A Supply Chain Risk Management Modelling for Balinese Aromatherapy Product by Pricing Optimization

Ida Bagus Dharma Yoga Santosa, Taufik Djatna, and Yandra Arkeman

***Abstract*—Risk mitigation using risk sharing approach is a method to minimize risk on supply chain management. Profit distribution is a way to share the risk among the supply chain level which means, the level which has the lower risk supposed to distribute their profit to the others which have the higher risk. In this paper, pricing optimization is needed to maximize and to balance the profit of each level including their stakeholder. This paper focused on Balinese aromatherapy product supply chain risk modelling which has three objectives: (1) to identify and (2) to evaluate the risk along Balinese aromatherapy product supply chain; and (3) to build a supply chain risk management model for Balinese aromatherapy product by pricing optimization. The result of the identification step showed that the Balinese aromatherapy products supply chain consisted of 51 risk. Then the result of evaluation showed that third sphere has the highest risk proportion among the others. The performance of each DMU was obtained by using Data Envelopment Analysis (DEA) method and became inputs of risk sharing model. In risk sharing model, the optimum price on each DMU sphere based on their weight of risk and their performance were generated. The result showed that the price fluctuation among the DMU altered to a smooth form after the model was implemented and these fluctuation occurred as an implementation result of risk distribution along the chain. This information becomess useful for decision maker related to supplier selection and contract mechanism, especially to pricing mechanism.**

***Index Terms*—Aromatherapy product, pricing optimization, risk sharing model, supply chain risk management.**

I. Introduction

Balinese aromatherapy products, such as spa, scrub, soap, perfume, and the others were coped high value of business since Bali has chosen as “The Best Spa Destination of The World in 2009” on SENSE Magazine version [1]. Considering this condition, this paper focused on Balinese aromatherapy product especially on Balinese Frangipani aromatherapy massage oil because frangipani is the most popular scent related to Balinese aromatherapy and also it is a local indigenous flower in Bali. There were transformations phase on this product, from its main commodity (frangipani flower) to its essential oil, until become its derivative product (Frangipani aromatherapy massage oil). This phase is occurred on each sphere along the chain and it is followed by added value and also risk.

Risk is defined as uncertainty of the thing that will be happened as a result of impact from recent decision [2]. Supply chain activities should be bounded by their risks in every supply chain level as a result of uncertainty of demand, supply, and internal companies [3]. Based on these problem, then the risk should be controlled to avoid financial loss of the companies [4]. In order to avoid risk, then it can be controlled by risk identification, risk measurement, and the management of the risk [5].

Risk mitigation using risk sharing approach is a method to minimize risk on supply chain management [6], [7]. Profit distribution is a way to share the risk among the supply chain level [8]-[10] which means, the stakeholders which have the lower risk supposed to distribute their profit to the others which have the higher risk. On its implementation, risk sharing model became a solution related to contract mechanism [10] which represents the relationship among the spheres. Pricing mechanism is one of the contract aspects. In order to maintain the sustainability of the supply chain, the pricing optimization is needed to maximize and to balance the profit of each stakeholder on its sphere. Based on these motivation, then a supply chain risk management modelling for Balinese aromatherapy product was proposed by using price optimization on purpose to help the decision maker about the information of optimum price of each sphere including their stakeholder.

In this paper, there are three main reasons that make this topic become interesting and necessary related to the sustainability of Balinese aromatherapy product supply chain. First, the aromatherapy product is a natural product which is made from agricultural resources. Refers to [11] and [12] agricultural resources have such characteristics that make it vulnerable of risk of each supply chain level. Second, each sphere along the supply chain have their own risk which also have different impact on the whole supply chain. Third, profit balancing between spheres along the supply chain is needed to obtain the equality of profit distribution on each sphere including their stakeholders.

The paper objectives are (1) to identify the risk of each sphere along Balinese aromatherapy product supply chain; (2) to evaluate its risk; and (3) to build a supply chain risk management modelling for Balinese aromatherapy product by pricing optimization. Specifically, it was discussed about the supply chain risk management methodology, the quantitative formulation that used on this model which is followed by computational experiment, and summary of this paper.

II. Supply Chain Risk Management Methodology

In this paper, a methodology to managing risk along the chain was proposed. The methodology consist of three main

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stages: (1) risk identification, (2) risk evaluation, and (3) risk management as seen in Fig. 1. Before the risks are identified, the configuration of aromatherapy product supply chain was identified first, and then the potential risk along supply chain were identified including their risk probability. Afterwards the contribution of added value on each sphere were calculated using Hayami approach and the risks were evaluated using risk index model. Finally, stakeholder performance on each sphere were calculated using DEA method and the optimum price were generated based on stakeholder risk and performance by using risk sharing model.

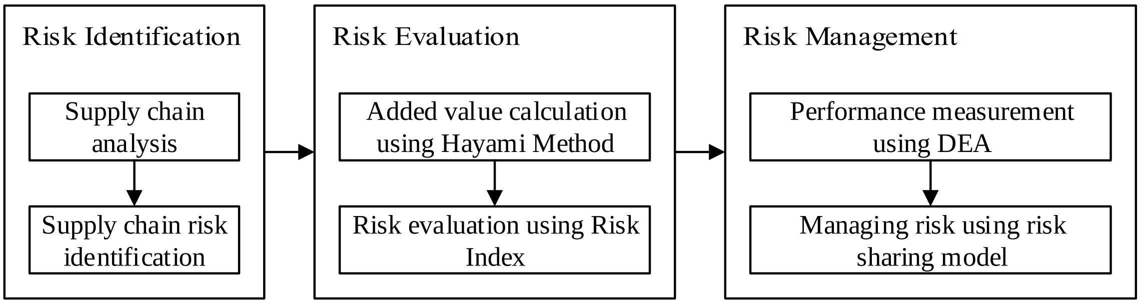

Fig. 1. Methodology of supply chain risk management.

III. Modelling Quantitative Formulation

A. The Identification of Sphere's Risk

Expert knowledge was involved on probability risk scoring of each supply chain level (sphere). There were four spheres (S_x) along the supply chain. Sphere is defined as the part of chain that composed the whole supply chain. Each sphere is consisted of its member named stakeholders. In this paper, it considered that there were four spheres along the Balinese aromatherapy product supply chain, there are collector (S_1), essential oil manufacture (S_2), aromatherapy product manufacture (S_3), and retailer (S_4). Each sphere has some of risk (S_{xi}) that have probabilities on causing the supply product failure ($P(S_{xi})$). The result of risk identification showed that at least there were 51 risk on the whole chain which is consist of 12 risks of collector, 15 risks of essential oil manufacture, 13 risk of aromatherapy product manufacture, and 11 risks of retailer.

B. Risk Evaluation

Based on the value of $P(S_{xi})$ that obtained from expert knowledge, then risks of each sphere were evaluated by using Risk Index method. Firstly, sphere added value proportions (β_x) on the whole chain were calculated using Hayami method template [13] and then the sphere consequence of the supply product failure (α_x) were determined by expert. The risk consequence is categorized into four categories [13] consist of vital (α_x=1), necessary (α_x=0,6), necessary (α_x=0,3), and desired (α_x=0,1). It is assumed there were 1000 kg of frangipani dry flower with 2,5% of yield and 0,7 gr/cm3 of frangipani essential oil density for added value calculation. Then, using all these information, the Risk Index of each sphere (RI_x) [13] is calculated using Risk Index formula as in (1):

$$RI_x = \alpha_x \beta_x \left(1 - \prod_{i=1}^{n} \left(1 - P(S_{xi}) \right) \right) \tag{1}$$

Based on the computational experiment, the results of risk index calculation of each sphere (RI_x) and also its proportion (WR_x) on the whole chain was generated as seen on Table I.

TABLE I: The Calculation Result of Risk Index

S_x	S_1	S_2	S_3	S_4
β_x	6,5%	44,6%	27,6%	8,3%
α_x	0,3	0,3	0,6	0,3
RI_x	0,047	0,067	0,199	0,023
WR_x	6%	39%	48%	7%

IV. Risk Management

A. Stakeholder Performance Measurement

In this paper, Data Envelopment Analysis (DEA) method was deployed to measure the efficiency of each sphere stakeholder which is known as Decision Making Unit (DMU). DEA method is deployed because this method is easy to implement and also it search the optimal solution based on benchmarking proses, so there are no limit on DEA attribute measurement to achieve its efficiency. DMU efficiency (θ_j) is affected by ratio of output (O_{mj}) and input (I_{nj}) when it compared with the other DMU. The value also depends on its output variable (w_{mj}) and input variable (v_{nj}). In this paper, Multiple Input and Multiple Output Charness-Cooper-Rhodess Data Envelopment Analysis (MIMO CCR DEA) is deployed which is represented as in (2):

$$\theta_j = \frac{\sum_{m=1}^{m_o} O_{mj} \cdot w_{mj}}{\sum_{n=1}^{m_o} I_{nj} \cdot v_{nj}} \tag{2}$$

where:

$$\sum_{m=1}^{m_0} O_{mj} \cdot w_{mj} \le \sum_{n=1}^{n_0} I_{nj} \cdot v_{nj}$$

and

$$\sum_{n=1}^{n_0} I_{nj} \cdot v_{nj} = 1$$

In its computational experiment, it assumed that there were seventy one DMU's which consist of thirty DMU in 1th sphere, twenty DMU in 2nd sphere, twenty DMU in 3rd sphere, and one DMU in 4th sphere. Then the performance of all DMU in first three spheres were measured by using DEA method. 4th sphere were not evaluated because this is the last sphere in the chain and it doesn't need to negotiate the contract with the next sphere (customer) based on their performance. Based on these conditions, thus it assumed retailer performance is in maximum condition. The performance evaluation consist of three attributes of inputs, there are total cost (I_1), order cycle time (I_2), and product price (I_3), and three attributes of outputs, there are quality (O_1), order fulfillment (O_2), and supply quantity (O_3). Based on these data, then the efficiency of each DMU were generated by using DEA measurement. DEA method was deployed by using R language [14]. The result of DEA measurement is represented in Table II.

TABLE II: THE RESULT OF DEA METHOD

Stakeholders	I_1	I_2	I_3	O_1	O_2	O_3	θ_{xj}
DMU_{11}	87000000	1	100720	93,00	67,00	372,00	0,898
DMU_{12}	87000000	5	98136	73,00	68,00	909,00	0,905
DMU_{13}	88000000	5	119202	57,00	95,00	170,00	1,000
:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:
DMU_{320}	337000000	1	22300	76,00	73,00	5620,00	0,946

B. Pricing Optimization

Risk sharing model [10] is adapted to balance the profit of each supply chain stakeholder by pricing optimization. Pricing optimization process is determined by involving the profit optimum (FP_{xj}), standard cost, and total production as seen in (4). In this model, Standard total cost and Total production for each sphere were obtained using Hayami calculation. Profit optimum is consisted of two parts, there are weighted profit and incentive. These components have the same proportion in profit optimum which means 50% of weighted total profit (WR_{xj} .F) was allocated on each stakeholder, where F is total profit along the chain based on Hayami calculation. Meanwhile, the other 50% was allocated as its performance incentive.

Incentive mechanism is determined based on stakeholder risk which is represented by coefficient of risk aversion (ρ), where the value of $\rho<1$. The value of risk aversion coefficient indicates the value of risk that should be minimized by the stakeholder which means the lower value of risk aversion coefficient indicates the stakeholder capability to achieve their maximum performance by using DEA measurement with θ=1 [15]. In other word, the better of stakeholder performance, the higher incentive is obtained as the reward. The formulation of pricing mechanism is represented in (3) and (4):

$$FP_{xj} = \frac{\left(WR_{xj} \cdot F\right)}{2} + \left(\frac{\left(WR_{xj} \cdot F\right)}{2} - \left(1-\theta_{xj}\right)\left(\frac{WR_{xj} \cdot F}{2}\right)\right) \quad (3)$$

$$\text{Optimum price} = \frac{FP_{xj} + \text{ Standard total cost}}{\text{Total production}} \quad (4)$$

Based on the data that we obtained from computational experiment, the result of this model is represented in Table III.

TABLE III: THE RESULT OF PRICE OPTIMIZATION

Stakeholders	θ_{xj}	WR_{xj}	FP_{xj}	Standard total cost	Optimum price	Current price	Gap
DMU_{11}	0.898	0.06	9355532	93500000	102856	100720	2136
DMU_{12}	0.905	0.06	9389541	93500000	102890	98136	4754
DMU_{13}	1	0.06	9857786	93500000	103358	119202	15844
:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:
DMU_{320}	0.946	0.48	82142692	326579661	22653	22300	353

From the result as shown in Table III, the optimum prices were generated which is fitted with the weight of risk on each sphere. For instance, in Fig. 2 it showed that the general optimum prices showed the lower value than the current prices. This condition might happen as a result of the imbalance risk distribution among each sphere. In other words, the optimum prices have showed the prices balancing based on the weight of collector risk which is the lowest among the others. In this sphere, the optimum price that supposed to be obtained to maximize the DMU profit is Rp. 103.358.

On the second spheres, the optimum price that supposed to be obtained by the DMU is Rp 4.949.712 and the optimum price based on its DMU performance is shown on Fig. 3. Generally, in this sphere, all prices become higher after this model was implemented. On the contrary, the current prices on the third sphere become lower generally than the optimum price. The optimum price that supposed to be obtained by the DMU in this sphere is Rp 22.780. The fluctuation price of each DMU on the third sphere is represented in Fig. 4. Lastly, the calculation in the next sphere showed that the optimum price in the last sphere (retailer) is Rp 28.206.

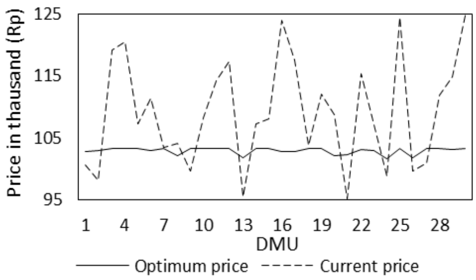

Fig. 2. The optimum price of all collector's DMU.

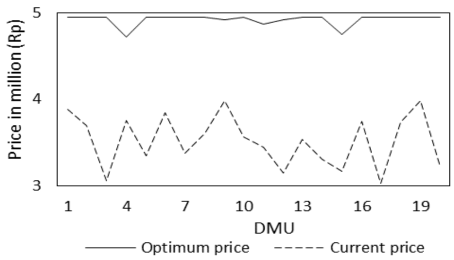

Fig. 3. The optimum price of all essential oil manufacture's DMU.

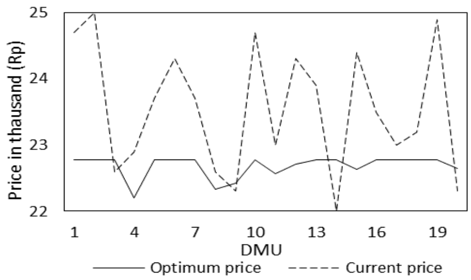

Fig. 4. The optimum price of all aromatherapy manufacture's DMU.

From the Fig. 2-Fig. 4, it also found that the current price fluctuation among the DMU was significantly fluctuated. Then after the model was implemented, the price fluctuation among the DMU became smoothly. On the model the fluctuation prices among the DMU occurred because of the difference rate of its efficiencies. In other words, if the DMU were not efficient, then some of its incentives is distributed or allocated to the next sphere as a compensation of its risk distribution. This information is useful for decision maker related to supplier selection and contract mechanism, especially to pricing mechanism.

V. Conclusion

The result of the identification step showed that the Balinese aromatherapy products supply chain consisted of 51 risk. The result of the risk evaluation using risk index showed 3rd sphere has the highest risk proportion among the others. By using DEA method, the performance of each DMU were generated which became inputs of risk sharing model. In risk sharing model, the optimum prices on each DMU sphere were obtained based on their weight of risk and their performance. It also found the price fluctuation among the DMU altered to a smooth form after the model was implemented and these fluctuation occurred as an implementation result of risk distribution along the chain. This information becomes useful for decision maker related to supplier selection and contract mechanism, especially to pricing mechanism.

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