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Analysis of Critical Success Factors of Six Sigma in Pakistani Small and Medium-Sized Enterprises

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Abstract**—**Six Sigma is a widely adapted quality improvement methodology applied throughout the world. Through this paper, an attempt has been made to identify Critical Success Factors (CSF) for successful implementation of Six Sigma in Pakistani Small and Medium-sized Enterprises (SMEs). A survey methodology was used to collect the data from SMEs in Pakistan. The results of this exploratory empirical research reflect the importance of different CSFs of Six Sigma implementation in SMEs in Pakistan. On the basis of extracted factors, a framework has been proposed for successful Six Sigma implementation in Pakistani SMEs. This study will provide a base for Pakistani SMEs and future researchers working in Six Sigma implementation and help them to prepare a road map to eradicate the hurdles in Six Sigma implementation.

Keywords**—**Critical success factors, small and medium-sized enterprises, Six Sigma, Pakistan.

I. Introduction

SIX Sigma as quality improvement framework has gained considerable attention in recent years. It was first initiated by Motorola by aiming at variably reduction, productivity maximization and quality improvement which ultimately lead Motorola to win the first Malcolm Baldrige National Quality Award in 1988 [1]. Within five years of its initiation Motorola achieved 3.4 parts per million defect rate [2]. Six Sigma is a well-established approach that seeks to identify and eliminate defects, mistakes or failures in business processes or systems by focusing on those process performance characteristics that are of critical importance to customers [3]. It focuses on identifying and eliminating "defects" in processes and has produced hundreds of millions of dollars in new profitability in a wide variety of industries [4]. Quality mature organization indicates Six Sigma as performance improvement tool. In short 'Six Sigma' is a statistical basis of measurement (3.4 DPMO), a philosophy and a goal: as perfect as practically possible, a methodology, a symbol of quality, a vision, a metric, a management philosophy [5].

II. Framework for Six Sigma

Six Sigma implementation projects includes its phases Define, Measure, Analyze and Control (DMAIC) for process improvements and Define, Measure, Analyze, Design and Verify (DMADV) for new product or service development and design quality levels. The DMAIC approach is followed to solve the problem of reducing variations and associated high defect rate. It is process improvement cycle and effective problem solving methodology. DMAIC is the primary frame work used to guide Six Sigma projects [6].

During new product development by organizations, DMADV is used as a problem solving process. Design for Six Sigma (DFSS) emphasizes the same critical parameters for a new product like a customer, supplier and process variation. The DFSS approach begins when an organization finds and analyzes the gaps between the processes that effect new product conformity effectively. All of these approaches are used for designing product, processes and services to improve Quality of product, satisfy customer, increase effectiveness of process and better selection of suppliers [7].

A. Tools and Techniques for Six Sigma

A number of tools and techniques are highlighted by researchers for Six Sigma implementation using the DMAIC or DMDV approach. Some of them are; Supplier Input Process Output Control (SIPOC), Process Mapping, Quality Function Deployment (QFD), Failure Mood Effect Analysis (FMEA), Pareto Analysis, Process Capability Analysis, Benchmarking, Design of Experiment, Cause and Effect Analysis.

B. Six Sigma for Manufacturing and Service

Manufacturing organizations improve profitability and customer satisfaction by implementing this methodology. In manufacturing organizations, Six Sigma is used to streamline manufacturing processes and to reveal the improvements for the integrated processes [8]. It works for process improvement, process designing and process management, reducing variation in the process, for a more quality stable product related to workers, raw material, machinery, working procedures and the environment, is produced. It is a disciplined technique that can be used for process variations not only covering manufacturing and but also for the service sector too [6].

C. CSFs of Six Sigma

Literature is full of case studies of Six Sigma implementation. But successful Six Sigma implementation depends on a number of factors which authors refer to as CSFs. The bases of intense literature review, 16 CSFs of Six Sigma, Upper Management Leadership and commitment, Education and continuous training of employees,

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Organizational infrastructure and resources, Effective communication and information flow, Understanding Six Sigma tools and methodology, Continual evaluation and motivation of the workforce, Linking Six Sigma to the market and customer needs, Formation of cross functional teams and knowledge sharing, Supplier capability enhancement and collaboration, Quality and innovation management, Human resource management, linking Six Sigma to corporate goals and strategies, Selection of right project and project management, Process mapping and re-engineering, Employee involvement and Development of right organizational culture, have been chosen for this study [9]-[12].

D. Upper Management Leadership and Commitment

The most identified CSF in the literature is top management commitment. Without continuous involvement and provision of appropriate resources and training from top management, the true importance of Six Sigma methodology cannot be achieved. Top leaders have to ensure that Six Sigma is the best strategy for process improvement and must be sustained before, during and after implementation of process [9].

E. Education and Continuous Training of Employees

Education and training of the employees of a company is the most important tool to effectively implement any quality tool. People are the most important asset of an organization. If they are not willing to do the work with you as part of implementation strategy, no measurable benefits can be achieved. When an organization trains and educates people and realizes the employee as an integral part of organization, Six Sigma or any other quality tool can give the best measurable results [9].

F. Organizational Infrastructure and Resources

The Six Sigma introduction and development program in any organization requires completely dedicated employee, cross-functional team and facilitative leadership behavior. Six Sigma's infrastructure means commitment of staff, top management, money, time and resources [10].

G. Effective Communication and Information Flow

For the successful implementation of any system, communication between organizational activities is basic important tool. The most resistance that comes for the successful implementation of Six Sigma is in the form of communication. If communication system is not appropriate, then management may not be successful in implementing any quality effecting strategy like Six Sigma, etc. Communication can be in the form of discussions with employee, seminars, a Six Sigma benefits awareness session and workshops, etc. [9].

H. Understanding Six Sigma tools and Methodology

If an organization wants to implement Six Sigma successfully then the tools and techniques must be clear and understood by all employees. Well planned implementation training tools need to be clearly understood. A healthy portion of the training includes three portions: one for tools and techniques (understanding DMAIC and DMDV technology), the second for leadership and the third for team work. Accurate data is required for proper analysis of the work and to support decisions of management. Metrics can be used for defects rate and cost of poor quality, etc. [9].

I. Continual Evaluation and Motivation of the Workforce

The barrier usually faced by the Six Sigma implementation is employee resistance to change. To remove this barrier at the very early stages of implementation, employees need to be evaluated and continuously motivated so that they are actively involved in the process of change from outdated methods to the Six Sigma tools and methodologies [9].

J. Linking Six Sigma to Market and Customer Needs

Customers are the priority of every organization. If organizations (manufacturing or services) are to improve the quality of their processes, first they must understand the customers' needs. Before the customer needs are find out, organizations must understand its business relations between organizations. To identify core business relations and customer needs are Critical to Quality characteristics. QFD is the best technique to understand the needs and expectations of customers and translate it into core business activities [9].

K. Formation of Cross Functional Teams and Knowledge Sharing

For successful Six Sigma implementation, one of the most important factors is team work. In any organization, projects can only be successfully implemented if the employees involved in that project work in collaboration with each other, while sharing data and knowledge with each other. It is management's responsibility to provide the environment within the organization which supports team management and knowledge sharing [11].

L. Supplier Capability Enhancement and Collaboration

Strong involvement of suppliers in the Six Sigma program can be beneficial for the organization to bring supplier closer to the customer to improve the quality of product/process. Six Sigma methodologies explain that to reduce variability in your process, organizations must have few suppliers with high performance capability analysis. If you want to be a Six Sigma company then you should involve supply chain management in your Six Sigma implementation strategy [12].

M. Quality and Innovation Management

Quality improvement is the main objective of Six Sigma, therefore, it is the primary objective for the organizations implementing Six Sigma to control and manage the quality and innovation activities. Steps needed to be taken to improve quality at the source [12].

N. Human Resource Management

Successful Six Sigma implementation also depends upon the way the employees and workforce is managed within the organizations. Selection of the right candidates with the proper training and tools are the most critical factors for the success of Six Sigma [9].

O.Linking Six Sigma to Corporate Goals and Strategies

Six Sigma cannot be considered as standalone activity. For the successful implementation Six Sigma must be combined with a business strategy. Six Sigma is not just about the use of tools with complicated statistics, it is a methodology to make profit for business during the process variability. Six Sigma is gains more importance during high scrap-rate, rework/rejection rate and low productivity, etc., situations. During its implementation process, the projects of Six Sigma and the objective plans (business strategy) must be aligned [12].

P. Selection of the Right Project and Project Management

Good project selection is very important, because well done is always better then well said. Project selection is the first step to move towards well done. Project selection must be always aligned with business strategy. Poorly selected projects are a major cause of frustration. A good project must be challenging, and project tracking and review must be conducted on a scheduled basis to meet the various targets set out as part of the business strategy. Most of the projects that fail to complete do so because of insufficient determination in following the guidelines and meeting the responsibilities related to the deadlines of project. Project status and progress must be reported to the top management [9].

Q.Process Mapping and Re-Engineering

As Six Sigma works from top to bottom to improve quality at each stage, another CSF highlighted by researchers is Process mapping and re-engineering, which helps to create a workflow diagram to highlight each and every stage included in the process and its parallel processes, which ultimately helps to identify the processes or activities which are non-value added and should be removed [12].

R. Employee Involvement

The success of Six Sigma lies in the hands of employees. As such, as much as possible, employees within an organization should be actively involved in all stages of a project, from the planning stage through to execution, and the final results stage. Employees must be able to take responsibility for their actions. This is possible if employees are involved in each stage of project implementation. It will also help to decrease the barriers in the implementation of Six Sigma culture that an organization can face [9].

Fig. 1 Frequency of CSF of Six Sigma highlighted in a sample of 30 papers

S. Development of the Right Organizational Culture

Six Sigma requires a change in thinking (mindset of people) to get change (better) in performance. An effective communication system is required to motivate individuals such as seniors, employees and customers, and also requires overcoming the fear associated with change and the fear of not achieving new targets. A communication plan must detail how Six Sigma is important to, and how the methodology of Six Sigma works within, your organization. Six Sigma implementation projects results should include practical feedback from employees about successes and obstacles of projects. Cultural change means Six Sigma must be part of daily life [12].

Fig. 1 presents the statistics of these 16 CSFs based on their frequency of appearance in 30 papers, which were chosen from a pool of research papers based on their relevancy to the topic of CSFs of Six Sigma.

III. Research Objectives and Methodology

The main purpose of any economic investment is to maximize profits and returns. SMEs are trying to adopt modern production practices using Six Sigma tools, while increasing global competition in terms of quality and productivity. However, this concept is still lacking in Pakistani SMEs. Very little research has been carried out to explore this concept in Pakistani SMEs. The objective was to carry out the study of CSF of Six Sigma in SMEs, regardless of the sector or type of industry. In order to get the answers to these questions, a survey methodology was developed focusing on the demographic questions about the respondent companies,

the number of years of Six Sigma practice and the CSFs of Six Sigma implementation. A list of 16 critical factors derived from the literature review is included in the questionnaire and respondent companies were asked to rank those factors on the level of importance on a 5-point Likert scale. A total of 300 SMEs are contacted through email and asked to take part in questionnaire and study. A total of 174 completed questionnaires were received, which gives a response rate of 58%.

IV. Result and Discussion

The demographics of the respondent enterprises are analyzed. The respondent's profile analysis shows that around 76% of SMEs (132) are from the Private sector, while 25% (42) represent Public sector SMEs. The concept of Six Sigma is still in the phase of maturity in Pakistani because the majority of respondent SMEs (50%) have adopted Six Sigma practices for less than three years and some of enterprises (12%) have not implemented it at all. The reliability test of the survey was conducted to measure the consistency of the survey, as it is widely adopted by researchers [13]. Cronbach's α value was calculated using SPSS software. The value of Cronbach's α is 0.811, which meets the desirable value of greater or equal to 0.6, as suggested by [14]. Hence the data was reliable to infer further analysis. The CSFs are compared on the basis of highly important and lest important factors by calculating the mean values of these factors using a methodology adopted from [15]. Table I shows the mean values of such factors.

A factor analysis using SPSS was applied. The analysis method used for the extraction of "Principle component analysis" with "Varimax" for the rotation and "0.5" value for "Suppressed Small Coefficients" to get better understandable results. The analysis was performed to extract four factors to get the desired results [16]. The data set had Kaiser-Meyer-Olkin Measure of Sampling with significance level < 0.000. The results are shown in Table II. The four components show a total of 67.87% of variation in the data.

Component-1 named as "Management support with effective communication". Component-2 named as "Workforce involvement, understanding and motivation". Component-3 named as "Project Selection, education and training". Component-4 named as "Linking Six Sigma to corporate and market goals".

To check the reliability of these components, the Cronbach's α test was performed on the four extracted components individually. All of the components have reliable Cronbach's α values greater than 0.60. If we remove any of the items from these components, the Cronbach's α values do not improve, which shows a good reliability of our components [17].

TABLE I
The level of Importance of CSFs

Item	Mean	SD	t-value
Upper Management Leadership and commitment	4.56	0.65	31.78*
Education and continuous training of employees	4.56	0.59	34.78*
Organizational infrastructure and resources	4.50	0.70	28.14*
Development of the right organizational culture	4.45	0.67	28.72*
Linking Six Sigma to corporate goals and strategies	4.43	0.83	22.71*
Quality and innovation management	4.35	0.65	27.31*
Linking Six Sigma to market and customer needs	4.26	0.95	17.52*
Effective communication and information flow	4.21	0.60	26.47*
Human resource management	4.16	0.58	26.13*
Understanding Six Sigma tools and methodology	3.98	0.96	13.49*
Selection of the right project and project management	3.83	0.62	17.56*
Formation of cross functional teams and knowledge sharing	3.71	0.70	13.36*
Continual evaluation and motivation of workforce	3.14	0.80	2.25*
Employee involvement	3.12	0.79	2.01*
Process Mapping and re-engineering	2.76	0.80	-3.96*
Supplier capability enhancement and collaboration	2.67	0.65	-6.78*

(*p < 0.05)

TABLE II
Principal Component Loading matrix for CSFs

Item	Components			
	1	2	3	4
Development of right organizational culture	.834	-	-	-
Upper Management Leadership and commitment	.821	-	-	-
Quality and innovation management	.776	-	-	-
Effective communication and information flow	.773	-	-	-
Human resource Management	.533	-	-	-
Process Mapping and re-engineering	-	.874	-	-
Supplier capability enhancement and collaboration	-	.814	-	-
Employee involvement	-	.745	-	-
Continual evaluation and motivation of workforce	-	.684	-	-
Understanding Six Sigma tools and methodology	-	.616	-	-
Selection of right project and project management	-	-	.561	-
Education and continuous training of employees	-	-	.913	-
Organizational infrastructure and resources	-	-	.700	-
Formation of cross functional teams and knowledge sharing	-	-	.529	-
Linking Six Sigma to corporate goals and strategies	-	-	-	.588
Linking Six Sigma to market and customer needs	-	-	-	.580
Percentage variance explained	22.74	21.90	13.05	10.17
Percentage cumulative variance explained	22.74	44.64	57.70	67.87

V. Conclusion

The objective of this paper was to analyze Six Sigma implementation and its CSFs in Pakistani SMEs. As literature shows a lack of studies of Six Sigma implementation in Pakistani SMEs; an attempt has been made to drive the researcher's attention towards this issue. The analysis shows that Pakistani SMEs are still far behind in the race of Six Sigma implementation, as around 51 percent of SMEs have less than three years of implementation of Six Sigma. Based on the survey analysis, Management commitment and leadership is the most critical factor in the success of Six Sigma implementation, which is in line with the study results of [18]. The other critical factors are Education and continuous training of employees, Organizational

infrastructure and resources, and Linking Six Sigma to corporate goals and strategies. Based on the results analysis, a framework has been proposed by the authors for successful Six Sigma implementation in Pakistani SMEs. Six Sigma is mostly implemented in the telecommunication sector. In this research, cultural change has gained greater importance for respondents. Future research can include a detailed study of the cultural change parameters in different sectors of Pakistani industries i.e. small or large firms in the manufacturing and service sectors. This study can include the type of cultural change that is required to embed the Six Sigma approach in a system/process.

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