A Fuzzy AHP Approach to Prioritization of Critical Success Factors for Six Sigma Implementation: Evidence from the Electronics Industry in Thailand

N. Somsuk and C. Simcharoen

***Abstract*—Six Sigma quality improvement methodology has received considerable attention in many manufacturing and service industries. There have been some studies identifying critical success factors for Six Sigma implementation. Within the resource constraints, an immediate adoption of all critical success factors may not be allowed. In order to be able to consolidate resources in some of the most important factors, the prioritization of critical success factors need to be determined. This will enable Six Sigma practitioners and policy makers to understand the relative importance among the factors and develop improvement strategies for resource provision. This paper aims to present fuzzy extended analytic hierarchy process (fuzzy AHP) based methodology with the use of triangular fuzzy numbers for pairwise comparison scale to prioritize critical success factors for Six Sigma implementation. The weights of critical success factors are determined by nine experts including six managers, two Six Sigma Black-Belts and one Brown-Belt from three multinational companies in the electronics industry located in Thailand. This paper is the first attempt to prioritize the critical success factors of implementing Six Sigma methodology by using fuzzy AHP approach. Finally, this paper concludes with contributions and suggestions for future research.**

***Index Terms*—Critical Success factors, fuzzy AHP, prioritization, six sigma**

I. Introduction

Six Sigma can be defined as a systematic approach that includes total quality management, strong customer focus, additional data analysis tools, financial results and project management [1]-[3] for strategic process improvement that relies strongly on statistical tools and scientific method to make reductions in customer-defined defect rates [4], [5]. Six Sigma applies a structured method to managing improvement activities, which is represented by a step-by-step problem-solving method as following: Define–Measure–Analyze–Improve–Control (DMAIC) used in process improvement or Define–Measure–Analyze–Design–Verify (DMADV) used in product/service design improvement [5]-[7].

One use of Six Sigma implementation is to improve the quality of process outputs by identifying and eliminating the causes of errors (or defects or failures) [8], [9] and minimizing variability in manufacturing and business processes by focusing on outputs that are critical to customers [8].

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Six Sigma has not only been widely and increasingly implemented [7], but also recognized as a powerful approach to achieve process improvements in both manufacturing and service industries [10]. The successful implementation of Six Sigma within organizations can give them an edge over their competitors.

To improve the success of Six Sigma implementation, there have been several studies in the literature that investigate to identify critical success factors and criteria of implementing Six Sigma methodology. But even though all critical success factors are known consequently organizations have to deal with a wide range of success factors. In fact, it is always infeasible for organizations to devote their efforts and resources to all critical success factors. Therefore, in order to be able to consolidate their efforts and resources in some of the most important factors, the prioritization of critical success factors need to be determined, and then only some critical success factors with the highest priority may be emphasized during the Six Sigma implementation process. So that Six Sigma managers can appropriately plan for resource allocation.

In order to incorporate expert opinions (usually subjective) through questionnaires, a fuzzy AHP is applied to obtain more decisive judgments by prioritizing the critical success factors and weighting them in the presence of vagueness. The fuzzy AHP approach uses the concepts of fuzzy set theory and hierarchical structure analysis to evaluate critical success factors in pairs, and quantify the relative importance of each factor to the successful implementation. By using fuzzy AHP approach, based on Chang's (1996) extent analysis, this paper is the first attempt to prioritize the critical success factors of implementing Six Sigma methodology. The knowledge on the prioritization of critical success factors of implementing Six Sigma will lead to better understanding of the operational and strategic management in the future. Moreover, this paper enables managers and practitioners to focus on some of the most important critical success factors in successful implementation of Six Sigma.

The remainder of this paper is organized as follows. The next section reviews the relevant literature and case studies. Section III describes the research methodology. Section IV presents an application of an integrated fuzzy AHP model to Six Sigma, and the research results. The last section includes conclusions, implications, limitations and future research directions.

II. Literature Review and Case Studies

A. Determining Success Criteria and Critical Success Factors for Implementing Six Sigma Methodology

From the various success criteria found in the literature review, the most critical success criteria of Six Sigma implementation are in terms of (defect reductions resulting) yield improvements, improved customer satisfaction and higher financial saving. It is possible to identify three Six Sigma success criteria in this study, as follows:

- Financial savings [11]-[13]: It can be described in many forms of savings related Six Sigma project(s) with perceived success including risk avoidance and cost avoidance [13].
- Customer satisfaction improvement [11], [12]: It is typically defined as an overall assessment of the performance of various attributes that constitute a product or a service [14]-[17]. The level of customer satisfaction can be improved by achieving operational excellence and then monitoring customer feedback periodically.
- Yield improvement: It can be defined as the percentage reduction in rejects or defects within a period of time. So, the yield of a process can be improved by reducing the rejects or defects, or achieving better control of a process (reducing process deviation) [18].

According to Brun’s study [19] on “critical success factors” (CSFs) of Six Sigma implementation, gathered from the 18 research papers, the five most frequently of CSF highlighted in these papers are adopted as CSFs in this paper. Three success criteria of Six Sigma implementation are as follows:

- Management involvement and commitment: It can be described as the top management involvement and provision of appropriate resources and training [20] and the continuous support and commitment from top management [21].
- Organizational infrastructure and culture: It can be described as having the necessary resources (such as some degree of skills communication, long term strategy, teamwork, the belt system and the project sponsors) to invest on the Six Sigma projects and to support the Six Sigma introduction and development program [22], [23].
- Education and training: The Six Sigma's education and training through the “belt system” (Black Belt, Green Belt, etc.) involve the large number of people [23]. The Six Sigma's belt-based education and training system makes the setting up and execution of Six Sigma projects much easier throughout the organization [22], [23].
- Linking Six Sigma to business strategy: It can be described as the establishment of a link between the Six Sigma project objectives and the business strategy in each Six Sigma project [22].
- Linking Six Sigma to customer: It can be described as the establishment of a link between the customer requirements and each of Six Sigma projects [22], [23]. In the process of linking Six Sigma to customer, there can be two main steps: (i) identifying the core processes, defining the key outputs of these processes and defining the key customers that they serve, and (ii) identifying and defining the customer needs and requirements [22].

B. Case Studies

Our case studies are manufacturers of computer-related products located in Thailand. They are a major player in the global market for many products, such as hard disk drives (HDDs), spindle motors for HDDs, semiconductors, and integrated circuit devices. These manufacturers have been dealing with Six Sigma projects such as cycle time reduction, minimizing their production/ operational costs, customer service improvement, and reducing response time for customer service excellence, etc. In this paper, an application of the fuzzy AHP method to prioritize the critical success factors of implementing Six Sigma methodology will be presented by using these case studies.

C. A Panel of Experts

A panel of experts is formed based on their knowledge, experience, and skills of training and implementing Six Sigma projects. Experts with multiple perspectives should be incorporated in the decision-making process by selecting the experts from different organizations [24]. Our nine experts consisting of six managers, two Black-Belts and one brown-belt from three multinational companies in the electronics industry located in Thailand. The experts have a mean experience in Six Sigma project/ implementation of 7.3 years (SD = 3.3).

D. Suitability of Fuzzy AHP for Success Factor Prioritization Problem in Six Sigma Implementation

The traditional AHP [25], [26] has been widely used across various industries in many applications such as for project selection [27], [28] allocating resources, and setting priorities [28], [29].

In this paper, we use a fuzzy AHP approach, based on Chang's (1996) extent analysis, to determine the weights of critical success factors of Six Sigma implementation because the weight determination problem primarily depends on subjective judgment or preference of experts in the field of Six sigma. In such a subjective judgment or preference, using a crisp value for pairwise comparison is not suitable because it does not accurately represent the individual semantic cognition state of the decision makers [28]. Fuzzy logic [30] is a proven scientific technique that allows us to convert linguistic measures into crisp measure using membership functions [28].

E. The Fuzzy Set Theory

The fuzzy set theory [30] is designed to deal with the extraction of the possible outcome from a variety of information expressed in vague and imprecise terms [31]-[33]. Fuzzy set theory treats to express vague data as a certain distribution which can be effectively implemented for logical reasoning, in terms of membership functions [31], [33].

In this paper each linguistic variable is defined by triangular fuzzy number because of its simplicity and computational efficiency [34]-[39]. According to the definition of Laarhoven and Pedrycz [40], a triangular fuzzy number should possess the basic features as following:

The fuzzy number A on a real number (R) to be a triangular fuzzy number if its membership function $\mu_A(x): R \to [0,1]$ is defined as

$$\mu_A(x) = \begin{cases} (x-l)/(m-l), & l \le x \le m, \\ (u-x)/(u-m), & m \le x \le u \\ 0, & otherwise \end{cases},$$

where l and u represent the lower and upper bounds of the fuzzy number A, respectively, and m is the most promising value of the fuzzy number A.

The triangular fuzzy number A is parameterized by the triplet (l,m,u). The operational laws of two triangular fuzzy numbers $A_1=(l_1,m_1,u_1)$ and $A_2=(l_2,m_2,u_2)$ are defined as follows [41], [42]:

Fuzzy number addition $\oplus$:

$$A_1 \oplus A_2 = (l_1,m_1,u_1) \oplus (l_2,m_2,u_2) = (l_1+l_2, m_1+m_2, u_1+u_2)$$

Fuzzy number subtraction Θ:

$$A_1 \ \Theta \ A_2 = (l_1,m_1,u_1) \ \Theta \ (l_2,m_2,u_2) = (l_1-l_2, m_1-m_2, u_1-u_2)$$

Fuzzy number multiplication $\otimes$:

$$A_1 \otimes A_2 = (l_1,m_1,u_1) \otimes (l_2,m_2,u_2) = (l_1l_2, m_1m_2, u_1u_2)$$

Fuzzy number division $\varnothing$:

$$A_1 \varnothing A_2 = (l_1,m_1,u_1) \varnothing (l_2,m_2,u_2) = (l_1/u_2, m_1/m_2, u_1/l_2)$$

Fuzzy number reciprocal:

$$(\widetilde{A})^{-1} = (l,m,u)^{-1} \cong (1/u, 1/m, 1/l) \text{ for } l,m,u>0$$

F. Fuzzy AHP Method

With the traditional AHP not being able to overcome the deficiency of the fuzziness during decision making, Laarhoven and Pedrycz [40] have evolved the traditional AHP into the fuzzy AHP by adapting the triangular fuzzy number of the fuzzy set theory into the pairwise comparison matrix of the AHP, for the purpose of solving vague problems, which occur during the analysis of criteria and judgment process [31], [40], [43], [44]. In this paper, Chang's (1996) extent analysis method [45], [46] is applied to the evaluation the critical success factors since the steps of this approach is similar to the traditional AHP and relatively easier than the other fuzzy AHP approaches [47], [48].

Triangular fuzzy numbers are used to represent subjective pairwise comparisons of experts' judgments. In this paper, the triangular fuzzy conversion scale is used to convert such linguistic scales into fuzzy scales in the evaluation model as shown in Table I.

TABLE I: MEMBERSHIP FUNCTION OF LINGUISTIC SCALE

Linguistic scales	Membership function
Equally important	(1, 1, 3)
Weakly important	(1, 3, 5)
Essentially important	(3, 5, 7)
Very strong important	(5, 7, 9)
Absolutely important	(7, 9, 9)

First the outlines of the extent analysis method on fuzzy-AHP are given and then the method is applied to a prioritization problem. Let $X=\{x_1, x_2, \ldots, x_n\}$ be an object set, and $U=\{u_1, u_2, \ldots, u_m\}$ be a goal set. According to Chang's [46] extent analysis, each object is taken and extent analysis for each goal is performed respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$M_{g_i}^1, M_{g_i}^2, \ldots, M_{g_i}^m, \ \ i=1,2,\ldots,n$$

where all the $M_{g_i}^j \ (j=1,2,\ldots,m)$ are triangular fuzzy numbers.

The procedure of fuzzy AHP can be given as following steps:

Step 1: Computing the value of fuzzy synthetic extent with respect to the i^{th} object, S_i.

Consider a triangular fuzzy comparison matrix expressed by

$$=\begin{bmatrix} M_{g1}^1 & M_{g1}^2 & \cdots & M_{g1}^m \\ M_{g2}^1 & M_{g2}^2 & \cdots & M_{g2}^m \\ \vdots & \vdots & \vdots & \vdots \\ M_{gn}^1 & M_{gn}^2 & \cdots & M_{gn}^m \end{bmatrix}$$

for $i=1,2,\ldots,n,\ j=1,2,\ldots,m$, if $i=j$ then $M_{g_i}^j=(1,1,1)$.

Then the value of fuzzy synthetic extent with respect to the i^{th} object is defined as

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j \right]^{-1} \qquad (1).$$

Step 2: Computing the degree of possibility of $S_i \ge S_j$ by the following equation;

$$V(S_i \ge S_j) = height(S_j \cap S_i) = \begin{cases} 1, & if\ m_i \ge m_j \\ 0, & if\ l_j \ge u_i \\ \frac{l_j-u_i}{(m_i-u_i)-(m_j-l_j)}, & otherwise \end{cases} \qquad (2)$$

where $S_i=(l_i, m_i, u_i)$ and $S_j=(l_j, m_j, u_j)$.

To compare S_i and S_j, both the value of $V(S_i \ge S_j)$ and $V(S_j \ge S_i)$ must be calculated.

Step 3: Computing the minimum degree possibility:

$Min\,V(S \ge S_1, S_2, \ldots, S_k)$

The degree of possibility of a convex fuzzy number to be greater than k convex fuzzy numbers S_i (for $i=1,2,\ldots,k$) can be defined as $V(S \ge S_1, S_2, \ldots, S_k)$

$$= V((S \ge S_1)\ and\ (S \ge S_2)\ and \ldots and\ (S \ge S_k)) \qquad (3).$$

Therefore, $Min\,V(S \ge S_1, S_2, \ldots, S_k)$

$$= Min\,V((S \ge S_1)\ and\ (S \ge S_2)\ and \ldots and\ (S \ge S_k)) \qquad (4)$$

Assume that $w_i' = Min\ V(S_i \ge S_k)$ for $k=1,2,\ldots,n$; $k \ne i$, then the weight vector is defined as

$$W' = (w_1', w_2', \ldots, w_n')^T \qquad (5)$$

Step 4: Normalizing the weight vectors.

Via normalization, the normalized weight (or priority) vectors $W=(w_1, w_2, \ldots, w_n)^T$ are computed as follows:

$$w_i = \frac{w_i'}{\sum_{i=1}^{n} w_i'} \qquad (6).$$

The priority vector W is a nonfuzzy (crisp) value.

III. Research Methodology

Via pairwise comparison, the pairwise comparison matrix called fuzzy judgment matrix is constructed. In this research, the triangular fuzzy number of the fuzzy set theory is brought directly into the pairwise comparison matrix of the AHP. The procedure of the fuzzy AHP is described as follows:

Step 1: Defining the problem and objective

The objective of this study is the prioritization of critical success factors for Six Sigma implementation. This objective can be achieved by analyzing the effects of the critical success factors on the success criteria.

Step 2: Developing a hierarchy model

Fuzzy AHP, an effective technique for analyzing a complex problem, can be applied for establishing weights in the hierarchical structure of environmental effects at each level. We establish a hierarchical structure for prioritization of critical success factors for Six Sigma implementation as shown in Fig 1. The hierarchical structure systematically accommodates the use of expert judgment.

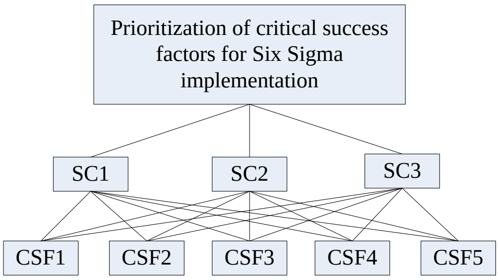

Fig 1. Hierarchical structure for prioritization of critical success factors for six sigma implementation.

where,

SC1 = Financial savings
SC2 = Customer satisfaction
SC3 = Yield improvements
CSF1 = Management involvement and commitment
CSF2 = Organizational infrastructure and culture
CSF3 = Education and training
CSF4 = Linking Six Sigma to business strategy
CSF5 = Linking Six Sigma to customer

Fig. 1 depicts a 3-level AHP model of prioritization of critical success factors of implementing Six Sigma methodology, by presenting the structural relationship between the success criteria and the critical success factors. The first level of the model expresses the overall goal of this study, which is the prioritization of critical success factors for Six Sigma implementation. This goal can be achieved by analyzing the effects of the critical success factors on the success criteria. The second level presents the three of success criteria. The lowest level features the critical success factors.

Step 3: Establishing the fuzzy judgment matrix

We establish a fuzzy judgment matrix for each of the lower level elements, and then make the comparison of elements using the pairwise comparison approach, the relative importance of the elements at the same level with respect to the element of their preceding level. Assign linguistic terms [28], [42] shown in Table I based on each expert's subjective judgments, to the pairwise comparisons by asking which one of two criteria (or of five critical success factors) is more important and how much more important is it with respect to the element of their preceding level.

Step 4: Aggregating opinions from several experts by using geometric mean

The informed judgments from a group of experts are aggregated through the geometric mean of individual experts' judgments. Let M_{ij}^k represent a subjective judgment of the k^{th} expert for the relative importance of two criteria (the i^{th} criterion-the j^{th} criterion). The fuzzy geometric mean M_{ij} from m experts is as following equation

$$M_{ij} = (M_{ij}^1 \otimes M_{ij}^2 \otimes \cdots \otimes M_{ij}^m)^{1/m} \quad (7)$$

IV. Research Results

As results of fuzzy evaluation of criteria and success factors with respect to SC1 (there are other two fuzzy evaluation of success factors with respect to SC2 and SC3,) which are the geometric mean values of the fuzzy judgment matrices are shown in Tables II and III.

TABLE II: Fuzzy Comparison Matrix of Three Success Criteria with Respect to the Goal

	SC1	SC2	SC3
SC1	(1, 1, 1)	(0.42, 0.66, 0.96)	(0.50, 0.71, 1.58)
SC2	(1.04, 1.53, 2.37)	(1, 1, 1)	(1.23, 1.83, 2.53)
SC3	(0.63, 1.40, 2.01)	(0.39, 0.55, 0.81)	(1, 1, 1)

TABLE III: Fuzzy Comparison Matrix of Five Critical Success Factors with Respect to SC1

	CSF1	CSF2	CSF3	CSF4	CSF5
CSF1	(1, 1, 1)	(0.89, 1.43, 3.18)	(0.81, 1.17, 2.63)	(0.91, 1.84, 3.43)	(0.40, 0.67, 1.31)
CSF2	(0.31, 0.70, 1.12)	(1, 1, 1)	(0.91, 1.24, 2.73)	(0.40, 0.53, 1.17)	(0.17, 0.22, 0.38)
CSF3	(0.38, 0.85, 1.24)	(0.37, 0.81, 1.10)	(1, 1, 1)	(0.41, 0.69, 1.35)	(0.43, 0.72, 1.43)
CSF4	(0.29, 0.54, 1.10)	(0.85, 1.89, 2.49)	(0.74, 1.44, 2.42)	(1, 1, 1)	(0.40, 0.60, 1.24)
CSF5	(0.76, 1.48, 2.49)	(2.63, 4.51, 5.96)	(0.70, 1.39, 2.35)	(0.81, 1.68, 2.49)	(1, 1, 1)

Taking the fuzzy judgment matrix of three criteria as an example, we calculate TFN values of three criteria by using the fuzzy evaluation values in Table II.

TFN values of criteria are as follows:

$$\begin{aligned} S_{1(SC1)} &= (1.92, 2.37, 3.54) \otimes (7.21, 9.68, 13.26)^{-1} \\ &= (1.92, 2.37, 3.54) \otimes (1/13.26, 1/9.68, 1/7.21) \\ &= (0.14, 0.24, 0.49) \end{aligned}$$

$$\begin{aligned} S_{2(SC2)} &= (3.27, 4.36, 5.90) \otimes (7.21, 9.68, 13.26)^{-1} \\ &= (3.27, 4.36, 5.90) \otimes (1/13.26, 1/9.68, 1/7.21) \\ &= (0.25, 0.45, 0.82) \end{aligned}$$

$$S_{3(SC3)} = (2.02, 2.95, 3.82) \otimes (7.21, 9.68, 13.26)^{-1}$$
$$= (2.02, 2.95, 3.82) \otimes (1/13.26, 1/9.68, 1/7.21)$$
$$= (0.15, 0.30, 0.53)$$

We calculate the degree of possibility of $S_i = (l_i, m_i, u_i) \geq S_j = (l_j, m_j, u_j)$ as follows:

$$V(S_{1(SC1)} \geq S_{2(SC2)}) = \frac{0.25 - 0.49}{(0.24 - 0.49) - (0.45 - 0.25)} = 0.53$$

$$V(S_{1(SC1)} \geq S_{3(SC3)}) = \frac{0.15 - 0.49}{(0.24 - 0.49) - (0.30 - 0.15)} = 0.85$$

$$V(S_{2(SC2)} \geq S_{1(SC1)}) = 1 \qquad (because of\ 0.45 \geq 0.24)$$

$$V(S_{2(SC2)} \geq S_{3(SC3)}) = 1 \qquad (because of\ 0.45 \geq 0.30)$$

$$V(S_{3(SC3)} \geq S_{1(SC1)}) = 1 \qquad (because of\ 0.30 \geq 0.24)$$

$$V(S_{3(SC3)} \geq S_{2(SC2)}) = \frac{0.25 - 0.53}{(0.30 - 0.53) - (0.45 - 0.25)} = 0.65$$

After that, we calculate the minimum degree possibility of $S_i \geq S_j$.

$$Min\, V(S_{1(SC1)} \geq S_{2(SC2)}, S_{3(SC3)}) = Min\,(0.53, 0.85) = 0.53$$
$$Min\, V(S_{2(SC2)} \geq S_{1(SC1)}, S_{3(SC3)}) = Min\,(1, 1) = 1$$
$$Min\, V(S_{3(SC3)} \geq S_{1(SC1)}, S_{2(SC2)}) = Min\,(1, 0.65) = 0.65$$

Then the weight vector obtained is as follows:

$$W' = (0.53, 1, 0.65)^T$$

Via normalization, the normalized weight vector obtained is as follows:

$$W = (0.24, 0.46, 0.30)^T$$

The calculations of local weights of the critical success factors with respect to the assessing criteria will not be given in this paper because they are similar to the calculation above. Finally, the overall weight of each success factor is calculated by multiplying its local priority weight with the 3 criteria relative weights.

After that we repeat the calculation of the local and overall weights for all levels in hierarchy. They can be calculated in the same way. They are not presented in this paper of space limitations. The results of prioritization for critical success factors are shown in Table IV.

TABLE IV: LOCAL AND OVERALL WEIGHT SCORE OF THE CRITICAL SUCCESS FACTORS AND THEIR PRIORITY RANKING

Critical success factor	Local weight score			Overall weight score	Priority ranking
	SC1 (0.24)	*SC2 (0.46)*	*SC3 (0.30)*		
CSF1	0.23	0.24	0.22	0.232	2
CSF2	0.14	0.18	0.19	0.173	4
CSF3	0.14	0.11	0.13	0.123	5
CSF4	0.20	0.20	0.24	0.212	3
CSF5	0.29	0.27	0.22	0.260	1

Parentheses ( ) denote the local weight of each success criterion.

Table IV shows the weights of critical success factors related to 3 criteria and also shows the overall weight and rank of each critical success factor. It can be concluded that from the experts' viewpoint through fuzzy AHP approach, linking Six Sigma to customer plays the most important role in improving the implementation of Six Sigma. The experts consider that management involvement and commitment is the second most important one, while education and training is the least important factor. To achieve the successful of Six Sigma implementation, they believe that customer satisfaction criterion should be focused most on those.

V. CONCLUSION

This paper studies the prioritization of the critical success factors in Six Sigma implementation by using the fuzzy AHP approach, based on Chang's (1996) extent analysis, which is applied to the electronics industry in Thailand, and this paper presents to demonstrate efficiency of the proposed approach. From literature review, three main success criteria and five critical success factors are determined and used in this study.

The prioritization of the critical success factors is very importance because it is infeasible to devote their efforts to all critical success factors. In promoting the success of implementing Six Sigma, practitioners and management team need to devote their efforts to some critical success factors that have the highest priority such as the linking Six Sigma to customer, and management involvement and commitment. Actually, in the beginning of implementing the Six Sigma, practitioners and management team should focus their efforts on the critical success factor that has the highest priority and gradually attend to the rest of the factors which have running priority afterwards. For the success criteria of implementing Six Sigma methodology, they need to focus on customer satisfaction as the first priority.

The priority of critical success factors enables practitioners and policy makers to understand the relative importance among the factors and develop an improvement strategy for an organization's resource provision.

For research limitations, the proposed methodology (fuzzy AHP, based on Chang's extent analysis) is tested only in our case studies, from three multinational companies in the electronics industry located in Thailand, which is the limitation of this paper. The robustness of the methodology can be tested by conducting several case studies in electronics industry and comparing the results with other countries or other existing methodologies.

Further studies may include sensibility analysis of the results of this study in order to determine the influence of these coefficients on the final result. The proposed approach of this study can be applied to different industries with more critical factors.

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