Chapter 10

Qualitative and Quantitative Analysis of Six Sigma in Service Organizations

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1. Introduction

Quality management has long been established as an important strategy for achieving competitive advantage. The aim of the businesses may differ, but the importance of customers is a matter of common interest. The ability of the organizations to adapt to new customer requirements in a globalized market is of vital importance for long-term success. Traditional quality initiatives such as statistical quality control, zero defects, and total quality management, have been key initiatives for many years. In last two decades, Six Sigma evolved as a new quality management initiative and now many organizations are working towards its implementation.

Six Sigma is a disciplined approach for improving manufacturing or service processes, based on defined metrics (Hahn et al., 1999). The strength of Six Sigma lies in its well defined framework involving methodology applying different tools and techniques (Goh, 2002). The Six Sigma journey started from Motorola in 1980s and spread its importance through adoptions by different high profile organizations such as General Electric (GE), Honeywell, Asea Brown Bovari (ABB), Lockheed-Martin, Polaroid, and Texas Instruments (Goh, 2002; Hahn et al., 1999). This initial success of Six Sigma has seen its implementation spreading in several other organizations mostly in mass-manufacturing sector (McAdam et al., 2005). These organizations adopted the systematic framework of Six Sigma through training and project management practices (Brady and Allen, 2006). The use of Six Sigma has been relatively high among many western organizations till now, see, for example, Inozu et al. (2006), Raisinghani et al. (2005), and Antony (2004b), but there exists a diversity of opinion among researchers regarding the actual benefits of Six Sigma. Literature explaining about the positive effects on financial performance can be found in e.g. Jones Jr. (2004), Goh (2002), Caulcutt (2001), and Rucker (2000). However, McAdam and Lafferty (2004), Senapati (2004), and Paul (1999), for instance, express a more pessimistic view regarding the benefit of Six Sigma investments.

Similar to Six Sigma, services in the last two decades have become an important part in economies of developed as well as for developing nations. The importance of services has also increased as it became a major employment provider (Cook et al., 1999). This increased importance of service sector has various researchers contributing to the service literature. The service research from its beginning can be divided into stages such as an initial realization of the difference between goods and service, the development of conceptual frameworks, the empirical testing of these frameworks and the application of the tools and frameworks to improve service management (Johnston, 1999). The various stages of service research have gained by the major contributions from marketing and after that to some extent from operations management field.

But in case of definitions, services still lack a unified definition and similar can be said about the classification scheme. So, there is a need to provide a universally accepted classification scheme which can be done through empirical derivation and considering different dimensions of service organizations. This will facilitate in exploration of service quality and service strategy (Cook et al., 1999). As service quality is now the major focus of service organizations, so a better understanding of unique characteristics of services will be helpful. This in turn will help spreading new quality initiatives such as Six Sigma, in services.

This spread, however, is limited in service industries. A key argument here is that many service processes are unseen, intangible, and even immeasurable. As such, they are not amendable to improvement using a Six Sigma approach. This thinking has turned out to be rather presumptuous at least for the health care, banking, and call center services which have been able to apply Six Sigma (Hensley and Dobie, 2005). Other services such as education and hospitality are also beginning to see Six Sigma applications.

The question of Six Sigma and its implementation and performance in service organizations has not before been under investigation. The literature includes many papers describing Six Sigma implementation in a variety of business types; however, very few of these papers report empirical research and include single case studies (Hendry and Nonthaleerak, 2005). Examples of non-manufacturing contexts discussed in the literature include healthcare and financial services, as well as in non-production internal functions within a manufacturing organization (Nonthaleerak and Hendry, 2008). The paper by Wyper and Harrison (2000), discuss Six Sigma implementation in non-manufacturing context and highlights the difficulties specific to that context. Does et al. (2002), present a comparison of eight Six Sigma projects in non-manufacturing processes with a theoretical manufacturing application in a case study company in the Netherlands. This paper addressed various problems, typical of non-manufacturing and also identified difficulties in tools application. They conclude that Six Sigma can be applicable in non-manufacturing contexts with minor adaptations. Given that, the research is based in a single case study setting, there are limits on the degree to which the conclusions can be generalized (Nonthaleerak and Hendry, 2008). McAdam and Lafferty (2004) conducted a survey in a single company on Six Sigma implementation issue from process and people perspective. They found low success of Six Sigma in non-manufacturing areas.

The literature on discussion about Six Sigma in service organizations also concentrate about issues in implementation due to inherent differences between manufacturing and service. The possible reason being the manufacturing roots of Six Sigma like other quality management initiatives. Antony (2004a), Benedetto (2003), and Sehwall and De Yong (2003), argue for example that there are certain differences in Six Sigma implementation in services from manufacturing which acts as a barrier in Six Sigma implementation in service organizations.

Failed implementation initiatives, especially as extensive as Six Sigma implementation, result in financial losses and potential resistance towards change among the actors involved. It is therefore of importance that the implementation strategies used are well adapted, see, e.g. Biolos (2002). Hence, the literature has conflicting evidence regarding the applicability of Six Sigma to non-manufacturing settings and therefore there is a need to investigate further this issue (Nonthaleerak and Hendry, 2008).

The studies so far focused on Six Sigma implementation in non-manufacturing context at project level. The studies are mostly single case studies and descriptive in nature. The survey based studies are either pilot survey or focused on a single organization. Thus, there are a number of key research gaps in the literature, which our research aims to address.

- There is insufficient empirical evidence to verify and further explain the Six Sigma CSFs identified in service organizations.
- The existing difficulties in Six Sigma implementation in service organizations are not well understood.
- There is a scope to contribute to Six Sigma implementation in service organizations by enhancing the knowledge about tools and techniques usage.

Our research will focus on individual Six Sigma projects in service organizations to fill the identified research gaps.

2. Background

2.1. Six sigma definitions and philosophy

In 1924, Walter A. Shewart from Bell Telephone Laboratories, proposed the concept of using statistical charts to control the variables of products manufactured at Western Electric. This was the beginning of statistical quality control (Small, 1956). Dr. Shewart kept on with his efforts and applied the fundamentals of statistical quality control to industry. This lead to the modern attention to the use of statistical tools for the manufacture of products and process, originated prior to and during World War II, when the United States of America geared up to a massive build-up of machinery and arms to successfully conclude the war (Brady, 2005). The Western Electric manufacturing company is noteworthy during this time because it was the breeding ground for many quality leaders, not only Shewart but Joseph Juran, Edwards Deming and Kaoru Ishikawa all worked there at some time (Dimock, 1977). Two prominent individuals were Deming and Juran. Deming promoted the use of the plan-do-check-act (PDCA) cycle of continuous improvement. Later Juran introduced the concepts of project by project quality improvement. Any discussion on quality today will most likely cite at least one

from the group of Deming, Juran, Crosby, Feigenbaum, and Ishikawa, if not all. They certainly represent the preponderance of information about quality. Adding to this group, Bill Smith, Motorola Vice President and Senior Quality Assurance Manager, is widely regarded as the father of Six Sigma, Shina (2002). Because Six Sigma was built on previous quality methodologies, a list of the pioneers of the quality and their contribution is included in Table 1.

According to Shina (2002) before, January 15, 1987, Six Sigma was solely a statistical term. Since then, the Six Sigma crusade, which began at Motorola, has spread to other companies which are continually striving for excellence. At Motorola, Six Sigma is defined as "A quality improvement program with a goal of reducing the number of defects to as low as 3.4 parts per million opportunities or 0.0003%". Six Sigma has a number of different meanings and interpretations (Henderson and Evans, 2000, pp 261). Its origin comes from statistics where sigma represents the amount of variation about a process average. From a business view of point, Six Sigma may be defined as "A business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet or exceed customer's needs and expectations" (Kwak and Anbari, 2006, pp 709). Various other definitions include:

- Six Sigma is a formal methodology for measuring, analysing, improving, and then controlling or locking-in processes. This statistical approach reduces the occurrence of defects from a three sigma level or 66 800 defects per million to a Six Sigma level or less than four defects per million (Bolze, 1998).
- Six Sigma is a comprehensive, statistics-based methodology that aims to achieve nothing less than perfection in every single company process and product (Paul, 1999).
- Six Sigma is a disciplined method of rigorous data gathering and robust statistical analysis to pinpoint sources of error and ways of eliminating them (Harry and Schroeder, 1999).
- Six Sigma as an information-driven methodology for reducing waste, increasing customer satisfaction, and improving processes, with a focus on financially measurable results (As defined by Minitab in Goh, 2002).

Quality Gurus	Contribution
Philip B. Crosby	Senior manager involvement; four absolutes of quality management; quality costs measurements
W. Edwards Deming	Plan-do-study-act; top management involvement; concentration on system improvement; constancy of purpose
Armand V. Feigenbaum	Total quality control/management; top management involvement
Kauro Ishikawa	Cause and effect diagram; company-wide quality control;
Joseph M. Juran	Top management involvement; quality trilogy; quality cost measurement
Walter A. Shewart	Assignable cause versus chance cause; control charts; plan-do-check-act; use of statistics for improvement

Table 1. Pioneers of quality and their contribution to Six Sigma knowledge bank (adapted from Wortman, 2001)

The statistical focus of various Six Sigma definitions reflects its basic philosophy. Six Sigma is an operating philosophy that can be shared beneficially by everyone, including customers, shareholders, employees, and suppliers. Fundamentally, it is also a customer-focused methodology that drives out waste, raises levels of quality, and improves the financial performance of organizations to breakthrough levels (Chua, 2001).

Six Sigma's target for perfection is to achieve no more than 3.4 defects, errors, or mistakes per million opportunities whether this involves the design and production of a product or a customer-oriented service process. It is from this target that the name Six Sigma originated.

Compared to a process that has greater variation, a process with less variation will be able to fit more standard deviations or sigmas between the process centre and its specification limits. An increase in the number of sigmas between the specification limits means the acceptance of fewer defects. More sigmas imply a more consistent manufacturing or service delivery process (Chua, 2001).

2.2. Tools and techniques and six sigma methodologies

The concept of Six Sigma was introduced at and popularized by Motorola in 1987. Six Sigma is a logical extension of Statistical Process Control (SPC). The concept behind SPC is simple enough but powerful, indeed. Variation is present in every production/operations process and such variation is due either to common causes or special causes. The breakthrough made by Shewart was the statistical definition and measurement of variation, where variation within three-sigma limits was deemed to be random and produced by common causes, and variation outside of the three-sigma limits was produced by special causes, indicating a process problem (Shewart, 1931). The $\pm 3\sigma$ process limits mean a defect rate of 2.7/1000 or 2,700/1,000,000 opportunities, if one ignores lateral shifts in the process, and the capability of the process is thus defined as the range of natural variation, that is, $\pm 3\sigma$, or Cpk = 6σ. Six-Sigma doubles the range of normal variation to $\pm 6\sigma$, and allows for a 1.5σ lateral shift in the process average. The result is a dramatic tightening of acceptable defect rate target to 3.4/1,000,000 opportunities.

The basic elements of Six Sigma are not new. SPC, failure mode effect analysis, gage repeatability and reproducibility studies, and other tools and techniques, have been in use for some time. Six Sigma offers a framework that unites these basic quality tools and techniques with high-level management support.

There is much literature available on tools and techniques used in Six Sigma. Tools are mostly referred to as having a clearly defined role but narrow in focus, whereas techniques have wider application and require specific skills, creativity, and training (Antony, 2006). Similar to CSFs, CTQs, and KPIs; there is limited literature which discuss about STTs specific to service organizations. Discussion on STTs in the literature is mostly on its usage at different phases of DMAIC methodology. De Koning and De Mast (2006) used seven different literature sources and provided a summary of STTs used in DMAIC phases. Some other literature provide classification scheme for tools and techniques used. Henderson and Evans (2000) discussed about tool sets in three groups; team tools, process tools, and statistical tools. As for Six Sigma tools and techniques specific to service organizations, Antony (2006) provides a grid as a guideline for services.

A number of classification schemes for STTs exists, the majority of which are based on the DMAIC methodology. The classification schemes by the American Society for Quality (ASQ) and by Nancy Tague (1995) called the Tool Matrix provide an exhaustive list of tools and techniques which can be used during Six Sigma implementation. The ASQ classification scheme and the tool matrix have almost similar categories. The only difference being in the number of tools and techniques each category.

2.2.1. Classification scheme of tools and techniques

a. ASQ Classification

According to ASQ, tools and techniques that are utilized in different phases of DMAIC are classified according to their uses. There are 7 broad categories: Cause Analysis Tools, Data Collection and Analysis Tools, Evaluation and Decision Making Tools, Idea Creations Tools, Process Analysis Tools, Project Planning and Implementation Tools, Seven Basic Quality Tools, and Seven New Management and Planning Tools.

Categories	Description	Tools
Cause analysis tools	Used to identify the cause of a problem.	Fishbone diagram, Pareto chart, Scatter diagram
Data collection and analysis tools	Used to collect or analysis data.	Check sheet, Control chart, Design of experiment, Histogram, Scatter diagram, Stratification, Survey
Evaluation and decision making tools	Used to select the best choices or to evaluate what is performance level of project so far.	Decision matrix, Multi-voting
Idea creations tools	Used to create ideas or organize ideas.	Affinity diagram, Benchmarking, Brainstorming, Nominal group technique
Process analysis tools	Used when an understanding of process flow is desired.	Flowchart, Failure mode effect analysis, Mistake-proofing
Seven basic quality tools	These tools are the most fundamental tools of quality control.	Cause and effect diagram/ Fishbone diagram, Check sheets, Control charts, Histogram, Pareto chart, Scatter diagram, Stratification
Seven new management and planning tools	Used to encourage innovation, communicate information and successful planning of key projects.	Affinity diagram, Relation diagram, Tree diagram, Matrix diagram, Arrow diagram, Process decision program chart

Table 2. Classification of tools and techniques according to ASQ
(Source: American Society for Quality Website)

b. Tool Matrix

In Nancy R. Tague's The Quality Toolbox (1995), she developed a Tool Matrix that classifies quality tools according to what the tools can offer. It is quite similar to the categorization suggested by ASQ, but differs, as it encompasses more tools.

Categories	Tools
Ideas creation	Affinity diagram, Brainstorming. Brain writing Nominal group technique, Relation diagram
Process analysis	Cost of quality analysis, Critical-to-quality analysis, Deployment flowchart, Flowchart Matrix diagram, Relations diagram, Requirements matrix, Requirements-and-measure matrix, Storyboard, Top-down flowchart, Work-flow diagram
Cause analysis	Contingency diagram, Fishbone diagram, Force field diagram, Is-is not matrix, Matrix diagram Pareto chart, Scatter diagram, Stratification, Tree diagram, Why-why diagram
Planning	Activity chart, Arrow diagram, Contingency diagram, Deployment flowchart, Flowchart Force field analysis, Matrix analysis, Mission statement, Operational definitions, Plan-do-check-act cycle, Relations diagram, Storyboard, Top-down flowchart, Tree diagram, Work-flow diagram
Evaluation	ACORN test, Continuum of team goals, Decision matrix, Effective-achievable matrix, List reduction, Matrix diagram, Mission statement checklist, Multi-voting, Plan-results matrix, PMI
Data collection and analysis	Box plot, Check sheet, Control chart, Histograms, Importance-performance analysis, Kologorov-Smirnov test, Normal probability plot, Operational definitions, Pareto chart, Performance index, Process capability, Requirements-and-measures tree, Run chart, Scatter diagram, Stratification, Survey

Table 3. Tool Matrix (Tague, 1995)

c. Innovation Tools

The literature on service design and development talks about various tools which are effective in describing and analysing service problems. The tools are shown in Table 4.

S. No.	Tool	Description
1	Structured analysis and design technique	Used to model service system
2	Function analysis	Maps customer requirements to required functions and means
3	Service blueprinting	Analyse and represents the steps in a service process

4	Quality function deployment (QFD)	Translate customers' needs and expectations into specifications that are relevant to companies
5	Root cause analysis	Identify potential service failure points, service outcome or process problems in service recovery process
6	Theory of Inventive Problem Solving (TRIZ)	Algorithmic approach for solving technical and technological problems
7	Axiomatic design	Maintain the independence of the functional requirements and minimize the information content in a design

Table 4. Innovation tools

2.2.2. Six sigma methodologies

2.2.2.1. DMAIC methodology

Much information is available about the DMAIC (define, measure, analyze, improve, control) methodology. DMAIC is used mostly for existing processes. This approach not only makes use of various tools and techniques, it also incorporates other concepts such as financial analysis and project schedule development. The DMAIC methodology is excellent when dealing with an existing process in which reaching a defined level of performance will result in the benefits expected. There are number of articles and books providing details about DMAIC methodology. Table 5 provides the details about each phase taken from one of the literature.

Phase	Description
Define	Identify, evaluate and select projects; prepare the mission; and select and launch the team
Measure	Measure the size of the problem, document the process, identify key customer requirements, determine key product characteristics and process parameters, document potential failure modes and effects; theorize on the cause or determinants of performance
Analyse	Plan for data collection; analyse the data and establish and confirm the "vital few" determinants of performance
Improve	Design and carry out experiments to determine the mathematical cause-effect relationships and optimize the process
Control	Design controls; make improvements, implement and monitor

Table 5. DMAIC methodology (Chua, 2001)

2.2.2.2. Design for Six Sigma (DFSS): Overview

The emergence of Six Sigma since 1980s has been phenomenal. Initially, the major focus of the organizations was to improve from their existing three sigma limits to Six Sigma limit of product or service quality. The importance of innovation in products and services has

changed the focus of organizations now more towards proactive approach rather than being reactive. The design for Six Sigma (DFSS) approach is relatively new compared to Six Sigma and is discussed in different ways in various literatures. Most of the literatures though agree that DFSS is a proactive approach and focuses on design by doing things right the first time. DFSS can be said as "A disciplined and rigorous approach to design that ensures that new designs meet customer requirements at launch" (El-Haik and Roy, 2005, pp 33). According to GE corporate research and development, the importance of DFSS is in the prediction of design quality up front and driving quality measurement and predictability improvement during the early design phases (Treichler et al, 2002). DFSS can also be explained as a data-driven methodology based on analytical tools which provide users with the ability to prevent and predict defects in the design of a product or service (De Feo and Bar-El, 2002). The major focus of DFSS approach is to look for inventive ways to satisfy and exceed the customer requirements. This can be achieved through optimization of product or service design function and then verifying that the product or service meets the requirements specified by the customer (Antony and Coronado, 2002).

The literatures also concentrate on the differences between DMAIC and DFSS approach. Though DFSS involves designing processes to reach Six Sigma levels and is considered as an aggressive approach, but it still lacks a single methodology unlike Six Sigma (Hoerl, 2004). The different methodologies used in DFSS are:

- IDOV (Identify, Design, Optimize, Validate)
- ICOV (Identify, Characterize, Optimize, Validate)
- DCOV (Define, Characterize, Optimize, Verify)
- DMADO (Define, Measure, Analyze, Design, Optimize)
- DMADV (Define, Measure, Analyze, Design, Verify)
- DMADOV (Define, Measure, Analyze, Design, Optimize, Verify)
- DCCDI (Define, Customer Concept, Design, Implement)
- DMEDI (Define, Measure, Explore, Develop, Implement)

Some of the other differences are:

- DFSS is a methodology that takes into account the issues highlighted by the end customers at the design stage while DMAIC solves operational issues (Ferryanto, 2005).
- Benefits in DFSS are difficult to quantify and are obtained in long term in comparison to Six Sigma, where the benefits are expressed mainly in financial terms and obtained rather quickly (*www.ugs.com/products/nx/bpi)*.
- The DMAIC methodology tends to provide incremental improvements in comparison to DFSS where there can be radical improvements (El-Haik and Roy, 2005).
- The projects improved through DMAIC methodology are constrained by the assumptions made during the development and design stages, whereas DFSS builds quality into the design by implementing preventive thinking and tools in the product development process (Smith, 2001).

The tools and techniques involved in the DFSS methodology are also somewhat different from those of the DMAIC methodology. DFSS includes innovation tools such as the theory

of inventive problem solving, axiomatic design, and quality function deployment, which DMAIC does not. Detailed information about the methodologies can be found in (Kwak and Anbari, 2006; Hendry and Nonthaleerak, 2005; El-Haik and Roy, 2005; Goel, et al., 2005; Raisinghani et al., 2005; Basu, 2004; Antony and Coronado, 2002; Stamatis, 2002 (a and b); Harry and Schroeder, 1999).

Though there are differences among Six Sigma and DFSS approaches but still these two complement each other. Different DFSS stages are shown in Figure 1. Problem definition is the first stage, where customer requirements are incorporated. This stage is followed by the characterization stage. The model of the problem in the process or engineering domain is developed at this stage, which is basically the translation of the voice of customer and the customer usage conditions into an engineering system (Ferryanto, 2005). As seen from Figure 1, improvements from the DMAIC are added to the model at the characterization stage. After model development, optimal and robust solutions are found out. At the last stage the solutions are verified for their usefulness to solve the real problem.

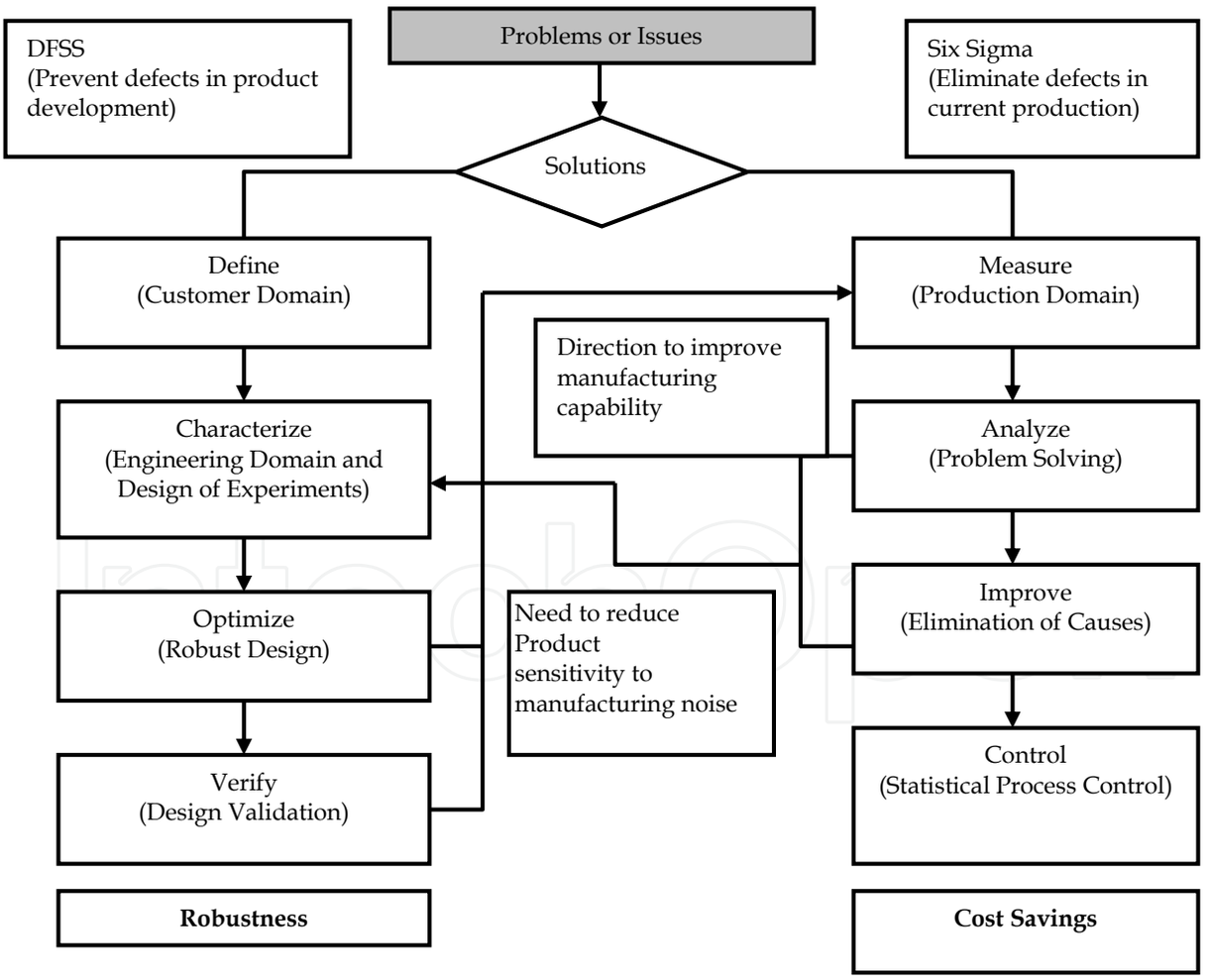

Figure 1. DFSS versus Six Sigma (Ferryanto, 2005)
* The DFSS model illustrated is Ford Motor Co.'s DCOV approach

2.3. Critical Success Factors (CSFs)

CSFs are the essential ingredients required for success of Six Sigma projects in an organization (Coronado and Antony, 2002). There have been many studies on CSFs. One of the earliest is by Harry (2000), who discussed about six success factors involving management's leadership, belt system, etc. Later on Antony and Banuelas (2002) mentioned twelve success factors which include management involvement and commitment, linking Six Sigma to business strategy, etc. There are several other studies and all of them have at least one common CSF, i.e. top management commitment. The discussion on CSFs by Antony (2006) is the only one specific to service organizations. Some of the common CSFs are discussed below.

i. Top management commitment and involvement
   Almost all the literature reviewed agrees that this factor is a must for successful Six Sigma implementation. And this has to be 'top-down' rather than initiated by a particular department or from the ground (Goh, 2002). Top management involvement helps to influence and restructure the business organization and the cultural change in attitudes of individual employees toward quality in a short implementation period (Henderson and Evans, 2000).

ii. Education and training
   Another important feature of Six Sigma is the elaborate training and certification processes that result in Black Belts, Green Belts, etc (Goh, 2002). Education and training help people understand the fundamentals of Six Sigma along with the application of tools and techniques to different phases of DMAIC. Training is part of the communication process to make sure that manager and employees apply and implement the Six Sigma techniques effectively (Kwak and Anbari, 2006).

iii. Cultural change
   Six Sigma is considered a breakthrough management strategy, and it involves the adjustment of a firm's values and culture. In some cases, substantial change to an organization's structure and infrastructure need to take place (Coronado and Antony, 2002). People facing cultural change and challenges due to the implementation of Six Sigma need to understand this requirement. Also needed are a clear communication plan and channels to motivate individuals to overcome resistance and to educate senior managers, employees, and customers on the benefits of Six Sigma (Kwak and Anbari, 2006).

iv. Customer focus
   Customer focus is one of the major requirements in implementing Six Sigma. This is emphasized in terms of critical to quality characteristics. Six Sigma is highly much more sensitive to requirements for customer satisfaction (Goh, 2002).

v. Clear performance metrics
   This is an important factor from a service point of view. Often the difficulty is with identifying what to measure (Sehwall and De Yong, 2003). Before starting any Six Sigma initiative it is better to have a clear idea and agreement on the performance metrics to be used.

vi. Attaching the success to financial benefits
Representing the success of Six Sigma projects in terms of financial benefits and measurement performance has made their selection and completion an important aspect for the organizations (Henderson and Evans, 2000). Financial benefits as a measure of achievement makes it easily understandable for the employees and helps them to relate to Six Sigma project outcome (Goh, 2002).

vii. Organizational understanding of work processes
The amount of effort that a service organization puts into measuring its work processes is important. Some organizations expend much time and effort in developing ways to measure the processes that ultimately impact customer satisfaction. Other organizations attempt this half-heartedly and measure only part of what is important to the customer. Like in hospitals the focus may be only on a particular laboratory or facility where the interaction with customer tends to be relatively greater. Because Six Sigma programs rely on measurements from processes, organizations with robust measurement systems in place are more likely to be ready for a Six Sigma implementation (Hensley and Dobie, 2005).

The factors discussed above are equally applicable to services and manufacturing. Our literature review found that top management commitment, education and training, cultural change, and financial benefits are the most important CSFs. Figure 2 summarizes the importance of the CSFs as seen by each of the articles that were reviewed.

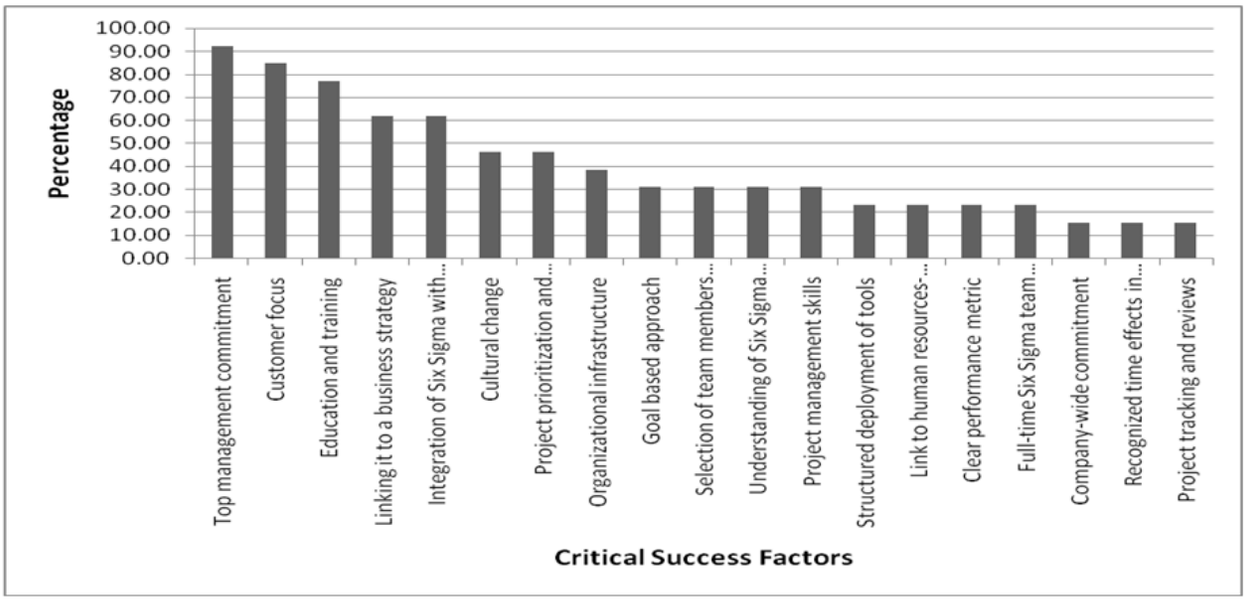

Figure 2. Percentage of articles mentioning each of 19 CSFs

2.4. Critical-to-Quality (CTQ) characteristics

In case of CTQs, we focused on its definitions mentioned in the literature. CTQ is defined in different ways in the literature but mostly they agree that it is a quality characteristic of product or service which is required to be improved from customer point of view. In other

words, CTQ is generated from critical customer requirements derived from voice of customer (refer Figure 3).

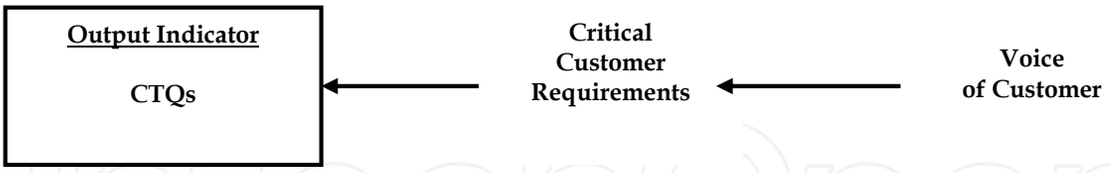

Figure 3. Understanding critical-to-quality (adapted from Muir, 2006)

CTQs are the key measurable indicators of a product or process whose performance standards or specification limits must be met in order to satisfy the customer. CTQs align improvement or design efforts with customer requirements. In a layman term, CTQs are what customers expect of a product or service. They are the spoken needs of the customer (isixsigma/dictionary). Six Sigma focuses on process improvement, and improving the service process is a major determinant of customer satisfaction.

The discussion on CTQs in the Six Sigma service literature is limited. Although services are widely different, the analysis from various literatures (Kwak and Anbari, 2006; Jones Jr., 2004; Sehwall and De Yong, 2003; Rucker, 2000) shows that some common CTQs exist across service. They are discussed below.

i. Time (service time, waiting time, cycle time)
   In the case of services where the customer is involved in the process itself, time is an important consideration. The following three types of time should be considered:

   a. Service time: The time required to serve a particular customer
   b. Waiting time: The time customer waits in the system to get the work done
   c. Cycle time: The total time including service and waiting time.

ii. Cost
   Like time, cost is sometimes a critical factor from the customer's point of view. The two are in fact intertwined. Customers may at times be willing to pay more for a service that can be completed in a shorter time. The trade-off between cost and time is, thus, important for services.

iii. Employee behaviour
   For services where there is high degree of customer contact, employee behavior may be an important consideration. An employee's attitude towards a customer's problem may well decide whether the customer wishes to continue being serviced by the organization.

iv. Information (accurate information, timely information)
   The growing importance of call center services shows the emergence of information needs. Getting the right information at the right time to one's customers is, thus, an important aspect from a customer point of view.

2.5. Key Performance Indicators (KPIs)

KPI is not well defined in the literature and there exist different interpretations of this term. Mostly the literature discuss about it as performance metrics, i.e., it is a measure of performance in terms of cost, quality, yield, and capacity (Basu and Wright, 2003; Hahn et al., 1999). A few of the suggested definitions of KPI is provided below (refer Table 6).

Author(s)	KPI Definitions
Hahn et al. (1999)	Performance metrics are established that directly measure the improvement in cost, quality, yield, and capacity.
Basu and Wright (2003)	KPIs are measurements of a performance such as asset utilization, customer satisfaction, cycle time from order to delivery, inventory turnover, operations costs, productivity, and financial results.
Antony (2006)	KPIs can be termed as performance metrics of Six Sigma.
ASQ Glossary	KPI is a statistical measure of how well an organization is doing in a particular area. A KPI could measure a company's financial performance or how it is holding up against customer requirements.

Table 6. Key performance indicator definitions

KPIs show actual data of a particular outcome. The outcomes of Six Sigma projects are usually required to be expressed in financial terms. This leads to a direct measure of achievement which is easy to understand (Goh, 2002). The majority of the KPI literature on Six Sigma in services talks about financial benefits. Other KPIs include expressions in terms of customer satisfaction and efficiency. Similar to CTQs, some KPIs are common across services. Some of the common KPIs are discussed below.

i. Efficiency
   Efficiency in a service industry means the timely delivery of services at a reasonable cost.

ii. Cost reduction
   Cost can be reduced by eliminating waste, such as reducing errors or mistakes in a process or reducing the time taken to complete a task. A concrete example is to reduce a patient's stay at a hospital (Heuvel et al., 2005), which can provide opportunity for more admissions.

iii. Time-to-deliver
   Like in manufacturing, the time to deliver a service determines organizational performance. Examples may be the timely delivery of information or document as per customer requirement.

iv. Quality of the service
   Quality of the service is a measure of the extent to which the service delivered, meets the customer's expectations. This depends on two aspects; one is the technical aspect and another is functional aspect. The technical aspect is the actual outcome of the service encounter. Functional aspect is the interaction between the service provider and customer i.e. the service process (Ghobadian et al., 1994).

v. Customer satisfaction
This factor is difficult to measure as it varies from service to service. For example, for a call center service, customer satisfaction is measured by the receipt of timely information. For a hospital, the comfort and assurance that patient feels may be the all important criterion (Sehwall and De Yong, 2003). Overall customer satisfaction can also be indicated by the retention rate of one's customer.

vi. Employee satisfaction
This is another intangible measure of organizational performance. Employee retention rate can be an excellent indicator of employee satisfaction. Financial benefits due to Six Sigma can provide employees with a means to visualize their contribution. This may increase employee morale and satisfaction (Henderson and Evans, 2000).

vii. Reduced variation
Statistical process control and Six Sigma refer to the reduction of variation through improved standards and consistency. In the case of services, variation reduction may be in terms of, for example, the cycle time of processing statements, or the decision cycle of a process (such as credit process in a bank) or the inaccuracy of a billing process and incorrect laboratory test results (such as in a hospital) (Sehwall and De Yong, 2003; Rucker, 2000).

viii. Financial benefits
The impact of Six Sigma on the bottom line is huge (Henderson and Evans, 2000). In comparison to success and failure as a measure, financial bottom lines are a better indicator of the impact of improvements as well as a vivid calibration of progress (Goh, 2002).

2.6. Six sigma in manufacturing and service organizations

Although different terms may be used, scrap and rework exist in services just as they do in manufacturing. Inconsistent and out-of-specification processes cost money to rework. Such examples in services may include the need to re-contact a customer to verify an order, providing an incorrect service, providing a substandard service, or even over-servicing or providing more than what is required. Some widely publicized success stories due to implementation in services include GE Medical Systems, Mount Carmel Health System, Virtua Health, GE Capital Corp, Bank of America, and Citibank. Limited application can also be found in call centers, human resources such as DuPont de Nemours (Bott et al., 2000; Wyper and Harrison, 2000) and in product support services such as by Caterpillar (Schmidt and Aschkenase, 2004) .

The literature analysis also revealed that applications are limited mostly to service organizations in North America and Europe. Benefits-wise, these are mostly expressed in financial terms and not much is published about the benefits in process improvement terms. The literatures (Brady and Allen, 2006; Inozu et al., 2006; Mortimer, 2006; Antony et al., 2005a; Dudman, 2005; Goel et al., 2005; Hensley and Dobie, 2005; Basu, 2004; McAdam and Evans, 2004; Schimdt and Aschkenase, 2004; Hill and Kearney, 2003; Sehwall and De Yong, 2003; Rucker, 2000; Hahn et

al., 1999; Harry and Schroeder, 1999; Paul, 1999) on Six Sigma application in manufacturing or services discuss mainly about CSFs, CTQs, KPIs and STTs. The following section provides an overview of these factors. Table 7 presents the similarities and differences of these between manufacturing and services on the basis of observations from the literatures.

Dimensions		Manufacturing	Service
CSFs		Top management commitment, education and training, cultural change, linking Six Sigma to customers, linking Six Sigma to business strategy, effective communication	Top management commitment, cultural change, clear performance metrics, customer focus, education and training, attaching the success to financial benefits, organizational understanding of work processes
CTQs	Similarities	Cycle time, cost of quality, machine or human error	
	Differences	Product performance characteristics such as, strength; weight, defects, poor packaging, breakage, defects, inventory reduction, product travel distance, poor packaging, quantity of rework, time spent in rework	Service time, waiting time, employee behaviour, responding to customer complaints, providing accurate and timely information to customers
KPIs		Cost savings, customer satisfaction, reducing variation, employee satisfaction, increasing productivity, product quality improvement	Efficiency, cost reduction, time to deliver, quality of the service, customer satisfaction, employee satisfaction
STTs	Similarities	Histogram, Pareto analysis, cause and effect analysis, brainstorming, flowchart, project charter, process mapping, root cause analysis, control charts	
	Differences	FMEA, DOE, SPC, gauge repeatability and reproducibility, measurement system analysis, regression analysis, QFD	

Table 7. CSFs, CTQs, KPIs, and STTs (manufacturing versus service)

The above table provides some important insights regarding Six Sigma implementation aspects in manufacturing and services. There are similar CSFs in manufacturing and services but their order of preference differs between two. This difference in order of preference can also be observed within the literature involving Six Sigma implementation in services. The paper by Antony (2004b) shows that linking Six Sigma to business strategy is the most important of success factors whereas some other literatures discuss that top management commitment is the most important one, followed by education and training (Johnson and Swisher, 2003; Henderson and Evans, 2000).

CTQs show similarities in terms of cycle time and cost. The concentration in manufacturing is more on product specifications/characteristics, inventory reduction, and reducing variation whereas services focus more on service time, waiting time, responding to customer, employee behaviour, etc. The reason for this difference can be because of more customer contact in services.

KPIs for both manufacturing and services show much similarity and are not much discussed in literatures. The application of tools and techniques has similarities in usage of flowcharts, process map, histograms, Pareto analysis, etc. The use of statistical tools and techniques such as SPC and regression analysis is more prominent in manufacturing may be because of ease of data collection and continuity of the process. The tools and techniques such as gauge repeatability and reproducibility is commonly used in manufacturing but not so in services, the reason is non-repeatable nature of service processes (Does et al., 2002).

2.7. Review summary

First, although the industry has an increased interest in Six Sigma implementation and many companies have gained the profits and advantages from this disciplined approach, the literature is limited and the research impacts of Six Sigma implementation and factors contributing to its success remain unclear. Many articles on the impact analysis of operations performance do not mention the detailed improvements in the operating areas, but focus on the overall bottom line impact. Therefore, it is necessary to do a deeper and more detailed study in this area.

Second, only a few articles were found that dealt with factors in the area of success factor analysis to Six Sigma implementation. Existing studies are not well integrated and current concepts in the field of Six Sigma are largely based on case studies, anecdotal evidences and are prescriptive in nature. Consequently there is little consensus on which factors are critical to the success of the approach (Nonthaleerak and Hendry, 2008; Brady, 2005). Most of the articles concentrated on few success factors and reported that top management commitment is the main factor to Six Sigma success (Goh, 2002; Henderson and Evans, 2000). However, many other factors affecting Six Sigma's success are important and need to be better documented.

To fill this gap, Antony and Baneulas (2002) identified 10 typical CSFs from their review of literature. Several others also provided sets of CSFs which have similarities or differences among them. It could be argued that this list of CSFs is comprehensive and that many of the issues are in common with those found for any implementation process, and are thus not specific to Six Sigma. However, all of the papers that identify these issues are descriptive in nature and there is a need to verify them through rigorous empirical research.

Finally, some authors have called for theoretic research (Nonthaleerak and Hendry, 2008; Schroeder et al., 2008; Oke, 2007; Brady and Allen, 2006), as too much research is focused only on description of practice rather than on theory development that is of use to practitioners as well as academics.

3. Research methodology

Management research is mainly based on deductive theory testing and positivistic research methodologies (Alvesson and Willmott, 1996). These methodologies incorporate a more scientific approach with the formulation of theories and the use of large data samples to observe their validity. However, these approaches mostly fail to give deep insights and rich data in Six Sigma practice within service organizations. Schroeder et al. (2007) state the need for more theory grounded and contingency based research rather than be restrictive to deductive approaches. Antony et al. (2007) and Nonthaleerak and Hendry (2008) emphasize this point by saying there is a *paucity of systematic and rigorous evaluation* in many Six Sigma studies.

In this section we describe the three phase approach for this study. First phase involved literature review and exploratory case studies. A small-scale questionnaire survey and 15 case studies were done in the second phase. The third phase included a large-scale questionnaire survey and further case studies. Questionnaire structure and design for each phase is also discussed. Then details about the measures are provided. Finally, we explain how we test the sample bias, which population is targeted, and how to proceed for the data collection.

3.1. Phase I – Macro study

This phase focused on providing the necessary breadth to produce an understanding of the implementation of Six Sigma in service organizations and from which reliable patterns and theories can be formed. Next phase of this research focused on the issues uncovered by the first.

The phase is termed as macro study (Leonard and McAdam, 2001), and it provides an overview not only of Six Sigma implementation in services, but also a database of critical success factors (CSFs), critical-to-quality (CTQ) characteristics, key performance indicators (KPIs), and set of tools and techniques (STTs).

The study included two services one is library and the other one is a call center. During this phase, interviews were conducted with a black belt, who was considered by the organization as most knowledgeable and responsible for Six Sigma implementation. The study concentrated on the implementation aspect of Six Sigma which involves CSFs, CTQs, KPIs, STTs, and also the difficulties faced. The BB provided an essential insight and understanding of Six Sigma implementation in service organizations. The other methods of data collection in this phase involved documentation and archival records.

Once the macro study is completed and insights are developed, preparation for next phase was done to focus on additional relevant questions that had arisen in phase one. This next phase involved a small-scale questionnaire survey and simultaneous case studies. The study included multiple respondents which overcame the problem of using single respondent in phase one. It also provided a degree of validation.

3.2. Phase II – Small-scale questionnaire survey and case studies

3.2.1. Small-scale questionnaire survey

At this phase a questionnaire survey of Singapore service organizations was conducted to understand the status of Six Sigma implementation. The survey was exploratory in nature as the objective was to gain insights about Six Sigma in service organizations. This kind of survey helps to uncover or provide preliminary evidence of association among concepts. Further, it can help to explore the valid boundary of a theory (Forza, 2002).

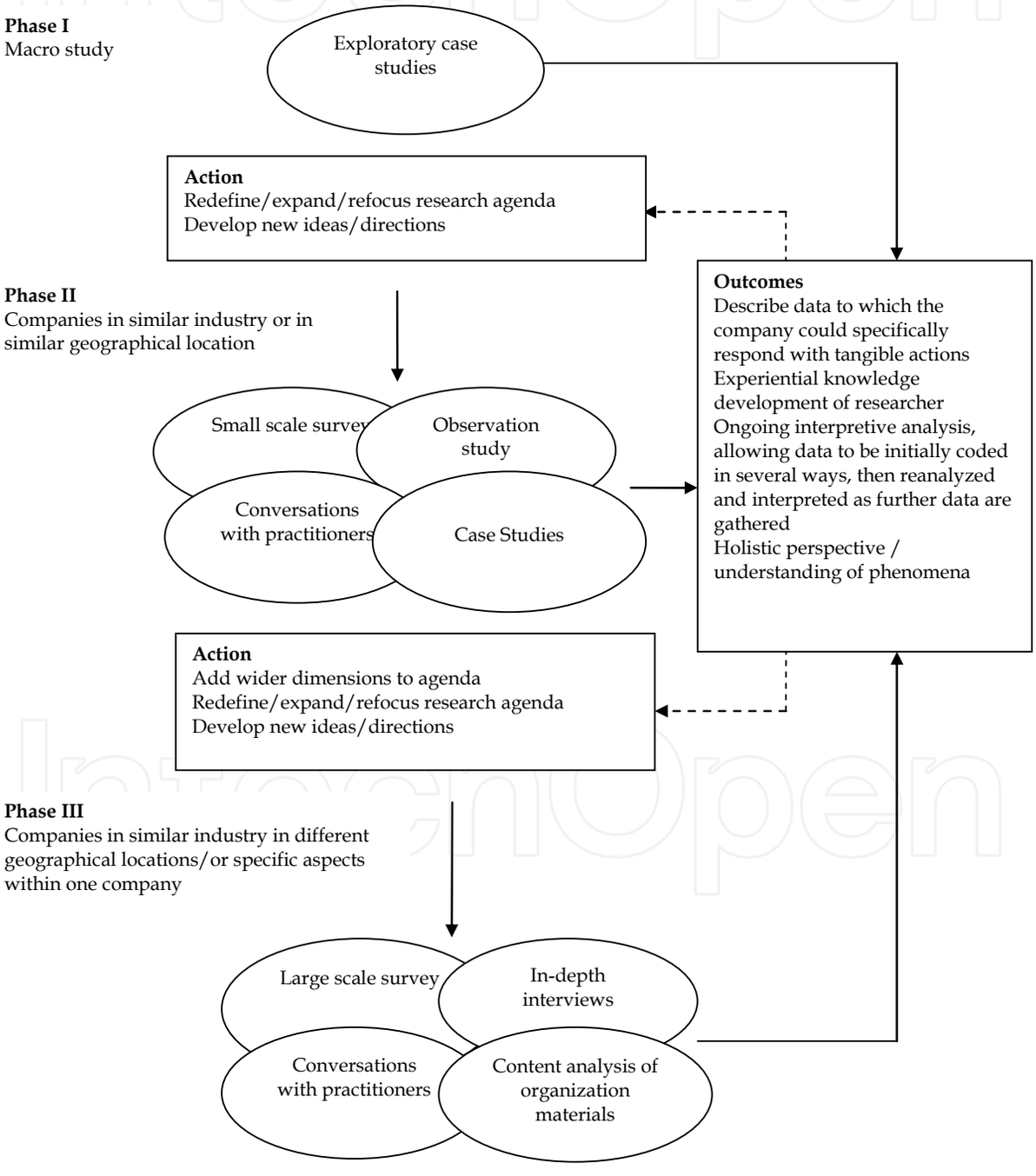

Figure 4. Three-phase approach (adapted from Leonard and McAdam, 2001; Gilmore and Carson, 1996)

Structure of the questionnaire

There are five parts in the questionnaire. The first part of the questionnaire is intended to get some general information of the respondent company, which includes the type of service organization, the size of the company, the type of company (local, multinational, or joint venture), whether they have quality department, there is a proper quality system in place, any business process improvement initiatives they are doing, and finally whether they have implemented Six Sigma. It is also designed as a filter to segregate the data based on service organizations which have or have not implemented Six Sigma.

The second part of the questionnaire attempts to identify the CSFs which are important while implementing Six Sigma in organization. The third part consists of two questions. First question is directed at identifying CTQs that are to be improved through Six Sigma implementation. Second question explores the tools and techniques used in Six Sigma DMAIC methodology and also in DFSS. The fourth part is focused on finding about KPIs while in the fifth part the objective is to identify the difficulties faced by service organizations in Six Sigma implementation. The fifth part is for those service organizations which have not implemented Six Sigma. There is one question in this part to explore about the reasons behind not implementing Six Sigma. The last part is designed to obtain background information on respondents including their name, job title, company, mailing address, phone/fax number, and e-mail. In order to share our findings with the respondents who are interested, we also left a space for them to tick whether they want to have the summary of our survey results.

Besides the six parts above, a cover letter with university letterhead explaining the aims and benefits of the research was designed.

Questionnaire design

The response format of the questionnaire is a major design consideration since this will alter the type and wording of the questions as well as focus on the type of analysis that the researcher wants to perform (Antony et al., 2007; Fowler, 2002; Kidder, 1986). For our research close-ended question format was considered since the data would be in a quantifiable form ensuring that statistical analysis can be used. Moreover, it is fast and easy to complete, enables automated data entry, and facilitates data analysis and summary of data (Antony et al., 2007; Fowler, 2002). The rating scale (Likert scale) and ranking used within this format is to obtain the answers from the respondents. The questionnaire focused on CSFs, CTQs, STTs, and KPIs as observed from the literature. CSFs, STTs, and KPIs are measured by a 5-point Likert-type scale (CSFs and KPIs: 1 = not important, 5 = very important; STTs: 1 = never, 5 = frequently). The Likert scale used provide a more precise measure than yes/no or true/false items and it is fast and easy to complete (Neuman, 2006). The rating scale used for few questions allows the respondents to indicate the relative importance of choices that facilitates the researchers in identifying the critical issues or factors (Antony et al., 2007).

Further, in the question content we intended to assure the respondents will be willing to answer honestly. To achieve this, personal information was not required across all the questions. The respondent profile which needed personal information was optional.

3.2.2. Case studies

The case studies in this phase focused on the critical issues that emerged from phase one. The case study was chosen as the research method primarily due to the nature of the research questions. Yin (1994) recommends this method as the most appropriate when contextual conditions are believed to be highly pertinent to the phenomenon of study. The case study method is also recommended when research questions embodies an explanatory component, such as in this study (how CSFs impact Six Sigma implementation in services?) (Yin, 1994).

Sample selection

We opted for an intricate sample design (Harrigan, 1983). This is a design where the sample is selected to coincide with sites that possess observable traits that are key factors in the propositions to be examined (Sousa and Voss, 2001).

The process for selecting individual service organizations was based on publicly available information and the respondents of small-scale questionnaire survey. From publicly available information, an initial list of 20 service organizations was compiled that were likely to comply with our research objective. 8 organizations which declined to participate in small-scale survey were removed from the initial list of 20, as they clearly mentioned about not revealing any data. We then started by contacting remaining 12 firms for participation in case study. At the end there were 3 firms which agreed to participate in the study. These 3 organizations were included for case study in next phase.

For second phase case studies we searched in public domain about the information available related to 17 organizations which were not interested for direct participation in the case study. We found Six Sigma implementation information related to 15 service organizations through different sources available. Finally second phase comprised 15 organizations which have completed around 29 projects between them for a period of 5 years, i.e. from 2003 to 2007.

Data collection procedure

A case study protocol was developed comprising a list of the research variables to address, and the respective questions, potential sources of information, and field procedures. Although data collection focused on the formal research variables, we also addressed other issues enabling us to understand the observed pattern of use of Six Sigma implementation, such as the history of use of its implementation and the difficulties experienced by the service organizations in using Six Sigma. Several data collection methods were used in both the phases including semi-structured interviews, direct observation, and secondary data.

Documentation

Evidence for case studies can be obtained from various sources such as documents, archival records, interviews, direct or participant observation, and physical artefacts. In this phase of

the study the data collection is based on documentary evidences, which helps in providing specific details to corroborate information and also inferences can be made from documents (Yin, 1994). The documents considered for this study is in the form of articles, interviews, and speeches published in journals, magazines, newspapers, and websites.

The first two phases of case studies were devised to provide a breadth of data and understanding of the Six Sigma implementation in service organizations. Along with the small-scale survey the second phase further enhanced the database on different aspects of Six Sigma implementation. The third phase will provide more rich and deep data, which involve a large scale questionnaire survey and case studies with in-depth interviews.

Phases one and two are specific and as detailed and rich in data as the third phase, but they are limited in time, access, and practitioner involvement. Thus, specific areas of inquiry could be examined, but a true behind the scenes, and multi-faceted picture and understanding could not be provided. To provide such an understanding, in-depth case studies and large-scale survey were needed that would allow a significant access to different managerial levels and inputs from the use of different research techniques. This constituted the third phase where case studies ran parallel with the second phase.

Unit of Analysis

Except for single case versus multiple-case design possibilities, one can also distinguish a case design separating and choosing between a single unit of analysis and multiple unit of analysis, see Yin (1994). In the literature, unit of analysis refers to a great variety of objects of study, for example, a person, a program, an organisation, a classroom or a clinic (Mertens, 1998), or a community, state or nation (Patton, 1987). Other authors have considered the unit of analysis as interviews or diaries in their entity, and the amount of space allocated to a topic or an interaction under study (Downe-Wamboldt, 1992).

For case studies, the overarching unit of analysis was the Six Sigma projects but there are sub-units that were investigated in order to reveal the main unit as realistically as possible. These sub-units are the experiences from different expertise (belt levels), the difficulties faced, the tools and techniques used, which also counts for the opinions among the actors involved in the implementation work. The reason behind choosing different expertise is because of different roles of black belt (BB) and green belt (GB) in Six Sigma project. BBs are the project leaders who are responsible towards project management while GBs are involved in data collection and analysis process. Following the experiences from different expertise will help in understanding the concerns from different levels, about Six Sigma projects.

Therefore, during the case studies different expertise in Six Sigma are chosen, which indicates that the chosen research design is an embedded multiple-case design. The replication does not necessarily mean that each case study needs to be either holistic or embedded (Hansson, 2003). The individual cases, within a multiple case study design may be either. When an embedded design is used, each individual case may include the collection and analysis of high quantitative data including the use of surveys within each

case (Yin, 1994). During this study, each individual case in the multiple-case design represented an embedded design. This unity between the individual cases was chosen in order to discover possible differences between the respondent groups, different levels of expertise and experience in Six Sigma implementation, as they may not share the same experience from an implementation process.

3.3. Phase III – Large-scale questionnaire survey and case studies

The small-scale questionnaire survey helped in understanding the status of Six Sigma in service organizations. It also highlighted certain issues which are required to be studied further in order to develop the theory. The next step is to conduct a large scale questionnaire survey and further case studies.

3.3.1. Case studies

The case study organizations were selected based on the idea of theoretical sampling. In case of theory building, theoretical sampling is preferable in comparison to generalizability concept in statistical studies. So, the cases are chosen for theoretical rather than statistical reasons (Schroeder et al., 2007; Eisenhardt, 1989).

The case studies in this phase involved three different service organizations and provided an opportunity for detailed understanding of Six Sigma implementation. After the second phase overall 8 organizations were contacted, 3 of which agreed to participate in the study. Similar to second phase, a range of data collection methods which include participant observation (e.g., organization tours), formal interviews, and review of company documents and archives, were used in this phase. This allowed a multi-perspective view on Six Sigma implementation in service organization.

Data collection procedure

Interviews

We conducted structured interviews with all the informants. In case of the four Staff Nurses for the healthcare service organization the questions were mainly towards their experience about the current projects, because of their limited knowledge of Six Sigma. The structured questionnaire involved questions on the Six Sigma initiative, project selection, Six Sigma implementation process, and the learning experience. As a part of Six Sigma initiative, we asked the informants about the reason they prefer Six Sigma over other initiatives, how the preparations were done to implement Six Sigma, and what was their approach to training personnel for Six Sigma. In project selection the informants were asked about the criteria of selection for the projects, factors involved in success of a project, and reasons behind unsuccessful projects. For the process of Six Sigma implementation, the questions are about their considerations on CTQs, tool and techniques used at different phases of DMAIC, selection criteria of STTs, and KPIs. We also asked the informants about their learning experience on the basis of Six Sigma's relevance to their organization, problems faced during the implementation process, and how they overcame those problems.

In total there were 10 interviews; 6 formal and 4 informal. All formal interviews were taped, transcribed, and coded. The list of interviewees is provided in Table 8.

Organization	Interviewee	Designation
Hospital	I1	Director, Human Resource
	I2	Head of Department
Construction and Related Engineering Service	I3	Assistant Director
	I4	Senior Development Officer
Consultancy	I5	Consultant
	I6	Building Manager

Table 8. List of interviewees

Having already established a database from the literature review, initial questionnaire survey, and exploratory case studies on different aspects of Six Sigma implementation in service organizations, phase three interviews were more focused and directed.

Participation in projects

In the case study of healthcare service organization, I was also involved in as a team member for two Six Sigma projects. This provided an opportunity to develop a partnership which lasted for six months. Combining retrospective and longitudinal study; as done in case of healthcare service organization for the study enhances construct, external, and internal validity (Barton, 1990). Moreover, this type of partnership in grounded theory research helps in observing phenomenon development and to develop framework from the collected data (Leonard and Mc Adam, 2001). Approaching the interviewees was not a problem, as I was visiting the organization on regular basis. This helped in getting completed answers on all questions and returning at a later date to seek clarification to questions that arose. For the other two organizations though there is no participant involvement, but the interviewees were approachable when required. Overall, interviewees represent different level in terms of experience and expertise with Six Sigma; this helps to avoid a bias or unqualified opinion which can be a problem in single respondent study (Nonthaleerak and Hendry, 2008; Voss et al., 2002).

My involvement in one of the case studies helped in observing changing attitudes towards Six Sigma and the development of the project. These observations included the challenges and issues involved in Six Sigma projects in service organizations. It allowed a more detailed history of Six Sigma implementation in the organization to be plotted, with wide access to documentation providing a clear picture of the reasoning for Six Sigma adoption, CSFs, CTQs, selection of tools and techniques, and the difficulties faced. Therefore, the case study research included an element of ethnography as what was being attempted was to learn the implementation of Six Sigma, and not only to accept or listen to the views articulated but also to actively use those views in discussion.

Documentation

The documentary evidences for information about these case studies is gathered through various sources which include websites such as Singapore Government website (PS21–

Public Service for 21st Century), articles, interviews and speeches from newspapers, magazines, and journals. Other sources of data are the reports and presentations of the completed projects.

This third phase of research was being carried out at the same time as the studies in phase two. The issues emerging from the previous phases were brought over and examined in the three case studies. Though, the specific questions raised during previous phases could not be specifically answered by these three case studies but wider issues that were replicated throughout were examined. Thus, these three case studies allowed greater detail and more intricate issues to be dealt with.

This phase also involves a large-scale questionnaire survey by focusing on companies which operate in different geographical locations, following the integrative approach suggested by Gilmore and Carson (1996). Combining such compatible and complimentary methods provide depth, breadth, and subtlety of information to the study (Carson and Coviello, 1996). This survey is done concurrently with the case studies and the responses from it further strengthen the development of conceptual framework for Six Sigma implementation in service organizations.

3.3.2. Large-scale questionnaire survey

Structure of the questionnaire

There are six parts in the questionnaire. The first part of the questionnaire is intended to get some general information of the respondent company, which includes the type of service organization, the size of the company, the type of company (local, multinational, or joint venture), whether they have quality department, there is a proper quality system in place, any business process improvement initiatives they are doing, and finally whether they have implemented Six Sigma. It is also designed as a filter to segregate the data based on service organizations which have or have not implemented Six Sigma. The second part of the questionnaire attempts to identify the CSFs which are important while implementing Six Sigma in organization. The third part consists of four questions. First two questions are related to CTQs. One is asking about definition of CTQ and the other is to identifying CTQs that are to be improved through Six Sigma implementation. Third question explores the tools and techniques used in Six Sigma DMAIC methodology and last one is about their selection criteria. The fourth part focused on finding about KPIs and its definition while in the fifth part the objective is to identify the difficulties faced by service organizations in Six Sigma implementation. The last part is for those service organizations which have not implemented Six Sigma. There is one question in this part to explore about the reasons behind not implementing Six Sigma.

Besides the six parts above, the web-based respondents were sent an introductory letter and follow-up letter by e-mail. In each e-mail, the targeted person was directed to a specific web page address posted on the university internet server, where the survey was presented. After completing the survey and pressing a *Submit* button, the responses were automatically saved on the internet server with a date and time stamp.

Questionnaire design

Following Gilmore and Carson's (1996) integrative approach, we focused on survey of service organizations in different geographical locations. Web-based surveys are one of the most preferred methods when data collection is to be done from organizations spread world-wide. They have several advantages over other collection methods, such as low cost, broader distribution, potentially higher response rates, faster survey turnaround time times and high selectivity (Coderre and Mathieu, 2004; Boyer et al., 2002; Klassen and Jacobs, 2001).

The design of the survey web page was similar to hard-copy survey. Like a paper survey, the respondents can scroll through questions in a particular section and also browse through the questions in other sections without any restrictions. They could also answer questions in any order and could complete the survey in several sessions. In terms of appearance user friendly features was designed (e.g. radio buttons, check boxes, scrollable dialog boxes, etc. where appropriate, given the nature of the question) to speed completion of survey (Kalssen and Jacobs, 2001; Dillman, 1999).

Similar to small-scale questionnaire survey, here also in the question content we intended to assure the respondents will be willing to answer honestly. To achieve this, there was no requirement for personal information in any of the questions. The respondent profile which needed personal information was optional.

4. The framework consolidation

The framework involves three sections. First is CSFs, followed by Six Sigma implementation, and bottom-line result. The Six Sigma implementation section consists of CTQs or measurable process parameters, DMAIC methodology, and STTs.

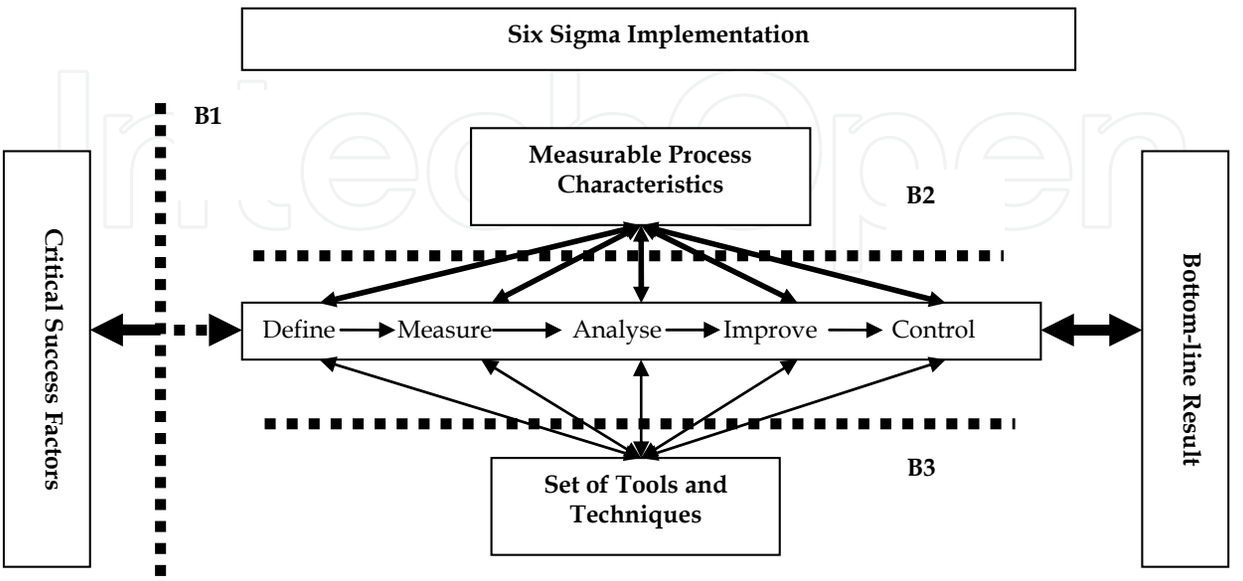

Figure 5. Conceptual framework for Six Sigma implementation in service organizations

The framework evolved on the basis of data collected through surveys, case studies, and continuous referrals with the literature. The initial framework developed was a kind of assessment model, i.e. in auditing role instead of an evaluative model to understand the dynamics of Six Sigma implementation in service organizations (Leonard and McAdam, 2001). There are works by Senapati (2004) and more recently by Parast et al. (2007) towards developing an assessment model for Six Sigma implementation. Though, both are descriptive in nature and lacks rigorous empirical research to support their applicability. We rather feel that a fuller understanding of dynamics of Six Sigma in service organizations, using suitable frameworks, will assist organizations to evaluate and predict the current and potential business benefits from Six Sigma implementation. Also, methods of reenergizing and directing Six Sigma efforts will be more specific and accurate. Furthermore there is a paucity of research literature in this area. Thus, our research study adds to the body of knowledge. The modified framework is presented in Figure 5.

4.1. Critical Success Factors (CSFs)

The idea of identifying CSFs as a basis for determining information needs of managers was popularized by Rockart (1979). In the context of Six Sigma implementation, CSFs represent the essential ingredients without which the initiative stands little chance of success (Antony et al., 2007). Based on this discussion and our findings from literature and data collected through surveys and case studies, CSFs are included in our framework. There are various CSFs identified but we feel only a few are essential as observed from the views of respondents from surveys and case studies.

First and foremost of CSF is top management commitment and involvement. Once top management buys in the decision to implement Six Sigma, they also have to involve themselves to ensure success of the program. This is highlighted by the respondents during interview sessions. They feel occasional involvement of top management during team meetings will motivate the team members and this will also help in solving certain problems which the team members cannot solve at their levels.

Next is support of team members. Since Six Sigma implementation requires project teams so, proper coordination and support between team members is an important aspect. Further in case of service organizations, the projects are done part-time so involvement of each member in team meetings becomes very important to keep everyone well versed about the project. This will also ensure timely completion of the project.

Linking Six Sigma to business strategy is another CSF which is mentioned both in surveys and case studies. This is important as there has to be alignment between the Six Sigma projects and company objectives as mentioned by one of the interviewee of consultancy service organization. This also ensures top management commitment towards Six Sigma program.

The surveys also highlighted two CSFs which are customer focus and education and training. Education and training on Six Sigma will be useful as it will help employees of

service organization overcome fear on the use of rigorous statistical and quality tools and techniques (Nonthaleerak and Hendry, 2008).

4.2. Critical-to-Quality (CTQ) characteristics

We also propose definition for CTQ to have a clear distinction with KPI. CTQ can be defined as product or service process characteristic derived from critical customer requirements whereas KPI as mentioned is more specifically performance metric. The following example (adapted from Frings and Grant, 2005) will help in understanding about CTQ clearly.

In a call centre scenario: Customer quote: "I consistently wait too long to speak to a representative" CTQ definition: Representative responsiveness; CTQ measure: Time on hold (seconds)

So in order to reduce the ambiguity between terms we use only CTQ which include both CTQ definition and CTQ measure. Since CTQ is actually process characteristics so for a clear understanding, in the framework we mention it as measurable process characteristics.

The CTQs or measurable process characteristics which are important from service organization's perspective are time, cost, and quality. The study shows that most of the Six Sigma projects associated with service organizations are concerned with reduction in time. From our analysis of service strategy context we found that cycle time is an important CTQ for mass service organizations whereas waiting time is critical for professional service organizations. Reduction in cost is concerned with cost of transaction and quality is related to improved accuracy in information provided to customer or improved reliability of service systems, etc. The most important aspect related to measurable process characteristics is our finding that it is context dependant. As our research showed that importance of process parameters vary across service types. So to overcome the barrier of identification of process parameters it will be useful to position service organizations as professional service, service shop or mass service.

4.3. Key Performance Indicators (KPIs)

It is observed that there is ambiguity about KPI. It is often synonymously used with CTQ. The practitioners feel it more as key process input/output variable rather than key performance indicator. Key performance indicator is more like performance metric as mentioned in some literature and is strategic in nature. Table 9 provides the definitions identified from our study. Majority of these definitions are related to organization strategy.

It can be observed from the above table that KPI is significant when interpreted in terms of overall organization strategy rather than specific to Six Sigma strategy. Another interpretation of it being similarity with CTQ makes us to think of a uniform and clearly understandable term instead of two different terms. We feel in this scenario the term measurable process characteristic mentioned in our framework definition can overcome this problem.

Strategic Oriented
KPI's is the chosen indicators to control a process and used to have data when a decision is required. KPIs are agreed in an organization as the measurement points without discussion.
The metrics that help guide the organization in the right directions. Tells you if you are succeeding in your goals.
We believe that excellence in service will be the nucleus for all actions and decisions. So the KPIs are a measure for our excellence in service and customer support. KPIs are based on SMART targets.
KPI is designed based on the results required and in line with the Company strategy.
We use KPIs to measure how we are doing on our strategic and financial goals.
KPIs are set up to indicate organization/department goals, set up dashboards and score cards w/ baseline metrics and monitor the performance based on key indicators.
Quantifiable indicators to measure the fit for purpose and efficiency of the organisation.
Process Oriented
Same as CTQs.
Key performance inputs.
KPI - key measure that are critical to evaluate the performance of a product/process.

Table 9. Definitions of KPI from large-scale survey

In case of Six Sigma, financial benefits or bottom-line result is the most common performance metric (Goh, 2002). So, in the conceptual framework instead of key performance indicator, bottom-line result is included as the main outcome.

4.4. Set of Tools and Techniques (STTs)

In general Six Sigma projects utilize a number of tools and techniques in different phases of DMAIC methodology. The service organizations utilize specifically lesser number of tools and techniques compared to manufacturing (Antony et al., 2007). Our study observed that generally organizations mention a number of tools and techniques applicable in Six Sigma implementation but closer analysis showed that actually the number is quite small. We also found that organizations which have limited success and progress with Six Sigma so far use more number of tools and techniques in comparison to those service organizations which have moderate progress and success. Based on our findings we provide a set of tools and techniques which can act as a guide and provide better advice to those attempting to implement Six Sigma in service organizations. Table 10 provides STTs applicable to specific DMAIC phases for Six Sigma implementation in service organizations.

4.5. Difficulties or barriers in Six Sigma implementation

We also observed that literatures were mainly talking about difficulties or obstacles in Six Sigma implementation in service organizations. The reasons cited such as the inherent differences between services and manufacturing, or differences in application of tools and techniques (Antony et al., 2007; Hensley and Dobie, 2005; Antony, 2004b; Benedetto, 2003).

Define	Project charter, Brainstorming, Flowchart, Process map, Project management
Measure	Cause and effect diagram, Pareto analysis, Brainstorming, Check sheet, Histogram, Normal probability plot, Flowchart, Matrix diagram, Work flow diagram, Project Management, Process capability analysis
Analyse	Cause and effect diagram, Pareto analysis, Brainstorming, Histogram, Normal probability plot, Flowchart, Matrix diagram, Work flow diagram, Project management, Analysis of variance, Root cause analysis, Process capability analysis, Descriptive statistics
Improve	Brainstorming, Flowchart, Check sheet, Decision matrix, Project management
Control	Control chart, Project management

Table 10. STTs for service organizations

There are also views that Six Sigma will not work for every service processes, and adjustments may be required for it to suit even for those processes for which it does apply (Biolos, 2002). Like much of the literature in this area these obstacles discussed are descriptive and does not involve empirical studies for support. Building-up on this gap and based on our data collection we identified difficulties faced by service organizations during Six Sigma implementation and included them in our framework. These obstacles goes beyond the inherent differences between service and manufacturing, are practical problems faced by the organizations which may or may not be specific to a certain service organization.

One is between CSFs and Six Sigma implementation. This barrier includes lack of support from team members, resistance to change, long-term sustaining of Six Sigma, attaching incentives to successful Six Sigma projects, staff turnover, and lack of support from employees not involved in Six Sigma project. The second barrier is between measurable process characteristics and the methodology. This includes difficulty in identifying process parameters, difficulty in collecting data, and time consuming effort in collecting data. The third barrier is between STTs and the methodology. This barrier includes difficulty in identifying proper STTs, some tools and techniques are too complex to use and requires more time to learn.

4.6. Summary

The framework developed on the basis of grounded theory methodology, is an attempt to understand the aspects of Six Sigma implementation and performance in service organizations. The study contributes to Six Sigma knowledge through development of theory and building a prescriptive model to advice both managers and scholars attempting to implement or study Six Sigma in service organizations. The framework provides a set of CSFs, measurable process characteristics, and tools and techniques which will act as a guide and also overcome the difficulties or barriers in Six Sigma implementation in service

organizations. The strength of our study is coming out of the service versus manufacturing differences paradigm and highlight the practical difficulties faced by service organizations in Six Sigma implementation.

5. Conclusion

Using qualitative analysis technique, we are able to find empirical support for critical success factors, measurable process parameters, tools and techniques, bottom line result and difficulties in Six Sigma implementation in service organizations. There exist different configurations of Six Sigma implementation for discriminating between high and low performance depending on the significance attributes to performance dimensions. This is in line with the systems approach to fit that upholds the criticality of the internal consistency of each design and match between the structural patterns of practices to the contingencies facing the organization. We are able to show which are the CSFs required for Six Sigma implementation at project level and how these CSFs can help in overcoming barriers observed at different phases of Six Sigma projects in service organizations. The research also highlights a set of tools and techniques used in Six Sigma projects and also explain the selection criteria for these STTs. One of the important developments is related to the interpretation of the term KPI related to Six Sigma at project level. KPI is better understood as key process input or output variables at Six Sigma project level and key performance indicator at strategic level in an organization. Last but not the least, understanding of the practical problems faced by service organizations during Six Sigma projects is a major contribution of our research since we feel this was one of the important missing links in existing literature.

5.1. Contribution to research process

We hope that this study encourages investigation of Six Sigma implementation in service organizations and promote rigorous development and explicit articulation of theories. It is necessary to increase theory development related to Six Sigma implementation that is grounded on relevant established theories and empirical evidence from related disciplines. So that empirical investigations of related phenomenon can be integrated into the building and modification of useful and interesting theories.

This study demonstrates the value of methodological triangulation in the development of framework and theory of Six Sigma implementation in service organizations using literature review, surveys, and case-based research. The use of different methods of investigation provides complimentary assessment of the same issues and brings out salient details that cannot be obtained by a single method of analysis.

The case-based research draws attention to the existence of contingencies and the need to further investigate the ambiguous role of contextual factors in affecting Six Sigma implementation in service organizations. Studies by Nonthaleerak and Hendry (2008); Schroeder et al. (2008); Antony (2004) prescribes that Six Sigma can be implemented in

service organizations, our study suggests that the implementation and impact of Six Sigma can be affected by contextual factors such as service types.

In summary, this research contributes to theory-grounded empirical research. This is a worthwhile endeavour because contributions to valid and reliable measurements and explicit theory development help lay a foundation for future Six Sigma implementation studies. By identifying and testing theories we encourage the development of a stream of cumulative research.

5.2. Contribution to practice

This study offers conceptual clarity and specificity on Six Sigma implementation in service organizations, managers can use a guideline for choosing the fundamental practices that they can implement. We provide conceptual and empirical evidence on CSFs, measurable process characteristics, STTs, and difficulties faced by service organizations, encouraging managers to plan and implement Six Sigma with a systematic view of service environment. Furthermore, there is empirical evidence of the importance of committed and involved leadership in the implementation of Six Sigma in service organizations. We also find that a general emphasis on company-wide Six Sigma projects is significant in differentiating high and low performance.

5.3. Final discussion and future directions

The study has shown that there is a relationship between successful Six Sigma implementation and financial performance. The study also reveals that there are common features of the implementation of process of Six Sigma in service organization context. However there are still several areas that require further investigation related to these findings.

5.3.1. Six sigma implementation and success, progress, and service types

Six Sigma and organizational success, progress can be further studied based on the specific service types. The studies can involve the organizations included in the investigation, in order to study whether the advantageous financial performance of Six Sigma projects also holds in a longer perspective. Advantageous financial performance might be considered a major encouragement for commitment and motivation among employees and management. Since their commitment and involvement is vital areas for sustaining Six Sigma, see Goh (2002), maintained advantageous financial performance is vital for the future progress of Six Sigma. Furthermore one could include other organizations from individual service types, which have won quality awards or reached a certain level in the assessment, in order to enlarge the empirical foundation and further outline how different levels of Six Sigma implementation affect financial performance.

Additionally, an investigation aiming at exploring major Six Sigma achievements, e.g. increased customer satisfaction, reduction in cycle time or waiting time, among

organizations that successfully implemented Six Sigma and studying their link to financial figures, could further explore the relationship between Six Sigma and success and progress. Also, a study of the major areas of costs when implementing Six Sigma compared with possible gain, and put in a relation to financial benefits after implementation, will possibly add supplementary information important for facilitating the understanding of the relationship between Six Sigma and its success and progress.

Furthermore, investigations based on individual service types and the effect on success and progress would further complement the findings presented within the framework of this thesis.

5.3.2. Six sigma implementation and service organizations

When considering the process of Six Sigma implementation in service organizations, several interesting opportunities could be mentioned for expanding the findings of the study. One appealing approach would be to do a longitudinal study in one or several service organizations that intend to start Six Sigma implementation in order to follow the implementation process in a more detailed manner and without being forced to totally rely on historical and personal information. A major problem with such a study might be that the outcome of the implementation efforts is not necessarily successful, i.e. the researcher will not know at the beginning that the study will investigate a successful Six Sigma implementation. If the studied organization(s) do not succeed in implementing, the findings may outline problems and reasons although not as reliable implications for successful implementation as the findings could have resulted otherwise.

Several core values of Six Sigma focus to a large extent on intangible factors related to e.g. support of team members, education and training, and top management issues. At the same time many of the concrete components, e.g. process parameters, tools and techniques, are more focused on tangible factors, of which some tools and techniques are statistical in nature and are not readily acceptable in service organizations. By making studies, with an increased focus on how service organizations which have implemented Six Sigma, address and develop intangible factors, and linking the findings to a further developed version of the implementation framework presented in chapter 7, an implementation framework even more adapted to service organizations could be created.

On the other hand, although the service organizations studied have implemented Six Sigma using CTQs, and STTs, with a focus on intangible factors, it is also very important to help service organizations to introduce and use different statistical tools and techniques to support and facilitate the handling and control of variation in process parameters in different ways. An interesting area is therefore, how to support service organizations' use of statistical tools and techniques. An approach might be to focus on a specific branch or sector in the service organization context. This will help to build a more specific background of the service organizations' characteristics within the chosen frame. By making such a study the specific characteristics of the included service organizations could be more accurately put in

relation to their implementation process. Consequently, an increased consideration of contextual issues might be obtained.

Finally, the data collected for this study used the key informant approach (Bonner et al., 2002; Kumar et al., 1993). Therefore, all conclusions should be interpreted with this possible bias in mind. In addition although the reviewers in the pre-test did not find the survey questionnaires difficult to do, it was found that some of the questions are difficult to understand by some of the respondents. It was likely that the respondents who answered the surveys were more interested in Six Sigma than the non-respondents. Future studies with multiple respondents are recommended in which respondents come from different seniority and functional areas.

5.4. Concluding remarks

Six Sigma as a quality management practice is gaining importance in service organizations. Literature review shows that Six Sigma is mainly implemented in healthcare and banking service organizations. There is limited literature exploring Six Sigma implementation in service organizations and lacks rigorous empirical approach. Our study findings suggest Six Sigma implementation in different service organizations such as information technology, transportation, utilities, etc. Further most of these organizations are in moderate success and moderate progress category regarding Six Sigma implementation. On the basis of service types, it is found that most of the organizations are mass services.

Exploration of Six Sigma aspects in service organizations showed the importance of top management commitment and involvement along with some other CSFs. It is also observed that CSFs, CTQs, and STTs are to a certain extent depends on service types. There is some variation in CSFs, CTQs, and STTs across service types. The use of tools and techniques showed that successful organizations use limited number of tools in comparison to less successful organizations. One of the most significant finding is about KPI. The terms interpretation is best understood from strategic viewpoint. From the perspective of Six Sigma KPI is similar to CTQ and can be interpreted as process parameter. Another finding is about the difficulties faced in Six Sigma implementation by service organizations, which shows rather than the difficulty of data collection; part-time involvement, extension of project timeline, and staff turnover during projects or after training are the major difficulties. Unknown to us as a reason for not implementing Six Sigma prompts us to further understand the unique nature of service organizations and provide a customized approach to Six Sigma implementation in service organizations.

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