THE CRITICAL SUCCESS FACTORS FOR SIX SIGMA IMPLEMENTATION

by

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ABSTRAK

Six Sigma telah berkembang meluas merata dunia, dalam aspek performasi, kualiti, pengurangan kos dan kepuasan pelanggan. Kebanyakan syarikat melaksanakan Six Sigma bagi mempunyai kelebihan kemenangan terhadap yang lain. Industri elektronik merupakan perintis dalam pelaksanaan and pengsijilan Six Sigma, maka, industri elektronik menrupakan singkatan kajian. Kajian ini merangkumi syarikat elektronik Malaysia yang mempunyai pengsijilan kualiti ISO sebagai sampel. Populasi kajian ini adalah daripada semua syarikat elektronik yang beroperasi di Malaysia yang telah berdaftar di bawah Direktori Antarabangsa Sirim QAS bagi pengsijilan produk and syarikat 2004. Kajian ini mengkaji faktor-faktor kritikal kejayaan Six Sigma yang memberikan keputusan tanggapan kejayaan Six Sigma kepada organisasi. Sampel mudah 200 syarikat elektronik dipilih daripada Direktori Antarabangsa Sirim QAS. 60 syarikat merupakan maklumbalas, yang memberi 30% sampel. Keputusan yang diperolehi adalah faktor-faktor kritikal memberi impak positif terhadap tanggapan kejayaan Six Sigma. Kajian ini menggunakan soal selidik sebagai instrumentasi utama dan dengan penggunaan perisian SPSS untuk menganalisis data yang diperolehi dan hipotesis berkaitan. Keputusan memberi kaitan positif di antara faktor-faktor kejayaan kritikal dengan tanggapan kejayaan Six Sigma perlaksanaannya di syarikat – syarikat Malaysia. Dengan ini, keputusan analisis akhir menunjukkan bahawa tanggapan kejayaan Six Sigma bergantung kepada faktor-faktor kejayaan kritikal semasa perlaksanaan.

ABSTRACT

Six Sigma has grown quickly throughout the world, in terms of companies' performance, quality, cost reduction and customer satisfaction. Most companies implement Six Sigma just to have a wining edge among others. As electronic industries pioneered the implementation and certification of Six Sigma, the study is narrowed to these industries. This study relates to Malaysian electronics companies with ISO quality certification as survey sample. The population of this study comprises of all the electronics companies operating in Malaysia that is registered under Sirim QAS International Directory of certified Products and Companies 2004. The research examined the critical success factors of Six Sigma which gives perceived Six Sigma success to the organizations. Out of the many companies in the Sirim QAS International Directory a simple sampel of 200 electronics companies chosen. The response was 60 companies, which gives a 30% of the sample. Results revealed that the critical success factors impact positively to perceive Six Sigma success. This research used questionnaire as the main research instrument with the help of SPSS software to analyze the obtained data and to test the related hypothesis. Finding revealed that there is a positive relationship between critical success factors with the perceive Six Sigma success implementation in the Malaysian companies. With this the final analysis resulted that the perceived Six Sigma success are dependent on the critical success factors of implementation.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Industries around the world need to continue to improve the quality of its products and services if it is to continue to compete effectively in both domestic and world markets. Statistical methods are an important tool in the quality improvement activities because they provide both descriptive and analytical methods for dealing with the variability in observed data. One of the most widely used tool is the Six Sigma method. Six Sigma has been around for decades many of them neglected it due to the difficulty and its discipline. Furthermore the use of computers have made these application possible where the outputs can be made to be very presentable. Industries often use this Six Sigma tool in various areas from improving the lead time, quality and management.

Today's leaders from the industries fond of Six Sigma simply because it has generated bottom-line results for all kinds of organizations in hundreds of cases. As the inventor of Six Sigma, Motorola has used Six Sigma methodology in product design, manufacturing, and services in every business unit where in one particular case Motorola have brought down manufacturing time for a product from 40 days to less than 1 hour. Six Sigma also drives strategy execution where in today's demanding business environment; organizations need reliable management systems capable of aligning strategy and delivering breakthrough results. In addition Six Sigma generates flexible and robust business processes. It can be applied to tackle a specific problem in a single department or to renew the entire business. Six Sigma provides companies with a common vehicle and language to frame business goals, focus

organizational energy and drive results. Its implementation involves building human capability with common approaches and tools to address business process issues. Industries found Six Sigma as a low risk investment the financial returns that far outweigh the investments required (Pande et al, 2000). That is why a lot more companies have followed the footsteps of Motorola, for example Pentagon, Nasa, Sony, 3M, Citicorp, General Electric, Texas Instruments, Intel, Seagate, Xerox and Hewlett Packard.

1.2 Why Six Sigma?

Six Sigma is a rigorous, focused and highly effective implementation of proven quality principles and techniques. Incorporating elements from the work of many quality pioneers, Six Sigma aims for virtually error free business performance. Sigma, s, is a letter in the Greek alphabet used by statisticians to measure the variability in any process. A company's performance is measured by the sigma level of their business processes. Traditionally companies accepted three or four sigma performance levels as the norm, despite the fact that these processes created between 6,200 and 67,000 problems per million opportunities.

The Six Sigma standard of 3.4 problems per million opportunities is a response to the increasing expectations of customers and the increased complexity of modern products and processes. A higher sigma quality level value is better. A Six Sigma quality level is said to equate to a 3.4 parts per million outside specification limits. Most organizations today operate between two and three sigma, however in U.S. the manufacturing firms frequently attain four sigma quality levels, whereas service firms often operate at quality levels of one or two sigma (Montgomery & Runger, 1999).

For Motorola, the originator of Six Sigma, the answer to the question "Why Six Sigma?" was simple which is survival. Motorola came to Six Sigma because it was being

consistently beaten in the competitive marketplace by foreign firms that were able to produce higher quality products at a lower cost. Today, Motorola is known worldwide as a quality leader and a profit leader. After Motorola won the Malcolm Baldrige National Quality Award in 1988 the secret of their success became public knowledge and the Six Sigma revolution was on. Initially, the concept of implementation of Six Sigma methodology at Motorola is to reduce quality costs, i.e. costs of not doing things right first time, costs of not meeting customer requirements, etc.

After Motorola other companies such as Texas Instruments, Kodak, General Electric, Sony and etc. have claimed great savings as a result of the implementation of Six Sigma projects. However, Six Sigma stresses the application of statistical and problem-solving tools and techniques in a methodical and systematic fashion to gain knowledge that leads to breakthrough improvements with dramatic impact on the bottom-line results. While the original goal of Six Sigma was to focus on manufacturing process, today, marketing, purchasing, billing and invoicing functions are also embarked on Six Sigma strategies with the aim of continuously reducing defects throughout the organization's processes (Dale, 2000).

1.3 Research Background

It would be a mistake to think that Six Sigma is about quality in the traditional sense. Quality, defined traditionally as conformance to internal requirements, has little to do with Six Sigma. Six Sigma is about helping the organization make more money. To link this objective of Six Sigma with quality requires a new definition of quality. For Six Sigma purposes the study define quality as the value added by a productive endeavor. Quality comes in two flavors: *potential quality* and *actual quality*. Potential quality is the known

maximum possible value added per unit of input. Actual quality is the current value added per unit of input. The difference between potential and actual quality is *waste*.

Six Sigma focuses on improving quality (i.e., reduce waste) by helping organizations produce products and services better, faster and cheaper. In more traditional terms, Six Sigma focuses on defect prevention, cycle time reduction, and cost savings. Unlike mindless cost-cutting programs, which reduce value and quality, Six Sigma identifies and eliminates costs which provide no value to customers, waste costs. For the effective introduction, development and implementation of a Six Sigma program in any organization, one should consider the factors which will drive the application of Six Sigma principles successful. This study therefore interested to study what are the factors that drive the application of Six Sigma principles successful.

1.4 Research Problem

However, there are several factors that are essential to the success of the implementation of Six Sigma. The identification of such factors will encourage their consideration when companies are developing an appropriate implementation plan (Mann & Kehoe, 1995). For example, Henderson and Evans (2000) have identified the key components of successful Six Sigma implementation, such as upper management support, organizational infrastructure, training, application of statistical tools and link to human resources-based actions (e.g. bonuses, promotions, etc.). Even though many authors have advocated the success factors at various places of the literature, very little attempt has been made to validate them by empirical research especially in the context of Malaysia.

The research question for this study is "what are the critical success factors for Six Sigma successes in the organizations in Malaysia?". The objective of this study is to

identify the most critical factors for the implementation of Six Sigma programs that will lead to success in Malaysian companies. The study will also make an attempt to understand the availability of common tools and techniques of Six Sigma implementations within Malaysian companies.

1.5 Research Objective

This study is to see if perceived Six Sigma success in the Malaysian companies is driven by combination of critical success factors, specifically single objective of the study are to:-

1. Identify and investigate the relationship of the critical success factors for Six Sigma success in the Malaysian companies.

1.6 Research Question

Six Sigma is referred to formal corporate management system that is responsible for the management, organization and improvement of environmental performance within the firm. This study therefore was mainly motivated by the quest to answer the following question:-

1. What are the critical success factors for Six Sigma success in the Malaysian companies and their relationship upon the perceived Six Sigma success?

1.7 Significance of Study

Great interest in the business community especially in electronic industries on Six Sigma implementation. In away, business communities review Six Sigma certification as a prerequisite for business continutivity and commerce. Clearly, this demand comes from our international and globalization effort to make markets more efficient and ease to command.

In addition to this, most of the electronics industries have experimented Six Sigma implementation and have shown major improvement in yield and cost reduction. Due to this, in recently years this practice has a major trend towards a widespread adoption and interest in Six Sigma. Six Sigma practice became a wining edge against comparative and competitive business. Thus, Six Sigma certification towards firms' performance and customer satisfaction becomes very important. Nevertheless there has been very little systematic research and studies on the critical success factors of Six Sigma especially on firms operating in Malaysia.

The outcome implications are the benefits prevailed from these critical success factors of Six Sigma to the firms. These benefits includes customer satisfaction, cost reduction, transformation of quality embracement culture and establishing an efficient organization. Lastly the outcome or the findings of this study is to understand how well implemented critical success factors contribute to the total success of Six Sigma.

1.8 Definition of Terms

In order to clarify the objective of this study, several key terms are defined as follows;

Six Sigma

Six Sigma is a management philosophy developed by Motorola that emphasizes setting extremely high objectives, collecting data, and analyzing results to a fine degree as a way to reduce defects in products and services. The Greek letter *sigma* is sometimes used to denote variation from a standard. The philosophy behind Six Sigma is that if you measure how many defects are in a process, you can figure out how to systematically eliminate them and get as close to perfection as possible. In order for a company to achieve Six Sigma, it cannot

produce more than 3.4 defects per million opportunities, where an opportunity is defined as a chance for nonconformance (George, 2003).

Management involvement and commitment

It is a rational social phenomenon based on planning, organizing, directing, coordinating, staffing, and control principles. Aiming to facilitate individuals and people to establish their organizations and projects for accomplishing their objectives and the organization's purposes efficiently and effectively, it could be a process or a system or a behavior. It can be applied to people, things, ideas, and on any activity or function (Harry & Schroeder, 2000).

Cultural change

Culture refers to norms of behavior and shared values among a group of people. Culture involves at least three components: what people think, what they do, and the material products they produce. Thus, mental processes, beliefs, knowledge, and values are parts of culture. Some anthropologists would define culture entirely as mental rules guiding behavior, although often wide divergence exists between the acknowledged rules for correct behavior and what people actually do (Harry & Schroeder, 2000).

Organization infrastructure

An infrastructure is a large-scale technological system, consisting of immovable physical facilities and delivering (an) essential public or private service(s) through the storage, conversion and/or transportation of certain commodities. The infrastructure includes those parts and subsystems necessary for fulfilling the primary storage, transportation and/or

conversion function(s) as well as those supporting a proper execution of the primary function(s) (George, 2003).

Training

Training means the process of providing for and making available to an employee, and placing or enrolling the employee in, a planned, prepared, and coordinated program, course, curriculum, subject, system, or routine of instruction or education, in scientific, professional, technical, mechanical, trade, clerical, fiscal, administrative, or other fields which will improve individual and organizational performance and assist in achieving the agency's mission and performance goals (Montgomery & Runger, 1999).

Project management skills

Project management is a methodical approach to planning and guiding project processes from start to finish. According to the Project Management Institute, the processes are guided through five stages: initiation, planning, executing, controlling, and closing. Project management can be applied to almost any type of project and is widely used to control the complex processes of software development projects (Lynne & Hare, 2006).

Project prioritization and selection, reviews and tracking Activities

Evaluating and selecting tools for prioritizing projects that is to improve selection decisions which associates working on the projects are invited to provide expertise and insight from the property (Yang, 2005).

Understanding the Six Sigma methodology, tools and techniques

The Six Sigma problem-solving methodology and tool set are known as DMAIC: Define, Measure, Analyze, Improve, and Control (Koning & Mast, 2005).

Linking Six Sigma to business strategy

Developing a strategy which is critical for any organization and equally important is having a mechanism to translate that strategy into action. In short, the challenge is to find a mechanism that engages and commits to action while allowing flexibility for local differences when justified. Act of aligning operations and improvements with business goals and objectives.

Linking Six Sigma to the customer

A person who receives the product or service of a process. One who buys or rates our process/product (In terms of requirements), and gives the final verdict on the same. This in turn acts as a hidden feedback which can be implemented leading to improvement to all the parameters of the Process Management.

Linking Six Sigma to human resources

Human resources are the people of an organization focused on the learning and growth perspective, essentially a cost center with an internal focus**.**

Linking Six Sigma to suppliers

Companies can define their objectives by sharing with their partners, achieve those objectives in real time, regardless of whether their partners. Companies can improve communication and collaboration with strategic trading partners, and eliminate costly manufacturing delays

caused by incomplete, missing, or old product information. All decisions will be made faster, and based on the most current information that everyone can work from simultaneously

1.9 Scope of the Study

This study builds on existing studies of Six Sigma in electrical and electronics companies. It analyses the Six Sigma success that perceived by electrical and electronics companies. The electrical and electronics industries are essential elements of many countries economies. They have played a significant role in the industrial development of all the newly industrialized economies (NIEs) of Asia. In the case of Malaysia, their contribution to the economy, has been, and still is, very substantial. Indeed, the electrical and electronics industries are the prime movers of quality management drive towards achieving quality improvement.

This study is designed to examine eleven critical factors for Six Sigma. Initially, the list of critical factors is selected from those described by quality practitioners as important to a quality improvement strategy and this study is interested to examine on how these factors influence the service quality. At the very least these critical factors give some idea about what should be examined about the relationship of these factors with the Six Sigma success especially in the electrical and electronics companies in Malaysia.

1.10 Organization of the study

There are five chapters in this research. Chapter 1 is the introduction, which contains research background, research problem, research objectives and research question. The research problem is to address the importance of conducting this research. Chapter 2, discusses on the literature review of all variables. This chapter highlighted previous research and findings by various researchers. This chapter is important to indicate that every variables

are supported by previous study, it is also to strengthen the research that will be carried out. Chapter 3 is to elaborate on how the study will be conducted, it is about the methodology of the research. This chapter will illustrate on population, sample, design, instrument and statistical analysis that will be used. This research will present chapter 4 that is the analysis of the result. Chapter 5 will be the final chapter, present on discussion, conclusion and implications of the research. It will also propose on future research to be conducted.

CHAPTER 2

LITERATURE REVIEW

1.1 Introduction

Six Sigma is a powerful breakthrough improvement business strategy that enables companies to use simple and powerful statistical methods to define measure, analyze, improve and control processes for achieving and sustaining operational excellence. Six Sigma was originally developed by Motorola in the 1980's and has since been implemented by a number of world class organizations such as GE, Honeywell, ABB, Sony, Texas Instruments, Ford, Johnson Control Systems, etc. with the purpose of reducing variability in processes, reducing quality costs, improving process capability and enhancing process throughput yield. For the effective introduction, development and implementation of a Six Sigma program in any organization, one should consider the factors which will drive the application of Six Sigma principles successful. This chapter therefore discusses the literature review on Six Sigma.

2.2 Infrastructure for Six Sigma

A very powerful feature of Six Sigma is the creation of an infrastructure to assure that performance improvement activities have the necessary resources. There are previous study has shown that failure to provide this infrastructure is the number 1 reason why 80% of all TQM implementations failed in the past. Six Sigma makes improvement and change the full-time job of a small but critical percentage of the organization's personnel. These full time change agents are the catalyst that institutionalizes change. The key to Six Sigma improvement success is the building up of an effective infrastructure. An effective

infrastructure lays the foundation for the success of the organization in its implementation of Six Sigma. It is a known fact today that the success of Six Sigma lays on the projects selected and their link to the strategy of their organization.

There have been enough publications on the selection of projects and the filters to be used for the prioritization of projects, however there are not enough details available on the building the key infrastructure for the deployment of Six Sigma. Six Sigma involves changing major business value streams that cut across organizational barriers. It is the means by which the organization's strategic goals are to be achieved. This effort cannot be lead by anyone other than the CEO, who is responsible for the performance of the organization as a whole.

Six Sigma, however, has different interpretations and definitions for different people. It is a formal and disciplined methodology for defining, measuring, analyzing, improving and controlling processes. The fundamental idea behind the Six Sigma philosophy is to continuously reduce variation in processes and aim at the elimination of defects or failures from every product, service and transactional process (Hoerl, 1998). Six Sigma can be defined in both statistical and business terms. In business terms, Six Sigma is a business improvement strategy used to improve profitability, to drive out waste, to reduce quality costs and improve the effectiveness and efficiency of all operations that meet or even exceed customers' needs and expectations (Antony & Banuelas, 2001). In statistical terms, Six Sigma is a term that refers to 3.4 defects per million opportunities (DPMO), where sigma is a term used to represent the variation about the process average.

One key to the success of the Six Sigma program is the step-by-step approach or road map using define, measure, analyze, improve and control (DMAIC) methodology. The definition phase entails the definition of the problem and the definition of critical quality

characteristics which are most important to customers. In the measure phase, select the most appropriate output quality characteristics to be improved and establish what is unacceptable performance or a defect for such characteristics. Once this is done, gather preliminary data to evaluate current process performance and capability. In the analysis phase, we need to analyze the root causes of defects or errors (the Xs or input variables). In the improvement phase, we need to reduce the defect rate or number of defects using simple but powerful statistical tools/ techniques. For some processes, several rounds of improvements may be required to achieve a desired process performance or capability. In the control phase, we need to sustain the improvement that has been achieved from the improvement phase.

Six Sigma accentuates financial returns to the balance sheet of an organization. It has been so successful in many organizations where performance is significantly improved beyond that which can be obtained through other means. The companies that have had success with Six Sigma say their efforts have been rewarded with significant savings from improved efficiency and quality. There are 10 myths of Six Sigma (Snee, 1999) which needs dispelling as listed below:-

1. Works only in manufacturing
2. Ignores the customer in search of bottom-line benefits
3. Creates a parallel organization
4. Is an add-on effort
5. Requires massive training
6. Requires large teams
7. Creates bureaucracy
8. Is just another quality program
9. Requires complicated, difficult statistics

10. Is not cost-effective

2.3 Factors for the Success of Six Sigma

In order to manage and optimize the process output, it is important that we identify the main factors which influence the output. The factors of Six Sigma play an identical role of input variables to any process. This section briefly reveals the factors that are necessary for the effective implementation of Six Sigma program. The first step was to carry out an exploratory study on the topic as similar studies were performed by authors such as Pande et al. (2000) and Henderson and Evans (2000). Moreover, it is also important to learn the importance of these success factors in a ranking or prioritized order, particularly in the Malaysian companies. The relative weightings of critical success factors (CSFs) would assist people to understand what factors are essential for making Six Sigma process successful and what factors are not important to the success. It would also assist people in organizations to gain a better understanding of the process of Six Sigma implementation. The following CSFs are identified from the literature.

2.3.1 Management involvement and commitment

Any successful initiative like Six Sigma requires top management involvement and provision of appropriate resources and training. The underlying principles of Six Sigma must be taught to senior managers within the organization. Jack Welch, the CEO of General Electric has strongly influenced and enabled the restructuring of the business organization and changed the attitude of the employees towards Six Sigma (Henderson and Evans, 2000). Without the continuous support and commitment from top management, the true importance

of the initiative will be in doubt and the energy behind it will be weakened (Pande et al., 2000).

Many previous quality initiatives, such as TQM, have been faced with a major difficulty, which has been a leadership attitude of ‘ Do as I say….. not as I do’. Some initiatives also faded out because the company leaders lost focus (Pande et al., 2000).

In order to overcome this problem, company leaders have to ensure that the Six Sigma initiative is a momentum for process improvement and hence it must be sustained over the long term. Good support from top management is imperative in the restructuring of the organization and achieving the cultural change and motivation of employees towards quality and the Six Sigma strategy to the business. The leaders have to be strong advocates of Six Sigma. Eagerness and enthusiasm shown by the leaders can go a long way in getting the rest of the employees on board.

2.3.2 Cultural change

A successful introduction and implementation of Six Sigma requires adjustments to the culture of the organization and a change in the attitudes of its employees. Employees have to be motivated and accept responsibility for the quality of their own work. It is worthwhile to note that when Six Sigma was initially rolled out at General Electric employees were at first very uneasy at the thought of having to learn statistics. This was due to the misconception that Six Sigma is essentially a statistical toolset. Today Six Sigma within General Electric is the way employees do their job in everyday life and it is nothing more than the mindset of people with the ultimate goal of "doing things right first time". The success of an organization in both the local and overseas markets depends heavily on the culture of that particular organization (Sohal, 1998). Six Sigma initiatives require the right mindset

and attitude of people working within the organization at all levels. The people within the organization must be made known and be aware of the need for change. Companies that have been successful in managing change have identified that the best way to tackle resistance to change is through increased and sustained communication, motivation and education (Henderson & Evans, 2000).

With a true cultural revolution in an organization come two basic fears on an individual level: fear of change and fear of not achieving the new standards. To overcome fear of change in any industrial environment, the people involved must understand the need for change. It would be ideal to create a communication plan that would address why Six Sigma is important, and how the methodology of Six Sigma works in organizations (Hendricks & Kelbaugh, 1998). It is also essential to restructure the organization to drive the culture change and make Six Sigma a part of everyday life. After implementation of Six Sigma projects, it is best to publish results, but these should not be restricted to just success stories but also admit and communicate stumbling blocks. This will help other projects in the pipeline to avoid the same mistakes and learn from mistakes.

2.3.3 Organization infrastructure

In addition to top-management, there also needs to be an effective organizational infrastructure in place to support the Six Sigma introduction and development program within any organization. The employees in an organization practicing Six Sigma are generally highly trained, have undergone rigorous statistical training, and lead teams in identifying, executing and managing Six Sigma projects. In many multinational corporations, Six Sigma initiatives are led by the CEO or vice-president, who is considered as the Six Sigma champion. This will be followed by the formation of master black belts, black belts, green

belts and other team members who are individuals who support specific projects in their area (Harry & Schroeder, 2000). Apart from the belt system, Six Sigma program also requires project sponsors (or champions in some organizations) who provide guidance to the project team and find and negotiate resources and budget for the project. The timing and readiness of the organization is also important. This is because Six Sigma effort requires a great deal of resources such as staff commitment, top management commitment, time, energy and costs, etc.

2.3.4 Training

It is critical to "communicate both the 'why' and the 'how' of Six Sigma as early as possible, and provide the opportunity to people to improve their comfort level through training classes" (Hendricks & Kelbaugh, 1998) before unleashing the employees into the world of Six Sigma. There is usually a hierarchy of expertise, which is identified by the "belt system". The belt system ensures that everyone in the organization is speaking the same language. This makes the setting up and execution of Six Sigma projects much easier throughout the organization. The curriculum in the belt system varies from organization to organization and consultant to consultant; however it needs to be provided by identifying the key roles of the people directly involved in applying Six Sigma. In order to be accredited to black belt, candidates must complete an application form to demonstrate how they have met the requirements in both training and practice of Six Sigma.

As mentioned that training is a crucial factor in the successful introduction and development of Six Sigma program. It is important to communicate both the ‘why’ and ‘how’ of Six Sigma as early as possible, and provide the opportunity to people to improve their comfort level through training classes (Hendricks & Kelbaugh, 1998). There is usually

a hierarchy of expertise, which is identified by the belt system. Within GE, the belt system is fundamentally divided into (Henderson & Evans, 2000):

a. **Champions** – fully trained business leaders promoting and leading the Six Sigma deployment in significant or critical areas of the business.
b. **Master Black Belts (MBBs)** – fully trained quality leaders responsible for Six Sigma strategy, training, mentoring, deployment and results.
c. **Black Belts (BBs)** – fully trained experts leading improvement teams across the business.
d. **Green Belts (GBs)** – individuals trained in Six Sigma supporting Six Sigma projects.
e. **Team members** – individuals supporting specific projects in their areas.

2.3.5 Project management skills

As Six Sigma is a project driven methodology, it is good practice for the team members to have project management skills to meet the various deadlines or milestones during the course of the project (Antony & Banuelas, 2001). Most of the projects on Six Sigma fail due to poor project management skills, setting and keeping ground rules, determining the meeting's roles and responsibilities.

2.3.6 Project prioritization and selection, reviews and tracking

There have to be proper criteria for the selection and prioritization of projects. Poorly selected and defined projects lead to delayed results and also a great deal of frustration. Pande et al. (2000) provide three generic categories of projection selection criteria. These are:-

1. Business benefits criteria
    a. impact on meeting external customer requirement;
    b. financial impact;
    c. impact on core competencies.
2. Feasibility criteria
    a. resources required;
    b. complexity;
    c. expertise available, etc.
3. Organizational impact criteria
    a. cross-functional benefits;
    b. learning benefits, i.e. new knowledge gained about the business, customers and processes.

Project reviews must be conducted on a regularly scheduled basis to drive the projects to a successful completion and closure. Review process would enable the black belts and green belts to follow the Six Sigma methodology correctly. Six Sigma champions should use the project review process to understand what the black belts and green belts see as barriers to the progress of their projects. It is good practice to have a project tracking system to track all projects which are submitted for consideration, accepted for implementation, in progress and completed.

2.3.7 Understanding the Six Sigma methodology, tools and techniques

A healthy portion of the Six Sigma training involves learning the principles behind the Six Sigma methodology, i.e. DMAIC methodology. During the training, employees learn three groups of tools and techniques, which are divided into process improvement tools and

techniques, leadership tools and team tools. For many Six Sigma projects, generally simple statistical tools or quality tools are more than enough to tackle the problem at hand (Hoerl, 1998).

However, for greater breakthrough improvements in business processes, certain advanced statistical tools and techniques (such as design of experiments, statistical process control, regression analysis, analysis of variance, etc.) are needed. In addition, there has to be a clear set of metrics that are used to measure process performance against customer requirements. Examples of metrics include defect rate, cost of poor quality, throughput yield, rolled throughput yield, etc. Accurate data are also required for analyzing potential root causes and support the team's decisions (Harry & Schroeder, 2000).

2.3.8 Linking Six Sigma to business strategy

Six Sigma cannot be treated as yet another stand-alone activity. It requires adherence to a whole philosophy rather than just the usage of a few tools and techniques of quality improvement (Dale, 2000). It needs to be clear how Six Sigma projects and other activities link to customers, core processes and competitiveness (Pande et al., 2000). Since the goal of every organization is to make profits, Six Sigma projects make business processes profitable while attacking variability which leads to high scrap rate, high rework rate, low productivity, etc. In every single project, the link between the project objectives and the business strategy should be identified.

2.3.9 Linking Six Sigma to the customer

A key element of the success of Six Sigma program is its ability to link to the customers. Projects should begin with the determination of customer requirements (Harry & Schroeder,

2000). However Pande et al. (2000) argue that before customer needs can be met successfully, there has to be a good understanding of the organization and its linkage to various business activities. The process of linking Six Sigma to the customer can therefore be divided into two main steps:-

1. Identifying the core processes, defining the key outputs of these processes and defining the key customers that they serve.
2. Identifying and defining the customer needs and requirements.

An important issue here is the selection of critical-to-quality characteristics (CTQs). These CTQs must be identified quantitatively in the starting phase of the Six Sigma methodology. Quality function deployment is a powerful technique to understand the needs and expectations of customers and translate them into design or engineering requirements. In service industry, the customer requirements are often ambiguous, subjective and poorly defined.

2.3.10 Linking Six Sigma to human resources

Human resources-based actions need to be put into effect to promote desired behavior and results. Some studies show that 61 per cent of the top performing companies link their rewards to their business strategies, while lower performing companies create minimal linkage (Harry & Schroeder, 2000).

2.3.11 Linking Six Sigma to suppliers

Many organizations that implement Six Sigma find it beneficial to extend the application of Six Sigma principles to management of their supply chain. The concept that "everybody

plays" created special challenges for General Electric Appliances (GEA). You cannot be a Six Sigma company without your suppliers participating in the culture change (Hendricks & Kelbaugh, 1998). The key element of successful integration of suppliers into Six Sigma is obtaining support up front from the highest levels of management in the supplier firm. Under Six Sigma philosophy, one way to reduce variability is to have few suppliers with high Sigma performance capability levels (Pande et al., 2000).

2.4 Research Framework

Although there are many factors related to critical success factors for Six Sigma, only eleven variables were selected; there are management involvement and commitment, project prioritization and selection, reviews and tracking, understanding the Six Sigma methodology, tools and techniques, linking Six Sigma to business strategy, linking Six Sigma to suppliers, training, company infrastructure, project management skills, linking Six Sigma to human resources and linking Six Sigma to customers as independent variables. These independent variables will be examined on the relationship with Perceived Six Sigma success as dependent variable. Refer to Figure 2.1 for the framework developed in this study.

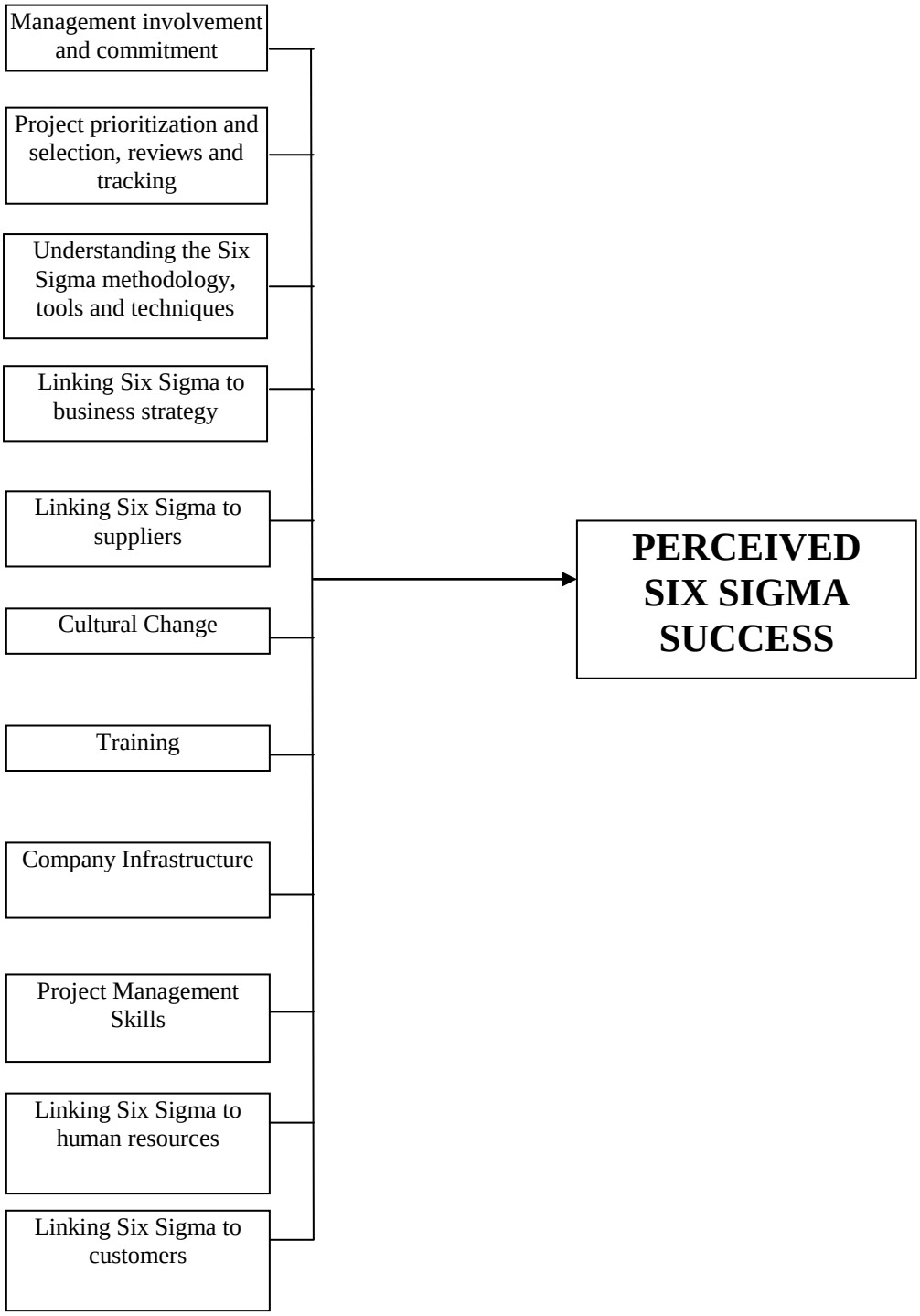

***Figure 2.1*: Theoretical Framework**