Factors that hinder Six Sigma implementation in manufacturing SMEs

[1]Anil Jacob, [2]M. Parameswaran
[1]M.Tech student, [2]Professor
[1]Department of production engineering,
[1]Government Engineering College Trichur, Thrissur, India

***Abstract*—Six Sigma is a business improvement strategy adopted by companies all over the world which will reduce the process variation and enhance product quality. Since its inception, Six Sigma has been mostly confined to the area of bigger companies with plenty of resources. But, this promising methodology is equally applicable to the small and medium size enterprises (SMEs) for improving their bottom-line. The purpose of this study is to identify the main factors that hinder Six Sigma implementation in manufacturing SMEs and to test if the level of importance attributed to those factors differ according to firms' size. The methodology includes conducting a survey through questionnaire based on previous deep literature review and analysing the responses using Microsoft Excel's statistics and SPSS (Statistical Package for Social Sciences) software. Findings reached from this research, highlighted five different factors affecting six sigma implementation: top managerial strategy, time and expected result, cost, complex procedures and employee involvement. Furthermore, results suggest that top managerial strategy assume greater importance in small size firms whereas cost assume greater importance in medium sized firms. The research focused specifically on the manufacturing firms in Kerala: thus, attention must be paid in attempting to generalize results. Understanding the main barriers that hinder six sigma implementation in SMEs may allow practitioners to plan more effectively their quality management system, especially faced with scarce resources.**

***Index Terms*— Six Sigma, SMEs, barriers, firms size**

I. INTRODUCTION

Six Sigma is an overall business improvement strategy rather than a quality initiative. Although Six Sigma has been implemented with great success in many large organizations, there is still less documented evidence of its implementation in smaller organizations. Due to increased importance of supply chain management issues in global market environment, large firms are mostly dependent on small and medium sized enterprises (SMEs) for providing high quality products and/or services at low costs. The continuously increasing demand for high quality products at low prizes and highly capable business processes by large organizations has left no choice on the SMEs to consider the introduction of six sigma business strategy. This demands that the SMEs should have robust quality management processes. Ongoing researches in this area shows its importance. The issues and factors that are acting as barriers for adoption of Six Sigma by SMEs have to be ascertained and solutions to be found out for eliminating them. In the field of quality management even though many works are being carried out regarding the improvement of quality in large organizations, medium firms and small scale industries, only few researches focused on comparative analysis between SME and larger firms, and even less between small firms and medium-sized ones. This provides a wide opportunity to carry out research in this field. The main objectives of this research is to identify the main factors that hinder Six Sigma implementation in manufacturing SMEs and to test if the level of importance attributed to those factors differ according to firms' size. Considering the second objective, several arguments and concerns highlighted throughout literature focusing on SME, the following hypothesis was proposed:

H_1. The level of importance attributed to Factors that hinder Six Sigma implementation differs according to firms' dimension.

II. LITERATURE REVIEW

Despite of the growing interest on quality management programs in SMEs in the recent past, the lack of understanding and analyzing about the vital reasons for such slow adoption of wide quality improvement-based strategies like Six Sigma is evident. Although management literature proves significant operational and organizational differences between SME and larger organizations, in the field of quality management, few researches focused on identifying/analyzing the difficulties and barriers confronted by SMEs in quality improvement programs implementation. The literature highlights several barriers confronted by SMEs in attempting to implement Six Sigma. Table I summaries empirical research on barriers to Six Sigma implementation. These are the 29 common Six Sigma implementation barriers regarding SMEs, identified through deep literature review.

Table I: Empirical research on barriers on Six Sigma implementation

Expensive start-up cost for Six Sigma projects	Kumar et al. (2009a, b), Sinthavalai (2006), Antony (2004)
Unclear cost of poor quality	Antony (2004, 2008a)
Large Investment in Six Sigma training	Taner et al. (2007)
Insufficient financial resources	Antony et al. (2005), Buch and Tolentino (2006), Taner et al. (2007)
Poor Estimation of financial gain	Martins et al. (2006), Mohamed Gamal Aboelmaged (2011)
Insufficient Time to work on Six Sigma projects	Antony et al. (2005), Buch and Tolentino (2006), Taner et al. (2007)
Lack of top management support	Dahlgaard and Dahlgaard-Park (2006), Snee (2001), Taner et al. (2007)
Lack of emphasis on voice of customers	Luís Mendes and Luís Lourenço (2014)
Lack of supportive organizational culture	Dahlgaard and Dahlgaard-Park (2006), Mohamed Gamal Aboelmaged (2011)
Poor measurement of customer satisfaction	Martins et al. (2006), Mohamed Gamal Aboelmaged (2011)
Delayed output of Large Six Sigma projects	Dahlgaard and Dahlgaard-Park (2006), Snee (2001)
Inadequate Six Sigma planning and alignment	Martins et al. (2006), Kwak and Anbari (2006)
Lack of knowledge about six sigma	Kumar et al. (2009a, b),), Buch and Tolentino (2006)
Inadequate Specialized Six Sigma training	Kwak and Anbari (2006), Snee (2001)
Intangibility of Six Sigma results	Antony and Desai (2009)
Complex Six Sigma tools and techniques	Sinthavalai (2006), Mohamed Gamal Aboelmaged (2011)
Misunderstanding of process and sub-processes	Antony (2004, 2008a)
Unclear prioritization of Six Sigma projects	Antony (2004, 2008a)
Complexity of data analysis	Mohamed Gamal Aboelmaged (2011), Taner et al. (2007)
Poor communication of quality data	Antony (2004, 2008a)
Incompetent Six Sigma skills	Martins et al. (2006), Buch and Tolentino (2006)
Satisfaction with other quality programs	Luís Mendes and Luís Lourenço (2014), Antony et.al (2005)
Difficult to identify process parameters	Antony (2004, 2008a)
Difficult to obtain performance baseline data	Mohamed Gamal Aboelmaged (2011), Taner et al. (2007)
Uncertainty of six sigma results	Mohamed Gamal Aboelmaged (2011), Martins et al. (2006),
Union's pressure	Luís Mendes and Luís Lourenço (2014), Antony et.al (2005)
Resistance to change	Antony (2004, 2008a), Taner et al. (2007)
Lack of dedicated Six Sigma professionals	Mohamed Gamal Aboelmaged (2011), Buch and Tolentino (2006)
Weak presentation of Six Sigma findings	Mohamed Gamal Aboelmaged (2011), Sinthavalai (2006)

III. RESEARCH METHODOLOGY

Since secondary data available is clearly insufficient to perform the research proposed, it was necessary to focus the methodology to a specific data gathering method which enables us to collect information directly from SMEs. Thus, considering the research's time horizon and the nature of information needed to perform the study, the data gathering method chosen was **survey** through **questionnaire** based on previous deep literature reviews. In order to study the firm's dimension, a distinction was made between small companies (25 lakhs – 5 crore) and medium-sized companies (5 crore – 10 crore) based on their financial assets. From a set of 29 possible reasons which could hinder Six Sigma implementation, previously collected through literature review, respondents were asked to evaluate each one through a five-point scale, where a value of 1 denoted none influence at all, and a value of 5 denoted extreme influence. The respondents involved in this questionnaire were managers, supervisors and owners of companies. They are considered as the suitable personnel who are likely to be leaders in charge of Six Sigma implementation. Totally 163 SMEs were included in the survey, 101 small scale industries and 61 medium scale industries.

Data gathered through the survey was submitted to SPSS software for testing, validation and factor analysis. Some of Microsoft Excel's statistics were also used for the analysis purposes. A t-test was also carried out in accordance with need of the research.

IV. RESULTS AND DISCUSSION

Factor Analysis

In order to reduce the number of factors that hinder Six Sigma implementation, data were submitted to a factorial analysis. The purpose of factor analysis is to reduce multiple variables to a lower number of underlying factors measured by these variables. Thus, in first place, it was necessary to conduct a reliability test in order to identify the internal consistency of data using Cronbach's alpha method. The Cronbach's alpha value was found to be 0.942 showing that the questionnaire was significant and

reliable. Table II highlights the different communalities, for each variable under consideration for the factorial analysis. In order to test the analysis acceptability two tests were performed: Bartlett's Test of Sphericity, and Kaiser-Meyer-Olkin Measure (KMO) of Sampling Adequacy. Significance obtained with Bartlett's Test of Sphericity is null, indicating that the sample intercorrelation matrix did not come from a population in which the intercorrelation matrix is an identity matrix. Furthermore, a KMO Measure of Sampling Adequacy about 0.822 suggest a meritorious degree of common variance.

As a result of the analysis performed, a set of five factors was kept, explaining 77.96 per cent of the total variance of the 29 potential reasons initially considered. A summary of the factors, the difficulties associated with each of the factors, their factor loadings, and eigenvalues, as well as the variance explained by each factor are presented in Table III and Table IV. Through a fast reading it can be observed that factors obtained present a reasonable consistence. Names assigned to each factor generated from the research are discussed in the following paragraphs.

Table II: communalities for six sigma implementation barriers

Sl. No.	Variables	Communalities
1	Lack of knowledge about six sigma	.896
2	Lack of top management support	.896
3	Inadequate six sigma planning and alignment	.940
4	Unclear Prioritization of Six Sigma projects	.839
5	Inadequate Specialized Six Sigma training	.530
6	Uncertainty of six sigma results	.411
7	Misunderstanding of process and sub-processes	.804
8	Lack of supportive organizational culture	.865
9	Poor communication of quality data	.885
10	Incompetent Six Sigma skills	.770
11	Weak presentation of Six Sigma findings	.653
12	Lack of Emphasis on the voice of customers	.909
13	Poor Measurement of customer satisfaction	.785
14	Intangibility of Six Sigma results	.779
15	Difficult to obtain performance baseline data	.796
16	Poor Estimation of financial gain	.584
17	Union's pressure	.890
18	Resistance to change	.854
19	Lack of dedicated Six Sigma professionals	.916
20	Insufficient Time to work on Six Sigma projects	.845
21	Delayed output of Large Six Sigma projects	.807
22	Complex Six Sigma tools and techniques	.826
23	Complexity of data analysis	.790
24	Difficult to identify process parameters	.860
25	Expensive Start-up cost for Six Sigma projects	.749
26	Large Investment in Six Sigma training	.728
27	Unclear cost of poor quality	.807
28	Insufficient financial resources	.775
29	Satisfaction with other quality programs	.420

Table III: Extraction of factors

Factor	Eigenvalue	% of Variance	Cumulative %
1	12.236	42.192	42.192
2	4.135	14.259	56.452
3	2.830	9.758	66.209
4	2.240	7.724	73.933
5	1.168	4.027	77.960

Table IV: Rotated component matrix

Factor Description	Factor				
	1	2	3	4	5
12- Lack of top management support	0.92				
17- Lack of emphasis on voice of customers	0.9				
09- Lack of supportive organizational culture	0.89				
08- Poor measurement of customer satisfaction	0.89				
18- Inadequate Six Sigma planning and alignment	0.86				
22- Misunderstanding of process and sub-processes	0.86				
07- Unclear prioritization of Six Sigma projects	0.85				
23- Satisfaction with other quality programs	0.81				
10- Difficult to identify process parameters	0.79				
20- Lack of knowledge about six sigma		0.88			
21- Inadequate Specialized Six Sigma training		0.86			
27- Poor communication of quality data		0.85			
28- Incompetent Six Sigma skills		0.85			
14- Union's pressure		0.84			
13- Resistance to change		0.83			
26- Lack of dedicated Six Sigma professionals		0.83			
29- Weak presentation of Six Sigma findings		0.62			
03- Expensive start-up cost for Six Sigma projects			0.91		
02- Large Investment in Six Sigma training			0.89		
01- Unclear cost of poor quality			0.88		
04- Insufficient financial resources			0.87		
05- Poor Estimation of financial gain			0.57		0.42
19- Complex Six Sigma tools and techniques				0.95	
24- Complexity of data analysis				0.92	
16- Difficult to obtain performance baseline data				0.73	
15- Insufficient Time to work on Six Sigma projects	0.41	0.34			0.7
25- Delayed output of Large Six Sigma projects	0.43				0.66
11- Intangibility of Six Sigma results	0.4		0.35		0.59
06- Uncertainty of six sigma results					0.56

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

Factor 1 – Top Managerial Strategy

As can be seen from Table IV nine variables were grouped under Factor 1, explaining around 42 per cent of variance (42.192 per cent to be precise). Most of the significant barriers grouped under this factor appear to relate to top managerial strategy. In fact, SME are usually characterized as flat hierarchical structures where, most of times, managers usually play key roles in the organization. Most of quality methods are not easily understood or correctly interpreted by top management in SME; such evidence can be a significant contribution for the weak level of quality practices implementation in the universe of smaller companies.

Factor 2 – Employee Involvement

In this second factor, employee involvement, eight difficulties that hinder Six Sigma implementation, were grouped which explains about 14.256 percent of the variance. Literature review suggests that smaller firms are more flexible regarding the implementation of new philosophies and management approaches, mainly due to the reduced number of workers and hierarchical levels, turning faster the process of change and making possible a family atmosphere, able to strengthen personal growth and to show workers how their role fits in the organization's global objectives.

Factor 3 – Cost

This factor accounts for 10 (9.758 to be precise) per cent of the variance, and focuses on various costs regarding Six Sigma implementation. The implementation of initiatives focused on quality improvement drive a set of additional costs which, at short term, can represent a heavy charge in SME financial structure. Given the lack of resources that usually characterizes companies of smaller dimension, it is natural that the forecast of additional "substantial costs", can difficult the development of Six Sigma program; furthermore, the uncertainty about eventual potential benefits reached, when compared to real costs supported from the first beginning of any changing program can determine whether an organization bet on such journey or prefers to act as done until now.

Factor 4 – Complex procedures

As can be seen from Table IV, three variables were grouped under this specific factor, explaining almost 7.72 per cent of variance. These variables focus towards complexity involved during the implementation of Six Sigma.

Factor 5 – Time and Expected Result

As can be observed from data (Table IV), "barriers" grouped under this factor are essentially related with the time and expected result. The four barriers under this factor explains 4.02 per cent of total variance. The uncertainty and intangibility of the Six Sigma results are is a serious concern regarding Six Sigma implementation in SMEs. As they are unaware of these facts they shows reluctance towards implementation of such Quality improvement programs.

Factors' Importance – A Comparative Analysis

In order to test if the level of importance attributed to aspects that hinder the process of Six Sigma implementation differed according to firms' dimension, regarding both individual variables and factors, an independent two tailed t-test was applied.

Table V: Factors that hinder Six Sigma initiatives and firms' size – results of t-test

	Factor and its related variables	Firms ' size	N	Mean	Std. Deviation	Sig.
Top Managerial Strategy	Factor 1-Top Managerial Strategy	Small	102	2.874	1.0611	0.00000000869*
		Medium	61	2.555	0.9958	
	07-Lack of top management support	Small	102	2.9902	0.93866	0.431607
		Medium	61	2.8689	0.957	
	08-Lack of emphasis on voice of customers	Small	102	2.9706	0.99956	0.23845
		Medium	61	2.7869	0.933	
	09-Lack of supportive organizational culture	Small	102	2.9902	1.12131	0.008073*
		Medium	61	2.541	0.97594	
	10-Poor measurement of customer satisfaction	Small	102	3.0098	1.13883	0.001611*
		Medium	61	2.4426	1.05711	
	12-Inadequate Six Sigma planning and alignment	Small	102	2.8824	0.97792	0.08585
		Medium	61	2.6066	0.9879	
	17-Misunderstanding of process and sub-processes	Small	102	2.8333	0.99587	0.005452*
		Medium	61	2.4098	0.88274	
	18-Unclear prioritization of Six Sigma projects	Small	102	2.8725	1.24018	0.061327
		Medium	61	2.5082	1.16366	
	22-Satisfaction with other quality programs	Small	102	2.6961	0.99294	0.041267*
		Medium	61	2.377	0.93388	
	23-Difficult to identify process parameters	Small	102	2.6275	1.08017	0.312461
		Medium	61	2.459	0.99287	

Employee Involvement	Factor 2-Employee Involvement	Small	102	2.588	1.0541	0.0502
		Medium	61	2.477	0.9458	
	13-Lack of knowledge about six sigma	Small	102	2.7353	1.04291	0.31517
		Medium	61	2.5738	0.95671	
	14-Inadequate Specialized Six Sigma training	Small	102	2.7745	1.1161	0.095241
		Medium	61	2.4754	1.08944	
	20-Poor communication of quality data	Small	102	2.6863	0.92255	0.618136
		Medium	61	2.6066	1.02109	
	21-Incompetent Six Sigma skills	Small	102	2.7255	0.96633	0.030423*
		Medium	61	2.4098	0.84414	
	26-Union's pressure	Small	102	2.4902	1.03163	0.777445
		Medium	61	2.4426	1.04123	
	27-Resistance to change	Small	102	2.5294	1.13195	0.403829
		Medium	61	2.3934	0.91794	
	28-Lack of dedicated Six Sigma professionals	Small	102	2.5098	1.14965	0.082662
		Medium	61	2.2295	0.88305	
	29-Weak presentation of Six Sigma findings	Small	102	2.2549	0.98188	0.001734*
		Medium	61	2.6885	0.74254	
Cost	Factor 3-Cost	Small	102	3.605	0.9708	0.0049*
		Medium	61	3.777	0.7496	
	01-Expensive start-up cost for Six Sigma projects	Small	102	3.7647	0.86947	0.582813
		Medium	61	3.8361	0.75675	
	02-Large Investment in Six Sigma training	Small	102	3.7255	0.90277	0.829756
		Medium	61	3.7541	0.76715	
	03-Unclear cost of poor quality	Small	102	3.6471	1.01129	0.37851
		Medium	61	3.7705	0.76143	
	04-Insufficient financial resources	Small	102	3.5098	1.02199	0.02918*
		Medium	61	3.8197	0.76394	
	05-Poor Estimation of financial gain	Small	102	3.3824	1.00537	0.018287*
		Medium	61	3.7049	0.71518	
Complex Procedures	Factor 4-Complex Procedures	Small	102	2.666	1.0984	0.0774
		Medium	61	2.513	0.8041	
	16-Complex Six Sigma tools and techniques	Small	102	2.7353	1.17673	0.561976
		Medium	61	2.6393	0.91347	
	19-Complexity of data analysis	Small	102	2.6863	1.12558	0.077473
		Medium	61	2.4262	0.7407	
	24-Difficult to obtain performance baseline data	Small	102	2.5784	0.98941	0.452052
		Medium	61	2.4754	0.74401	
Time and Expected Result	Factor 5-Time and Expected Result	Small	102	2.799	1.2956	0.1042
		Medium	61	2.643	1.1073	
	06-Insufficient Time to work on Six Sigma projects	Small	102	3.1176	1.11065	0.003386*
		Medium	61	2.6393	0.91347	
	11-Delayed output of Large Six Sigma projects	Small	102	2.7745	1.31937	0.475196
		Medium	61	2.918	1.18737	
	15-Intangibility of Six Sigma results	Small	102	2.7549	1.32333	0.348537
		Medium	61	2.5738	1.10241	
	25-Uncertainty of six sigma results	Small	102	2.549	1.36887	0.600363
		Medium	61	2.4426	1.1765	

Notes: Means of factors were obtained from variables' scores grouped in each one. Each of potential reasons was weighted, in a scale from "Extreme influence" (5) to "Without any Influence" (1). Assessing how each one could contribute to hinder quality improvement programmes. *$p < 0.05$

Concerning the hypothesis, any significance value less than *0.05* reveals there is a significant statistical difference between small and medium firms considered for study. Results summarized in the above Table V highlight a weak statistical support. In fact, among five factors considered, data enhance significant statistical differences only in two cases: "Top managerial strategy" and "Cost". Results show that four of the nine variables grouped under the first factor reveal significant statistical differences; lack of supportive organizational culture, poor measurement of customer satisfaction, misunderstanding of process and sub-processes, satisfaction with other quality programs.

Results although highlight that, in any of this factor's dimensions, averages for medium-sized companies are systematically lower than those evidenced by smaller ones. Thus, although in a first instance, one could think that top managerial strategy would have a larger importance for medium companies, considering its conditionings in the search for quality improvement; data showed that smaller companies are those that attribute larger importance to such factor.

Concerning the second factor with significant differences (Cost), data summarized in Table V highlight that two among the five variables representatives of the factor, present significant statistical differences: insufficient financial resources, poor estimation of financial gain, and unlike in the previous factor, conditionings seems to affect medium-sized companies at a larger scale, even though the perception was it would have got greater importance regarding smaller firms. The results showed that medium-sized companies are those that attribute larger importance to "cost" as factor that hinder Six Sigma initiatives.

Concerning the other factors without significance differences (Complex procedures, Time and Expected Result and Employee involvement), the variables grouped under "Complex procedures" doesn't show any sort significant statistical differences where as two variables grouped under "Employee involvement", i.e. Incompetent Six Sigma skills and Weak presentation of Six Sigma findings shows a significant difference. Results highlighted that the averages for small companies are systematically higher than those evidenced by medium-sized ones, which signifies that these variables have got greater importance regarding smaller firms.

Although there are not significant statistical differences between small and medium-sized firms regarding the factor "Time and Expected Result", results show that there are differences respecting to one of its variable ("Insufficient Time to work on Six Sigma projects"). Once again, small-sized firms seems to be affected at a larger scale than medium ones, suggesting that difficulties felt by medium firms in attempting to implement Six Sigma, have a minor influence regarding the time to work on Six Sigma projects.

V. CONCLUSION

The basic rationale behind this research is our belief that successful Six Sigma implementation is not a secured green field in various organizational contexts. While there is a little amount of research focusing the obstructive role of barriers to Six Sigma implementation, the impact of organizational factors on these barriers, particularly in a developing country context, has been given minimal attention. The main aim of this research was to identify and analyze the main factors that hinder Six Sigma implementation, from the perspective of manufacturing SMEs and to test if the level of importance attributed to these factors differ according to SMEs' dimension. In accordance, by means of factor analysis, 29 Six Sigma barriers were reduced into 5 valid barrier factors which accounts for 77.96 per cent of total variance explained. These barrier factors include Top Managerial Strategy, Employee Involvement, Cost, Complex procedures and Time and Expected Result. It was observed that among these factors two of them showed significant statistical differences (Top Managerial Strategy and Cost). The former showed greater importance towards small firms whereas the latter showed greater importance towards the medium-sized firms. These results suggest that organizations should not waste their resources preparing for overcoming all Six Sigma barriers. Instead, high attention should be given to the most significant barriers in relation to organizational need. Also, empowering the workers and the same time boosting the level of Six Sigma awareness and knowledge among top managers are of key priority in local manufacturing organizations.

VI. LIMITATIONS OF STUDY AND FUTURE SCOPE

The study is confined to the manufacturing sector within Kerala. Consequently, in order to test the external validity of these findings, further researches require replication of this same study in other part of country. Some of the other limitations where less number of medium scale industries surveyed and regarding the credibility of the responses.

Since research on this area is relatively limited, a natural extension of this investigation would be to study SMEs deal with all those factors that hinder Six Sigma initiatives, and especially how these are overcome within the stipulated time period. Despite time and cost requirements, further researches may consider exploring longitudinal research designs in order to understand and analyze the dynamic nature of problems faced by the SMEs. Moreover, considering the obtained results, a special attention should be also paid on the different characteristics that may intensify the different barriers identified.

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