ◯ 7 Quality commitment is very strongly more important than leadership support
- ◯ 9 Quality commitment is extremely more important than leadership support

Compare the relative importance between Leadership support and Review & Tracking Performance (R & T P) with respect to Improvement and monitoring *
Mark only one oval.

9 Leadership support is extremely more important than (R & T P)

7 Leadership support is very strongly more important than (R & T P)

5 Leadership support is strongly more important than (R & T P)

3 Leadership support is moderately more important than (R & T P)

1 Leadership support and (R & T P) are equal important

3 (R & T P) is moderately more important than leadership support

5 (R & T P) is strongly more important than leadership support

7 (R & T P) is very strongly more important than leadership support

9 (R & T P) is extremely more important than leadership support

Compare the relative importance between Middle management involvement and effective communication with respect to Improvement and monitoring. *
Mark only one oval.

9 Middle management involvement is extremely more important than effective communication

7 Middle management involvement is very strongly more important than effective communication

5 Middle management involvement is strongly more important than effective communication

3 Middle management involvement is moderately more important than effective communication

1 Middle management involvement and effective communication are equal important

3 Effective communication is moderately more important than middle management involvement

5 Effective communication is strongly more important than middle management involvement

7 Effective communication is very strongly more important than middle management involvement

9 Effective communication is extremely more important than middle management involvement

Compare the relative importance between Middle management involvement and Quality commitment with respect to Improvement and monitoring. *
Mark only one oval.

- 9 Middle management involvement is extremely more important than quality commitment
- 7 Middle management involvement is very strongly more important than quality commitment
- 5 Middle management involvement is strongly more important than quality commitment
- 3 Middle management involvement is moderately more important than quality commitment
- 1 Middle management involvement and quality commitment are equal important
- 3 Quality commitment is moderately more important than middle management involvement
- 5 Quality commitment is strongly more important than middle management involvement
- 7 Quality commitment is very strongly more important than middle management involvement
- 9 Quality commitment is extremely more important than middle management involvement

Compare the relative importance between Middle management involvement and Review & Tracking Performance (R & T P) with respect to Improvement and monitoring. *
Mark only one oval.

- 9 Middle management involvement is extremely more important than (R & T P)
- 7 Middle management involvement is very strongly more important than (R & T P)
- 5 Middle management involvement is strongly more important than (R & T P)
- 3 Middle management involvement is moderately more important than (R & T P)
- 1 Middle management involvement and (R & T P) are equal important
- 3 (R & T P) is moderately more important than middle management involvement
- 5 (R & T P) is strongly more important than middle management involvement
- 7 (R& T P) is very strongly more important than middle management involvement

9 (R & T P) is extremely more important than middle management involvement

Compare the relative importance between Effective communication and Quality Commitment with respect to Improvement and monitoring. *

Mark only one oval.

9 Effective communication is extremely more important than quality commitment

7 Effective communication is very strongly more important than quality commitment

5 Effective communication is strongly more important than quality commitment

3 Effective communication is moderately more important than quality commitment

1 Effective communication and quality commitment are equal important

3 Quality commitment is moderately more important than effective communication

5 Quality commitment is strongly more important than effective communication

7 Quality commitment is very strongly more important than effective communication

9 Quality commitment is extremely more important than effective communication

Compare the relative importance between Effective communication and Review & Tracking Performance (R & T P) with respect to Improvement and monitoring. *

Mark only one oval.

9 Effective communication is extremely more important than (R & T P)

7 Effective communication is very strongly more important than (R & T P)

5 Effective communication is strongly more important than (R & T P)

3 Effective communication is moderately more important than (R & T P)

1 Effective communication and (R & T P) are equal important

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5 (R &T P) is very strongly more important than effective communication

7 (R & T P) is very strongly more important than effective communication

9 (R & T P) is extremely more important than effective communication

Compare the relative importance between Quality commitment and Review & Tracking Performance (R & T P) with respect to Improvement and monitoring. *
Mark only one oval.

- ◯ 9 Quality commitment is extremely more important than (R & T P)
- ◯ 7 Quality commitment is very strongly more important than (R & T P)
- ◯ 5 Quality commitment is strongly more important than (R & T P)
- ◯ 3 Quality commitment is moderately more important than (R & T P)
- ◯ 1 Quality commitment and (R & T P) are equal important
- ◯ 3 (R & T P) is moderately more important than quality commitment
- ◯ 5 (R & T P) is strongly more important than quality commitment
- ◯ 7 (R & T P) is very strongly more important than quality commitment
- ◯ 9 (R & T P) is extremely more important than quality commitment

5 Comparison between the associated-sub criteria of Verification and continues improvement with respect to Verification and continues improvement. Compare the relative importance between Leadership support and Middle management involvement with respect to Verification and continues improvement. *
Mark only one oval.

- ◯ 9 Leadership support is extremely more important than middle management involvement
- ◯ 7 Leadership support is very strongly more important than middle management involvement
- ◯ 5 Leadership support is strongly more important than middle management involvement
- ◯ 3 Leadership support is moderately more important than middle management involvement
- ◯ 1 Leadership support and middle management involvement are equal important
- ◯ 3 Middle management involvement is moderately more important than Leadership support
- ◯ 5 Middle management involvement is strongly more important than leadership support
- ◯ 7 Middle management involvement is very strongly more important than leadership support

9 Middle management involvement is extremely more important than leadership support

Compare the relative importance between Leadership support and Effective communication with respect to Verification and continues improvement. *
Mark only one oval.

- 9 Leadership support is extremely more important than effective communication
- 7 Leadership support is very strongly more important than effective communication
- 5 Leadership support is strongly more important than effective communication
- 3 Leadership support is moderately more important than effective communication
- 1 Leadership support and effective communication are equal important
- 3 Effective communication is moderately more important than leadership support
- 5 Effective communication is strongly more important than leadership support
- 7 Effective communication is very strongly more important than leadership support
- 9 Effective communication is extremely more important than leadership support

Compare the relative importance between Leadership support and quality commitment with respect to Verification and continues improvement . *
Mark only one oval.

- 9 Leadership support is extremely more important than quality commitment
- 7 Leadership support is very strongly more important than quality commitment
- 5 Leadership support is strongly more important than quality commitment
- 3 Leadership support is moderately more important than quality commitment
- 1 Leadership support and quality commitment are equal important
- 3 Quality commitment is moderately more important than leadership support
- 5 Quality commitment is strongly more important than leadership support
- 7 Quality commitment is very strongly more important than leadership support
- 9 Quality commitment is extremely more important than leadership support

Compare the relative importance between Leadership support and Review & Tracking Performance (R & T P) with respect to Verification and continues improvement. *
Mark only one oval.

- ◯ 9 Leadership support is extremely more important than (R & T P)
- ◯ 7 Leadership support is very strongly more important than (R & T P)
- ◯ 5 Leadership support is strongly more important than (R & T P)
- ◯ 3 Leadership support is moderately more important than (R & T P)
- ◯ 1 Leadership support and (R & T P) are equal important
- ◯ 3 (R & T P) is moderately more important than leadership support
- ◯ 5 (R & T P) is strongly more important than leadership support
- ◯ 7 (R & T P) is very strongly more important than leadership support
- ◯ 9 (R & T P) is extremely more important than leadership support

Compare the relative importance between Middle management involvement and effective communication with respect to Verifications and continuous improvement. *
Mark only one oval.

- ◯ 9 Middle management involvement is extremely more important than effective communication
- ◯ 7 Middle management involvement is very strongly more important than effective communication
- ◯ 5 Middle management involvement is strongly more important than effective communication
- ◯ 3 Middle management involvement is moderately more important than effective communication
- ◯ 1 Middle management involvement and effective communication are equal important
- ◯ 3 Effective communication is moderately more important than middle management involvement
- ◯ 5 Effective communication is strongly more important than middle management involvement
- ◯ 7 Effective communication is very strongly more important than middle management involvement

9 Effective communication is extremely more important than middle management involvement

Compare the relative importance between Middle management involvement and quality commitment with respect to Verification and continues improvement. **Mark only one oval.*

9 Middle management involvement is extremely more important than quality commitment

7 Middle management involvement is very strongly more important than quality commitment

5 Middle management involvement is strongly more important than quality commitment

3 Middle management involvement is moderately more important than quality commitment

1 Middle management involvement and quality commitment are equal important

3 Quality commitment is moderately more important than middle management involvement

5 Quality commitment is strongly more important than middle management involvement

7 Quality commitment is very strongly more important than middle management involvement

9 Quality commitment is extremely more important than middle management involvement

Compare the relative importance between Middle management involvement and Review & Tracking Performance (R & T P) with respect to Verification and continues improvement. *
Mark only one oval.

9 Middle management involvement is extremely more important than (R & T P)

7 Middle management involvement is very strongly more important than (R & T P)

5 Middle management involvement is strongly more important than (R & T P)

3 Middle management involvement is moderately more important than (R & T P)

1 Middle management involvement and (R & T P) are equal important

3 (R & T P) is moderately more important than middle management involvement

5 (R & T P) is strongly more important than middle management involvement

- 7 (R & T P) is very strongly more important than middle management involvement
- 9 (R & T P) is extremely more important than middle management involvement

Compare the relative importance between Effective communication and Quality commitment with respect to Verification and continues improvement. *
Mark only one oval.

- 9 Effective communication is extremely more important than quality commitment
- 7 Effective communication is very strongly more important than quality commitment
- 5 Effective communication is strongly more important than quality commitment
- 3 Effective communication is moderately more important than quality commitment
- 1 Effective communication and quality commitment are equal important
- 3 Quality commitment is moderately more important than effective communication
- 5 Quality commitment is strongly more important than effective communication
- 7 Quality commitment is very strongly more important than effective communication
- 9 Quality commitment is extremely more important than effective communication

Compare the relative importance between Effective communication and Review & Tracking Performance (R & T P) with respect to Verification and continues improvement. *
Mark only one oval.

- 9 Effective communication is extremely more important than (R & T P)
- 7 Effective communication is very strongly more important than (R & T P)
- 5 Effective communication strongly more important than (R & T P)
- 3Effective communication is moderately more important than (R & T P)
- 1 Effective communication and (R & T P) are equal important
- 3 (R & T P) is moderately more important than effective communication
- 5 (R & T P) is strongly more important than effective communication
- 7 (R & T P) is very strongly more important than effective communication

9 (R & T P) is extremely more important than effective communication

Compare the relative importance between Quality commitment and Review & Tracking Performance (R & T P) with respect to Verification and continues improvement. *

Mark only one oval.

- 9 Quality commitment is extremely more important than (R & T P)
- 7 Quality commitment is very strongly more important than (R & T P)
- 5 Quality commitment is Strongly more important than (R & T P)
- 3 Quality commitment is moderately more important than (R & T P)
- 1 Quality commitment and (R & T P) are equal important
- 3 (R & T P) is moderately more important than quality commitment
- 5 (R & T P) is strongly more important than quality commitment
- 7 (R & T P) is very strongly more important than quality commitment
- 9 (R & T P) is extremely more important than quality commitment

Respondent's comments

Are there any more criteria and sub-criteria should have been considered and needed to included, please provide details?

Are there any criteria or sub-criteria should have no value added and need to be deleted, please provide details?

Submit

Never submit passwords through Google Forms.

Appendix C

The rest of descriptive analysis of LSS integrated model

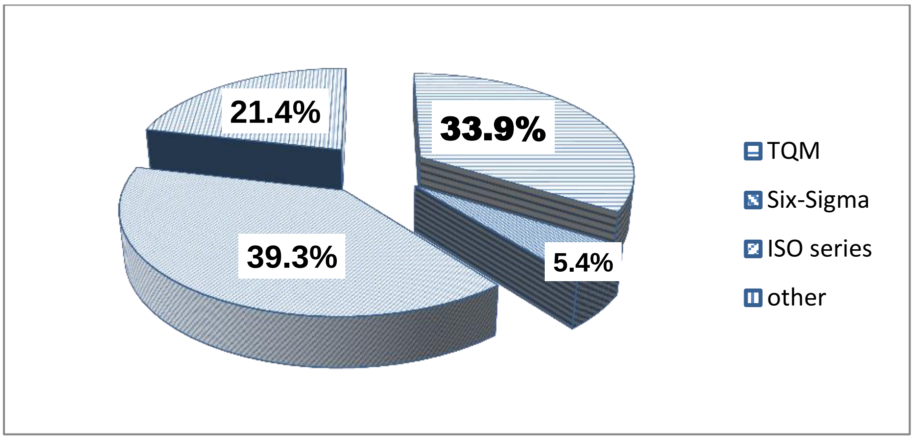

Figure. C-1. Type of quality management system of respondents organisations

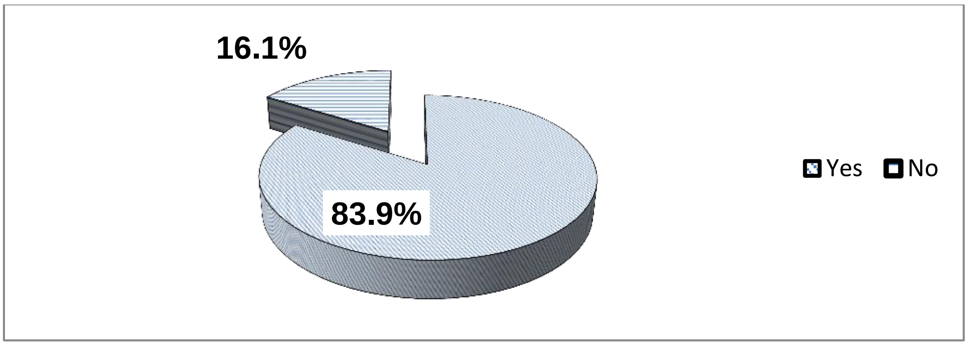

Figure. C-2. Level of the awareness with LSS approach

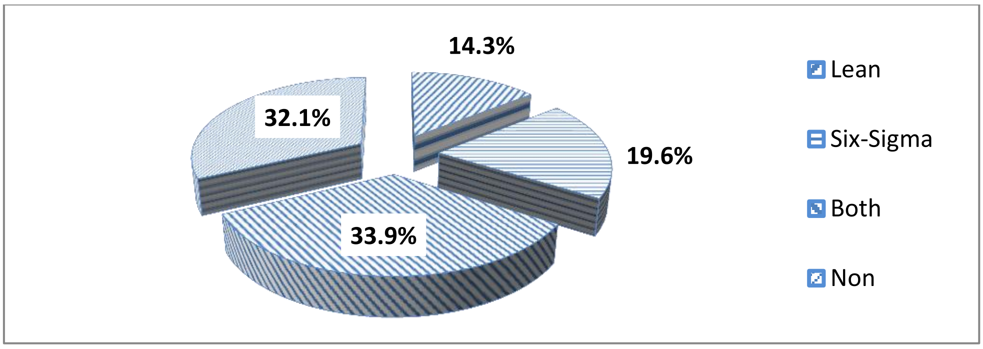

Figure C-3. Attendance of Formal training in Lean or Six-Sigma

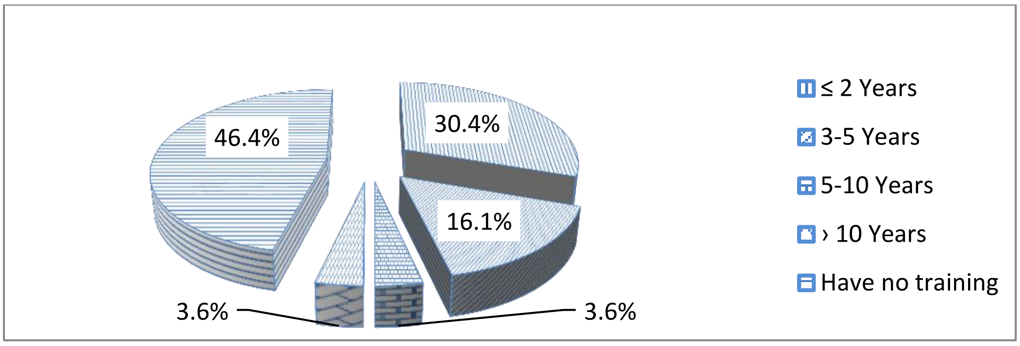

Figure C-4. Duration of the formal training

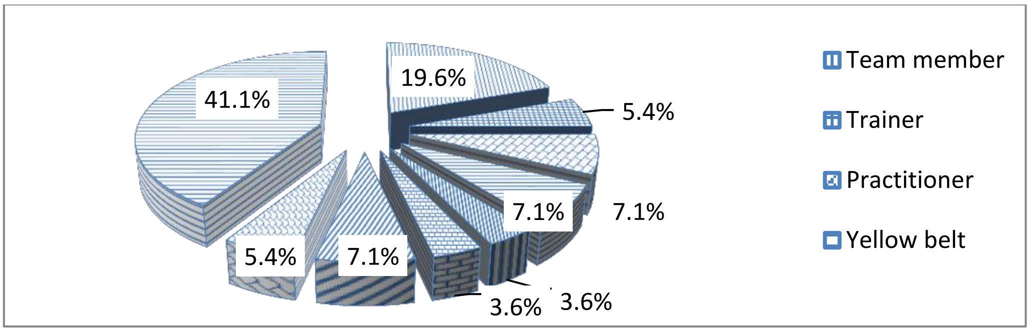

Figure C-5. Role of respondents within lean or six-sigma organisation

Table C-1. Level of awareness with LSS Tools and techniques

NO	Tool name	Frequency		Percentage (%)	
		Yes	NO	Yes	No
1	5S	40	16	71.4	28.6
2	DMAIC	29	27	51.8	48.2
3	TPM	37	19	66.1	33.9
4	Causes and effect cart	37	19	66.1	33.9
5	Kanban.	29	27	51.8	48.2
6	SMED	18	38	32.1	67.9
7	VSM	27	29	48.2	51.8
8	Pareto Analysis	41	15	73.2	26.8
9	Brainstorming	44	12	78.6	21.4
10	SPC	35	21	62.5	37.5
11	DOE	29	27	51.8	48.2
12	Benchmarking	40	16	71.4	28.6
13	PDCA	40	16	71.4	28.6
14	Regression analysis	33	23	58.9	41.1
15	QFD	31	25	55.4	44.6
16	Kaizen events	25	31	44.6	55.4
17	ANOVA	23	33	41.1	58.9
18	Process Flowchart / Mapping	44	12	78.6	21.4
19	Process capability analysis Cp &;Cpk	29	27	51.8	48.2
20	PERT Chart	32	24	57.1	42.9
21	SIPOC	23	33	41.1	58.9
22	Force Field Analysis	14	42	25	75
23	Poka-Yoke	19	37	33.9	66.1
24	Run Charts	18	38	32.1	67.9
25	FMEA	28	28	50	50
26	Histogram	48	8	85.7	14.3
27	Project Charter	32	24	57.1	42.9

Table C-2. The major problems facing quality system of Respondents organisations

NO	Quality problem	Frequency		Percent (%)	
		Capable	Incapable	Capable	Incapable
1	Lack Cost driven and priorities	29	27	51.8	48.2
2	Track which quality efforts work in a market place	31	25	55.4	44.6
3	Investment in training	23	33	41.1	58.9
4	Employee commitment	30	26	53.6	46.4
5	Defects	30	26	53.6	46.4
6	Decision Making Technique	29	27	51.8	48.2
7	Organising of documentation	30	26	53.6	46.6
8	Quality assurance Auditing	27	29	48.2	51.8
9	Inability to analyse how good the processes are	24	32	42.9	57.1
10	Utilizing problem solving techniques	31	25	55.4	44.6
11	Risk analysis and Uncertainty	31	25	55.4	44.6

Table C-3. The potential motivations of adopting LSS approaches

NO	LSS motivation	Results of respondents in percentage %				
		Strongly disagree	Disagree	Moderate	Agree	Strongly Agree
1	To meet the customer's requirements and needs.	8.9	1.8	5.4	35.7	42.2
2	To improve the organisation's productivity and overall efficiency.	7.1	3.6	1.8	33.9	53.6
3	To improve Organisation's profitability.	5.4	3.6	3.6	39.3	48.2
4	To achieved the organisation's objectives.	5.4	5.4	19.6	37.1	32.1
5	To follow industrial trends	7.1	12.5	25.0	37.5	17.9
6	To reduce production cost / service cost.	5.4	3.6	8.9	50.0	32.1
7	. To gain competitive advantage	5.4	10.7	3.6	37.5	42.9
8	To improve product quality and service.	7.1	5.4	3.6	28.6	55.4
9	To expand market share.	7.1	17.9	25.0	19.6	30.4
10	To gain and improve customer's confidence in your product / service.	10.7	1.8	12.5	37.5	37.5
11	Enhance organisation's reputation	7.1	3.6	14.3	35.7	39.3
12	To attract more customers.	7.1	3.6	25.0	28.6	35.7
13	Develop management techniques.	7.1	3.6	13.1	42.9	30.4
14	To improve the organisation's productivity and overall efficiency.	7.1	3.6	1.8	33.9	53.6

Table C-4. The potential benefits that could be gunned by adopting LSS

NO	Importance of LSS tools and techniques	Results in percent %				
		Very Less	Less	Moderate	Much	Very much
1	Cultural Change	3.6	14.3	26.8	35.7	19.6
2	Improved customer satisfaction	3.6	3.6	19.6	33.9	39.3
3	Reducing defects and Rework.	1.8	3.6	7.1	46.4	41.1
4	Aware of quality among employees	1.8	5.4	10.7	46.4	35.7
5	Improved productivity	7.1	1.8	7.1	35.7	48.2
6	Enhancing competitive position	1.8	1.8	16.1	44.1	36.7
7	Increasing customer's confidence and relations.	3.6	7.1	16.1	35.7	37.5
8	Reduced warranty claim cost.	8.9	3.6	28.6	42.9	16.1
9	Reduce Inventory	5.4	8.9	23.2	42.9	19.6
10	Improved sales.	1.8	7.1	16.1	58.9	16.1
11	Organised working environment.	3.6	1.8	16.1	41.1	37.5
12	Generate new business opportunities	7.1	8.9	23.2	30.4	30.4

Table C-5.. Utilisation of LSS tools and applications

NO	Tool name	Results in percentage (%)				
		Never been used	Used only once	Moderate	Used frequently	Used continuously
1	5S	46.4	1.8	12.5	30.4	8.9
2	Kanban	57.1	8.9	16.1	12.5	5.4
3	Pareto Analysis	37.5	7.1	17.9	17.9	19.6
4	Brainstorming.	25.0	7.1	10.7	32.1	25.0
5	VSM	46.4	8.9	16.1	19.6	8.9
6	PDCA	28.6	7.1	10.7	33.9	19.9
7	Cause and effect diagram	20.0	5.4	21.4	26.8	21.4
8	SPC	33.9	8.9	10.7	39.3	7.1
9	SMED	66.1	10.7	10.7	8.9	3.6
10	Benchmarking	30.4	8.9	21.4	32.1	7.1
11	Regression analysis	46.4	10.7	23.2	17.9	1.8
12	DOE	51.1	14.3	14.3	17.9	1.8
13	PERT	37.5	8.9	14.3	26.8	12.5
14	QFD	50.0	8.9	10.7	19.6	10.7
15	Force field Analysis	62.5	10.7	14.3	5.4	7.1
16	Poka-yoke	67.9	16.1	7.1	7.1	1.8
17	Kaizen events	66.1	8.9	12.5	7.1	5.4
18	Run charts	55.4	10.7	14.3	12.5	7.1
19	ANOV	62.5	7.1	19.6	7.1	3.6
20	FMEA	55.4	5.4	17.9	12.5	8.9
21	SIPOC	57.1	10.7	14.3	10.7	7.1
22	Process Flowchart / Mapping	28.6	7.1	19.6	30.4	14.3
23	Histogram	37.5	12.5	10.7	28.6	10.7
24	Project Charter	53.6	10.7	14.3	10.7	10.7
25	Process capability analysis Cp/ Cpk	44.6	7.1	19.6	17.6	10.7

Table C-6. Usefulness of LSS tools to respondents organisations

NO	Tool name	Results in percentage (%)				
		Not useful	**Less useful**	**Moderate**	**Useful**	**Very useful**
1	5S	8.9	3.6	14.3	28.6	44.6
2	Kanban	14.3	7.1	25.0	26.8	26.8
3	Pareto Analysis	3.6	3.6	21.4	37.5	33.9
4	Brainstorming.	3.6	3.6	17.9	28.6	46.4
5	VSM	7.1	5.4	23.2	41.1	23.2
6	PDCA	7.1	5.4	19.6	28.6	39.3
7	Cause and effect diagram	3.6	5.4	23.2	21.4	46.4
8	SPC	3.6	8.9	25.2	37.5	28.6
9	SMED	7.1	8.9	42.9	19.6	21.4
10	Benchmarking	7.1	5.4	21.4	25.0	41.1
11	Regression analysis	5.4	7.1	35.7	30.4	21.4
12	DOE	7.1	14.3	32.1	32.2	23.2
13	PERT	7.1	7.1	35.7	30.4	19.6
14	QFD	7.1	10.7	28.6	30.4	23.2
15	Force field Analysis	8.9	8.9	41.1	21.4	19.6
16	Poka-yoke	16.1	8.9	35.7	23.2	16.1
17	Kaizen events	8.9	16.1	25.0	30.4	19.6
18	Run charts	5.4	10.7	33.9	25.0	25.0
19	ANOV	12.5	10.7	39.3	23.2	14.3
20	FMEA	5.4	10.7	17.9	33.9	25.0
21	SIPOC	8.9	12.5	25.0	28.6	25.0
22	Process Flowchart / Mapping	5.5	3.6	23.6	32.7	34.5
23	Histogram	5.5	14.5	16.4	32.7	30.9
24	Project Charter	5.4	17.9	21.4	30.4	25.0

Table C-7. Evaluation the contents of the proposed model

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.8	1.8	1.8
	Disagree	1	1.8	1.8	3.6
	Moderate	13	23.2	23.6	27.3
	Agree	28	50.0	50.9	78.2
	Strongly agree	12	21.4	21.8	100.0
	Total	55	98.2	100.0	
Missing	System	1	1.8		
Total		56	100.0		

Table C-8. Evaluation The suitability of the proposed LSS model for manufacturing organisations

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	1.8	1.8	1.8
	Disagree	2	3.6	3.6	5.4
	Moderate	14	25.0	25.0	30.4
	agree	17	30.4	30.4	60.7
	Strongly Agree	22	39.3	39.3	100.0
	Total	56	100.0	100.0	

Table C-9. Evaluation Ability of the proposed model to boost competitiveness and profit

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	1.8	1.8	1.8
	Disagree	2	3.6	3.6	5.4
	Moderate	11	19.6	19.6	25.0
	agree	28	50.0	50.0	75.0
	Strongly Agree	14	25.0	25.0	100.0
	Total	56	100.0	100.0	

Table C-10. Evaluation the ability of the model to overcome the complexity of LSS implementation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	1.8	1.8	1.8
	Disagree	2	3.6	3.6	5.4
	Moderate	11	19.6	19.6	25.0
	agree	28	50.0	50.0	75.0
	Strongly Agree	14	25.0	25.0	100.0
	Total	56	100.0	100.0	

Table C-11. Evaluation the ability of the model to overcome the complexity of LSS implementation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	11	19.6	22.0	22.0
	No	39	69.6	78.0	100.0
	Total	50	89.3	100.0	
Missing	System	6	10.7		
Total		56	100.0		

Table C-12. Evaluation in terms of anything missing and should be added to the contents of the proposed model

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	7	12.5	12.5	12.5
	No	49	87.5	87.5	100.0
	Total	56	100.0	100.0	

Table C-13. Evaluating the importance of the CSFs of LSS implementation

NO	CSF	Results in percent (%)				
		Not importa nt	Slightly importa nt	Moderat e	Important	Very important
1	Linking to customer	3.6	7.3	23.6	21.8	43.6
2	Change management and organizational culture	3.6	3.6	35.7	19.6	37.5
3	Education and Training	5.5	0	16.4	9.1	69.1
4	Top Management involvement and participation	3.6	0	21.4	12.5	62.5
5	Effective Communication	3.6	1.8	27.3	16.4	50.9
6	Linking to business strategy	5.5	3.6	16.4	16.4	58.2
7	Project prioritization and selection	3.6	5.5	29.1	21.8	40.0
8	Linking to Suppliers	10.7	5.4	25.0	25.0	33.9
9	Project management	3.6	0	25.5	27.3	43.6
10	Business plan and Vision	7.1	1.8	26.8	23.2	41.1
11	Monitoring and evaluation of performance (performance measurement)	3.7	3.7	24.1	16.7	51.9
12	[Organizational structure	5.5	5.5	38.2	18.2	32.7

Table C-14. Impede factors for LSS implementation

NO	CSF	Results in percent (%)				
		Very low	Low	Moderate	high	Very high
1	Internal resistance	7.1	8.9	28.6	30.4	25.0
2	Poor project selection	5.4	19.6	28.6	35.7	10.7
3	Lack of Leadership	5.4	8.9	26.8	21.4	37.5
4	Lack of Tangible results	5.4	8.9	23.2	44.6	17.9
5	Availability of process	7.1	10.7	26.8	32.1	23.2
6	Change management	3.6	5.4	32.1	37.5	21.4
7	Changing business focus	3.6	18.2	30.9	41.1	5.4
8	Competing projects	10.7	8.9	33.9	35.7	10.7
9	Unmanaged expectations	7.1	14.3	25.0	37.5	16.1
10	Poor training and coaching	7.1	7.1	19.6	23.2	42.9
11	Low employee retention	10.7	16.1	21.4	25.0	26.8

Appendix D

The rest of descriptive analysis of SS-TQM integrated model

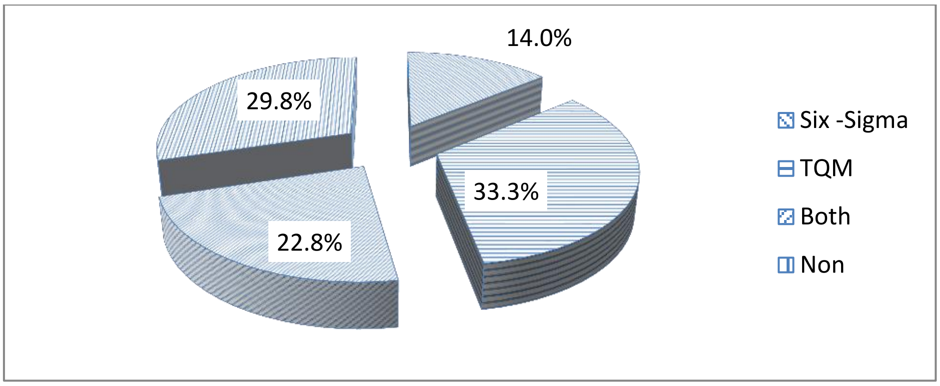

Figure D-1. Attendance any formal training on Six-Sigma or TQM approaches

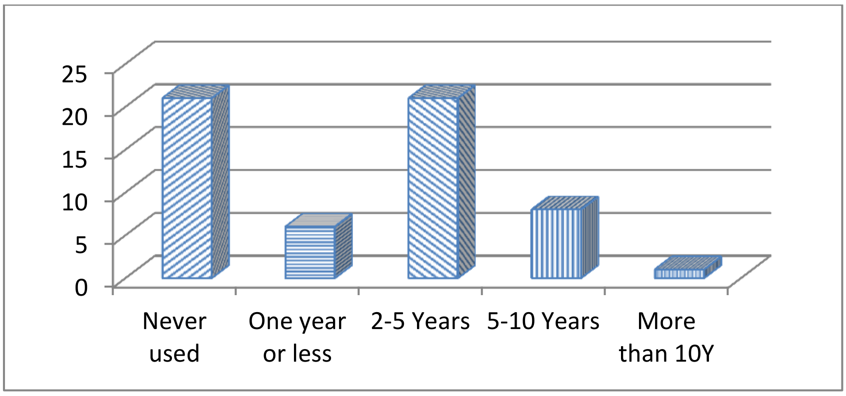

Figure D-2. The duration of using Six-Sigma or/and TQM approach

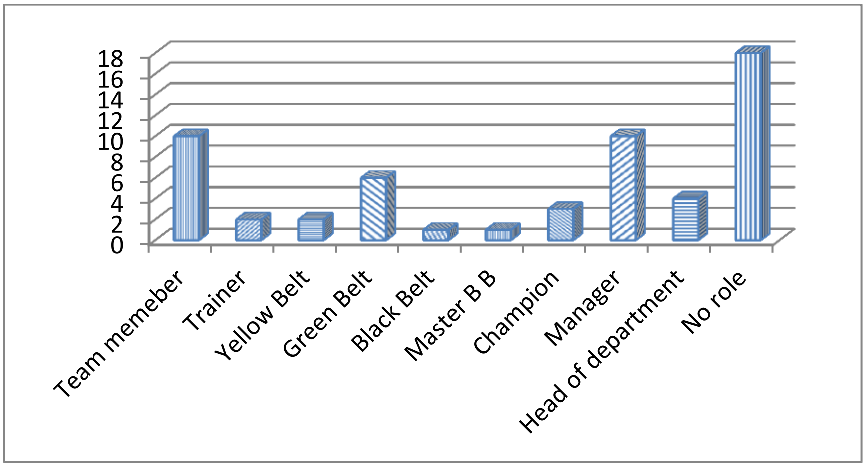

Figure D-3. Role of respondents within six-sigma TQM

Table D-1. Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Evaluation the contents of the strategic elements.	22.649	22.768	.748	.586	.927
Evaluation the contents of the implementation elements	22.614	22.170	.881	.795	.915
Evaluation the contents of the Performance excellence elements	22.789	22.991	.771	.657	.925
Evaluation the capability of the model for manufacturing organization	22.772	23.036	.731	.600	.929
Evaluation the effectiveness of the model to boost Organization's competitiveness and profit	22.807	22.409	.783	.666	.924
Evaluation the ability of the model to overcome the complexity of TQM-Six Sigma implementation	22.772	22.893	.788	.682	.923
Evaluation the model in terms to achieve the organisation goals	22.649	23.089	.808	.682	.922

Table D-2. Type of quality management system of respondent's organisation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Six-sigma	8	14.0	14.0	14.0
	TQM	11	19.3	19.3	33.3
	ISO Series	23	40.4	40.4	73.7
	Other	15	26.3	26.3	100.0
	Total	57	100.0	100.0	

Table D-3. Level of awareness with Six-Sigma TQM tools and techniques

NO	Tool name	Frequency		Percentage (%)	
		Yes	NO	Yes	No
1	PDCA	42	15	73.7	26.3
2	DMAIC	51	5	89.5	8.8
3	Pareto Analysis	32	25	56.1	43.9
4	TPM	50	7	87.7	12.3
5	Brainstorming	50	7	87.7	12.3
6	Causes and effect cart	40	17	70.2	29.8
7	SPC	39	18	68.4	31.6
8	DOE	29	28	50.9	49.1
9	Benchmarking	42	15	73.7	26.3
10	Regression analysis	29	28	50.9	49.1
11	Force Field Analysis	30	27	52.6	47.4
12	QFD	42	15	73.7	26.3
13	Run Charts	35	65	61.4	38.6
14	ANOVA	42	86	73.7	26.3
15	FMEA	38	19	66.7	33.3
16	Process Flowchart / Mapping	35	22	61.4	38.6
18	Histogram	41	16	71.9	28.1
19	Taguchi methods	33	24	57.9	42.1
20	Project Charter	27	30	47.4	52.6
21	Cp Cpk	32	25	56.1	43.9
22	PERT Chart	25	32	43.9	56.1
24	SIPOC	30	27	52.6	47.4

Table D-4. The major problems facing quality system of Respondents organisations

NO	Quality problem	Frequency		Percent (%)	
		Yes	No	Yes	No
1	Decision Making Technique	31	26	54.4	45.6
2	Risk analysis and Uncertainty	38	19	66.7	33.3
3	Lack of cost driven and priorities	27	30	47.4	52.6
4	Investment in training	34	23	40.4	59.6
5	Fail to track which quality efforts work in a market place	32	25	56.1	43.9
6	Employee commitment	33	24	57.9	42.1
7	Resources management	27	30	47.4	52.6
8	Follow up the documentation process	33	24	57.9	42.1
9	The right organisation of storage space	20	37	35.1	64.9
10	The right selection of raw material	13	44	77.2	22.8
11	Involvement of top management and support	28	29	49.1	50.9
12	Middle management involvement and realisation of teamwork	27	30	47.4	52.6
13	Defects	35	22	61.4	38.6
14	Machine setup and control	20	37	35.1	64.9
15	The right planning and following maintenance program	29	28	50.9	49.1
16	Taking action for continuous improvement	38	19	66.7	33.3
17	Market and sales management	22	35	61.4	38.6
18	Rescheduling organisation	29	28	50.9	49.1
19	Utilisation problem solving technique	31	26	54.3	45.7

Table D-5. Utilisation of Six Sigma and TQM tools and techniques

NO	Tool name	Results in percentage (%)				
		Never been used	Used only once	Used rarely	Used frequently	Used continuously
1	Pareto analysis	40.6	5.3	20.0	28.1	7.0
2	Brainstorming techniques	12.8	8.8	13.8	36.6	28.1
3	PDCA	28.1	12.3	12.3	28.1	19.3
4	Cause and effect diagram	28.1	14.0	15.8	33.3	8.8
5	SPC	19.3	15.8	12.3	29.3	23.3
6	Benchmarking technique	18.1	8.8	17.5	36.3	19.3
7	Regression analysis	47.4	14.0	21.1	12.3	5.3
8	Design of experiments (DOE)	42.1	15.8	17.5	15.8	8.8
9	PERT chart (program evaluation and review technique)	43.9	19.3	15.8	19.3	1.8
10	Quality function deployment (QFD)	54.4	24.6	7.0	14.0	0.0
11	Force field Analysis	56.1	19.3	12.3	12.3	0.0
12	Run charts	30.4	8.8	12.3	24.0	26.6
13	ANOVA	45.6	12.3	15.8	21.1	5.3
14	Failure mode effect analysis (FMEA)	38.6	10.5	22.8	21.1	7.0
15	SIPOC (suppliers, input, process, output, customers)	45.6	10.5	15.8	21.1	7.0
16	Process flowchart/mapping	11.1	10.5	22.8	25.8	29.8
17	Histogram	33.3	15.8	22.8	14.0	14.0
18	Taguchi Methods	61.4	14.0	12.3	12.3	0.0
19	. Process capability analysis	43.9	8.8	19.3	24.6	3.5
20	Project Charter	40.4	17.5	19.3	17.5	5.3

Table D-6. Usefulness of Six Sigma and TQM tools and techniques to respondents' organisation

NO	Tool name	Results in percentage (%)				
		Not useful	Less useful	Moderate	Useful	Very useful
1	Pareto analysis	24.6	17.5	15.8	19.3	22.8
2	Brainstorming techniques	3.5	15.8	8.8	19.3	52.6
3	PDCA	3.5	12.3	17.5	19.3	47.4
4	Cause and effect diagram	8.8	10.5	17.5	28.1	35.1
5	SPC	10.6	14.0	15.8	22.8	26.8
6	Benchmarking technique	10.5	12.3	21.1	24.6	31.6
7	Regression analysis	21.1	22.8	14.0	31.6	10.5
8	Design of experiments (DOE)	19.3	7.3	12.3	40.4	21.1
9	PERT chart (program evaluation and review technique)	15.8	12.3	31.6	29.8	10.5
10	Quality function deployment (QFD)	37.3	10.1	10.3	31.6	10.7
11	Force field Analysis	28.1	22.8	24.6	21.1	3.5
12	Run charts	15.8	15.8	19.3	26.3	22.8
13	ANOVA	31.6	8.8	10.5	29.8	19.3
14	Failure mode effect analysis (FMEA)	19.3	7.0	17.5	35.1	21.1
15	SIPOC (suppliers, input, process, output, customers)	24.6	10.5	14.0	35.1	15.8
16	Process flowchart/mapping	10.5	7.0	14.0	36.8	31.6
17	Histogram	7.0	24.6	15.8	28.1	24.6
18	Taguchi Methods	38.6	14.0	22.8	19.3	5.3
19	Process capability analysis	19.3	14.0	24.6	26.3	15.8
20	Project Charter	12.3	19.3	22.8	33.3	12.3

Table D7. Evaluation the proposed model in terms of contents of the strategic elements.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.8	1.8	1.8
	Disagree	3	5.3	5.3	7.0
	Moderate	16	28.1	28.1	35.1
	Agree	20	35.1	35.1	70.2
	Strongly agree	17	29.8	29.8	100.0
	Total	57	100.0	100.0	

Table D-8. Evaluation the proposed model in terms of contents of the implementation elements

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.8	1.8	1.8
	Disagree	3	5.3	5.3	7.0
	Moderate	12	21.1	21.1	28.1
	Agree	26	45.6	45.6	73.7
	Strongly agree	15	26.3	26.3	100.0
	Total	57	100.0	100.0	

Table D-9. Evaluation the proposed model in terms of contents of the Performance excellence elements

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.8	1.8	1.8
	Disagree	2	3.5	3.5	5.3
	Moderate	22	38.6	38.6	43.9
	Agree	19	33.3	33.3	77.2
	Strongly agree	13	22.8	22.8	100.0
	Total	57	100.0	100.0	

Table D-10. Evaluation the proposed model in terms of suitable and applicable for manufacturing organization

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	3.5	3.5	3.5
	Disagree	2	3.5	3.5	7.0
	Moderate	17	29.8	29.8	36.8
	Agree	24	42.1	42.1	78.9
	Strongly agree	12	21.1	21.1	100.0
	Total	57	100.0	100.0	

Table D-11. Evaluation the proposed model in terms of boost Organization's competitiveness and profit

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	5.3	5.3	5.3
	Disagree	2	3.5	3.5	8.8
	Moderate	14	24.6	24.6	33.3
	Agree	28	49.1	49.1	82.5
	Strongly agree	10	17.5	17.5	100.0
	Total	57	100.0	100.0	

Table D-12. Evaluation the proposed model in terms of overcome the implementation complexity of Six Sigma TQM

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	3.5	3.5	3.5
	Disagree	2	3.5	3.5	7.0
	Moderate	15	26.3	26.3	33.3
	Agree	28	49.1	49.1	82.5
	Strongly agree	10	17.5	17.5	100.0
	Total	57	100.0	100.0	

Table D-13. Evaluation the proposed model in terms of attainment its long term goals and business expectations

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.8	1.8	1.8
	Disagree	1	1.8	1.8	3.5
	Moderate	17	29.8	29.8	33.3
	Agree	24	42.1	42.1	75.4
	Strongly agree	14	24.6	24.6	100.0
	Total	57	100.0	100.0	

Table D-14. Evaluation the proposed model in terms of anything missing which should be added to the proposed model

Frequency	Percent	Valid Percent	Cumulative Percent
4	7.0	7.0	7.0
53	93.0	93.0	100.0
57	100.0	100.0	

Table D-15. The potential motivations of Six-Sigma TQM approach

NO	Six-Sigma TQM motivation	Results of respondents in percentage %				
		Strongly disagree	Disagre e	Moderate	Agree	Strongly Agree
1	To meet the customer's requirement and needs	0.0	0.0	19.3	38.6	41.7
2	To improve the organization's productivity and overall efficiency	0.0	0.0	14.0	43.9	42.1
3	To improve Organization's profitability	0.0	0.0	24.6	40.4	35.1
4	To achieve the organization's objectives	0.0	3.5	26.3	38.6	31.6
5	To reduce production cost / services cost	0.0	7.0	15.8	42.1	35.1
6	To reduce production cost / services cost	0.0	1.8	17.5	42.1	38.6
7	To follow industrial trends	.00	1.8	31.6	44.1	25.5
8	To gain competitive advantage	0.0	1.8	22.8	42.1	33.3
9	To improve product quality / quality of service	0.0	7.0	12.3	38.6	42.1
10	To expand to overseas market	1.8	8.8	38.6	42.1	8.8
11	To gain and improve customer's confidence in your product or services	1.8	1.8	28.1	54.4	14.0
12	To exceed customer satisfaction and fitful customer delight	0.0	8.8	24.6	50.9	15.8
13	To enhance and support the organization's reputation	1.8	5.3	21.1	56.1	15.8
14	To attract more customers	1.8	3.5	31.6	42.1	21.1
15	To develop the organization management techniques.	0.0	8.8	22.8	47.4	21.1
16	To achieve sustainable improvement	0.0	3.5	24.6	35.1	36.8

able D-16. The importance of the CSFs to successful implementation of Six-Sigma TQM in manufacturing organizations

NO	CSFs	Results in percent (%)				
		Not important at all	Slightly important	Important	Quite Importa nt	Very important
1	Organization infrastructure	3.5	8.8	24.6	26.3	36.8
2	Top management and leadership support	0.0	3.5	21.1	26.3	49.1
3	Investment in training	0.0	8.8	22.8	36.8	31.6
4	Middle management involvement	0.0	5.3	26.3	33.3	35.1
5	Communication	0.0	7.0	21.1	21.1	50.9
6	Understanding DMAIC strategy to deal with quality issues	0.0	17.5	15.8	43.9	22.8
7	Understanding the usage of six-sigma and TQM tools and techniques and how to use it in the right action	1.8	1.8	24.6	43.9	28.1
8	Investing in the adequate resources	0.0	1.8	19.3	47.4	31.6
9	Utilize IT to support implementation	0.0	5.3	24.6	43.9	26.3
10	Use of the best talent	0.0	7.0	26.3	43.9	22.8
11	Knowledge and competence the employees	0.0	5.3	22.8	43.9	28.1
12	Ability to learn from mistakes and history	0.0	1.8	19.3	49.1	29.8

Table D-17. Impede factors for Six-Sigma TQM implementation

NO	CSF	Results in percent (%)				
		Very low	Low	Moderate	high	Very high
1	Internal resistance	3.5	3.5	33.3	33.3	26.3
2	Poor project selection	3.5	10.5	29.8	42.1	14.0
3	Lack of Leadership	7.0	3.5	22.8	19.3	47.4
4	Lack of Tangible results	1.8	5.3	26.3	42.1	24.6
5	Availability of process	1.8	3.5	35.1	31.6	28.1
6	Change management	3.5	7.0	40.4	31.6	17.5
7	Changing business focus	5.3	1.8	45.6	40.4	7.0
8	Competing projects	3.5	7.0	33.3	38.6	17.5
9	Unmanaged expectations	5.3	7.0	33.3	40.4	14.0
10	Poor training and coaching	1.8	3.5	33.3	38.9	22.8
11	Low employee retention	1.8	8.8	31.6	36.8	21.1

Appendix E

The rest of the descriptive analysis of the proposed framework

Table E-1. The current quality system of the respondents organisation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Six-sigma	3	4.8	4.8	4.8
	Lean operation	4	6.5	6.5	11.3
	TQM	5	8.1	8.1	19.4
	Other	50	80.6	80.6	100.0
	Total	62	100.0	100.0	

Table. E-2. The awareness level with *Six-Sigma, Lean and TQM tools/techniques*

NO	Tool name	Frequency		percentage	
		yes	no	yes	no
1	DMAIC process	55	7	88.7	11.3
2	PDCA	54	8	87.1	12.9
3	VSM	51	11	82.3	17.7
4	5S	49	13	79	21
5	Prato analysis	54	8	87.1	12.9
6	Root causes analysis	55	7	88.7	11.3
7	Total Productive Maintenance (TPM)	56	6	90.3	9.7
8	Brainstorming techniques	61	1	98.4	1.6
9	Cause and Effect diagram / Analysis	57	5	91.9	8.1
10	Statistical Process Control (SPC)	58	3	93.5	6.5
11	Design of Experiments (DOE)	53	9	85.5	41.5
12	Kaizen events	41	21	66.1	33.9
13	Kanban/ Line balancing	27	23	59.7	40.3
14	Poka-yoke	37	23	59.7	37.1
15	Single Minute Exchange of Die (SMED)	37	25	59.7	40.3
16	Benchmarking	50	10	80.6	16.1
17	Regression analysis	47	15	75.8	42.2
18	Force field Analysis	34	28	54.8	45.2
19	Quality function deployment (QFD)	54	7	66.1	33.9
20	Run charts	47	15	75.8	42.2
21	ANOVA	48	14	77.4	22.6
22	Failure mode analysis	49	12	79	19.4
23	Process flowchart/mapping	54	7	87.1	11.5
24	Histogram	51	11	82.3	17.7
25	Taguchi Methods	44	18	71	29
26	FMEA	49	12	79	19.4
27	Project Charter	39	21	62.9	33.9
28	Process capability analysis	49	10	79	16.1
29	Cost of poor quality	49	13	79	21
30	PERT chart (program evaluation and review technique)	27	35	43.5	56.5

Table E-3. The potential motivations of the integrated quality management approach

NO	Integrated quality management motivation	Results of respondents in percentage %				
		Strongly disagree	Disagree	Moderate	Agree	Strongly Agree
1	To meet the customer's requirement and needs	0	0	14.5	50	35.5
2	To improve the organization's productivity and overall efficiency	0	0	6.5	50	43.5
3	To improve Organization's profitability	0	0	8.1	48.4	43.5
4	To achieve the organization's objectives	0	0	12.9	46.8	40.3
5	To reduce production cost / services cost	0	1.6	16.1	30.6	51.6
6	To follow industrial trends	0	0	33.9	58.1	8.1
7	To gain competitive advantage	0	0	22.6	62.9	14.5
9	To improve product quality / quality of service	0	0	4.8	46.8	48.4
9	To expand to overseas market	1.6	3.2	29	54.8	11.3
10	To gain and improve customer's confidence in your product or services	0	0	9.7	71	19.4
11	To exceed customer satisfaction and fitful customer delight	0	0	19.4	67.7	12.9
12	To enhance and support the organization's reputation	0	0	19.4	66.1	14.5
13	To attract more customers	0	0	19.4	64.5	16.1
14	To develop the organization management techniques.	0	1.6	14.5	72.6	11.3
15	To achieve sustainable improvement	0	0	8.1	61.3	30.6

Table.E-4. the CSFs for successful implementation of the proposed framework

NO	CSFs	Results in percent (%)				
		Not important at all	Slightly important	Important	Quite Important	Very important
1	Organization Structure	0	8.1	22.6	38.7	30.6
2	Customer focus	0	4.8	27.4	35.5	32.3
3	Linking to supplier	0	6.5	19.4	27.4	46.8
4	Training and education	0	16.1	14.5	45.2	24.2
5	Top management and leadership support	1.6	1.6	24.2	45.2	27.4
6	Effective communication	0	1.6	17.7	50	30.6
7	Middle management involvement	0	4.8	22.6	48.4	24.2
8	Quality commitment	0	6.5	24.2	46.8	22.6
9	Review and tracking performance	1.6	4.8	22.6	45.2	25.8

Table E-5. The impede factors for the proposed framework

CSFs	Results in percent (%)				
	Very low	Low	Moderate	high	Very high
Internal resistance	0	0	19.4	67.7	12.9
Poor project selection	0	6.5	29	54.8	9.7
Lack of Leadership	0	1.6	4.8	56.5	37.1
Lack of Tangible results	0	1.6	9.7	48.4	40.4
Availability of process	0	0	8.1	53.2	38.7
Change management	0	12.9	19.4	56.5	11.3
Changing business focus	0	17.7	25.8	51.6	4.8
Competing projects	0	6.5	35.5	50	8.1
Unmanaged expectations	0	1.6	4.8	53.2	40.3
Poor training and coaching	0	0	16.1	50	33.9
Low employee retention	0	1.6	19.4	56.5	22.6