CHAPTER 5

PRIORITIZATION OF CRITICAL SUCCESS FACTORS AND SENSITIVITY ANALYSIS

This chapter, an application of the fuzzy AHP model to prioritize the critical success factors and criteria for functional upgrading is presented. The hierarchical model for prioritizing the critical success factors, which is linked to the RBV of the firm, the relational view, and the institutional theory based on the fuzzy AHP approach, is developed. Besides sensitivity analysis performed to evaluate the robustness of the ranking results is also presented.

5.1 The Fuzzy AHP Results

To determine the weights of applicable success factors by using fuzzy AHP method, a multi-level hierarchical model was formed based on the applicable success factors and criteria, and then they were prioritized using fuzzy AHP approach as follows:

First, the selection of experts is crucial and should be well-considered (Laws et al., 2004). In this study, the middle- and senior-level professionals in electronics industry in Thailand with more than ten years experience in implementing upgrading practices as well as Thai senior consultants with more than ten years experience in functional upgrading implementing are preferred as experts for the collection of their opinions and concerns. Chen, Ho, and Kocaoglu (2009) argued that the number of experts should be large enough to assure multiple perspectives, and small enough to make the research manageable. Hence, the experts consisted of twenty persons: six senior-level managers, seven middle-level managers, and seven consultants. Therefore, there exists a (rather) balanced representation of all groups of experts, with multiple perspectives to be incorporated in the prioritization process (Hoffman, 1982).

The procedure of fuzzy AHP approach to calculate weights of the factors is as follows:

1. Developing a hierarchical model for prioritizing the success factors: In developing a hierarchical model for prioritizing the critical success factors, the model shown in the Figure 5-1 is constructed with five levels. The top level presents the overall goal of this study, which is the prioritization of critical success factors for functional upgrading in electronics industry. The second level presents the decision criteria that comprise the five performance indicators within four BSC clusters. The third level presents the four of dynamic capabilities as mediating factors in the relationship between critical success factors and performance indicators. The fourth level presents the three categories of critical success factors whereas the lowest level denotes the critical success factors.

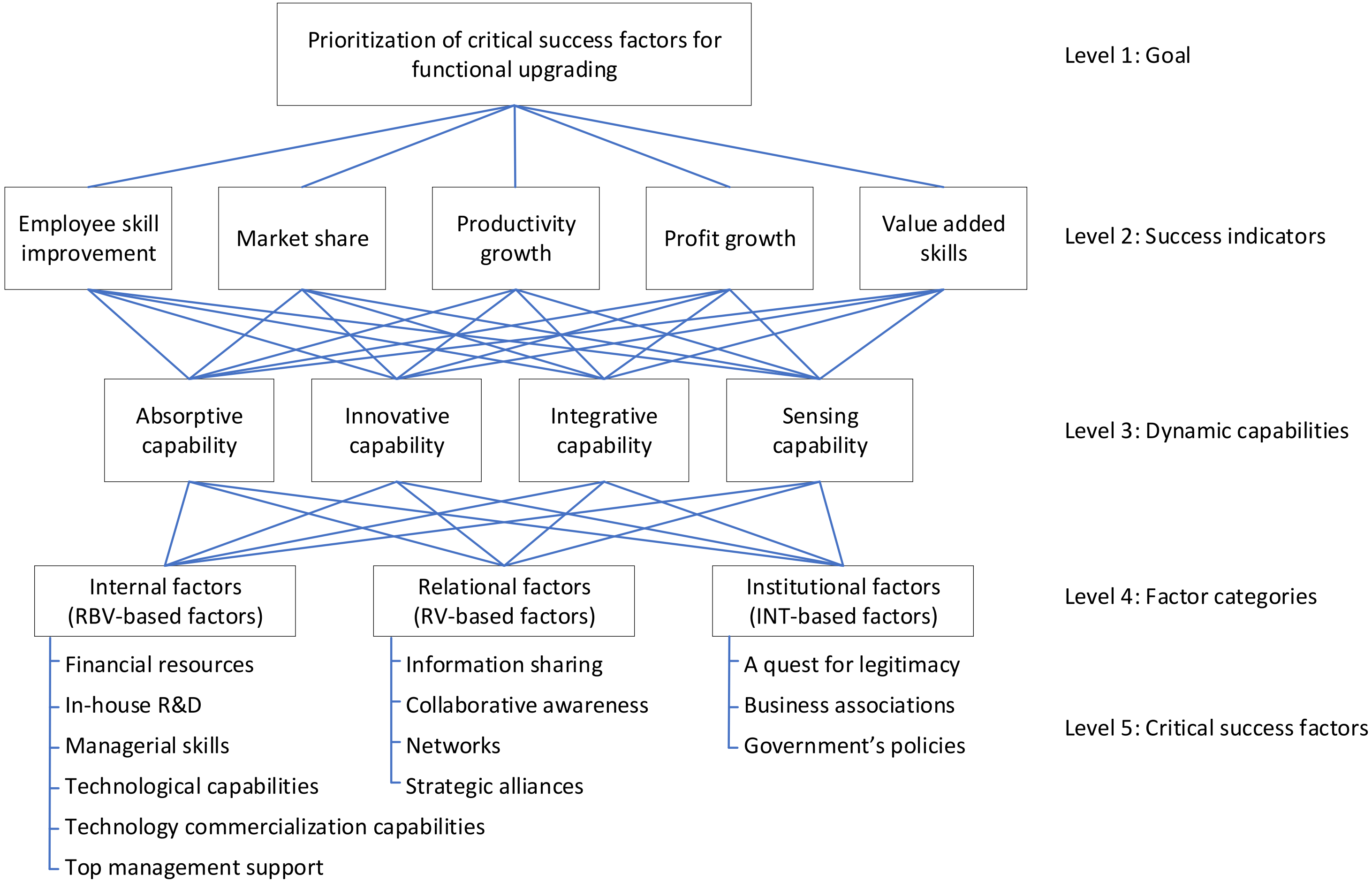

Figure 5-1 A hierarchical model for prioritization of critical success factors for functional upgrading in electronics industry from Thai experts' perspective

2. Establishing a fuzzy judgment matrix (or a pair-wise comparison matrix): the fuzzy AHP-based questionnaires were provided to collect information from the experts. Each expert was asked to assign linguistic terms based on his/her subjective judgment, to the pair-wise comparisons by asking which one of two elements is more important and how much more important it is with respect to their upper level. In decision-making, each expert gave his/her preference on the elements using fuzzy judgment matrix. After getting the answers from experts in linguistic terms, these linguistic judgments were then converted to triangular fuzzy sets as defined in Table 3-1.
3. Combining the opinions from several experts by using geometric mean: the perception of each expert varied according to individual experience and knowledge.
4. Repeating the calculation of the local priority weights for all levels in hierarchy.
5. Calculating the global priority weight of each element: the global priority weight of each element was calculated by multiplying its local weight with its corresponding weight along the hierarchy.

Accordingly, the fuzzy AHP model was developed to determine the weights of thirteen success factors in three categories for functional upgrading process. Table 5-1 shows the local and global weight scores of the elements as well as their priority rankings. The final priority results are ranked based on their own global weights.

Table 5-1

Local and Global Weight Scores and Rankings of Critical Success Factors

Performance indicators (criteria)	**Global weights**	**Ranking**	**Dynamics capabilities**	**Global weights**	**Ranking**	**Critical success factors**	**Local weights**	**Local Ranking**	**Global weights**	**Global Ranking**
Employee skill improvement	0.144	4	Absorptive capability	0.193	4	**Internal factors (0.454)**				
Market share	0.269	2	Innovative capability	0.250	2	(RBV-1) Financial resources	0.187	3	0.085	6
Productivity growth	0.095	5	Integrative capability	0.236	3	(RBV-2) In-house R&D	0.099	6	0.045	13
Profits growth	0.297	1	Sensing capability	0.321	1	(RBV-3) Managerial skills	0.128	4	0.058	10
Value added growth	0.195	3				(RBV-4) Technological	0.250	1	0.114	1

Performance indicators (criteria)	Global weights	Ranking	Dynamics capabilities	Global weights	Ranking	Critical success factors	Local weights	Local Ranking	Global weights	Global Ranking
						capabilities				
						(RBV-5) Technology commercialization capabilities	0.125	5	0.056	11
						(RBV-6) Top management support	0.212	2	0.096	4
						Relational factors (0.337)				
						(RV-1) Inter-organizational Information sharing	0.199	3	0.067	8
						(RV-2) Collaborative awareness	0.187	4	0.063	9

Performance indicators (criteria)	Global weights	Ranking	Dynamics capabilities	Global weights	Ranking	Critical success factors	Local weights	Local Ranking	Global weights	Global Ranking
						(RV-3) Networks	0.331	1	0.112	2
						(RV-4) Strategic alliances	0.282	2	0.095	5
						Institutional factors (0.209)				
						(INT-1) A quest for legitimacy	0.215	3	0.045	12
						(INT-2) Business associations	0.324	2	0.068	7
						(INT-3) Government's policies	0.461	1	0.097	3

Note. Parentheses () denote the global weight of each category of critical success factors

According to this result (Table 5-1), the most significant (highest-global weight) performance indicator is 'profits growth' for functional upgrading, followed by 'market share', whereas the least significant indicator is 'productivity growth'. In level 3 of the model, the 'sensing capability' is viewed as the most significant dynamic capabilities, which enables functional upgrading through economic and value-added products meet market needs and accomplish its aims, followed by 'innovative capability', whereas the experts viewed 'absorptive capability' as the least significant one. In level 4, the category of 'internal factors' is the most significant for dynamic capability development, followed by the 'relational factors' and 'institutional factors' respectively. And in level 5, the three most significant critical success factors are 'technological capabilities', 'networks', and 'government's policies' respectively, whereas 'in-house R&D' is the least significant one.

5.2 Results of Sensitivity Analysis

In order to be more confident about the ranking obtained under the vagueness and imprecision in expert judgment, it is important to carry out a sensitivity analysis to investigate the robustness of the ranking results (Guo & Zhao, 2015). Sensitivity analysis was carried out by exchanging the weights of two performance indicators (or criteria) among themselves, while the weights of other performance indicators remain unchanged (Gumus, 2009; Hussain, Mandal, & Mondal, 2018; Önüt, Kara, & Isik, 2009; Önüt & Soner, 2008) to analyze how changing the performance indicator weights influence on the ranking results (the outputs of the model).

In this study, since there were five performance indicators involved in the decision-making problem (and we chose to switch the weights of two performance indicators from the set of five performance indicators), therefore, ten combinations were analyzed for the sensitivity analysis, with each combination stated as a scenario (S). Therefore, ten scenarios were obtained, and accordingly, ten different calculations for re-determining the weights of critical success factors for each scenario were performed.

Different names were given for each calculation. For example, the 'C1-2' meant that the weights of the 1st and 2nd performance indicators were switched (while the weights of the 3th, 4th, 5th, and 6th performance indicators remained the same), and this new scenario was named 'S1'. The weights of critical success factors were re-calculated, and then, the critical success factors were re-ranked for each scenario. The results of sensitivity analysis are shown in Table 5-2.

Table 5-2

Results of Sensitivity Analysis

Critical success factors	Rankings										
	S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
	No change	**C1-2**	**C1-3**	**C1-4**	**C1-5**	**C2-3**	**C2-4**	**C2-5**	**C3-4**	**C3-5**	**C4-5**
(RBV-1) Financial resources	6	6	6	6	6	6	6	6	6	6	6
(RBV-2) In-house R&D	13	13	12	13	13	12	13	13	12	12	13
(RBV-3) Managerial skills	10	10	10	10	10	10	10	10	10	10	10
(RBV-4) Technological capabilities	1	1	1	1	1	1	1	1	1	1	1
(RBV-5) Technology commercialization capabilities	11	11	11	11	11	11	11	11	11	11	11
(RBV-6) Top management support	4	4	4	4	4	3	4	4	3	3	4
(RV-1) Inter-organizational Information sharing	8	8	8	8	8	8	8	8	7	8	8

Critical success factors	Rankings										
	S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
	No change	**C1-2**	**C1-3**	**C1-4**	**C1-5**	**C2-3**	**C2-4**	**C2-5**	**C3-4**	**C3-5**	**C4-5**
(RV-2) Collaborative awareness	9	9	9	9	9	9	9	9	9	9	9
(RV-3) Networks	2	2	2	2	2	2	2	2	2	2	2
(RV-4) Strategic alliances	5	5	5	5	5	5	5	5	5	5	5
(INT-1) A quest for legitimacy	12	12	13	12	12	13	12	12	13	13	12
(INT-2) Business associations	7	7	7	7	7	7	7	7	8	7	7
(INT-3) Government's policies	3	3	3	3	3	4	3	3	4	4	3

Note. S1, S2… S10 are scenarios 1, 2… 10 respectively, and 'Ci-j' means the weights of the i^{th} and j^{th} criteria are switched, while the rest of the criteria weights remained the same.

Based on the results in Table 5-2, the rankings are similar across all scenarios. Besides, under all scenarios, the results of sensitivity analysis indicate that, 'technological capabilities' is the highest priority factor, followed by the 'networks' that influence the performance of functional upgrading, whereas 'in-house R&D' and 'a quest for legitimacy' are the two lowest priority factors.

Furthermore, the ranking gained from each of ten scenarios (S1, S2… S10) was compared with the original ranking achieved by the base scenario (S0) which had no exchanging of weights, and were then validated comparatively using the Spearman's rank correlation coefficient (r_s) by using Eq. 4:

$$r_s = 1 - \frac{6\sum_{i=1}^{n}(d_i)^2}{n(n^2-1)} \quad (4)$$

where d_i is the difference between each pair of ranks and n is the number of pairs of values.

The Spearman's rank correlation coefficients for paired-comparison rankings are given in Table 5-3.

Table 5-3

Spearman's Rank Correlation Coefficients

Comparison	Spearman's rank correlation coefficient (r_s)
S0 vs S1	1.000*
S0 vs S2	0.995*
S0 vs S3	1.000*
S0 vs S4	1.000*
S0 vs S5	0.989*

Comparison	Spearman's rank correlation coefficient (r_s)
S0 vs S6	1.000*
S0 vs S7	1.000*
S0 vs S8	0.984*
S0 vs S9	0.989*
S0 vs S10	1.000*

*Note. *Correlation is significant at the 0.01 level (2-tailed)*

According to this result in Table 5-3, it is found that p-values of all ten paired-comparison rankings < 0.01, it is clearly evident that the original ranking achieved by the base scenario (S0) is significantly correlated with the ranking gained from each of ten scenarios. So, it can be concluded that there is no statistically significant difference between the two comparative rankings of critical success factors with 99% confidence interval. Moreover, it can be said that there is a convergence of their opinions on the ranking as well.

Concluding Remark

This chapter presented an application of the fuzzy AHP model to prioritize the critical success factors and criteria for functional upgrading, and also presented the hierarchical model for prioritizing the factors (as in Figure 5-1), which is linked to the RBV of the firm, the relational view, and the institutional theory based on the fuzzy AHP approach. The local and global weight scores of the elements as well as their priority rankings were explored (as in Table 5-1). Besides, sensitivity analysis was carried out by exchanging the weights of two performance indicators (or criteria) among themselves, and the ranking gained from each of ten scenarios were then validated comparatively using the Spearman's rank correlation coefficient.