The Asian Journal of Technology Management Vol. 9 No. 2 (2016): 98-108

Modelling of Risk Management for Product Development of Yogurt Drink Using House of Risk (HOR) Method

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Abstract. *Product Development is essential for the company to stay steady or advance in the market competition. However, the main challenge in product development is associated with the uncertaincy risks that may appeared during the design process. Such risks may affect the success rate of the product development and may contribute either to a small or a huge loss, in which the sustainability of the company can also be affected. To mitigate the risks in product development, risk management is critical. CV. XYZ is a company producing dairy-based products such as mozzarella cheese and yogurt. This research is aimed to identify the potential appeared risks, to arrange the priority order of risk agents and to conceptualize the risk mitigation strategy to be applied. A Yogurt drink product development is needed by CV. XYZ to support the company goals of the product and market expansion. House of Risk (HOR) method was used in this research. Two phases included in the identification process, namely marketing and product development design. The research results have examined 20 risks with 27 identified risk agents. Using the Aggregate Risk Potential (ARP) value, and Pareto 80:20 principal, this study provides a strategic guideline as how to mitigate the top-three identified risk agents.*

Keywords: *House of risk (HOR), product development, risk management, yogurt drink*

1. Introduction

With increasingly tight competition in the market due to a fast-growing food sector, the survival of food industries are greatly affected and challenged. Some challenges faced by these industries include uncertain market demand, short product life cycle, rapidly changing customer needs (Kim, 2013), a wide product variety, as well as, complex and length supply chain (Zhou et.al, 2015). Thus, to survive in the competitive market, the food industries are substaintially depended on their product development, either from redesigning an existing product or from creating a new product.

Product development is the development of original products, product improvements, product modifications, and new brands through the firm's own research and development efforts (Kotler & Armstrong, 2010). If the product development is successful, the company profits will increase (Amue & Adiele, 2012); and new products will be different and stand out more compared to their competitors. However, Monsef & Ismail (2012) argued that, based on several case studies, there was a low success rate in product development project as indicated by the failure rate of ~80%. This was caused by several risk factors include operational risk, market or competition risk, financial risk, talent risk, cultural and political risk (Brash & Capozzi, 2008). Vargaz-Hernandez (2011) added that the risks associated with environmental, technical, human resources, integration, management, marketing, and strategic are critical success factors in product development.

The risk is a situation involving uncertainty of a certain event to happen within the particular time interval (Lokobal, 2014). Selim & McNamee in Sarens et al. (2006), define risk as a concept utilized to indicate the effect of the uncertainty regarding the event and/or the result occurred from the event that might allow the effect of materiality to happen towards the organization's objectives and

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Received: December 20th, 2016; Revised: February 10th, 2017; Accepted: February 21st, 2017
Doi: http://dx.doi.org/10.12695/ajtm.2016.9.2.4
Print ISSN: 1978-6956; Online ISSN: 2089-791X.

goals. According to Susilo & Kaho (2010), the implementation of risk management enables the company to better control the associated risk. Risk events are closely related to risk agents. Geraldin et al. (2009) argued that risk agents are factors that will most likely to cause the risk to happen. Thus, mitigation or risk handling needs to be carried out to reduce the occurring risks (Yasa et al., 2013).

Many studies have reported the application of risk analysis in food industries and non-food industries (Kim, 2013; Lokobal, 2014; Nuchpho et al., 2014). Several methods such as Analytic Hierarchy Process (AHP), fuzzy AHP, FMEA, Bayesian Network methods, have been widely used in the risk analysis, due to their accuracy results (Chin et al., 2008; Geraldin et al., 2009; Tampubolon et al., 2013). For example, Yet, et al., (2016) applied Bayesian Network methods to analyze the costs and the benefits of the agricultural development project taking into account the relevant risks. Tian & Yan (2013) used the fuzzy AHP for risk assessment on the general design of the satellite. Likewise, the use of FMEA and fuzzy FMEA on the study of product design system has also been reported by Chin, et al. (2008). While, in a study of innovation and best practice in education; the application of the fuzzy concept to investigate failure modes and effects analysis is integrated with fuzzy TOPSIS - fuzzy AHP (Kutlu & Ekmekçioğlu, 2012). In addition to risk analysis methods, house of risk (HOR) has also been widely applied to assess and the risks, as well as to formulate an integrated risk mitigation strategies (Lutfi & Irawan, 2012; Pujawan & Geraldin, 2009).

CV. XYZ located in Jurnorejo Village, Batu, East Java is a dairy company producing a variety of dairy-based products, including Yogurt drink. Yogurt drink is a fermented milk containing lactic acid bacteria, and is beneficial for digestion health. This product is generally made from low-fat milk, diluted with water to reduce total solid or mixed with yogurt to reduce its viscosity (Hartati et.al, 2012). According to Yildiz (2010) and Tamime (2006), the total solid in yogurt drink should not more than 11%.

The objectives of this research is to identify the potential risks that may arise from Yogurt drink product development, to clasify the priority of risk agents and to conceptualize the risk mitigation strategies using HOR method. Then, the design of risk mitigation strategies was arranged in accordance with the criteria and the needs of companies.

2. Research Methods

The identification of product development activity was applied on marketing and product designing phase. Questionnaire was used as the instrument in this research. Determining and selecting the respondents were based on the expertise in providing justification to the associated risks and their mitigation strategies. Four expert respondents, include the Company Director, Head of Marketing division, Head of Production division, and Head of Research and Development division, were asked to answer the questionaire. Data were collected for 3 months, June -August 2016. The details of collecting and processing the data is explained as follows:

2.1. Mapping of Product Development Activity

The risk identification was started from the planning phase, concept developing phase, system level designing phase, detail designing phase, testing and improvement phase, and initial production phase in each stage.

2.2. HOR Phase 1

HOR was used as the measuring method in this research. HOR Phase 1 was a severity assessment of the risk event, risk agent occurrence assessment, and correlation between the risk event and the risk agent (Pujawan & Geraldin, 2009). The assessment was conducted by questionnaire sent to 4 (four) expert respondents. The results from the questionnaire were used as the Aggregate Risk Potential (ARP) value, which further be used to determine the priority of risk agents as a basis for mitigation initiatives. Risk agent priority was resulted from Pareto 80:20 principle. The formula for ARP value is provided in equation (1), below:

$$ARPj = Oj \sum Si \; X \; Rij \quad \ldots\ldots\ldots \; (1)$$

Description :
ARPj = Aggregate Risk Potential on risk agent 'j', j = 1,2,3,….n
Oj = Occurrence of risk agent 'j', j = 1,2,3,….n
Si = Severity of a risk, i = 1,2,3,….,n
Rij = Correlation level between 'i' risk and 'j' risk, ij = 1,2,3,…,n
k = Respondent 'k', k = 1,2,3,…..,n

2.3. HOR Phase 2

HOR phase 2 was conducted to conceptualise the mitigation strategy to be applied by CV XYZ to tackle the appeared risk. The Total Effectiveness (TEk) of each strategy was calculated using Equation (2), aimed to explain the effectiveness level of mitigation strategy in terms of handling the risk agents.

$$TEk = \sum j\ ARPj\ Ejk\ k \quad \text{…….. (2)}$$

Description :
TEk = *Total Effectiveness*
ARPj = *Agregate Risk Potential* on risk agent 'j', j = 1,2,3,…..,n
Ejk = Correlation level between risk agent 'j' and mitigation strategy 'k, jk = 1,2,3,…n
k = Respondent 'k', k = 1,2,3,……n

Then, the assessment of Degree of Difficulty (Dk) on the respective mitigation strategies was carried out using the Likert Scale with a 3-5 point scale. The value of 3 indicates that the mitigation strategy is less difficult to be applied, the value of 4 shows medium difficulty, and value of 5 shows that the mitigation is difficult to be applied. And the last step is to calculate the ratio of Effectiveness to Difficulty (ETD) to determine the rank in the priority order of mitigation strategy that later will be applied. The ETD is calculated based on formula as shown in equation (3):

$$ETDk\frac{TEk}{Dk} \quad \text{……. (3)}$$

3. Results and Discussion

3.1. House of Risk (HOR) Phase 1

HOR Phase 1 is the risk identification phase utilized to determine the priority of risk agent in which should be applied with the mitigation risk. HOR Phase 1 was carried out by implementing the risk identification and risk assessment which included severity assessment, occurrence, and correlation level between risk agent and ARP value calculation. The ARP value was used to see the risk agent priority that will be applied with mitigation by ordering the ARP value from the smallest to the largest.

1. Risk Event and Risk Agent Identification

The identification of risk event and risk agent was obtained from the expert respondents which includes the Director of the company, Marketing division, Production division, and also Research and Development division. Twenty risk events followed by 27 risk agents have been identified to be pottentially appeared in each stage of product development activity. The details can be in Table 1 and Table 2.

2. Severity Assessment

Severity is a measurement of how severe that the loss or damage may appear from various kind of targets. A ranking system is then established on the severity of the appeared impacts (Hariyati & Rusdiansyah, 2009). The impact of an event was valued using the scale of 1 to 10 based on their significance effects. The value of 1 has the lowest significance meanwhile 10 has the most severe impacts. The severity assessment on each identified risk event was examined from the questionnaire given to all selected respondents. The result of severity assessment is shown in Table 3.

Table 1.
Risk Event and Risk Agent of Marketing Phase

Phase	Risk event code	Risk event	Risk agent code	Risk agent
Marketing	E1	Error in analysis market needs	A1	Inaccuracy research and development division in analyzing market needs
	E2	Error in determining market segments	A2	Misunderstanding of marketing divisions in the determination of market segments
	E3	Error in determining consumer needs	A3	Research and development division error in the determination of consumer needs
	E4	Error of strategy determination of market leader	A4	Marketing strategy error in the determination of market leader
	E5	Error of determining competitor	A5	Lack of information regarding the competitors
	E6	Risk in determining the selling price and profit	A6	Error of cost analysis management
	E7	Risk of subsequent strategic planning	A7	Error of management planning
	E8	Risk of failure in promotion	A8	The lack of promotion
	E9	Risk of errors in planning a trial product	A9	Misunderstanding of division of research and development in the composition to make yogurt drink
	E10	Risk of not being massive initial promotional products	A10	Error of promotions used
			A11	Promotions that are used do not follow the existing trend

Source: (Primary Data, 2016)

3. The Assesment of Correlation Level between Risk Event and Risk Agent

The following step is to asses the correlation between the risk event and risk agent. If the risk event caused the appearance of a risk agent, there is a correlation between the two of them (Tampubolon et al., 2013). Using the data from the questionaire, the level of correlation is divided into the scale of 0 (no correlation), 1 (low correlation), 3 (medium correlation), and 9 (high correlation). The result of this assessment can be seen in Table 3.

4. Calculation of ARP Value

ARP value shows the level of risk agent in relation to its frequency of appearance. High ARP value is proportional to the severity of the impact given by the risk agent (Lutfi & Irawan, 2012). The ARP value was calculated based on the severity value, occurrence, and correlation obtained from previous steps. The ARP value was calculated on each risk agent using the formula (1), and the results can be seen in Table 3. Below is the example of the ARP calculation:

$$\begin{aligned} ARP1 &= O1(S1 \times R11) \\ &= 3(5 \times 9) \\ &= 135 \end{aligned}$$

Table 2.
Risk Event and Risk Agent of Design Product Phase

Phase	Risk Event Code	Risk Event	Risk Agent Code	Risk Agent
Design	E11	Errors in determining the concept of the product	A12	Invalid Market analysis
			A13	The flow of information that is not appropriate from the marketing division to research and development division
	E12	Risk determination industrial scale	A14	Error of division research and development and production in industrial scale determination
	E13	Risk of errors in determining the composition of products	A15	Error of Production Division in Yogurt Drink Production
	E14	Risk of increased costs of product design	A16	The flow of information is not appropriate from the marketing division to division production
	E15	Selection of materials incompatible	A17	Error of management supervision
			A18	Not having a fixed standard material
	E16	Risk of errors in determining the critical point material	A19	Errors division of production and research and development in materials characterization analyze
			A20	Unskilled labor
	E17	Risk of control error determination industrial design	A21	Division of research and development wrong in making a design according to company standards
			A22	Lack of supporting technologies
	E18	Risk of reliability testing error yogurt drink	A23	Raw materials used have different quality standards
	E19	Risk of errors durability testing yogurt drink	A24	Division research and development and production incorrect in testing material
			A25	Raw materials used have different quality standards
	E20	Risk of errors in product evaluation	A26	Division of marketing, research and development and production incorrect in evaluating the products that have been made
			A27	The lack of information for product evaluation

Source: (Primary Data, 2016)

3.2. HOR Phase 2

HOR Phase 2 is the mitigation strategy planning stage. The mitigation strategy was arranged based on the correlation between the mitigation strategy and risk agent. The values for TEk, Dk, and ETDk were also calculated in HOR Phase 2 to determine the order of the arranged strategy.

1. Risk Evaluation

Risk Evaluation was performed to rank the risk agents necessary to be applied with the mitigation strategy. Pareto Diagram was used as a measuring instrument on this step, plotted by ordering ARP values from the largest to the smallest, followed by calculating the cumulative value of risk agent and the percentage. This diagram functioned as a media to identify risk agent needed to be applied with the mitigation strategy. Three risk agents were selected based on Pareto 80:20 principle. According to the previous research by Fendi & Yuliawati (2012), the Pareto principle using the ratio of 80:20 illustrated that 80% of the risk events appeared from 20% of the risk agents causative to the risk events. Figure 1 is the ARP Value Pareto Diagram from each risk agent. The most appearing risk agent was A5 lack of information regarding the competitors) with the ARP value of 180.

2. Mitigation Risk Strategy Arrangement

Mitigation Risk Arrangement was used to handle the top three highestranked risk agents. Table 4 shows eleven mitigation strategies that can be applied by CV XYZ to manage the identified risk agents. The following are risk agents index along with the mitigation risk strategy that is applicable at CV XYZ.

a) Lack of Information Regarding the Competitors (A5)
   One of the indicator to measure the market orientation is the competitors (Setiawan, 2013). According to Li et al. (2006), the advantage of competition defined as the ability of each company to create the value that is unable to be found in any of its competitors. The applicable strategies to mitigate this risk are collecting an additional informationregarding the competitors (PA1), increasing the field observation of the competitors (PA2), conducting a comparative study with the competitors (PA3), and arranging a systematical and frequent planning schedule concerning about competitor identification an analysis (once in two weeks) (PA4).
b) Error of Cost Analysis Management (A6)
   Cost Analysis determines the sustainability of a product because cost analysis calculates selling price and profit obtained inside its scope. It is important to have an excellent cost analysis management in product development to create a competitive product in the aspect of price and profit. The applicable mitigation strategies are repairing the cost analysis planning mechanism (PA5), conducting a cost analysis management training (PA6), and carrying out a frequent analysis on the raw material and the selling price fluctuation (once in a week) (PA7).
c) Error of Production Division in Yogurt Drink Production (A15)
   The error of yogurt drink production could generate a huge loss if this happens frequently. The raw material to make Yogurt drink are highly perishable therefore proper handling method is critical to achieve the optimum quality of finished good. The applicable mitigation strategies are conducting a training and human resources development in production division (PA8), recruiting more experienced employees (PA9), creating a fixed Production Standard Operational Procedure (PA10), and supervising all production activities (PA11).

3. Correlation between Mitigation Risk Strategy and Risk Agent

The determination of correlation value between mitigation risk strategy and risk agents was aimed to investigate the relation and effect of mitigation towards the identified risk agents. The assessment was carried out using the questionaire . The level of correlation is divided into the scale of 0 represents no correlation, 1 represents low correlation, 3 represents medium correlation, and 9 represents high correlation. The result of the determination of the correlation between risk agent and risk strategy is shown inTable 5.

Table 3.
HOR Phase 1

		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	*Severity*
MARKETING	E1	9																											5
	E2		9																										6
	E3			3																									5
	E4				3																								6
	E5					9																							5
	E6						9																						6
	E7							3																					7
	E8								3																				6
	E9									3																			5
	E10										9	3																	5
DESIGN	E11												1	1															6
	E12														3														5
	E13															9													6
	E14																1												4
	E15																	3	3										5
	E16																			3	3								5
	E17																					1	9						4
	E18																							3					4
	E19																								3	3			5
	E20																										3	3	5
Occurance		3	2	3	3	4	3	2	4	1	3	4	2	2	3	3	2	3	3	3	2	3	4	3	2	2	2	2	
ARP		135	108	45	54	180	162	42	72	15	135	60	12	12	45	162	8	45	45	45	30	12	144	36	30	30	30	30	
Ranking		**5**	**7**	**11**	**10**	**1**	**2**	**16**	**8**	**23**	**5**	**9**	**24**	**24**	**11**	**2**	**27**	**11**	**11**	**11**	**18**	**24**	**4**	**17**	**18**	**18**	**18**	**18**	

Source: (Primary Data, 2016)

Description:
En = Risk Event
An = Risk Agent
ARP = Value of ARP
Empty column shows a value 0, indicating no correlation

4. Calculation of TEk and The Result of Dk

TEk value is necessary to asses the level of effectiveness from each mitigation strategy esigned to handle the appearing risk agents. Each mitigation strategy was assessed using the Likert Scale. The TEk value was calculated using equation (2). Table 4 shows the result of TEk calculation and Dk assessment. The example of TEk calculation is as follows:

$$TE1 = \sum (9\ x\ 180) = 1620$$

5. Calculation ofETD Ratio

ETD calculation is important to determine the rank of priority from the available mitigation strategy. The highest value of ETD shows the most effective mitigation strategy to avoid the risk agents. The result of ETD calculation can be also be seen in Table 4**.** The example of ETD calculation is as follows:

$$ETDk = \frac{1620}{4} = 405$$

6. Table of HOR Phase 2

HOR Phase 2 (Table 5) indicated the order of mitigation risk strategies applicable for the product development at CV XYZ. The priority was arranged based on ETD value from the largest to the smallest.

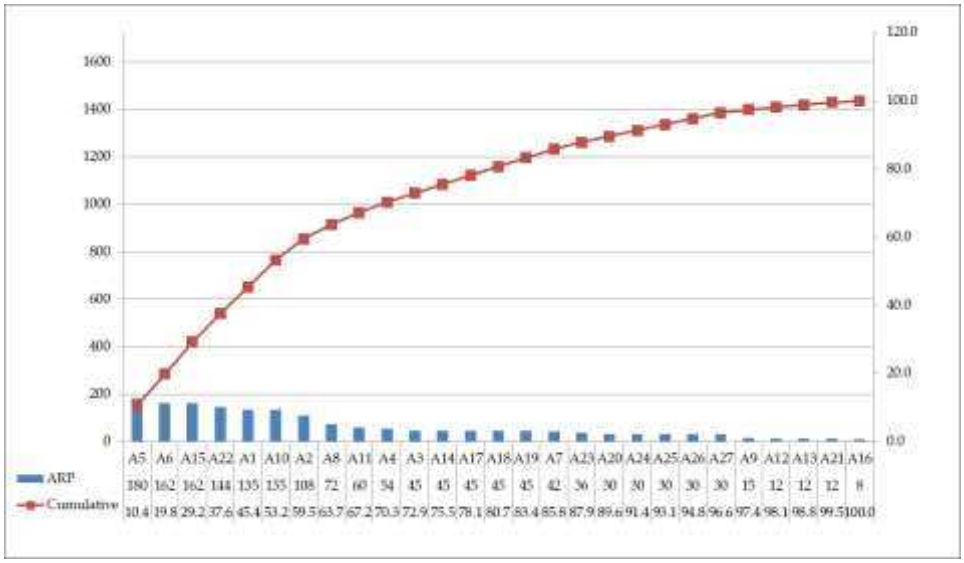

Figure 1. Pareto Diagram of the ARP Value

Table 4.
Risk Agents and Mitigation Strategy

Risk Agent Code	Risk Agent	ARP	Strategy Code	Mitigation Strategy
A5	Lack of Information Regarding the Competitors	180	PA1	Collecting an additionalinformation regarding the competitors
			PA2	Increasing the field observation of the competitors
			PA3	Conducting comparative study with the competitors
			PA4	Arranging a systematical and frequent planning schedule concerning about competitor identification an analysis (once in two weeks)

A6	Error of Cost Analysis Management	162	PA5	Repairing the cost analysis planning mechanism
			PA6	Conducting a cost analysis management training
			PA7	Carrying out a frequent analysis on the raw material and the selling price fluctuation (once in a week)
A15	Error of Production Division in Yogurt Drink Production	162	PA8	Conducting a training and human resources development in production division
			PA9	Recruiting more experienced employees
			PA10	Creating a fixed Production Standard Operational Procedure
			PA11	Supervising all production activities

Source: (Primary Data, 2016)

Table 5.
HOR Fase 2

Risk Agent	Mitigation Strategy											ARP
	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	
A5	9	9	9	9								180
A6					9	9	3					162
A15								9	3	9	9	162
TEk	1620	1620	1620	1620	1458	1458	486	1458	486	1458	1458	
Dk	4	4	5	4	4	5	5	4	5	4	3	
Etd	405	405	324	405	364.5	291.6	97.2	364.5	97.2	364.5	486	
Ranking	2	2	8	2	5	9	10	5	10	5	1	

Source: (Primary Data, 2016)

Description:
PAn = mitigation strategy number 'n'
An = risk agents number 'n'
TEk = *Total Effectiveness value*
Dk = *Degree Of Difficulty value*
Etd = *Effectiveness to Difficulty value*
Empty spaces shows the value 0, in which represented no correlation

The research suggested that there are 11 mitigation strategies need to be applied in yogurt drink production at CV XYZ. These include: 1) Supervising all production activity, 2) Collecting of an additional information regarding the competitors, 3) Increasing the field observation of the competitors, 4) Arranging a systematical and frequent planning schedule concerning about competitor identification ana analysis (once in two weeks), 5) Repairing the cost analysis planning mechanism, 6) Conducting a training and human resources development in production division, 7) Creating a fixed Production Standard Operational Procedure, 8) Conducting a comparative study towards the competitors, 9) Conducting a cost analysis management training, 10) Carrying out a frequent analysis on the raw material and the selling price fluctuation (once in a week), 11) Recruiting more experienced employees.

4. Conclusion

It was concluded that the product development of the yogurt drink at CV. XYZ were identified 27 the risk agents. From these 27 risk agents, three were selected as the risk that needs immediate handling based on pareto diagram. Those risks were lack of information regarding the competitors, Error

of cost analysis management, and Error of production division in yogurt drink production. Eleven mitigation strategies were obtained to be applied in product development of yogurt drink at CV XYZ which is to to supervise all production activity, to add more of collecting information regarding the competitor, to increase the field observation of the competitors, to arrange systematical and frequent planning schedule concerning competitor identification and analysis (once in two weeks), to repair the cost analysis planning mechanism, to hold a training and human resources development in production division, to create fixed Production Standard Operational Procedure, to hold comparative study towards the competitors, to hold cost analysis management training, to frequently analyze the raw material and selling price fluctuation (once in a week), and to recruit more experienced employees.

The findings of this research have been provided a different viewpoint on the study of management technology, particularly on risk management on product development in dairy-based food industry. The results also confirmed that the HOR method is quite effective to analyze risks and to formulate the mitigation strategies for any identified risks in each stage of the product development.

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