SWOT분석을 토대로 한 서비스 FMEA에서의 개선조치전략

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Corrective Action Strategy based on SWOT Analysis in Service FMEA

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Abstract

Service FMEA may yield several possible corrective actions for each failure mode with large RPN. Corrective actions for each service failure are usually interrelated with the customers and environmental elements of the service system. SWOT analysis can provide an effective way to analyze the inner and outer environmental impacts for each corrective action. In this paper, we suggest a way for selecting and ranking corrective strategy in service operation based on SWOT analysis. Every candidate of corrective action strategy is ranked and evaluated on the basis of the impact factors of the SWOT variables, correlations between possible corrective actions and SWOT variables, and RPNs of service failures. The most desirable set of corrective actions is selected considering the preference score of each corrective action, required resources and budgetary allowance. The proposed methodology is demonstrated with an illustrative example.

1. Introduction

As a sector that contributes more than 70% to the global domestic product, the importance of delivering reliable service operation is undeniable. Nevertheless, literature discussing new challenges on reliability studies, such as Yadav and Singh(2008), still focus on product design and manufacturing. Kim *et al.*(2007) noted the importance of using the FMEA(failure mode and effect analysis) as a tool to assess the risk of reliability problems in business operation. Seyedhosseini and Hatefi(2009) stated that determination of systematic method to rank corrective actions based on risk assessment tool is still less explored research area. In FMEA literature, Bluvband *et al.*(2004) used the RPN(risk priority number) reduction ratio before and after implementing corrective action. And Carmignani (2009) suggested the *PriorityProfitability Diagram* as a tool for selecting corrective improvement strategy.

Despite many endeavors have been dedicated to developing techniques on ranking corrective action, most ideas are still based on impacts from in-

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ner business system. And few considers the impacts from outer business system. Furthermore, previous studies are mainly focused on the domain of product design and manufacturing. Recently, FMEA is used in service as well as manufacturing industries as an effective way of improving a system. Since the customer participates and plays an important role in service operation, the service system is unavoidably interrelated with its environment. Thus, to improve a service system, the influence of environmental impact should also be considered. The SWOT(strength weakness opportunity threat) analysis is an effective tool that describes interrelationship between business systems with their environments.

In this paper, we tried to present an alternative approach for selecting and ranking service corrective action strategy based on SWOT analysis in Service FMEA. Employing the SWOT variables in FMEA will enable the practitioners to quantify the impact from both inner and outer business system before proposing strategic corrective actions. In section 2, we provide a brief overview on FMEA and SWOT analysis. In section 3, we suggest a framework on integrating FMEA and SWOT analysis. And then we provide a method to estimate the rank of corrective action which linked with SWOT variables. In section 4, to facilitate the practitioners, an illustrative case example is provided with a detailed application procedure. At last, discussions and conclusions from the case study are presented.

2. Overview of FMEA and SWOT Analysis

2.1 Service FMEA

Service FMEA is a technique used to identify any actual and potential service failure modes which can occur during service provision, determine their effects to service customers, rank the severity of the effects and take appropriate actions to avoid the reoccurrence of the failures in the future. The role of FMEA as means for business strategy improvement is growing due to the birth of new business standard such as ISO 31000 for risk management system. In FMEA, criticality of failure effect is measured in the metric named RPN. The RPN is a number obtained as the product of severity failure ratings, detection of failures ratings, and occurrence of failure ratings. For detailed definitions, classifications, and criteria of rating can be referred to such as Stamatis (1995). The effectiveness of a solution to curb quality problems is manifested by the magnitude of the risk reduction ratio. The higher the ratio, the more effective a corrective action would be.

2.2 SWOT analysis

SWOT is a kind of strategic tool which is based on the result of scanning the company's inner and outer environmental situations. al-Rousan and Qawasmeh(2009) defined *strength* in SWOT analysis as "any organizational characteristics that can be used to compete against their competitors." Acc- ording to Laaksolahti(2005), some such organizational characteristics are talents, speed, collaboration, shared mind-set and coherent brand identity, accountability, learning, leadership, customer connectivity, innovativeness, and efficiency. Flouris and Yilmaz (2010) defined the *weakness* as "any organizational capability shortage which may make organizations fail to compete against their competitors or any organizational attributes which company does not do well." Both strengths and weaknesses variables are locating in the internal company environment, thus easier to control and manage than threats and opportunities which usually come from the external environment.

According to Trzcielinski and Trzcielinska (2011), *opportunity* is defined as "any internal and external favorable factor which can be a solution to the problems faced by companies." Mbachu and

Frei(2010) separated opportunity into two classes, *strategic opportunity* which can be exploited to gain competitive advantages and *potential opportunity* that is currently un-utilized but still has potential of being exploited in the near future. Meanwhile, *threat* is defined as "any unfavorable factor which hinders achievement of the objectives of the company." Threat can also be classified into two categories, *potential threat* that potentially impacts against the company goal and *real threat* that the company faces during its daily operation. By SWOT analysis, the company can adjust its position in obtaining its possible benefit based on opportunity and threat recognition. Nevertheless, relying only on the conventional SWOT analysis based on qualitative measure is not enough in guiding strategy selection process. Helms and Nixon(2010) argued that quantitative estimation of SWOT variables is becoming mandatory for managerial purpose. However, the conventional SWOT technique does not accommodate such attribution. In addition, Ghazinoory *et al.*(2011) stated that decision makers should also consider interdependencies among decision factors and appropriate selection of strategy based on observed threat and opportunities during threat-opportunity assessment.

3. Integrated Model of FMEA and SWOT Analysis

3.1 The model framework

Figure 1 shows a framework of linking the FMEA with SWOT analysis. The procedures to select and rank corrective action priority can be described as the following steps:

Step 1. Determine the list of critical failure modes based on their corresponding RPNs. Information on the list of potential and actual failure modes can be obtained from historical data, brainstorming among FMEA members, or from customers' feedbacks.

Step 2. Determine the list of potential causes of critical failures and their potential corrective actions. The outcome of this stage is a set of candidate solutions.

Step 3. Perform scanning of internal and external environments of the company to determine list of internal and external SWOT variables, market and competitors' profiles, external resources, and also competitive advantages. The inputs are information from customers, stakeholder, and possibly expert opinions. The outputs of this step are market situation, competition profiles, and also internal and external SWOT variables.

Step 4. Categorize, and quantify the impacts of SWOT variables on the company. The AHP (Analytic Hierarchy Process) may be used to estimate the weight of SWOT variables.

Step 5. Determine the degree of relationship among corrective actions and all SWOT variables by estimating the values of their *correlations*. Use Delphi Method among FMEA members. Brief procedure to use Delphi Method can be referred to Asadi and Daryaei (2011).

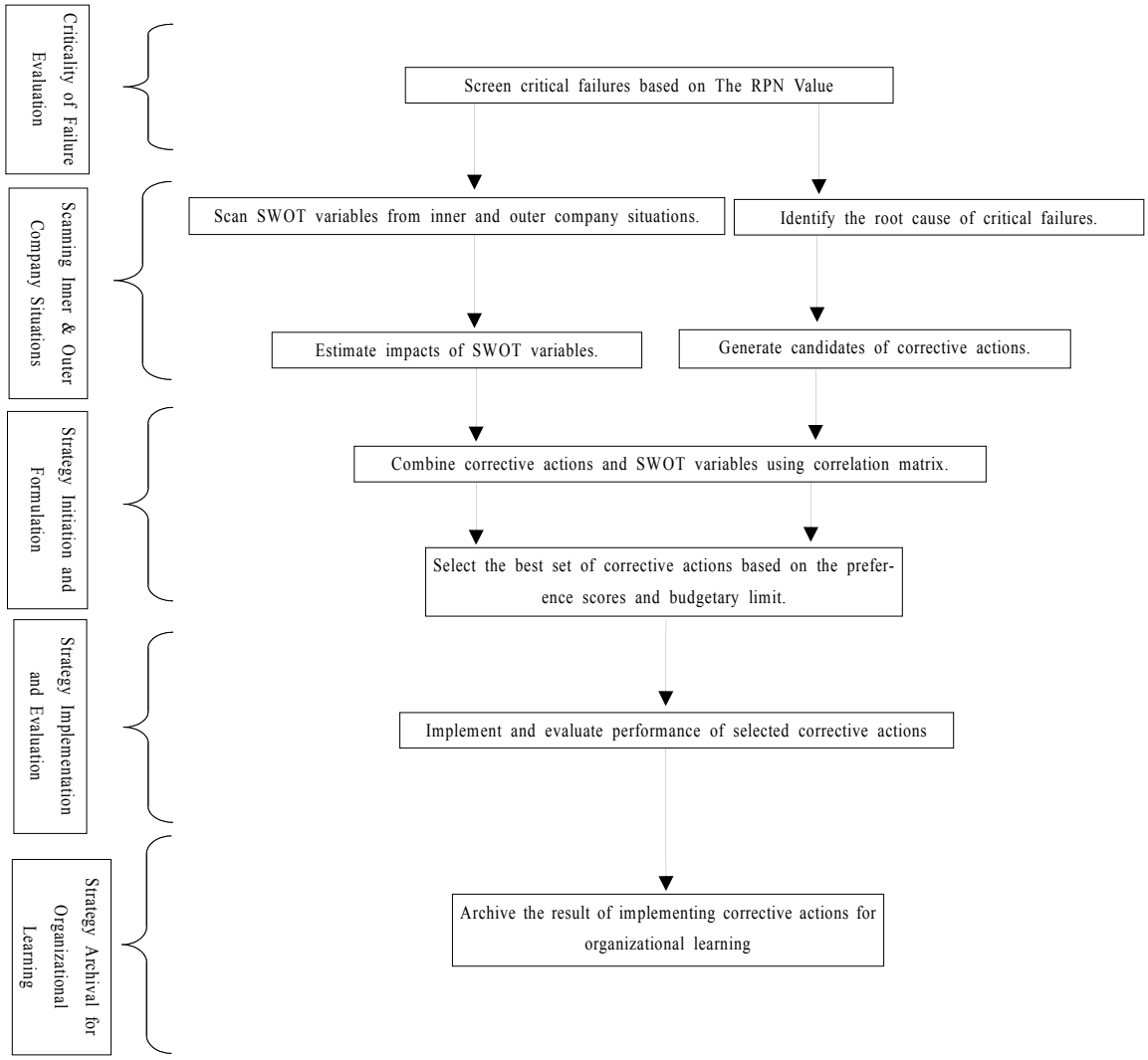
Step 6. By obtaining the values of impact factor and correlation from step 4 and 5, calculate the preference score for each corrective action. Corrective action with the highest preference score will be the first candidate to be selected besides considering its cost efficiency.

Step 7. Considering the implementing cost, calculate the cost efficiency for each corrective action.

Step 8. Rank the competing corrective actions based on their cost efficiencies. Compare their implementation costs and the budgetary limit. The corrective action whose implementing cost is larger than the budgetary limit is infeasible. The corrective action with the largest cost efficiency and still within budgetary limit will be the most favorable.

Step 9. Determine the success criteria of the selected corrective action.

Step 10. Upon implementing strategy, successful and unsuccessful corrective actions will be evident. Investigate the root cause of failed corrective



<Figure 1> The framework for linking FMEA and SWOT analysis

actions. Document the results of corrective actions for organizational learning.

3.2 Evaluating impacts of SWOT variables

Based on the ultimate goal of the company in obtaining benefit for their business, Lee (2010) stated that the attractiveness level of opportunity can be estimated based on its possibility to trigger numerous benefits such as market share increase, company growth, company efficiency in running business, and customer satisfaction. There are usually many opportunity variables for a company, say $O_1, O_2, ..., O_k$. The company can obtain some economic benefits by taking advantage of any opportunity variable. The impact of each opportunity variable may be evaluated by 1-5 Likert like scale considering the size of its resulting economic benefits. Thawengsaengkulthai and Tannock (2008) may be referenced on using such numerical scales. Denote the impact factors of the opportunity variables by $IFO_1, IFO_2, ..., IFO_k$. In running their businesses, companies often face unfavorable situations which hinder achievement of their business goals. Suppose that there are l threat variables,

that is, $T_1, T_2, \ldots, T_l$. Quantification of adverse effect due to the occurrence of a threat can be accomplished by counting its expected loss. Einarsson and Rausand (1998) suggested that business threat quantification should cover both internal and external threats. Using similar logic of quantifying opportunity, the expected losses due to the occurrences of threat attacks are evaluated with threat impact factors $IFT_1, IFT_2, \ldots, IFT_l$ by 1-5 Likert like scale. Patel and Zaveri (2010) may be referenced for quantifying negative impacts of threat events' occurrence.

Denote the strength and weakness variables by $S_1, S_2, \ldots, S_m$. and $W_1, W_2, \ldots, W_p$. In attempt to estimate the values of organizational strengths and weaknesses, Hunger and Wheelen (2002) proposed the use of internal factor analysis. Xing and Xian (2010) provided an exemplar on estimating the weights of strength and weakness variables using AHP(analytical hierarchy process). Referring to these previous works, the impacts of $S_1, S_2, \ldots, S_m$ and $W_1, W_2, \ldots, W_p$ are evaluated as Likert like scale by $IFS_1, IFS_2, \ldots, IFS_m$ and $IFW_1, IFW_2, \ldots, IFW_p$, respectively.

3.3 Correlation between corrective actions and SWOT variables

For each service failure, we may have several corrective actions possible. Suppose that we have n service failure modes, $FM_1, FM_2, \ldots, FM_n$ and r_i corrective actions $CA_{i1}, CA_{i2}, \ldots, CA_{ir_i}$ possible for FM_i. Since the customers themselves participate and play important roles in any service process, every service system is strongly interrelated with its inner and outer environments including its customers. Thus, the corrective actions inevitably have considerable correlations with at least one of the environmental variables, i.e. SWOT variables, of the service system.

The correlation between a corrective action and a SWOT variable may be positive or negative. If a corrective action increases the possibility of taking advantage of an opportunity, the correlation between the two should be positive. On the other hand, some corrective action may help prevent a threat from occurring, the correlation will be negative. Since the correlation must be between -1 and 1, we suggest the following rule to assign a number to the correlation between a corrective action and a SWOT variable:

i) If the corrective action enhances the occurrence of the SWOT variable, assign 0.9, 0.6, and 0.3 to their strong, moderate, and weak correlation, respectively.

ii) If the corrective action prevents the SWOT variable from occurring, assign -0.9, -0.6, and -0.3 to their strong, moderate, and weak correlation, respectively.

iii) If there is no relation between the two assign 0 to their correlation.

The relationship between the corrective actions and the SWOT variables can be summarized as Table 1. For illustration, Table 1 shows an illustrative correlation matrix between the corrective actions and the SWOT variables for the failure mode FM_1.

3.4 Selecting corrective actions

Selecting corrective actions is a complicated task since many considerations must be taken into accounts. We first calculate the preference score for each corrective action. We obtain the preference score of CA_{11} by the following formula;

$$PS_{11} = \sum_{i=1}^{m} R_{CA_{11}S_i} IFS_i - \sum_{i=1}^{p} R_{CA_{11}W_i} IFW_i + \sum_{i=1}^{k} R_{CA_{11}O_i} IFO_i - \sum_{i=1}^{l} R_{CA_{11}T_i} IFT_i. \quad (1)$$

The preference scores for other corrective actions can be obtained similarly. The preference score reflects the relative size of expected benefits obtained by using SWOT variables when the corresponding corrective action is implemented.

< Table 1> The correlation matrix between corrective actions and SWOT variables for FM_1

	SWOT Variables	Impact Factor	Corrective Actions		
			CA_{11}	...	CA_{1r}
Strength(S)	S_1	IFS_1	$R_{CA_{11}S1}$	...	$R_{CA_{1r_1}S_1}$
	...	...	...	...	...
	S_m	IFS_m	$R_{CA_{11}S_m}$	...	$R_{CA_{1r_1}S_m}$
Weakness(W)	W_1	IFW_1	$R_{CA_{11}W_1}$	...	$R_{CA_{1r_1}W_1}$
	...	...	...	...	...
	W_p	IFW_p	$R_{CA_{11}W_p}$	...	$R_{CA_{1r1}W_p}$
Opportunity (O)	O_1	IFO_1	$R_{CA_{11}O_1}$	...	$R_{CA_{1r1}O_1}$
	...	...	...	...	...
	O_k	IFO_k	$R_{CA_{11}O_k}$	...	$R_{CA_{1r1}O_k}$
Threat(T)	T_1	IFT_1	$R_{CA_{11}T_1}$	...	$R_{CA_{1r1}T_1}$
	...	...	...	...	...
	T_l	IFT_l	$R_{CA_{11}T_l}$	...	$R_{CA_{1r1}T_l}$

Next, we must have information of costs necessary to implement corrective actions. We assume the implementation cost of every corrective action can be estimated without difficulty from the past business operation experience. Once the cost information is obtained, we calculate the cost efficiency for each corrective action. For example, the cost efficiency of CA_{11} is obtained by

$$CE_{11} = (RPN_1 \times PS_{11}) \ / \ IC_{11}, \qquad (2)$$

where IC_{11} is the implementing cost for CA_{11}. The values of cost efficiency for the other corrective actions can be obtained similarly. The corrective action with the largest value of cost efficiency will have the highest priority to be implemented within the budgetary limit. For clear comparison among corrective actions, we may use Table 2. A corrective action with implementing cost beyond the budgetary limit is infeasible and has an "X" mark in the “Feasibility” column of Table 2.

<Table 2> Comparison among corrective actions

Failure Mode	RPN	Corrective Action	Preference Score	Implementing Cost	Cost Efficiency	Feasibility
FM_1	RPN_1	CA_{11}	PS_{11}	IC_{11}	CE_{11}	O
		...	...	...	...	...
		CA_{1r_1}	PS_{1r_1}	IC_{1r_1}	CE_{1r_1}	X
...	...	...	...	...	...	...
FM_n	RPN_n	CA_{n1}	PS_{n1}	IC_{n1}	CE_{n1}	O
		...	...	...	...	...
		CA_{nr_n}	PS_{nr_n}	IC_{nr_n}	CE_{nr_n}	O

Normally, there are several RPNs for each failure mode corresponding to the failure causes. But, we assume only one RPN as shown in Table 2 to avoid too much complexity and focus on presenting our main idea.

3.5 Evaluating performance of implemented corrective actions

After selecting certain corrective actions, the next step is to implement them for effective improvement. According to Wheelen and Hunger (2008), several aspects should be considered prior to implementation such as budgetary feasibility, the ownership of corrective actions, communication with the stakeholder and supplier(s), key success factors and procedural aspects. Seyedhosseini *et al.* (2009) suggests three aspects that the success criteria may be based on; the real amount of time spent, the actual costs that the company spent, and the real performance specification achieved upon implementing selected corrective actions. A successfully implemented corrective action should have positive effects against all these success criteria.

Some examples of business performance indicators to measure the success of implemented corrective action can be referred to Mann and Kehoe (1994). In case the selected corrective action is failed, the root cause of failure may be identified according to Wheelen and Hunger (2008, p.264). For organizational learning and feedback, documenting successful and failed implementation of corrective actions into a data base is invaluable step for maturing companies in tackling the future business problems.

4. Illustrative Example

In this section, an example from Chuang (2007) is used for illustrative purpose. The case example is related to application of combination of FMEA and service blueprint in improving service design of hyper market consumer goods service in Taiwan as setting. In this study, however, the work of Chuang(2007) is used for demonstration purpose only, to select corrective action from the result of FMEA assessment with an assumed set of SWOT variables.

The RPN threshold for critical failures is assumed to be 24. Since this example is provided for illustration purpose, only a part of failure modes and possible causes of case study reference will be used. And evaluation of the performance of selected corrective actions is not covered.

Referring to the application procedures describ-

<Table 3> Critical failure modes and RPNs of the case example (Excerpted from Chuang (2007))

Service Dimension	Failure Modes	RPN	Effects	Possible Causes
Reliability	Unreliable supply of goods/ merchandise	27.29	• Shortage of goods • Loss sale • Customers complaint • Complicating job allocation and • replenishment activity • Adverse goodwill of store	• Poor supplier evaluation and relationship • Inappropriate supplier relationship management • Insufficient inventory of suppliers • Inadequate marketing research • Lack of upward communication • Insufficient customer relationship focus • Failure to match supply and demand
Tangible	Air conditioning malfunction	25.38	• Food deterioration or spoil • Customer complain • Customer leave	• Poor maintenance of air conditioning • Aged air-condition • Fail to adjust the sales floor temperature based on number of customers on the sales floor • Poor electric power design

ed section 3.1, the problem of case study is solved as below:

Step 1. As a result of FMEA session, two critical failure modes are identified, "Unreliable supply of goods/merchandise" with RPN 27.29 and "Air conditioning malfunction" with RPN 25.38. Their effects and possible causes are also listed in Table 3.

Step 2. Generate potential corrective actions for every possible failure cause. Generating potential corrective actions is accomplished upon identifying possible failure causes. For example, occurrence of the faulty service "Unreliable supply of goods" is possibly caused by numerous causes as seen in the third column of Table 4. Potential corrective actions are also given in the fourth column. All the possible causes and potential corrective actions for the second failure mode "Airconditioning malfunction" are also given accordingly. In term of quantity, there are 11 potential corrective actions to tackle the service quality problems.

For illustrative purpose, in the subsequent parts of this study, only the first three corrective actions for each service failure mode will be used in explaining application of the model.

Step 3. The list of internal and external SWOT variables is obtained by performing internal and external environmental scanning for the company. Totally, 13 conceptual SWOT variables were generated for the case company. The theoretical criteria for weighting impact factor of SWOT variables are also presented in Table 5.

Step 4. The value of impact factor of each SWOT variable is estimated by multiplying its weight and rating scale. In this study; a 1 – 5 Likert like scale is used as rating scale for simplicity and ease of use. A rating 1 is assigned to the least important, poor, and insignificant categories and scale 5 is assigned to the very important, outstanding, and significant categories. Note that the magnitude of economic impact of threat and opportunity variables depend on the company's situation and team judgments. The results on estimating of all SWOT variables are summarized in Table 6.

The value of SWOT variables' impact factors shows that "High staff dedication for learning" is becoming the biggest company strength, "Lack of business facility" is the greatest company weakness, "The chance on increase on customers' demand variety" is the biggest opportunity, and "Une- xpected rise in commodity prices" is the largest treat variable.

<Table 4> Potential corrective actions for critical failure modes

Service Failure Mode	RPN	Possible Cause	Potential Corrective Actions
Unreliable supply of goods/ merchandise (FM1)	27.29	• Poor supplier evaluation and relationship • Inappropriate supplier relationship anagement • Insufficient inventory of suppliers • Inadequate marketing research • Lack of upward communication • Insufficient customer relationship focus • Failure to match supply and demand	• Perform supplier evaluation (CA11) • Improve supplier relationship(CA12) • Add adequacy of suppliers(CA13) • Improve technique of marketing research(CA14) • Facilitate upward communication(CA15) • Improve focus on customer relationship communication(CA16) • Improve capability to perform supply and demand estimation (CA17)
Air conditioning Malfunction (FM2)	25.38	• Poor maintenance of air conditioning • Aged air-condition • Fail to adjust the sales floor temperature based on the number of customers on the sales floor • Poor electric power design	• Train engineering staff on air conditioner maintenance (CA21) • Purchasing power generating equipments(CA22) • Improve empowerment of operation staff on the sales floor (CA23) • Re-check the air-condition configuration (CA24)

<Table 5> SWOT variables and their corresponding criteria

SWOT Groups	Criteria	SWOT Variables
Strength	• Capability of strength variables to solve company problem • Company capability to utilize strength variables to solve the problems	Employee loyalty (S1)
		Strategic location of the hyper market (S2)
		High staff dedication for learning (S3)
Weakness	• Capability of company in minimizing the weakness • Capability of weakness variables in disturbing company goals	Limited suppliers (W1)
		Lack of business facility (W2)
		Few chances for staff development(W3)
Opportunity	• Company capability to take advantage of opportunity occurrence • The amount of resources spent to chase the opportunity • The attractiveness of opportunity in terms of monetary value	Possibility of sales growth due to internet shopping (O1)
		Possibility of growing distribution of goods and service (O2)
		The chance on increase of customers' demand variety(O3)
Threats	• Threat capability in hindering company objective • Company capability in mitigating the negative impact • The estimated time spent for recovery when threat events occurred • The estimated negative impact when threat occur (in monetary term)	Growing number of competitor (T1)
		Unfaithful employee (T2)
		The change of supplier preference to competitors (T3)
		Unexpected rise of commodity price (T4)

<Table 6> The value of impact factor of SWOT variables

SWOT Groups	Criteria	SWOT Variables	Weight	Rating	Impact Factor
Strength	• Capability of strength variables to solve company problem • Company capability to utilize strength variable to solve the problems	Employee loyalty (S1)	0.262	5	1.310
		Strategic location of the hyper market (S2)	0.328	3	0.984
		High staff dedication for learning (S3)	0.410	5	2.050
Weakness	• Capability of company in narrowing down the weakness • Capability of weakness variables in • disrupting company goals	Limited suppliers (W1)	0.288	5	1.440
		Lack of business facility (W2)	0.565	4	2.260
		Limited opportunity for staff development(W3)	0.147	3	0.441
Opportunity	• Company capability to take advantage of opportunity occurrence • The amount of resources spent to chase the opportunity • The attractiveness of opportunity in terms of monetary value	Possibility of sales growth due to internet shopping (O1)	0.180	4	0.720
		Possibility of growing distribution of goods and service (O2)	0.144	5	0.720
		The chance on increase of customers' demand variety(O3)	0.676	5	3.380
Threats	• Threat capability in hindering business target. • Capability of company in mitigating the negative impact of treat occurrence • The estimated time spent for recovery when threat events occurred • The estimated negative impact when • threat occur (in monetary term)	Growing number of competitor (T1)	0.126	5	0.630
		Unfaithful employee (T2)	0.155	3	0.465
		The change of supplier preference to competitors (T3)	0.161	4	0.644
		Unexpected rise of commodity price (T4)	0.558	5	2.790

Step 5. The correlation between corrective actions and SWOT variables are estimated. The guidance to categorize the value of correlation coefficient is based on section 3.3. For example, when a corrective action is strongly correlated with a certain SWOT variable, the correlation coefficient between the two is assigned 0.9. The correlation matrix of all corrective actions with every quadrant of SWOT group is presented in Table 7.

Step 6. The preference score for every potential corrective action is calculated using equation (1) and represented in the last row of Table 7. Referring to the corrective action preference score of every potential corrective action, the strategy option "Perform supplier evaluation(CA_{11})" is becoming the first preference to prevent reoccurrence of the failure mode "Unreliable supply of goods/merchandise," followed by "Add adequacy of suppliers (CA_{13})" and "Improve supplier relationship (CA_{12})". Meanwhile, for solving the failure mode "Air conditioning malfunction," "Train engineering staff on air conditioner maintenance(CA_{21})" is firstly preferred, followed by "Improve empowerment of operation staff on the sales floor(CA_{23})" and "Purchase a power generating equipment(CA_{22})."

Step 7. Company must spend resources for funding the preferred corrective actions. Considering the resource requirements, the implementing cost is estimated for each corrective action. And then, by using equation (2), the cost efficiency of each corrective action is calculated. Based on the cost-efficiency ratio, the rank of corrective actions can be assigned. The higher the cost efficiency of a corrective action, the more favorable the corrective action would be, under the condition that the implementing cost is still below budgetary limit. The result of estimating the cost efficiency for each of the potential competing corrective ac-

<Table 7> The CA-SWOT correlation matrix

		Failure Mode	Unreliable supply of goods			Air conditioning malfunction		
SWOT Variables		Impact Factor	CA11	CA12	CA13	CA21	CA22	CA23
Strength	S1	1.310	0.6	0.3	0	0.6	0	0.6
	S2	0.984	0	0	0	0	0.6	0
	S3	1.440	0.9	0.6	0.3	0.9	0	0.6
Weakness	W1	1.440	-0.9	0.9	-0.9	0	0	0
	W2	2.260	0	0.9	0.3	0.6	-0.6	0.9
	W3	0.441	0	0	0	-0.3	0	0
Opportunity	O1	0.720	0.3	0.6	0.3	0.6	0.3	0.3
	O2	0.720	0.3	0.6	0.3	0.3	0	0.3
	O3	3.380	0.9	0.9	0.9	0.9	0.3	0.9
Threat	T1	0.630	0.6	0.6	-0.3	-0.3	-0.3	-0.3
	T2	0.465	0	0	0	0.3	0	0
	T3	0.644	-0.3	-0.6	-0.3	0	0	0
	T4	2.790	0.3	0.3	0	0	0.3	0
Preference Score			5.830	1.004	4.906	4.598	2.528	3.279

<Table 8> Feasibility of implementing corrective actions

Failure Mode	RPN	Potential Corrective Actions	Preference Score	Implementing Cost($)	Cost Efficiency	Feasibility
Unreliable supply of goods/ merchandise	27.29	Perform supplier evaluation (CA11)	5.830	150	1.061	O
		Improve supplier relationship(CA12)	1.004	100	0.274	O
		Add adequacy of suppliers(CA13)	4.906	350	0.383	X
Air conditioning malfunction	25.38	Train engineering staff on air conditioner maintenance (CA21)	4.598	180	0.648	O
		Purchase a power generating equipment (CA22)	2.528	320	0.201	X
		Improve empowerment of operation staff on the sales floor (CA23)	3.279	50	1.664	O

tions is shown in Table 8.

For solving the service problem “Unreliable supply of goods/merchandise,” the corrective action “Perform supplier evaluation(CA_{11})” is the first priority to be chosen and the corrective action “Train engineering staff on air conditioner maintenance(CA_{21})” is becoming the first choice for solving “Air conditioning malfunction.”

Step 8. Determine the feasibility of each corrective action by considering the implementing cost and budgetary limit. Assume that the budgetary limit of the company is only $300 to cover whole potential corrective actions. Based on Table 8, the company is possibly taking corrective actions “Perform supplier evaluation (CA11),” “Improve supplier relationship(CA12),” “Train engineering staff on air conditioner maintenance(CA21),” and “Improve empowerment of operation staff on the sales floor(CA23).” Considering both the budgetary limit and the cost efficiency, CA11, CA23, and CA12 are selected. Note that, even if CA21 is the best choice for curing “Air conditioning malfunction,” it cannot be implemented once CA11 is selected because of the budgetary limit.

Step 9. Determine the key success factors for the corrective actions. For getting success, some criteria should be considered in implementing corrective actions. Theoretical criteria for success of

<Table 9> Key success factors for implementing corrective action.

Problem	Corrective Action	Ownership	Performance Criteria	Key Success Factors
Unreliable supply of goods	Perform supplier evaluation (CA11)	Purchasing Manager & Quality Assurance Manager	Reduction of the lateness frequency in goods delivery and improvement of goods quality	• The procedure to evaluate suppliers is known. • The skill to evaluate suppliers is available • Approval from top management
	Improve supplier relationship (CA12)	Purchasing Manager/ Public Relation Manager	Reduction of the lateness frequency in goods delivery	• Availability of person with high communication skill with suppliers. • Availability of incentive for strengthening business relationship with suppliers.
Air conditioning malfunction	Improve empowerment of operation staff on the sales floor(CA23)	Human Resource Department	Reduction in air conditioning malfunction frequency	• The existence of fund to raise awareness of customer care culture among operation staffs

implementing selected corrective actions are described in Table 9. For example, for solving the service quality problem "Unreliable supply of goods /merchandise," the company should adopt "Perform supplier evaluation(CA11)" with the responsible person of purchasing manager and quality assurance manager. The performance criterion is "Reduction of the lateness frequency in goods delivery and improvement of goods quality". In order to make the selected corrective action workable, the success factors "The procedure to evaluate suppliers is known," "The skill to evaluate suppliers is available," and "Approval from top management" are required to be satisfied.

5. Discussions

Ideally, the conceptual model of integration of SWOT analysis into FMEA –based corrective action should be tested in real service operation setting for obtaining higher confidence level in its validity and reliability. However, since this study aimed to demonstrate the theoretical procedures to select improvement effort based on SWOT analysis, conceptual case study is used. In attempt to propose theoretical SWOT variables used in the example, we consulted the references such as Wheelen and Hunger (2008), and Foong (2007). The typical case example is chosen as to Yin (1994) since this study is aimed to answer "why" and "how" research questions and the researchers have no direct control of the object under study. Some underlying assumptions are:

- The value of cut off RPN to delineate among critical and non critical failure modes is known in advance.
- Every single conceptual corrective action is supposed to be linked with single root cause of failure.
- Opportunities observed by FMEA team are assumed not to be used by competitors.
- SWOT variables are assumed independent among others.
- The observation time for SWOT variables is negligible.

This study is aimed to narrow down the gaps on FMEA based prioritization of corrective actions. To improve capability of decision makers in preparing strategic preventative measures, FMEA is combined with SWOT analysis. Impacts of all internal and external business variables are scanned before proposing corrective actions. To demonstrate the procedures in practice, an illustrative example is provided on implementing the proposed model. Some potential benefits of the model for theoretical and practical purposes are as follows:

- This study presented a new theoretical model on linking corrective actions with all internal and external business variables. This will give benefit of keeping the company from possibility of suffering greater losses caused by considering only the negative impact from inner business system.
- The framework and procedures present an exemplary for practitioners on how to solving business reliability problems by considering impacts of inner and outer business variables.
- The model provides a new approach to estimating the efficiency of corrective action based on a financial criterion. It also pinpoints some other criteria for achieving success in implementing corrective actions.

Despite the possible benefits, the theoretical model presented in this study possesses some recognizable limitations if implemented in practice. Those limitations are as below:

- The SWOT variables in real industrial practice and within various service settings need to be tested to improve validity and robustness of the proposed model.
- Time, a critical dimension in delineating opportunity and threat, is neglected in the coverage of the model. Ignorance on time when determining SWOT variables will make corrective

actions to be unrealistic.

- As politicking is naturally occurring in daily situation among group-based improvement efforts, the risk due to conflicts occurrence among teams needs to be considered.
- The reality that some companies are risk takers and some others are risk averters are not accommodated by quantification of SWOT variables in the model.
- The fuzziness of the criteria on the value of rating in weighing SWOT variables is unavoidable in practice. The fuzzy nature of decision makers' classification on impact of SWOT variables are not facilitated by the model.
- In real situation, likelihood of success or failure is uncertain when practitioners implement corrective actions. Unfortunately, the model of corrective action ranking in this study is escaping such aspect.
- Since strength of relationship among corrective action and SWOT variables is based on the correlation, any inaccuracies in estimating the correlation value will make corrective action ranking becomes less accurate.
- In real situation, correlation between SWOT variables themselves are existing and such reality is not covered by the model.

6. Conclusion

This study has proposed a conceptual model for selecting corrective action priority based on SWOT analysis in service FMEA. Our survey on previous FMEA references indicated that the basis to rank of corrective actions is still based on the impact from the inner business system. Ignorance on considering impact from the outer business systems will possibly cause the business system to suffer from unexpected losses.

The proposed model provides a method on how to couple SWOT analysis and FMEA, how to estimate efficiency of corrective actions, and what key criteria should be fulfilled in making service improvement efforts successful. With our model, practitioners are able to consider all of favorable and unfavorable business variables from both inner and outer company systems prior to selecting corrective action. Thus, they are able to take advantages to chase the opportunities and avoid threat occurrences.

Considering that this study is still at its initial stage, some future research directions are possible. First, testing this model in real and varying service delivery system will give practitioners some insights on its appropriateness to tackle service quality problem. Second, the model may be expanded to the case without assumption of independence among SWOT variables. Third, as companies are collaborating among others, expanding the proposed model in curbing service business quality problems under collaborative framework with supplier involvement may be further studied. Fourth, as corrective actions are aimed to achieve multiple business objectives, integration of Balance Scorecard into the proposed model my be considered. At last, following Krishna et al. (2011), reiterating the application of the integrated model of FMEA and SWOT analysis in selecting corrective actions under multiple service delivery deviations may also be studied.

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