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Provide a Model to Identify and Rank the Challenges of Implementing Six Sigma in Manufacturing Industries

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Abstract

Background/Objectives: Iran's automotive industry is not expected progress despite efforts to create suitable quality control methods such as TQM and Six Sigma. There's much debate but the most important thing that can be referred to lack of sufficient information on the factors and key challenges to effective implementation of quality processes such as Six Sigma. **Methods/Statistical Analysis:** In this study to identify factors and challenges in the implementation of Six Sigma deals and finally, the optimal allocation of resources and help managers decide to pay Ranking Factors. This study from the method perspective of descriptive-survey and from the target perspective of application. Place territory inquiries are Iran Khodro and Saipa companies and the period of study on 1393. To identify the factors affecting the implementation of Six Sigma was used the Delphi method and to determine relationships between variables was used structure equations model. The rating factors identified as AHP Fuzzy Multi Attribute Decision Making techniques. **Results:** As a result, 5 variables were identified as the most important factors affecting the implementation of Six Sigma: Top management commitment, training systems, prioritization of projects, customer-oriented, and organizational culture. Finally, based on the FAHP commitment of senior management, organizational culture, educational system, customer focus and prioritization of projects were ranked. **Conclusion/Application:** The objective of this paper is identify factors and challenges in the implementation of Six Sigma deals and finally, for help managers to resource allocation decisions, rank the factors described above.

Keywords: FAHP, Important Factors, Six Sigma, SEM

1. Introduction

The six sigma is a set of techniques and tools for organization performance improvement by reducing time consuming and wasting issues. It is a trade marketing approach which improves system management, business and financial issues by considering the costumer satisfaction. Previous studies and researches[1,2] specified the benefits of six sigma in project management, engineering and business system. Six sigma methodology to reduce defects in the manufacturing sector, first as a cost and cycle time work was introduced and has quickly consolidated its position in the manufacturing organization[3]. Perhaps it is stated that the application of Six Sigma developed for various reasons, such as modifying compensation or poor customer satisfaction. On the other hand, several studies are indicating a failure of the implementation of Six Sigma in manufacturing[4]. Browse failure Six Sigma projects reflects the fact that despite the recognition of the benefits of Six Sigma methods and factors affecting it, the position of these factors is not well understood as[5] stated that less than 50 percent of the surveys are satisfied with their Six Sigma programs. On the other hand, the automotive industry in our country has made significant progress in recent years but is still a good position in the global markets. One of the most important reasons that experts have pointed to improvement is not expected despite the automotive industry's efforts to

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create suitable quality control methods such as TQM and Six Sigma. There's much debate but the most important matter is referred to the lack of sufficient information on the factors and key challenges to effective implementation of quality processes such as Six Sigma. Therefore, in this study to identify factors and challenges in the implementation of Six Sigma deals and finally, for help managers to resource allocation decisions, rank the factors described above.

2. Literature Review

Six-Sigma is a concept that was originated by Motorola Inc. in the USA in about 1985. At the time,they were facing the threat of Japanese competition in the electronics industry and needed to makedrastic improvements in their quality levels. Six-Sigma was a way for Motorola to express its qualitygoal of 3.4 DPMO where a defect opportunity is a process failure that is critical to the customer much as 1.5 S.D. off the target. Factoring a shift of 1.5 S.D. in the process mean then results in a 3.4 DPMO. This goal was far beyond normal quality levels and required very aggressive improvement efforts. Some of the process for fast tracking and increasing the system response can be operate with lower sigma levels. Which is depends on the strategic importance of the process and its value. If a process is at the two or three sigma level, it will be relatively easy and cost effective to reach the four sigma level. However, difference between five or six sigma levels with two or three sigma levels is higher and requires more cost and time to achieve desirable results. Six Sigma's implicit aim is to improve all processes, but not to the 3.4 DPMO level necessarily. Organizations need to determine an appropriate sigma level for each of their most important processes and strive to achieve these. As a result of this goal, it is incumbent on management of the organization to prioritize areas of improvement. In overall it can be said that the return on investment for the improvement effort and the strategic importance of the process specify whether the process should be improved and the appropriate target sigma level as anaim[5]. Previous researches have not studied the six sigma classification in detail, which resulted in some confusion and disarrangement in six sigma process. In this paper to develop the concepts and principles of Six Sigma, the following definition is offered: Six Sigma is an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates.

In order to achieve the best results of Six Sigma, the main contribution is covering costumer requirements and determining the critical points relative to quality.

One popular method uses Define Measure, Analyze, Improve and Control (DMAIC) as the five steps in process improvement. A somewhat different set of steps called Design for Six Sigma is used for radical or incremental product design (define, measure, analyze, design and verify). Whatever method is chosen, however, it is important that the method be carefully followed and a solution not offered until the problem is clearly defined. Data and objective measurement is critical at each step of the method. The standard statistical quality tools are incorporated into the structured method as needed. However, Six Sigma guidelines demonstrate an integration of proper tools at each step of the method. This careful integration of tools with the methods is unique to Six Sigma. Six Sigma uses a variety of improvement specialists to achieve its goals, often referred to as Black Belts, Master Black Belts, Green Belts and Project Champions. Full-time Black Belts lead improvement projects and typically receive 4 weeks of training. Master Black Belts receive even more training, and generally serve as instructors and internal consultants. Green Belts are part-time improvement specialists that receive less training since they provide supporting roles on the improvement projects. Finally, Project Champions who identify strategically important projects for the improvement teams and provide resources, typically receive an orientation to Six Sigma rather than detailed training. As can be seen, intensive and differentiated training is an integral part of the Six Sigma approach. Now that Six Sigma has been defined the main tenets of goal theory are considered which forms a basis for understanding Six Sigma.

Antony et al. (2003), and Fuller (1994) investigated the six sigma approach according to statistical, randomness, quantitative and qualities standards. From the statistical point of view, the term six sigma is defined as having less than 3.4 defects per million opportunities or a success rate of 99.9997% where sigma demonstrates the difference of process mean. If mentioned process operates at three sigma level for quality control, this is interpreted as achieving a success rate of 93% or 66,800 defects per million opportunities. It is concluded that, the six sigma method is a strict method from the quality control view, for this reason most of the systems and mangers still use a three sigma for their organization. In other words, three sigma can improve the system characteristics and performance acceptably in regard to six sigma, which saves cost and time consuming. The manger of organization should determines the sigma level according to organization policy and importance.

3. Research Method

Our research method regarding the object isapplied and regarding the collecting data is descriptive–survey. The collecting data tool is aquestionnaire. The method of collecting data in the questionnaires is the DELPHI method. To determine the validity of questionnaire was used of the Inconsistency Rate. That according to this that the calculated coefficient is equal to 0.0024, then its stability can be confirmed. Since the more a decision making to be involved in the human source and complex systems, the more fuzzy phenomenon is dominant in the system, we use of the fuzzy method to rank the suppliers.

Our cases in a random way selected and include all the experts of Iran Khodro and Saipa corporations (100 individuals).

Sampling method in first phase is simple random and the determination of sample size follows Cochran's formula:

$$n = \frac{N \times z^2_{\alpha/2} \times p \times q}{\varepsilon^2 \times (N-1) + z^2_{\alpha/2} \times p \times q} = \frac{100 \times (1.96)^2 \times 0.5 \times 0.5}{(0.05)^2 \times 99 + (1.96)^2 \times 0.5 \times 0.5} \approx 79$$

Therefore, the required sample size is 79 people.

Since the second phase used fuzzy hierarchical analysis methodfor the ranking of factors, in this phase will not be sampled and selected all experts to answer (6 individuals).

In this paper in order to identify key factors to successfully implement Six Sigma in manufacturing industry after studying the history of research using the Delphi method to identify the most important challenges described above. Then, using structural equation model to determine the relationship of each of the key factors in the implementation of Six Sigma and finally we ranking the key factors with fuzzy Analytical Hierarchy Process based on the degree of importance.

4. Data Analysis

Structural Equation Modeling (SEM) was conducted to estimate the fitness of the model, and to perform the SEM analysis the LISREL 8.30 program was used. The most practical indices were used to estimate the model fitness, including: X^2/df, Root Mean Square Error of Approximation (RMSEA), Goodness of Fit Index (GFI), Comparative Fit Index (CFI) and Adjusted Goodness of Fit Index (AGFI). Scores lower than 5 for the X^2/df index reveals an acceptable rate; in other words, smaller scores in this index indicate a better fitness of the model. In this study, the X^2/df was 1.051, which attests to the appropriate fitness of the model. An RMSEA equal to or lower than 0.05 is suitable for tested models, but scores above 0.05 and up to 0.08 propose an agreeable error of approximation in the model. Models with their RMSEA at 0.10 and higher are considered to have low fitness. GFI and AGFI show to what degree the model hasbetter fitness when compared to the model's non-existence. For the model to be acceptable, GFI, AGFI and CFI should be equal to or higher than 0.90. Figure 1 shows the research model.

Table 1 shows the goodness of fit indices for the estimated model. As can be seen, the X^2/df score is 1.123, which lies within the acceptable range. Additionally, the RMSEA score is 0.029, which is lower than 0.08, and is thus within the acceptable range. The scores for AGFI, GFI and CFI, which are 0.803, 0.83and 0.993, respectively, reveal the acceptability of these scores for the model. In total, one can say the examined model has an appropriate fitness. Table 1 shows the Goodness of fit indices for the second-rank model.

And finally we prioritize key factors based on importance. This is so important because we have limited resources and the complexity of decision is high and this ranking helps managers allocate resources and appropriate

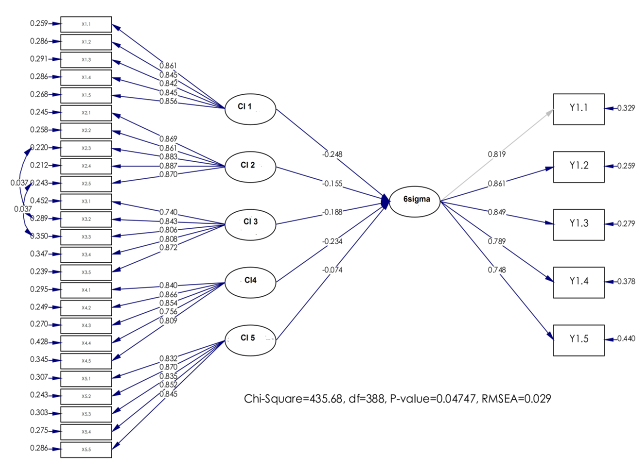

Figure 1. Research model.

Table 1. Goodness of fit indices for the second-rank model

(6)	(5)	(4)	(3)	(2)	(1)	
					0.819	1. Six Sigma
				0.826	-0.534	2. Top management support
			0.818	0.423	-0.441	3. Education System
		0.822	0.423	0.491	-0.509	4. Project prioritization
	0.827	0.483	0.327	0.419	-0.503	5. Organizational Culture
0.801	0.315	0.281	0.307	0.389	-0.345	6. Customer relationship management
0.684	0.677	0.675	0.669	0.683	0.671	AVE
0.889	0.903	0.917	0.921	0.917	0.901	CR
0.799	0.876	0.877	0.881	0.877	0.889	Cronbach's Alpha
3.559	3.303	3.324	3.157	3.225	2.380	Average

Chi-Square = 435.68, df = 388, (χ^2/df = 1.123<3), RMSEA = 0.029<0.1, AGFI = 0.803>0.8, GFI = 0.83>0.8, CFI = 0.993>0.9, NFI = 0.95>0.9, NNFI = 0.992>0.9, IFI = 0.993>0.9, RFI = 0.944>0.9,

decision that allocate resources to the factors have the greatest impact on the implementation of Six Sigma.

Then we explained the fuzzy analytic hierarchy process in accordance with the structure of the study.

4.1 Establish a Hierarchical Structure with Elements of the Decision

After the formation of hierarchical structure strategies at each level of the hierarchy are mutually connected at a higher level compared to the strategy. Table 2 shows the Standards paired comparison matrix.

4.2 Create a Positive Fuzzy Matrix

According to Buckley (1985) matrix two positive Fuzzy matrix numbers is defined as follows:

$$\tilde{R} = [\tilde{r}_{ij}]^k \qquad (1)$$

Table 3 shows the Standards paired comparison fuzzy matrix.

4.3 Fuzzy Weight

Based on the Lambda-Max method that was developed in 2001 by Buckley and Stvra that calculates the fuzzy weight

Table 2. Standards paired comparison matrix

Customer relationship management	Organizational Culture	Project prioritization	Education System	Top management support	
3	2	2	1	1	Top management support
0.5	3	3	1	1	Education System
1	3	1	0.33	0.5	Project prioritization
2	1	0.33	0.25	0.5	Organizational Culture
1	0.5	1	2	0.33	Customer relationship management

Table 3. Standards paired comparison fuzzy matrix

Customer relationship management	Organizational Culture	Project prioritization	Education System	Top management support	
(2,3,4)	(1,2,3)	(1,2,3)	(1,1,1)	(1,1,1)	Top management support
(0.5,0.7,1)	(2,3,4)	(2,3,4)	(1,1,1)	(1,1,1)	Education System
(1,1,1)	(2,3,4)	(1,1,1)	(0.33,0.5,1)	(0.5,0.7,1)	Project prioritization
(1,2,3)	(1,1,1)	(0.33,0.5,1)	(0.25,0.33,0.5)	(0.5,0.7,1)	Organizational Culture
(1,1,1)	(0.5,0.7,1)	(1,1,1)	(1,2,3)	(0.33,0.5,1)	Customer relationship management

$$W_b^k = (w_i)_b^k; w_a^k = (w_i)_a^k; W_c^k = (w_i)_c^k, \mathrm{i} = 1, 2, \ldots, \mathrm{n} \tag{2}$$

$$M_a^k = \min\left(\frac{W_{ib}^k}{W_{ia}^k} | 1.\mathrm{i.n}\right) \tag{3}$$

$$M_c^k = \min\left(\frac{W_{ib}^k}{W_{ic}^k} | 1.\mathrm{i.n}\right) \tag{4}$$

$$W_{ia}^{*k} = M_a^k W_{ia}^k \tag{5}$$

$$W_{ia}^{*k} = M_c^k W_{ic}^k \tag{6}$$

Thus, the initial Fuzzy weights will be as follows:

Table 4 shows the Initial Fuzzy weights.

And according to the description. Table 5 shows the Final Fuzzy weights.

4.4 Integrating the Views of Decision Makers and End-Prioritizing

The geometric mean used for the combined fuzzy weights of the decision-making.

$$\tilde{W}_t = \left(\prod_{k=1}^{k} \tilde{W}_i^k\right)^{\frac{1}{k}}, \forall k = 1, 2, \ldots, K \tag{7}$$

$$0.CC_i.1; CC_i = \frac{d - (\tilde{W}_i, 0)}{\mathrm{d}^*(\tilde{W}_i, 1) + d - (\tilde{W}_i, 0)} \tag{8}$$

Table 6 shows the the final weight of the criteria.

As seen in Table 5 is the most important strategy of top management commitment and then the factors of organizational culture, educational system, customer relationship management and Project prioritization.

Table 4. Initial Fuzzy weights

W_1^1	(0.24,0.36,0.48)
W_2^1	(0.36,0.48,0.6)
W_3^1	(0.18,0.27,0.38)
W_4^1	(0.11,0.17,0.24)
W_5^1	(0.17,0.24,0.38)

Table 5. Final Fuzzy weights

W_1^1	(0.29,0.36,0.38)
W_2^1	(0.44,0.48,0.48)
W_3^1	(0.22,0.27,0.30)
W_4^1	(0.14,0.17,0.19)
W_5^1	(0.2,0.28,0.38)

Table 6. Final prioritize factors affecting the implementation of six sigma in the automotive industry

Rank	W_i		CC_i		$d^*(\tilde{W}_t, 1)$	$d^-(\tilde{W}_t, 0)$	
1	0.4685	W_1	0.47	CC_1	0.53	0.46	Top management support
3	0.2864	W_2	0.27	CC_2	0.73	0.27	Education System
5	0.246	W_3	0.16	CC_3	0.87	0.16	Project prioritization
2	0.308	W_4	0.35	CC_4	0.65	0.35	Organizational Culture
4	0.2687	W_5	0.17	CC_5	0.83	0.17	Customer relationship management

5. Conclusion

The findings of this research will help to develop knowledge of Six Sigma because we have tried to provide empirical and accordance evidence for Iranian managers and planners organizations to take better decisions about organizational resources. In the recent years the advantages of using six sigma in improving the organization quality and performance are highlighted. Factors influencing successful six sigma projects include management involvement and organizational commitment, project management and control skills, cultural change, and continuous training. Considering the main characteristics, disadvantages, and shortcomings of six sigma provides possibility to achieve the best performance and operation of six sigma. It allows them to better support their organization's strategic direction and increasing needs for coaching, mentoring, and training. The statistical aspects of six sigma must complement business perspectives and challenges to the organization to implement six sigma projects successfully. Various approaches to six sigma have been applied to increase the overall performance of different business sectors.

However, integrating the data-driven, structured six sigma processes into organizations still needs improvement. Cultural changes require time and commitment before they are strongly implanted into the organization. Considering the main characteristics, obstacles, and shortcomings of the six sigma method allows organizations to better support their strategic directions, and increasing needs for coaching, mentoring, and training. It also provides opportunities to better implement six sigma projects. The objective of this study is identify factors and challenges in the implementation of Six Sigma deals and finally, for help managers to resource allocation decisions, rank the factors described above.

Top management's commitment to quality is a key element in the successful implementation of Six Sigma. This commitment to design fault-free processes to reduce the deviation and variation processes and creating sustainable processes to improve the performance. The importance of organization culture in second place shows that successful implementation of Six Sigma is to create a new culture that able to make the changes needed to achieve continuous improvement. A change in the current culture of an organization requires honest attitude. Project prioritization showed that Six Sigma projects should be targeted on improving processes and products that have a direct impact on the company's financial and operational objectives. Thus, each project must determine the relevance of the strategy. Since the Six Sigma principles and techniques of advanced statistical variation exists, personnel training, is a key factor in success. The Six Sigma program, the knowledge about the function of process improvement methodologies, tools and techniques of statistical process, the activities of the project team, implementation, and use of customer requirements is essential.

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