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A Risk Management Framework for New Product Development: A Case Study

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ABSTRACT

This research designed and implemented a supply chain risk management platform and applied it to a case study of reduced-fat Lanna pork sausage as a new product development project. The proposed framework has three stages: risk identification, risk assessment, and risk mitigation. Seventeen risk agents with 17 risk events were identified based on SWOT analysis and the Porter Five Forces concept through the process of planning, sourcing, making and delivering, partially captured from the supply chain operations reference model in the first stage. In the second stage, an house of risk (HOR) framework was applied to present the impacts of each risk agent. In the third stage, eight risk agents with high impact were selected to design 21 preventive actions. Finally, three preventive actions with the highest effectiveness to difficulty ratio scores—'sales evaluation of familiar products', 'increasing distribution channels and promotions to improve sales', and 'work flow improvement for work safety'—were then recommended for this new product development.

Keywords: New Product Development, Risk Management, House of Risk (HOR), Effectiveness to Difficulty Ratio (ETD)

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1. INTRODUCTION

New product launches rapidly because of changing business strategies or customer needs. New products are introduced to increase market share or improve brands. Also, some product needs to be included newly trends such as environmental (Ishii *et al.*, 2004) and health concerns during the process of product development. In addition, new products also face uncertain risks that are difficult to foresee. New product lifecycle is an important factor that should be considered to position the new product's role in the market (Ishioka *et al.*, 2003).

Susterova *et al.* (2012) addressed that product development projects should include risk assessment that allows managers to identify and measure the risks associated with resource constraints and then develop appropriate responses.

In small and medium enterprises (SMEs), March-Chorda *et al.* (2002) mentioned three critical success factors in product development: 1) top management support, 2) product development planning and process, and 3) analysis of market requirements. For food sectors, the obstacles are the uncertainty of market acceptance and the uncertainty about foreseeable market acceptance. In addition, food products usually have long product lifecycle that obstruct the introduction of new food products.

Lanna pork sausage (Sai Oua) is a famous local food product in the northern area of Thailand. Sai Oua is one of the local food products produced mostly by SMEs in Northern Thailand. Furthermore, Nakkiew *et al.* (2012) mentioned that Thai local producers need more innovative, systematic, and standardized approach to adjusting themselves in mass production. Moreover, to ensure that new local food products can survive in the market, identification of the risk of introducing the product to the market is strongly recommended.

Basic recipes of Sai Oua are pork, lard, and spices stuffed in pork intestines. Sai Oua is considered a high fat food product, composed of 36% of fat from 100 g of the product (http://thailocalfood.azurewebsites.net), so reduced fat concept is initiated due to the new trend in health concern.

As addressed in Stewart-Knox and Mitchell (2003), the success of reduced fat product depended on the communication among producers, retailers, and food technologists. Thus, risk management in supply chain is needed to successfully launch the new reduced fat product.

This research paper proposes a risk management framework for launching new products, and applies this framework to a case study of reduced fat Lanna pork sausage. The main objectives of the research are to identify, evaluate, and mitigate the supply chain risks. The advantage of this risk management framework supports local food producers to be aware of and provide the preventive actions for risks that can influence the new local food product development.

The organization of this paper is as follows. Preliminaries, including risk identification, evaluation and mitigation tools, are explained in Section 2. The proposed framework is explained in Section 3. Section 4 describes the case study of reduced-fat Lanna pork sausage. Discussion and conclusion are presented in Sections 5.

2. PRELIMINARIES

This section briefly addresses risk identification, evaluation and mitigation tools.

2.1 Risk Identification Tool

2.1.1 SWOT analysis

SWOT is the acronym for strengths, weaknesses, opportunities, and threats. SWOT analysis is used for investigating internal and external factors (Koo *et al.*, 2011). SWOT was applied originally to complex business environments and then expanded to encompass larger territories (Duarte *et al.*, 2006).

2.1.2 Porter Five Forces

Porter Five Forces are a framework for business strategy and industry analysis proposed by Michael E. Porter in 1979. The five forces include the threat of substitute products or services, the threat of established rivals, the threat of new entrants, the bargaining power of suppliers, and the bargaining power of customers.

2.2 Risk Evaluation and Mitigation Tools

The house of risk (HOR) Model developed by Pujawan and Geraldin (2009) combines two well-known tools: the house of quality function deployment and the failure mode and effect analysis. There are two stages of HOR that are HOR1 and HOR2. HOR1 ranks risk agents based on their aggregate risk potential (ARP_j) scores. HOR2 prioritizes proactive actions that the company should perform. Thus, the HOR model is effective for evaluating and mitigating risks.

To apply HOR1, the risk identification step requires risk agents and events. The risk agent occurrence score (O_j), risk event severity score (S_i), and correlative score for each risk agent and event pair (R_{ji}) were used in the ARP_j calculation as in Eq. (1).

$$ARP_j = O_j \sum_i S_i R_{ji} \quad (1)$$

The relationship of each parameter (score) in the ARP_j calculation using an example with three risk agents and two risk events is presented in Table 1. The HOR1 model helped rank all risk agents. Then, preventive actions (PA_k) were designed for risk agents with high ARP_j scores.

All preventive actions were evaluated in HOR2 using the total effectiveness to difficulty ratio (ETD_k) to select practical and effective preventive actions. ETD_k is calculated from the ratio between total effectiveness of action (TE_k), calculated as Eq. (2), when E_{jk} was the correlative score between risk agent j and preventive action k, and the degree of difficulty performing action k (D_k) as Eq. (3).

$$E_k = \sum_i ARP_j E_{jk} \quad \text{for all } k \quad (2)$$
$$ETD_k = TE_k / D_k \quad (3)$$

An example of the HOR2 model using two risk agents and three preventive actions is shown in Table 2.

Table 1. Example of HOR1 model

	Risk agent (A_j)			Severity score of risk events (S_i)
	A_1	A_2	A_3	
Risk event (E_i)				
E_1	$R_{1,1}$	$R_{2,1}$	$R_{3,1}$	S_1
E_2	$R_{1,2}$	$R_{2,2}$	$R_{3,2}$	S_2
Occurrence score of risk agents (O_j)	O_1	O_2	O_3	-
Aggregate risk potential (ARP_j)	ARP_1	ARP_2	ARP_3	-
Rank of priority (risk agent)	R_1	R_2	R_3	-

Table 2. Example of HOR2 model

	Preventive action (PA_k)			Aggregate risk potential (ARP_j)
	PA_1	PA_2	PA_3	
Treated risk agent (A_j)				
A_1	$E_{1,1}$	$E_{1,2}$	$E_{1,3}$	ARP_1
A_2	$E_{2,1}$	$E_{2,2}$	$E_{2,3}$	ARP_2
Total effectiveness of action (TE_k)	TE_1	TE_2	TE_3	-
Degree of difficulty performing action k (D_k)	D_1	D_2	D_3	-
Total effectiveness to difficulty ratio (ETD_k)	ETD_1	ETD_2	ETD_3	-
Rank of priority (preventive action)	R_1	R_2	R_3	-

The highest ETD_k score indicates the most effective preventative actions.

3. PROPOSED FRAMEWORK

There are three steps of risk management that are risk identification, evaluation and mitigation (Pujawan and Geraldin, 2009). This study considered supply chain risk management including process of planning, sourcing, making and delivery that partially captured from the supply chain operations reference (SCOR) model (The Supply Chain Council Inc., 2008).

From Figure 1, risk identification is the first step. During this step, SWOT and Porter Five Forces were used to identify risk agents and risk events. Then, the risk evaluation process of HOR1 was applied to calculate *ARP* scores during the risk assessment step. *ARP* scores were calculated based on the risk agent occurrence score, risk event severity score, and relationship score between each risk agent and risk event derived from the questionnaire based on the identified risk agents and events from the first step. The scores depended on a number of assessors. The fuzzy set theory was applied when there were five or more assessors. *ARP* scores were used in prioritizing and selecting risk agents for preventive action preparation. The final step was risk mitigation. Preventive actions were proposed to solve or prevent risk agents having high *ARP* scores. During this step, ETD_k and TE_k of each preventive action were computed. The high ETD_k indicated effective and practical preventative actions. A case study was

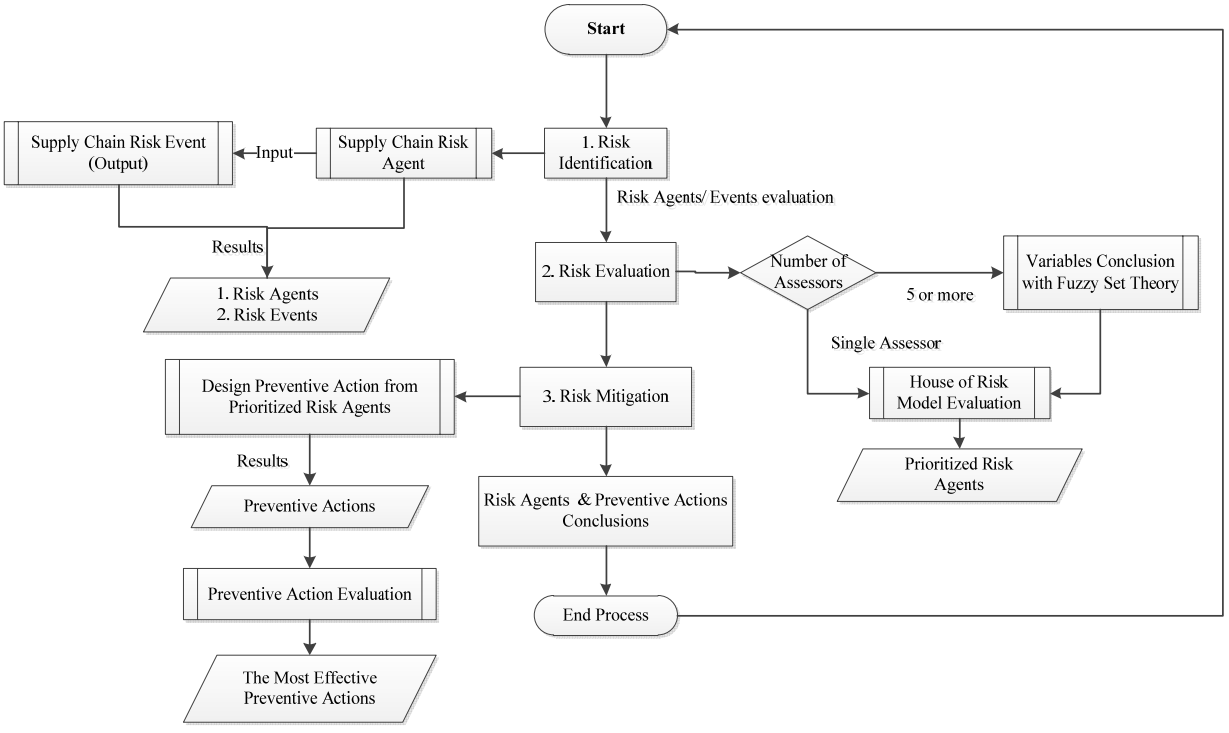

Figure 1. Risk management framework for developing a new product.

used to present the application of this framework.

4. CASE STUDY

Lanna pork sausage (Sai Oua) is a well-known local food product of Northern Thailand. A new product idea, reduced-fat Lanna pork sausage, was developed to satisfy health-conscious customers. It used low-fat ingredients instead of the traditional lard. Changing the recipe affected both the cooking and taste, and thus producers and customers. A risk management study was necessary to help ensure the producer that the new product would not fail during market launch.

The proposed risk management framework for this case study follows.

4.1 Risk Identification

Risk agents were identified using two techniques, SWOT and Porter Five Forces.

4.1.1 SWOT

Risk agents were identified based on SWOT analysis. Only weaknesses and threats were considered to analyze the internal and external risk factors because they give unfavorable effects on the process of new product development.

The weaknesses and threats of reduced-fat Lanna pork sausage were identified as follows.

- Weaknesses:
  (1) Misidentification of customer requirements.
  (2) Low product confidence due to no food safety and quality certifications.
  (3) Highly complex production process leading to higher cost and longer production time.
- Threats:
  (1) Uncertainty of customer demand.
  (2) Uncertainty from suppliers, i.e., late delivery and low quality raw materials.

4.1.2 Porter Five Forces

(1) Intensity of competitive rivalry: reduced-fat product tended to succeed more than standard products (Stewart-Knox and Mitchell, 2003). Competition in the same industry was at the medium level.
(2) Bargaining power of suppliers: material market fluctuation brought bargaining power of this product into medium level. The fluctuation might lead to considering single or multiple suppliers.
(3) Bargaining power of customers: bargaining power was quite high due to low brand royalty. The original products in the market also had less differentiated product taste.
(4) Threat of new entrants: new products usually have a small number of new entrants, resulting in a low threat level.
(5) Threat of substitute products or services: any local food product was included in this category due to the originality and uniqueness. The threat level was high.

The SWOT and Porter Five Forces analyses identified 17 risk agents as shown in Table 3. They are grouped according to major supply chain processes and their occurrence scores. Occurrence scores assessed by 10 Lanna

Table 3. List of risk agents

Major process	Code	Risk agent	Occurrence score
Plan	A_1	Failure to identify customer needs	2.00
	A_2	Varying customer demand	2.33
	A_3	Lack of standardization	1.67
	A_4	Inaccurate demand forecasts	2.00
	A_5	Responding from same products competitors	2.33
Source	A_6	Raw material supply fluctuation	2.67
	A_7	Single supplier risk	1.67
	A_8	Multiple suppliers risk	2.00
Make	A_9	Workplace accident	1.33
	A_{10}	Damaged engines and equipment	1.67
	A_{11}	Limited production capacity	2.67
	A_{12}	Event causes stuck in product processing	1.67
	A_{13}	Planning and designing in product processing failed	1.33
Deliver	A_{14}	Accidents occurring during delivery	1.33
	A_{15}	Improper distribution planning solution	1.67
	A_{16}	Product quality during delivery	2.33
	A_{17}	Errors during delivery	1.33

pork sausage shops and final scores were computed based on fuzzy triangular theory. Occurrence scores ranged from 1 to 5, with a high score indicating frequently occurring risk agents and a low score indicating rarely occurring risk agents.

Seventeen risk events were then identified, as shown and described in Table 4. The severity scores from each risk event were also assessed from 10 Lanna pork sausage shops and final scores were computed based on fuzzy set theory. Severity scores ranged from 1 to 5, with a high score indicating an event with severe damage and a low score an event with less damage.

The correlation between each risk agent and event identified here was used to compute *ARP* scores during the risk evaluation step.

4.2 Risk Evaluation

To evaluate risk, the occurrence score of each risk agent, severity score of each risk event, and correlation between each risk agent and event were used to calculate the *ARP* score as in Eq. (1). The eight risk agents having high *ARP* scores are shown in Table 5. These are used to design preventive actions (*PA*) for risk mitigation in the next section.

4.3 Risk Mitigation

To mitigate risk, an HOR2 model was proposed for calculating TE_k and ETD_k as shown in Eqs. (2) and (3). The eight risk agents having the highest *ARP* scores were considered in preventive action design. Preventive actions were proposed based on three approaches of risk mitigation: risk awareness, risk sharing, and risk transfer (Pujawan and Geraldin, 2009). One case study producer was consulted on the proposed preventive actions. Consequently, 21 preventive actions were specified and assessed. Then, the level of difficulty, D_k, and relationship scores between each risk agent and preventive action (E_{jk}) were derived from an in-depth interview. The results of D_k are shown in Table 6.

D_k ranged from 1 to 5, with a low score indicating an action that was difficult to implement and a high score indicating an action that was easy to implement. All preventive actions were evaluated by computing TE_k and ETD_k scores, with high TE_k and ETD_k scores indicating the most appropriate preventive actions. Three preventive actions—PA_4 Sales evaluation of familiar products, PA_6 Increasing distribution channels and promotions to improve sales, and PA_{11} Work flow improvement for work safety—were recommended to the case study company for managing risks of the new reduced-fat Lanna pork sausage product (Table 7).

Table 5. Results of *ARP* score

Rank	Risk agent (A_j)	ARP score (ARP_j)
1	A_6	133.15
2	A_5	120.30
3	A_{12}	118.74
4	A_4	83.15
5	A_2	69.48
6	A_{13}	65.78
7	A_7	65.19
8	A_8	62.22

ARP: aggregate risk potential.

Table 4. List of risk events

Major process	Code	Risk event	Occurrence score
Plan	E_1	Failed product launches	2.67
	E_2	Inadequate capacity planning	1.67
	E_3	Lack of product reliability	2.00
	E_4	Excess of supply	2.00
	E_5	Excess of demand	2.00
	E_6	Consumption of substitute products	2.33
Source	E_7	Rising raw material cost	2.67
	E_8	Raw material shortage	2.67
	E_9	Damaged raw materials	2.33
	E_{10}	Lack of quality materials	2.33
	E_{11}	Limited capacity from single supplier	1.67
	E_{12}	Improper storing of raw materials	2.33
	E_{13}	Late materials	2.33
Make	E_{14}	Longer/stuck in product processing time	2.00
Deliver	E_{15}	Damaged products	2.67
	E_{16}	Late delivery of product	2.00
	E_{17}	Lack of distribution channels	2.33

Table 6. List of preventive actions

Code	Preventive action	D_k
PA_1	Collecting price of each raw material (month/year)	3
PA_2	Considering alternative suppliers	3
PA_3	Hoarding raw materials (nonperishable materials)	4
PA_4	Sales evaluation of familiar products	2
PA_5	Examination quality of familiar products	2
PA_6	Increasing distribution channels and promotions to improve sales	2
PA_7	Increasing product reliability/advertising	3
PA_8	Recording risk event, its frequency and factors interrupting processing time	4
PA_9	Knowledge demonstration of equipment and engines, providing warning sign	3
PA_{10}	Redesigning new plant layout	3
PA_{11}	Work flow improvement for work safety	2
PA_{12}	Forecast accuracy evaluation	2
PA_{13}	Adjusting production capacity to increase forecast accuracy	3
PA_{14}	Extending product inventory	3
PA_{15}	Collecting sales data for adjusting production capacity	3
PA_{16}	Production performance evaluation	2
PA_{17}	Improving manager's supply chain management skills	2
PA_{18}	Improving production planning	2
PA_{19}	Supplier evaluation (e.g., raw material price, quality, and punctuality)	3
PA_{20}	Selecting alternative supplier or providing contract between firm and supplier	3
PA_{21}	Selecting new supplier or having multiple suppliers	3

Table 7. Results of top three PA_k

PA_k	TE_k	ETD_k
PA_4	1259.44	629.72
PA_6	1216.00	608.00
PA_{11}	1081.48	540.74

PA: preventive action, TE: total effectiveness of action, ETD: effectiveness to difficulty ratio.

Three preventive actions—PA_4 Sales evaluation of familiar products, PA_6 Increasing distribution channels and promotions to improve sales, and PA_{11} Work flow improvement for work safety—were suggested to the case study company for risk management of the new reduced-fat Lanna pork sausage product.

5. DISCUSSION AND CONCLUSION

This paper proposed a framework for managing the risk of new product development. The proposed framework was illustrated using a case study of reduced-fat Lanna pork sausage. The framework is composed of three basics steps: risk identification, risk evaluation, and risk mitigation. For risk identification, SWOT and Porter Five Forces analyses were used to identify risk agents and events. The second and third steps—risk evaluation and risk mitigation—used the concept of HOR. Then, preventive actions were provided for the critical risks previously identified during risk evaluation. Finally, after risk mitigation, the practical and effective preventive actions were proposed.

The results of the case study show that the three preventive actions identified by the case study reflected the company worries with the new product launch. Their primary concern was how to compete with their competitors, so the company decided that studying their competitors and expanding distribution channels to easily contact customers are important for the survival of the new product.

In this research, during the step of risk identification, risks agents were identified from SWOT and Porter Five Forces concepts. For risk agents from SWOT analysis, only weaknesses and threats were considered because these two factors had disadvantage on product launching. Thus, they can evaluate the risk event severity score or S_i to derive *ARP* scores. In the case of including strengths and opportunities to identify risk agents, they may give some advantage on *ARP* calculation. Thus, *ARP* score of each risk agent can be decreased if there is some relationship among strengths, weaknesses, opportunities, and threats.

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