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A Design of Supply Chain Risk Management for Cocoa Based Agroindustry at South Sulawesi to Balance Risk

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A B S T R A C T

Cocoa agroindustry in South Sulawesi experienced problems such as imbalance of supply chain management and profit distribution of risks assumed by each of the actors in the supply chain. Those issues became the driving factors that interfere with the emergence of a variety of risk supply chain sustainability. Appropriate risk management processes required by the model approach to create a balanced risk among supply chain actors. This study aims to design a model to ensure and increase profit cocoa supply chain actors. Risk mitigation approach implemented with the risk sharing model which aims to improve profitability and continuity supply chain's actor. The orientation of the model output is not only tosustain the supply chain but at the same time to increase the total profit on the whole supply chain actors. Balancing risk optimization are done through risk specific calculation and performance of supply chain actors into risk sharing models. The performance of each supply chain actors is calculated with the DEA approach. Total profit improvement among supply chain actor causing risk sharing models in this study have a good bargaining position against all supply chain actors. The design of the of contract structure resulted a form of quantitative models as a tool for coordinating mechanism of risk sharing models for supply chain actors. Through the risk sharing model approach in this study, the design of the supply chain can be produced that have sustainability as well as profitability.

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1. INTRODUCTION

Indonesia is the big once of cocoa beans producer in Asia and Oceania area. Based on International Cocoa Organization data, forecasting of Indonesia cocoa beans production in 2021/22 up to 180 thousand tones (International Cocoa Organization, 2022). Indonesian cocoa has a characteristic that is not have by other countries. There is high melting point, flavorful fruit and has fatty acid contains is lower. But un-fortunately the quality of our cocoa is still low enough so that

productivity is small. So largest of cocoa plantations in Indonesia which 95% are smallholders, equivalent to 4.1 million farmers, therefore, cocoa is an important commodity in the economy of the people.

Refers to data from (Badan Pusat Statistik, 2020), South Sulawesi is one of the 34 Indonesia provinces which supply 15.32% cocoa beans (or 110.418 tons) from Indonesia, but in fact there is an imbalance between the distribution of profits and risks borne by each of the cocoa supply chain actors (Sriwana et al., 2014), (Ahoa et al., 2020), (Aini et al., 2014), (Aisyah et al., 2018), (Adha, 2017). Value of the selling priceis not proportional to the magnitude of the risk to be borne by the upstream supply chain actors particularly farmers.

The process of risk balancing for any actor involved in the supply chain network can be done through the distribution of profits proportionate and balanced mechanism (Fan & Stevenson, 2018), (Behzadi et al., 2018), (Ho et al., 2015). Supply chain risk management is an integral function of the supply network (Gurtu & Johny, 2021). (Gonçalves et al., n.d.) did the risk sharing through a negotiation process between farmers and other actors in the supply chain by the model stakeholder dialogue. Perform a risk balancing in the manufacturing industry, by creating actors that act as a counterweight (intermediary) between suppliers and retailers. In ideal conditions should have taken the greater the risk that farmers in pursuit of agricultural cultivation, the greater the profit that can be acquired. The imbalance between the distribution of profits earned in the cocoa supply chain actors South Sulawesi with risks involved in carrying out its business activities affect the sustainability of cocoa products.

The complexity of the problems in South Sulawesi cocoa development can be seen of them: 1) Accumulation of risk in one sphere of supply chain network, 2) Lack of quantity of raw material supply from the upstream (Upstream) supply chain network, 3) Gain accumulate in the downstream actors (Downstream) supply chain network, 4) low quality raw materials for organic farming has not been standardized, 5) not to create better coordination at each supply chain actors to address the problem (risk) occurring along the supply lines, and 6) the absence of chain design a good supply of cocoa in South Sulawesi.

This paper objective are: (1) to identify and evaluate the risk of each sphere along South Sulawesi cocoa supply chain; (2) to formulate risk mitigation through the risk sharing model approach; and (3) to build a sustainable supply chain risk management modelling for south Sulawesi cocoa by increase profil on each sphere. In this paper, we discuss sbout 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.

2. RESEARCH METHOD

In this paper, a methodology to managing risk along the chain was proposed. The methodology consist of three main stages: first, risk analysis, second, performance measurement using DEA and third, risk sharing model as seen figure 1. Before the risks are identified, the configuration of cocoa supply chain, its spheres and 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 risk were evaluated using risk index model. After that, stakeholder performance on each sphere were calculated using DEA method and the balance risk were generated based on stakeholder risk and performance by using risk sharing model. Finally, design the structure contract.

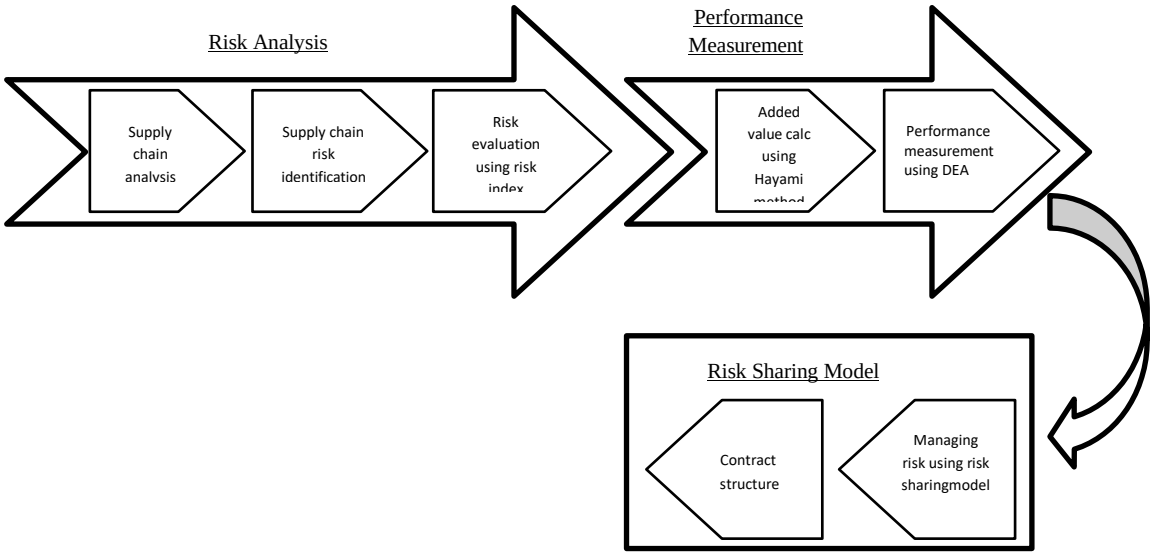

Fig. 1. Methodology of supply chain risk management

3. RESULT AND DISCUSSION

Techniques and Modelling Quantitative Formulation

The identification of Sphere's risk. Expert knowledge were involved on probability risk scoring of each sphere.There were four spheres (Sx) 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, we considered there were four spheres along the South Sulawesi cocoa supply chain, there are farmer (S1), collector (S2), wholesaler (S3), and industry (S4). Each sphere has some of risk (Sxi) that probably cause the supply product failure (P(Sxi)). The result of risk identification showed that at least there were 53 risks on the whole chain which is consist of 15 risks of farmer, 13 risks of collector, 14 risks of wholesaler, and 11 risks of industry.

Risk evaluation. Based on the value of P(Sxi) that obtained from expert knowledge, then risks of each sphere were evaluated by using Risk Index method. Firstly, sphere added value proportion (βx) on the whole chain were calculated using Hayami method template and then the sphere consequence of the supply product failure (αx) were determined by expert. The risk consequence is categorized into four categories consist of vital (αx=1), necessary (αx=0,6), necessary (αx=0,3), and desired (αx=0,1). It is assumed there were 100 kg of cocoa bean 32% of yield for added value calculation. Then, using all these information, the Risk Index of each sphere (RIx) is calculation using Risk Index formula as follows (Eq.1) (Teniwut et al., 2019).

$$RIx = \alpha x \beta x \left(1 - \prod \frac{n}{i=1} \left(1 - P\left(Sxi\right)\right)\right) \quad (1)$$

Based on our computational experiment, we obtained the result of risk index calculation of each sphere (RIx) andalso its proportion on the whole chain as seen on table 1.

Table 1. Result if risk index calculation

S_x	S_1	S_2	S_3	S_4
β_x	0,95	0,033	0,96	0,071
α_x	0,60	0,30	0,30	0,30
RI_x	0,157	0,010	0,288	0,021
RI_x proportion	64,11%	1,12%	32,36%	2,41%

Stakeholder Performance Measurement. In this paper, we have used DEA method to measure the efficiency of each sphere stakeholder which is known as Decision Making Unit (DMU). We used DEA method because this methodis easy to implement and also it can find the optimal solution based on benchmarking proses, so there are no limit on DEA attribute measurement to achieve its efficiency. DMU efficiency (θi) is affected by ratio of output (Oij) and input (Iij) when it compared with the other DMU. The value also depends on its output variable (wij) and input variable (vij).

Based on DEA efficiency formula, there are two approaches to maximize, first by maximizing the output and thesecond way is by minimizing the input. In this paper, we proposed "Multiple Input and Multiple Output Charness Cooper Rhodess Data Envelopment Analysis (MIMO CCR DEA)" which is represented as follows (Eq. 2):

$$\theta j = \frac{\sum_{j=i}^{n0} Oij\ Wij}{\sum_{j=i}^{n0} Iij\ Vij} \quad (2)$$

Where :

$\sum_{j=i}^{n0} Oij\ Wij \leq \sum_{j=i}^{n0} Iij\ Vij$ and $\sum_{j=i}^{n0} Iij\ Vij = 1$

In its computational experiment, we assumed that there were forty-one DMU's which consist of twenty DMU ina 1th sphere, twenty DMU in 2nd sphere, five DMU in 3rd sphere, and one DMU in 4th sphere. Then we measured the performance of all DMU in first three sphere. We didn't evaluate the 4th sphere 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 this condition, thus we assumed industry performance is in maximum condition. The performance that we evaluated consist of three attributes of inputs (total cost (I1), order cycle time (I2), and product price (I3)), and four attributes of outputs (quality (O1), order fulfillment (O2), supply quantity (O3)). Based on these data, then we calculated the efficiency of each DMU by using DEA measurement. The result of DEA measurement is represented in Table 2.

Table 2. Result of DEA measurement

Stakeholders	I_1	I_2	I_3	O_1	O_2	O_3	y^i
DMU_3	10360000	5	28000	16,00	42,50	720	1,0000
DMU_4	10360000	2	28000	14,00	50,00	750	0,7500
DMU_5	10560000	3	26000	7,20	49,48	470	0,7500
:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:
DMU_{45}	22780000	5	34000	40,38	98,21	31200	1

Risk Sharing Model. In this paper, we proposed risk sharing model to balance the profit of each supply chain stakeholder by increase profit. Pricing (FPyi) optimization process is determined by combining the fix price (Fyi) andits performance incentive (I). Incentive mechanism is determined based on stakeholder risk which is represented by coefficient of risk aversion (ρ), where the value of ρ<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 (θ=1).

In this model, the pricing mechanism consist of two parts, there are fix price and incentive. These components have the same proportion in pricing mechanism which means 50% of

total price was allocated on each stakeholder. Meanwhile, the other 50% was allocated as its performance incentive. Incentive has given a dynamic, it depends on stakeholder performance. In other word, the higher of stakeholder performance, the higher incentive is obtained as thereward. The formulation of pricing mechanism can be seen as follows (Eq. 3):

$$\text{FPyi} = \frac{(WRiFy)}{2} + \left\lfloor \frac{(WRiFy)}{2} + (1 - \theta) + \frac{(WRiFy)}{2} \right\rfloor \quad (3)$$

Based on the data that we obtained from our computational experiment, the result of this model is represented in table 3.

Table 3. Result of sharing model

Stakeholders	FP_{yi}	WR_f	FP_{pi}	Standar Total Cost	Optimum Price	Current Price	GAP
DMU_3	1,000	0,571	3.020.990	135.000	31.560	26.000	5.560
DMU_4	0,750	0,571	3.302.949	135.000	34.379	28.000	6.379
DMU_5	0,750	0,571	4.027.986	135.000	41.630	28.000	13.630
:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:
DMU_{45}	1	0,288	19.260	16.000	35.520	35.000	520

From the result as shown in table 3, we were generated the optimum price which is fitted with the weight of riskon each sphere.

Contract structure. In this paper, contracts designed through a process of characterizations based on markers specific risks that it faces a coordination model proposed in this model. Each seeks to maximize retail sales of all products have been ordered (Expected Utility) so as to give the impression as a supplier to the seller when faced with the question of the number of supply and price to be enforced during the booking period. Vendors will be oriented opposite to maximize the total profit acquired (Expected Value) by increasing the quantity of orders from retail. So formulate for EV farmers by setting the selling price through the RS model is (Eq.4):

$$\boldsymbol{E}[\boldsymbol{V}([\prod](\boldsymbol{F}, \boldsymbol{c}, \boldsymbol{\theta}))] = \boldsymbol{F_{yi}} + (\boldsymbol{F_{yi}} - ([\mathbf{1} - \boldsymbol{\theta_{yi}}]^{+}. \boldsymbol{F_{yi}})) \quad (4)$$

It means the value of the products farmers will be rewarded based formulations have been developed in the RS model.with farmers based on the goal to increase the sale value of the product (ev), then the maximum profit that can be obtained by maximizing the value of EU industry through the counter mechanism (M (Q)) is as follows (Eq.5) :

$$Max\ Q = \sum i \in M\ (Q)(E\ [\Pi\ S^{v}_{opt}\ (F, c, \theta) = k]) \quad (5)$$

If

$$(Q)\left(E\left[\sum i \in M\ (Q)(E\ [\Pi\ S^{v}_{opt}\ (F, c, \theta) = k]\right]\right) \geq ri$$

$$\boldsymbol{F_{yi}} + (\boldsymbol{F_{yi}} - ([\mathbf{1} - \boldsymbol{\theta_{yi}}]^{+}. \boldsymbol{F_{yi}})) \geq \boldsymbol{F}_{\text{yj}} + (\boldsymbol{F_{y}}\text{i} - ([\mathbf{1} - \boldsymbol{\theta_{y}}\text{j}]^{+}. \boldsymbol{F_{y}}\text{j}))$$

$$\forall ie M\ (Q), J \in Q$$

4. CONCLUSION

The result of the identification step showed that the South Sulawesi supply chain consist of 53 risks. Then based on our evaluation, we obtained that third sphere has the highest risk proportion among the others. By using DEA method, we obtained the performance of each DMU which became inputs of our risk sharing model. In risk sharing model, of the profit distribution process can be known RS model can change farmers riskweight to be 0.4 while margins for farmers for each kg of cocoa bean sales increased of Rp. 9,200. RS model also can be optimized the distribution risk in to create a balancing risk from each sphere of supply chain. The design of a sustainable supply chain is obtained through a mechanism models RS and draft contract structure that proved to increase total profit of farmers, collector, wholesaler and industry. The increase in total margin offarmers, collectors, traders and industry can be achieved through improving the performance of each actor. Through this model significantly proven to increase total profit actor implications for the sustainability of supply so that to create a sustainable cocoa supply chain.

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