Risk Management of Agroindustry Supply Chain using Logistics Performance Perspective

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Abstract— **this study has successfully developed a risk based performance prediction model of sustainable palm oil supply chain. Application of non-numeric method proved quite effective in providing performance predictions. The developed model was verified by applying the model to predict the performance of Indonesia palm oil supply chain. Result of predictions model has also been validated by comparing predicted results with the current situation. This was show that the model is valid. Performance prediction of Indonesia palm oil supply chain in the next year is poor. Performance prediction of each aspect is ordinary. Performance prediction of each indicator in general is ordinary except demand, quality of finished product, timeline of delivery and inventory is very good. In addition, applications of proposed model also need to be tested more widely.**

Keywords— **Risk, performane, palm oil, prediction, supply chain**

I. INTRODUCTION

Enhance the competitiveness of Indonesia's palm oil industry is very important because Indonesia has been the biggest palm oil producer in the world. Obviously various strategies of production, distribution and marketing must be well defined to enhance competitiveness in global markets. This is important manner because of various economic or a political barrier to non-tariff from various countries has become serious threat. For example, the U.S. Government has considered that palm oil does not belong to the sources of raw materials for renewable energy because it contains elements about 20% of greenhouse emissions. Australia has established the Food Standards Act Amendment in 2011 which requires food sources of raw materials must meet the standards set. European NGOs still continue to make a black campaign against palm oil ASEAN and this can be a barrier to entry into the European market. This situation has shown that the formulation of the palm oil supply chain strategy should accommodate sustainability issues.

Supply chain performance is measured in time, cost, reliability, and flexibility. But these outcomes depend on local inputs that affect the supply chain within a country. There are trade-related procedures. There is the supply for trade-related support services. And there is infrastructure, which includes ports, roads, railroads, airports, and information and communications technology (ICT). Sound policymaking requires informed dialogue with stakeholders, especially those in the private sector. Global benchmarks such as the Logistics Performance Index (LPI) play an important informative role. By showing countries how they stack up against their competitors and highlighting the costs of poor logistics, the LPI catalyzes progress helping policymakers and the private sector build a strong case for reform.

The purpose of this study is to develop a prediction model of risk of sustainable palm oil supply chain. The model is a decision support tool that is needed by decision makers to make targets. The model develops using non-numeric techniques. Risk prediction model will serve as a guide for decision makers to decide the values of each target.

II. LITERATURE REVIEW

The sustainability concept was developed to enhance the benefits of economic, social and environment in the context of business strategy at the same time [1]. Sustainability concept is a perspective to harmonize between economic, environmental, and social [20]. SCM is an approach to the whole operation to be performed efficiently and effectively. Sustainable supply chain management (s-SCM) is an approach to manage supply chain in harmony with resource utilization as input and convert these inputs to achieve economic benefits, positive impact of ecological and social development simultaneously.

According to Bloemhof [3], the area of sustainable supply chain management consisting of two fields namely conflict resolution of particular interest and closed loop system. First field is triple-P concept that focused on optimizing profit (economic aspect), people (social aspect) and environmental and secondly, the closed-loop system is combining forward and reverse supply chains by closing material flows to limit emissions and residual waste. Sustainable supply chain is similarly with other terms as reverse logistics [17], closed-loop supply chain management [7], green supply chain management [21], and green marketing [18].

Supply chain strategy should have a performance management system to ensure success in achieving the targets which have been designated as an improvement plan. Performance management of the s-SCM has become a complicated issue because it involves several actors who have interests and different agendas in the transverse [5]. However, performance management is needed by decision makers for activities planning and controlling of strategic, tactical and

operational [8]. In principle, performance management consists of four phases, namely design, measurement, evaluation and improvement. This study focuses on the improvement phase that requires the prediction target.

Many studies have been conducted in the field of supply chain performance management. Hadiguna et al. [13] have formulated indicators for sustainable supply chain of automotive industry. Baghwat and Sharma [2] have applied the balanced scorecard to measure and evaluate supply chain operations. Gunasekaran et al. [8] have formulated measures and metrics to measure supply chain performance at the strategic, tactical and operational. Kleijnen and Smits [14] have performed a critical analysis of various metrics for supply chain performance of particular manufacturing company. Hervani et al. [10] have developed a model of green performance measurement. Wu et al. [25] have investigated the performance metrics of high-tech companies. Some previous studies focused on determining measures and metrics of supply chains. It is very important for performance measurement and prediction.

Performance assessment methods have also been widely developed in previous studies. Ganges and Carpinetti [6] has designed performance prediction model using fuzzy logic. Vanteddu et al. [23] has designed performance measurement applications using MS Excel. Olugu and Wong [16] have designed performance measurement of closed loop of automotive industry using fuzzy expert system. El-Baz [4] has integrated fuzzy logic and analytic hierarchy process for supply chain performance measurement. Some of these previous models have been focused on measurement based on achievement of the past. In performance management system, prediction performance is necessary to set target of performance indicators as part of the improvement plan. In addition, events in the future will be faced with uncertain situations so that these can lead to risk. Previous models have not considered the issue of risk in performance management. In fact, risk-based performance prediction model has not been found in previous studies.

If the measurement of supply chain performance plays an important role then this means that the prediction performance is important as well as the completeness of the application of performance management systems. According to Ganapathy and Narayanan [9] decision-making in supply chain management can be classified into two decisions, namely the development of systems and system performance evaluation. System development can be understood as decision management for material flow and information flow both hard and soft systems. Performance evaluation system is aimed to manage the results of several programs that have been implemented. According Nudurupati et al. [15] organizations should evaluate performance in order to assist rapid decision-making process in the framework of the principles of agility and responsiveness. According Estampe et al. [5] supply chain performance evaluation will involve multiple actors with their respective interests in achieving strategic goals. According to Searcy et al. [22] an organization must consider the various plans that have been conducted and how the infrastructure will impact on the design and implementation of performance assessment system. Prediction of supply chain performance is a part of soft system category that built from the database and model base. Output of prediction model is intended to provide flexibility for decision makers in determining the numerical value of the target in the future.

III. METHODOLOGY

The research was done in several stages. First, study of the palm oil supply chain system is done by reading the relevant references such as Hadiguna et al. [11] and Hadiguna [12]. In addition, this stage has also been carried out discussions with practitioners of Indonesian palm oil industry and observations. The result understands about material flow of material and information flow of palm oil supply chain system. The second is to acquire sustainability performance indicators which consist of three aspects: economic, political and social environment. The used indicators of this paper are referring to Hadiguna [12].

Third stage is to formulate the algorithm by applying the concept of non-numeric multi criteria decision making that has been defined by Yager [26]. This algorithm is developed with the involvement of past performance and risk level of each indicator. Variable model is a non-numeric type. The reason for this variable type is to provide flexibility for decision makers to translate non-numeric into numerical prediction. Performance variables defined in several levels: excellent (P7), very good (P6), pretty good (P5), ordinary (P4), poor (P3), very poor (P2), and worse (P1). Risk variable is formulated namely none (P7), much less impact (P6), little impact (P5), moderate (P4), considerable impact (P3), significant impact (P2), very significant impact (P1). Scale is indicating rank order of each.

The fourth is to build a rule base that can guide decision-making groups to decide the value of the improvement targets for the next period. Input that needed for this operation is a predicted value of performance. This input will be processed in a certain protocol that produces a specific suggestion in order to determine the value of performance targets. The protocol was formulated based on discussions with various parties' specialized academics and researchers who are experts in the field of palm oil. The formulation of this protocol is still very shallow because of performance-oriented Indonesian palm oil in general. However, the model logic can be applied specifically or customized accordance with industry and government needs.

Fifth, the proposed algorithm is implemented in a computer program. This stage aims to verify whether the algorithm is working in accordance with the logic set. Verification process uses primary data that collected using questionnaire. Number of respondents is 15 persons which qualification of the respondent is a person who has knowledge and experience of both academic and practical in the field of oil palm industry. The educational background of respondents is master and doctoral degrees.

IV. RESULT

Performance prediction model requires two types of inputs that are past performance and risk levels. Past performance is measurement result of each indicator which reflects achievement of previous period. The results of these measurements will be used as input to predict future performance. Because the used concept is non-numerical measurements while past performance is numerically then the performance measurement results need to be converted into a non-numeric. Previous section has outlined the levels of performance variables. Risk level is to represent priority of each indicator. The greater impact of risk level means that the indicator is a priority. The role of risk level in predicting performance is a failure possibility of action plans in order performance improvement. Risk level values obtained from the risk assessment process.

Basically, this algorithm works with two levels of prediction that is prediction of performance for each indicator and partial predictions overall performance. Partial performance prediction is obtained by assessing past performance and risk level of each indicator. The results of prediction performance of each indicator can be aggregated into an average prediction of future system performance. In this paper did not explain how the non-numerical value of past performance is obtained. Likewise, the risk level of each indicator is not described. Modelling in this paper only focused on the explanation of procedure to predict performance.

The process of prediction operation using particular scale that described in the previous section. This operation is performed for each indicator. The value of the past performance of each indicator is transformed by value negation. Negation process is obtained by getting the inverse of value. Then, negation values of each indicator are compared to values of risk level. Principle of this operation is selecting based on the maximum or highest value. Outcome of this operation is a prediction performance of each indicator.

Furthermore, predictive values of each indicator can be aggregated into an average value. The value of aggregation is called a prediction performance of the system. The procedure is comparing the predictive value of all indicators and selecting the minimum value or the smallest. This is final stage of prediction procedure. Next, decision makers' group need to interpret the performance prediction in numerical form. Target values could be a reference to previous period.

Another part of the proposed model is a rule in setting the target. Decision-making groups should be assisted with the recommendations issued by the model. Therefore, the proposed model should be complemented with a rules base or protocol. Basically, the rule base that proposed in this paper can be customized according to the situation in particular company. Operating procedures of the proposed recommendation for setting the target value is to apply IF and THEN rule. IF rule consists of predicted values of performance, while THEN rule is recommendations consisting of decreasing, increasing, and maintaining. Only three types of recommendations are proposed in this study.

Model verification is done to check whether the model is working in accordance with the formulated logic. The verification process requires the input data so that the checking can be done accurate. Verification process is performing refer to published data by Hadiguna [12] where data was obtained from distributing questionnaires by 15 respondents. Table I contains past performance, risk level and performance predictions for one period ahead. Prediction column is obtained from the highest ranking scale.

TABLE I
RISK LEVEL AND PREDICTION

Factors	Performance Indicators	Achievement	Risk level	Prediction
Economic	Demand volume	P6	P3	P6
	Product price	P4	P4	P4
	Raw material price	P4	P4	P4
	Quality of finished product	P6	P3	P6
	Timelines of delivery	P6	P3	P6
	Product inventory	P6	P3	P6
	Losses	P4	P4	P4
	Manufacturing cost	P4	P4	P4
	Bullwhip effect	P4	P3	P4
Environment	Energy consumption	P4	P4	P4
	Waste treatment	P4	P4	P4
	Reuse and recycle material	P4	P4	P4
	Natural disaster	P3	P4	P4
	Remanufacturing	P4	P4	P4
	Land condition	P4	P4	P4
	Green technology	P4	P4	P4
Social	Labour strike	P4	P4	P4
	Mass demonstration	P3	P4	P4
	Environment act	P4	P4	P4
	Local custom	P4	P4	P4
	Crime attack	P4	P4	P4

There are two types of aggregation that can be conducted to obtain sub system performance prediction and whole system prediction. Aggregation of each factor can be obtained by aggregating past performance and risk level first. Furthermore, the comparison carried out to predict aggregate performance of sustainability factors. Similarly, aggregation of the overall system can be done by first aggregating the performance and level of risk. After that, the comparison can be carried out in order to get predictions of the overall system performance. The results of aggregation process on the sub-system can be seen in Table II. Level of aggregation for the whole system is a P3 for the performance, P3 to the risk that the prediction performance of the system is a P3.

TABLE III
RISK AGREGATION

Sub system	Performance	Risk	Prediction
Economics	P4	P3	P4
Environment	P4	P4	P4
Social politics	P3	P4	P4

V. Conclusion

This study has successfully developed a risk based performance prediction model of sustainable palm oil supply chain. Application of non-numeric method proved quite effective in providing performance predictions. The developed model was verified by applying the model to predict the performance of Indonesia palm oil supply chain. Verification results show that the model has been able to work in accordance with the principles set out. Result of predictions model has also been validated by comparing predicted results with the current situation. The result is no difference between the predicted performances with the situation that is happening today. This shows that the model is valid.

Performance prediction of Indonesia palm oil supply chain in the next year is poor. Performance prediction of each aspect is ordinary. Performance prediction of each indicator in general is ordinary except demand, quality of finished product, timeline of delivery and inventory is very good. Recommendation is necessary to ensure that performance can be better than predicted results. Predicted results are an early warning to decision makers. In general, the recommendation aimed to increase the target value of each performance indicator.

A further study is to develop comprehensive models. Direction of model development is to integrate risk assessment, performance assessment, performance prediction and system information. This integration will create a model of business intelligence. In addition, applications of proposed model also need to be tested more widely.

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