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A Comprehensive Framework for Six Sigma Critical Success Factors with an Experience in a Developing Country

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1. Introduction

Six Sigma is a business strategy and a systematic methodology, use of which leads to breakthrough in profitability through quantum gains in service quality, product performance, productivity and customer satisfaction. Today Six Sigma has been considered as a strategic approach to achieve excellence in operations and service performance through the effective utilization of statistical and non-statistical tools and techniques (Antony, 2004). Like other programs emerging under the TQM umbrella, Six Sigma requires a transformational change in an organization's culture, structure, and processes. The emergence of Six Sigma as a distinct approach to TQM occurred in 1987 at Motorola (Larson, 2003).

Six Sigma is a disciplined approach to define, measure, analyze, improve and control processes that result in variability and defect reduction. Six Sigma is a business improvement strategy that seeks to find and eliminate causes of defects or mistakes in business processes by focusing on outputs that are of critical importance to customers (Snee, 2003). It is a powerful approach to process improvement, reduced costs and increased business profitability and revenue growth. Six Sigma originated at Motorola in the early 1980s in response to a challenge to achieve ten-fold reduction in product failure levels in five years. Six Sigma has both management and technical components. The focus of management component is to select the right people for Six Sigma projects, select the right process metrics, provide resources for Six Sigma training, provide clear direction and guidance with regard to project selection, etc. The focus of technical component is on process improvement by reducing variation, creating data which explains process variation, using statistical tools and techniques for problem solving, etc. In statistical terms, Six Sigma means 3.4 defects per million opportunities (DPMO), where sigma is a term used to represent the variation around the average of a process.

Today, Six Sigma is exploited by many organisations such as GE, Honeywell, Sony, Caterpillar, J P Morgan, American Express, Common Wealth Health Corporation, Lloyds TSB, City Bank, Jaguar, Kodak, Ford and Starwood Hotel Group (Antony & Fergusson, 2004).

These contrast results make Six Sigma implementation a complex and central process, where the CSFs in its implementation must be recognised. Although different resources are now available on Six Sigma subjects, it seems there are only a few, in which CSFs are addressed. In the following, the efforts made in the literature are reviewed in case of CSFs for successful implementation of Six Sigma projects; then, a case study is presented in which a set of CSFs are analyzed in major car maker companies in Iran. In terms of the case study, the aim of this paper is to find out which factors have the successful companies experienced as more critical in reaching Six Sigma goals.

2. Critical Success Factors (CSFs) in Six Sigma projects

CSFs are those factors which are critical to the success of any organisation, in the sense that if objectives associated with the factors are not achieved, the organisation will fail catastrophically (Rockart, 1979). In the context of Six Sigma project implementation, CSFs represent the essential ingredients without which a project stands little chance of success.

In comparison with traditional approaches of quality management, Six Sigma is the most effective concept because of the interrelationship between its strategy, organisational structures, procedures, tools and methods (Pfeifer et al., 2004). In the following, some other results of the literature study on Six Sigma CSFs are presented.

Antony & Fergusson (2004) have conducted an investigation in the software industry. They considered the following ten CSFs for the Six Sigma projects (Antony & Fergusson, 2004):

- Leadership engagement and uncompromising commitment of top management
- Supporting organizational infrastructure
- Cultural change
- Six Sigma training
- Linking Six Sigma to business strategy
- Accountability
- Customers involvement
- Understanding the Six Sigma methodology
- Project management
- Project prioritization and selection

According to the results of their investigation, leadership engagement and uncompromising commitment of top management, cultural change, linking Six Sigma to business strategy and customers involvement have had the highest scores and therefore, needed more concentration. Henderson & Evans (2000) also suggested upper management/involvement, organization infrastructure, training and statistical tools as the major components for a successful Six Sigma implementation (Henderson & Evans, 2000).

Buch & Tolentino (2006) conducted a survey, in which 216 employees of a large US company completed 15 months after the implementation of a Six Sigma quality improvement program (Buch & Tolentino, 2006). Respondents were asked to indicate the extent to which they had the skills and resources needed for successful participation in Six Sigma (success expectancies). Their findings imply that employees as a group had low expectancies for both skills and resources, but those expectancies were significantly higher for program participants than for non-participants. The ten items they considered in their survey as Six Sigma CSFs are as follows:

- Know how to scope project
- Knowledge of quality process
- Knowledge of tools
- Knowledge of work processes
- Knowledge of statistics
- Know how to get involved
- Adequate management support
- Access to quality tools
- Access to professionals
- Have adequate time

As it is clear, the above items are mostly related to training and knowledge of Six Sigma concepts and project management subjects.

Coronado & Antony (2002) have addressed the following 12 CSFs of Six Sigma projects:

- Management involvement and commitment
- Cultural change
- Communication
- Organization infrastructure
- Training
- Linking Six Sigma to business strategy
- Linking Six Sigma to customer
- Linking Six Sigma to human resources
- Linking Six Sigma to suppliers
- Understanding tools and techniques within Six Sigma
- Project management skills
- Project prioritization and selection

Most of the above 12 factors are similar to the work of Antony & Fergusson (2004). However, the 12 items seem more complete comparing to the items addressed in the former resources.

In other investigations by Pande et al. (2000) and George (2002), Success factors and benefits of Six Sigma are highlighted as:

- Customer focus for project choice
- Project feasibility of the projects in a limited timeframe
- Evaluation of resp. of profitability
- Consequent agreement on objectives and controlling of results
- Focus on the essential business processes
- Application of an approved toolset
- Consequent enabling of employees and provision of resources

Finally, Antony (2004) conducted a survey in a number of UK service organizations. He considered the following 13 items as CSFs:

- Linking Six Sigma to business strategy
- Customer focus
- Project management skills
- Executive leadership and senior management commitment
- Organizational infrastructure
- Project selection and prioritization
- Management of cultural change

- Integration of Six Sigma with financial accountability
- Understanding the DMAIC methodology
- Training and education
- Project tracking and reviews
- Incentive program
- Company-wide commitment

Like previous studies, in which Antony was the first author or the co-author, the above items seem complete and encompass almost all CSFs addressed in the literature. Antony (2004) also found that linking Six Sigma to business strategy is the most addressed CSF. This would be aligned with Mikel Harry's definition of Six Sigma as a breakthrough improvement business strategy. Six Sigma creates a sense of urgency by emphasizing rapid completion of projects in four to six months (Snee & Hoerl, 2003). Therefore, it was not surprising that "project management skills" was rated very high. Antony (2004) further studied the critical factors and criteria of Six Sigma project selection. He addressed the following eight important CSFs:

- Linkage to strategic business plan and organizational goals
- Sense of urgency – how important is the proposed project for improving your overall business performance (both financial improvement and service process performance improvement)
- Select projects which are doable in less than six months. If the project scope is broader, the time to completion increases, the cost of the project deployment will increase. This would lead to frustration among the key players due to lack of progress, diversion of manpower away from other activities, delay in realization of financial benefits, etc.
- Project objectives must be clear, succinct, specific, achievable, realistic and measurable
- Establish project selection criteria – the following criteria may be considered during the project selection process:
 - Impact on customer needs and expectations
 - Financial impact on the bottom-line
 - Duration of the projects considered
 - Resources required for projects under consideration
 - Expertise and skills required to carry out the projects
 - Probability of projects success
 - Risk involved in projects
 - Projects have the support and approval of senior management
 - Define project deliverables in terms of their impact on one or more critical characteristics in the service such as CTQ, critical-to-cost or critical-to-delivery
 - Projects must be selected based on realistic and good metrics (DPMO, SQL, Capability Indices, etc.)

Finally, Shahin (2006) proposed the essential or key ingredients which are necessary for the effective implementation of Six Sigma projects. Comparing to the literature, it seems the proposed CSFs addressed by Shahin (2006) encompasses almost all those factors addressed in the literature. A comprehensive framework is developed and depicted in Figure 1, representing those CSFs. The factors are positioned in the Figure in a way that denote the business architecture and the dominated as well as the core CSFs. Shahin (2006) stressed that among the factors addressed in the Figure, leadership and top management commitment, linking Six Sigma to business strategy, supporting organizational infrastructures, and

training and understanding Six Sigma concepts are the most important factors, any organization should consider in its Six Sigma project. It is important to note that in some resources the later mentioned factors are also referred to as the organizational activities and as the first and main pillar in the hierarchy of TQM implementation program.

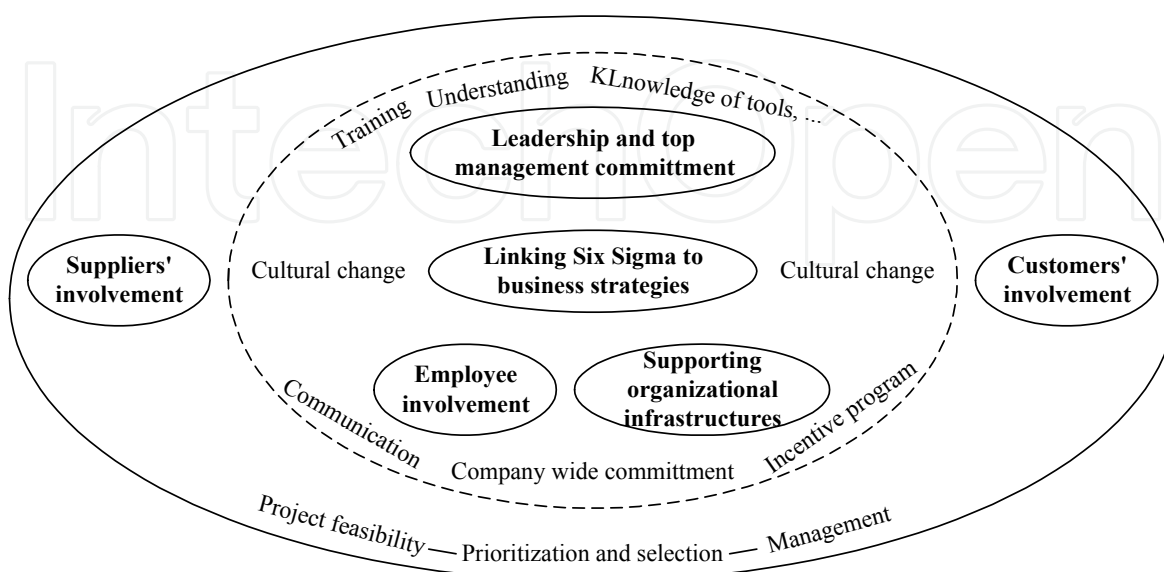


Fig. 1. Six Sigma CSFs: A comprehensive framework developed from Shahin (2006)

3. Case Study

The case study has been conducted in five major car maker companies in Iran. The companies include Iran Khodro, Saipa, Bahman Motors, Kerman Motors and Saipa Sazegostar. Among the companies, Iran Khodro and Saipa contribute to the majority of the shares in the market. The statistical population consists of 2600 respondents. They include Six Sigma champions, team leaders, Black Belts, Green Belts, team members and consultants from top and middle managers, supervisors and experts. The data is gathered in 2006 and after a pilot study, a sample of 260 respondents were considered and asked to fill the questionnaires, based on a 95% confidence level, 5% accepted error and 0.2 standard deviation.

All the data is gathered by questionnaire. Considering the availability of respondents, totally 251 out of the 260 nominated responded to the questionnaire, which indicates a high rate of response. A seven point scale is used for rating the influence of CSFs (1: no influence – 7: very high influence).

Initially 51 questions were included in the questionnaire, which were further classified under 10 major categories as Six Sigma CSFs. This study summarizes the final results of the analysis on the 10 categories. The categories are as follows:

- 1) Management commitment and involvement
- 2) Cultural changes
- 3) Organizational infrastructures
- 4) Training
- 5) Project manager skills
- 6) Selection, evaluation and prioritization of Six Sigma projects

- 7) Understanding methodology and techniques of Six Sigma
- 8) Linking Six Sigma to business strategy
- 9) Linking Six Sigma to customers
- 10) Linking Six Sigma to employees

The reliability of the data for each company is measured by Cronbach’s Alpha, ranging from 0.896 to 0.975. Also, the value of all companies is computed as 0.954. As it is clear, all the values can be considered as satisfactory (Nunnally, 1978).

In Table 1, the mean value of the influence of each of the CSFs is given for each of the companies. In Table 2, the CSFs are prioritized, based on their corresponding mean value of influence in Table 1.

CSFs	Iran Khodro	Saipa	Bahman Motors	Kerman Motors	Saipa Sazegostar	All companies
1	5.58	6.04	5.90	5.86	5.65	5.81
2	5.44	5.71	5.72	5.13	5.29	5.46
3	5.43	5.80	5.78	5.39	5.32	5.55
4	5.45	5.57	5.32	4.68	5.44	5.29
5	5.78	5.88	5.90	4.90	5.93	5.68
6	5.59	5.70	5.80	5.10	5.84	5.61
7	5.54	5.80	6.34	6.20	6.04	5.99
8	5.43	5.74	5.86	5.47	5.48	5.59
9	5.89	5.79	6.38	5.80	5.96	5.97
10	5.78	5.70	5.64	5.40	5.46	5.60
All CSFs	5.59	5.77	5.87	5.39	5.64	5.65

Table 1. Mean value of the influence rates of CSFs

CSFs	Iran Khodro	Saipa	Bahman Motors	Kerman Motors	Saipa Sazegostar	All companies
1	5	1	3	2	5	3
2	8	7	8	7	10	9
3	10	4	7	6	9	8
4	7	10	10	10	8	10
5	3	2	4	9	3	4
6	4	9	6	8	4	5
7	6	3	2	1	1	1
8	9	6	5	4	6	7
9	1	5	1	3	2	2
10	2	8	9	5	7	6

Table 2. Prioritization of the influence rates of CSFs

Also, in Table 3 and Table 4, the mean and standard deviation values of CSFs are presented, considering the 10 categories and the 5 companies, respectively.

Companies	Mean	St. Dev.
Iran Khodro	5.5910	0.2808
Saipa	5.7730	0.1254
Bahman Motors	5.8460	0.3115
Kerman Motors	5.3930	0.4652
Saipa Sazegostar	5.6410	0.2808

Table 3. Mean and standard deviation values of CSFs, considering the 10 categories

CSFs	Mean	St. Dev.
1	5.8060	0.1884
2	5.4580	0.2590
3	5.5440	0.2281
4	5.2920	0.3534
5	5.6780	0.4385
6	5.6060	0.2990
7	5.9840	0.3192
8	5.5960	0.1919
9	5.9640	0.2428

Table 4. Mean and standard deviation values of CSFs, considering the five companies

One-way analysis of variance is used to find if there exists any difference between mean values of companies. According to the results, the null hypothesis, in which the means are all assumed as equal is rejected ($p\text{-value}=0.010$). Moreover, Tukey-HSD test with significance level of 0.05 is used to point out which of the companies is different with others, in case of the mean value of the influence rates. The results indicate that significant differences exist between Saipa, Bahman Motors and Kerman Motors.

Also, one-way analysis of variance is used to find if there exists any difference between mean values of CSFs. According to the results, the null hypothesis, in which the means are all assumed as equal is rejected ($p\text{-value} = 0.008$). Tukey-HSD test with significance level of 0.05 is used to point out which of the companies is different with others, considering the mean value of the influence rate. The results indicate that significant differences exist between CSFs no. 7, 9 and 4, i.e. between understanding methodology and techniques of Six Sigma, linking Six Sigma to customers and training.

Continuing the analysis, the prioritization rates in Table 2 are considered and one-way analysis of variance is used to find if there exists any difference between mean values of CSFs. According to the results, the null hypothesis, in which the means are all assumed as equal is rejected ($p\text{-value} = 0.000$). Again, Tukey-HSD test with significance level of 0.05 is used to point out which of the CSFs is different with others, considering the prioritization values. The results Indicate that significant differences exist between CSFs no. 7, 9 and 3; 1, 7, 9 and 2; and 1, 5, 7, 9 and 4. Therefore, it seems that CSF no.4 has difference with a greater number of CSFs. The results are somehow compatible with former analysis, in which significant differences existed between CSFs no. 7, 9 and 4, considering the mean value of the influence rates.

4. Discussion and conclusions

This paper reviewed literature on the CSFs of Six Sigma implementation in different sectors, worldwide and a comprehensive framework was proposed for Six Sigma critical success factors (CSFs). All those factors were extracted from literature review and seem essential for optimizing financial return from Six Sigma projects and for achieving the full potential of its application in all organizations. A case study was also conducted, in which the CSFs were prioritized in five major car maker companies who applied and experienced a number of Six Sigma projects in Iran, as a developing country.

According to the literature review, it was found that factors such as leadership and top management commitment, linking Six Sigma to business strategy, supporting organizational infrastructures, and training and understanding Six Sigma concepts are the most important factors, any organization should consider as first priorities in its Six Sigma project. However, some boundaries and limitations might exist in each of the reviewed studies, such as the number of companies, available resources, time constraints, etc. In some of the reviewed resources, it was found that due to the limited budget and time constraints, postal surveys were carried out for data collection. On the other hand, in some of the other reviewed resources, semi-structured interviews with employees in the companies enabled the author to have a deeper insight into the practice of Six Sigma business strategy. Considering the research limitations, according to Gillham (2000), the scaled questions have disadvantages because respondents often do not use the whole scale. This was also found in the case study presented in this study, in which a seven point scale was used in the questionnaire and the mean value of CSFs had a range of 5.10 to 6.38, denoting considerable, high and very high influence.

The results of the case study imply that not all companies have equal mean values of CSFs. Also, their influence rates of CSFs are not equally prioritized. Also, it has been found that almost all CSFs have same values, except for "training" that has a smaller value. Furthermore, it was highlighted that although companies such as Iran khodro and Saipa have similarities, for instance in having most of the market share, the CSFs do not have the same prioritization in both of the companies. In the analysis of the data of all companies, it was found that "understanding methodology and techniques of Six Sigma" had the highest mean value and the first priority, while, "training" had the lowest mean value and the last priority. From one point of view, this seems ambiguous; but after interviewing with top and executive managers it was found that Iranian companies are dealing with the problem of training effectiveness. In other words, there might not be any problem with scheduling or financing the training programs, rather the main problem is in implementation and taking the learnt theories into action. They were not sure whether they have used correct tools and techniques. An important point is that they do not have any defined system for measuring the effectiveness of their Six Sigma training programs.

Another important result from the analysis is the second priority, i.e. "linking Six Sigma to customers", which has a mean value of 5.97, and is very close to 5.99 that is the value of the first priority, i.e. "understanding methodology and techniques of Six Sigma". It might be due to the fact that almost all companies were found to have problems and difficulties in their after sales services in recent years and therefore, customer satisfaction is now the first strategic priority for them. However, considering the strategic plans written in the car companies, such as Iran Khodro and their policy of developing exports in the next 20 years,

increasing quality and satisfying customers' preferences seem very important and therefore, it becomes reasonable to have "linking Six Sigma to customers" as the second priority.

It should be noted that as addressed by Shahin (2006), factors such as leadership and top management commitment, linking Six Sigma to business strategy, supporting organizational infrastructures, and training and understanding Six Sigma concepts are the most important factors, any organization should consider as first priorities in its Six Sigma project. Almost all those factors were considered in the 10 categories of CSFs in the case study and their corresponding priorities were computed as: 3, 7, 8, 10 and 1, respectively.

Due to the nature of TQM and Six Sigma, training and education will always be a primary lever for change, although the case study provided a different outcome. Perhaps it is due to the low mean value that "cultural changes" had in the case study (the ninth priority after "training", which had the 10th priority). Considering cultural changes, it seems that some companies that have succeeded in managing change have identified that the best way to tackle resistance to change is through increased and sustained communication, motivation and education. It is important as well to get as much practical feedback as possible from employees, plan the change through a detailed Six Sigma implementation milestone, delegate responsibilities when possible and empower people to make their own decisions.

In addition to the CSFs addressed, further factors and measures could be considered. For instance as some organizations define some criteria in order to measure their degree of success in their Six Sigma projects, they include financial impact on the bottom-line, reduction of defect rate or bug rate, reduction of cost of poor quality (COPQ), improvement of process capability and reduction in the number of customer complaints.

The integration of Six Sigma with quality management systems is a further step towards TQM. Future challenges for the implementation of Six Sigma will be the link of Six Sigma with the existing approaches of quality management and a smart qualification which is oriented at the existing knowledge in the organisations. In order to demonstrate the call for action for linking the approaches of Six Sigma and quality management systems (QMS), the strengths and weaknesses of each approach should be presented. Main challenges for a successful implementation of Six Sigma might be the smart integration in existing management systems. However, in the scope of Six Sigma projects, single process steps have to be systematically analyzed and improved.

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