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Supply Chain Configuration Using Hybrid SCOR Model and Discrete Event Simulation

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Abstract—**Malaysia is one of the suppliers of palm oil in the world, but their downstream industry still exported semi-finished product to several developed countries. This shows that supply chain configuration in the palm oil industry is still not optimal. This paper contributes to measure value added of crude palm oil that is processed by palm oil downstream industry. Measuring was done using a simulated approach on supply chain configuration with integrating SCOR model and discrete event simulation. Finding in this research show the highest value added in distribution crude palm oil is scenario IV, which it is more valuable if palm oil downstream industries are able to produce finish product to the end customer. Furthermore, the simulation results can construct supply chain configuration in order to support decision-making process.**

Index Terms—**supply chain, SCOR model, discrete event simulation, crude palm oil**

I. Introduction

Nowadays, palm oil is a source of vegetable oil with the highest demand in the world [1]. It causes many developed countries to import palm oil products from producer such as Malaysia which has large areas of palm oil plantations. Furthermore, the main product from the plantation is Fresh Fruit Bunch (FFB) which it is produced into palm oil derivative products such as Crude Palm Oil (CPO), kernel, fiber, empty bunch and shell [2], [3]. The highest volume of demand for palm oil derivative products is CPO which produced by the milling industry [4].

Annual report of the Malaysian Palm Oil Board (MPOB) in 2013 [5] showed Malaysia has several palm oil downstream industries involving 45 crushers, 55 refineries and 17 oleochemcials that are capable of producing the finished products to the end customer. Nevertheless, this country still distributes semi-finished products of palm oil through the port. This condition proves that the highest of value added in palm oil derivative products in Malaysia is not in the finished products, but in the semi-finished products [6].

This research will identify the transformation value of palm oil products into finished products. Determination of value-added products will be calculated from FFB to be finished products to deliver to the end customer. Then, the focus of research will be directed for distribution of CPO through various industry processes in Malaysia. Transformation of value-added CPO will involve some industries as suppliers, manufacturing and customers. It can be viewed as an integrated palm oil supply chain industry. Thus, it is necessary to solve problem in supply chain configuration on the distribution of CPO in the palm oil downstream industry.

This study uses a simulation approach on several stages in palm oil processing industries that process CPO as feedstock. Describing of the business process will use the Supply Chain Operations Reference (SCOR) model approach that identifies the process based on the relationship between supplier, manufacturing and customer into several stages of the Plan, Source, Make, Deliver and Return [7]. In addition, supply chain configuration will be developed into discrete event simulation in the business process. Thus, integration SCOR model and discrete event simulation in simulation supply chain model is expected to determine the value-added palm oil derivative products from feedstock into the finished products. Methodology in this paper will build the supply chain configuration into four scenarios. These scenarios based on the processing of FFB into CPO and continued to be processed in the palm oil downstream industry. Case study in this research will be carried out on the palm oil industry in Malaysia. Furthermore, this research is also expected to give contribution to the industry and policy makers in order to consider increasing productivity of palm oil industry in Malaysia.

II. Supply Chain Simulation

The supply chain is a process transformation of raw materials into a product from the supplier to the end customer with supporting information, financial, material and knowledge [8]. Moreover, purpose managing of the supply chain is to increase value-added products to customers in order to obtain the maximum benefit of the company [9]. A process that occurs in the supply chain can be described based on sequence process. So, modeling of business process is needed to measure supply chain configuration. There is a method used for business process

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reengineering that is SCOR models.

Supply chain operational reference (SCOR) is developed by Supply Chain Council. This approach is used as a modeling tool, a set of key performance indicators, and a benchmarking tool [10]. In this study, SCOR method will be used to build business process that aims to measure supply chain configuration.

According to Beshara et al. [11], improving the overall performance in the supply chain configuration that supports relationships among entities within a network can be simulated. Therefore, simulation techniques can solve the problem as randomness and interdependence [12]. Distribution of CPO on palm oil downstream industry uses a batch production system [13] so it can be categorized into a discrete event which is more suitable simulated using the method of discrete event simulation. Thus, hybrid method of SCOR model and discrete event simulation are expected to support the decision-making process in detail at the operational level.

III. Case Study

Crude palm oil is one of the results palm oil derivative products from the milling process. This product is obtained from the extraction of FFB. Based on MPOB of standard oil processing in milling, average Oil Extraction Rate (OER) of FFB is 20.25%. CPO has had added value because the product may be sold to another industry to continue into derived products to the end customer. Furthermore, CPO is processed in the refinery industry through the stages of Refining, Bleaching and Deodorization [14]. The main products of the refinery are olein that can be used as raw material for cooking oil and stearin can be used as raw materials for margarine shortening and specialty fats. In addition, PFAD is refinery byproduct that will be processed by the oleochemical industry.

The finished products of the palm oil downstream industry have basically been providing value-added because these products have been exported to be able to fulfill the demands of the industry. Nevertheless, rarely research that conducts about enhancing in value-added of palm oil derivative products that are produced by supply chain downstream industry.

This study will build scenarios to determine the added value. This determination of the terms of four scenarios that will be built in the software simulation:

I. 100% of CPO of the result milling process will export
II. 20% of CPO exported but the remaining 80% will be produced in the local industry through the refinery process. The finished products of the refinery will continue to be exported through the port.
III. 100% of CPO will be sent to the refinery process. Its result will deliver to export through the port.
IV. 100% palm oil will be produced at the refinery. All of Finished product of refinery process will deliver to oleochemical or local industry. Thus, these products are exported to the end customer.

The above scenarios will be determined using hybrid methods SCOR models and discrete event simulation. In addition, description of the CPO distribution in several industries can be seen in figure 1.

IV. Hybrid SCOR Model and Discrete Event Simulation

This section analysis of developing supply chain using simulation modeling using hybrid SCOR model and discrete event simulation

A. SCOR Model

SCOR model will be implemented by using the software process wizard, which adoption SCOR model version 8.0. The software provides modules to build a business process model into supply chain configuration. This tool can describe business process into several levels. Level 1 is process type which defines the scope and content of the SCOR model involving Plan, Source, Make, Deliver and Return. Moreover, level 2 is process categories which a company can configure the supply chain structure from 30 process categories. It means the operational strategy for supply chain is developed through the configuration that their own choice. Summary of business process reengineering can be show through *the thread diagram*. It serves to build a block diagram of SCOR model. This tool show interconnected flow material between operations of the supply chain involving the relationship between supplier, manufacturer and customer.

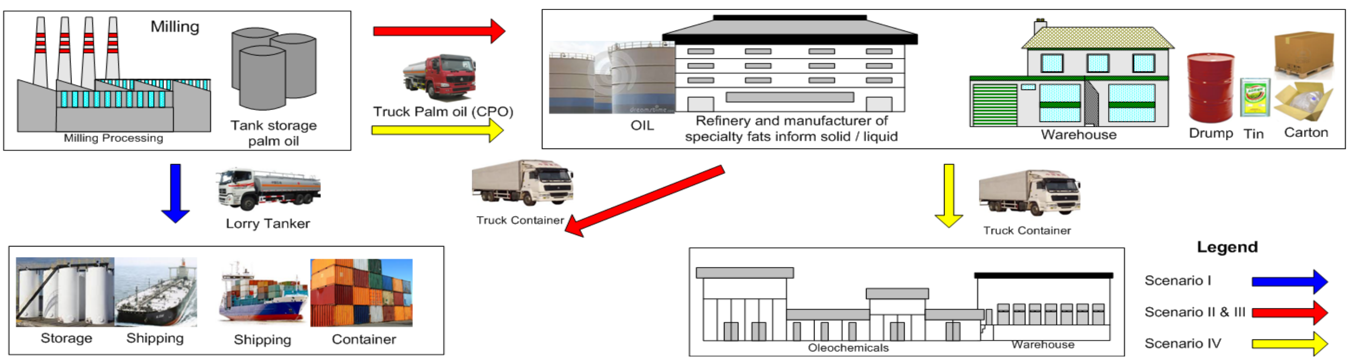

Fig. 1. Scenario of CPO distribution in palm oil downstream industry

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Four scenarios consider the model separately using process categories in SCOR level 2 into process *thread diagram* which can be seen in figure 2 as follows:

The scenario I, milling industry handle the sourcing of stock raw material as fruit fresh bunch from plantation (S1). Then, it processes to produce CPO using the make-to-stock approach in manufacturing (M1). Finish product distributes to the port using lorry tanker on the deliver stocked (D1). The source and the deliver will return if it presents the defect product (SR1 and DR1).

Scenario II, this scenario involves business process on milling process, refinery process and port. Thus, stage of Source, Make and Deliver on milling will be added to the process category in the refinery. In addition, finish product in milling distributes 20% of CPO to the port using the deliver stocked (D1) and 80% of CPO to refinery process using the deliver make-to order (D2). CPO as the source stocked product (S1) in refinery will handle production into Make-to-stock (M1). Then, distribution of finish product using the lorry bonded box to distribute to the port with adopting strategic on the delivered stocked product (D1) and The delivered made-to-order product (D2).

Scenario III, all process categories is similar to Scenario II, except that 100 % CPO will process in the refinery. Thus, finish product of refinery not only in form liquid product, but also solid product. Refiner allows the returning excess product (DR3).

Scenario IV, process categories within the milling and refinery will also implement to distribute for local industry. Result of refinery such olein, stearin and PFAD deliver to local market in order to produce final product that deliver to end customer. Furthermore, finish product as palm oil derivative products are exported as the source stocked in the port (S1) and then port possible to return to the source excess product (SR3).

B. Discrete Event Simulation

This section aims to develop simulation models using discrete event simulation. The model has been built using ARENA 14. Several elements into data collection based on SCOR model and discrete event simulation can be seen in table 1.

TABLE I
SUMMARY OF DATA COLLECTION

Parameter	Item
FFB production	(ton/hour)
Working time	(hour/year)
No of milling, refinery and oleochemical	(industry)
Percentage of OER (FFB to CPO)	(%)
Price of FFB and CPO	(RM/ton)
Transportation cost to local and port	(RM/ton)
Production Olein, Streain, PFAD,Oleo	(ton/hour)
Capacity lorry tanker and bonded box	(ton/tank)

Evaluation of the real systems is done by measuring the performance of the model based on SCOR method that includes business process into stages of the Plan, Source, Make, Deliver and Return. The Plan serves to aggregate demand and supply in each industry that process CPO. In addition, the balancing between demand and supply is obtained by matching the forecasting of demand and supply with resources of production. Thus, the raw material can be scheduled and prevent the shortage of raw materials.

In Source, the parameters which appear in business process related to the supply of raw material in production as the source feedstock of FFB and CPO. As the result, there are the different between the price of finished product whenever sell in local industry and export. Then, Make relates to the ability of production by the industry. In this case, it means a process of transforming raw materials into finished products that can enhance the value-added products by the millings, refiners and oleochemicals.

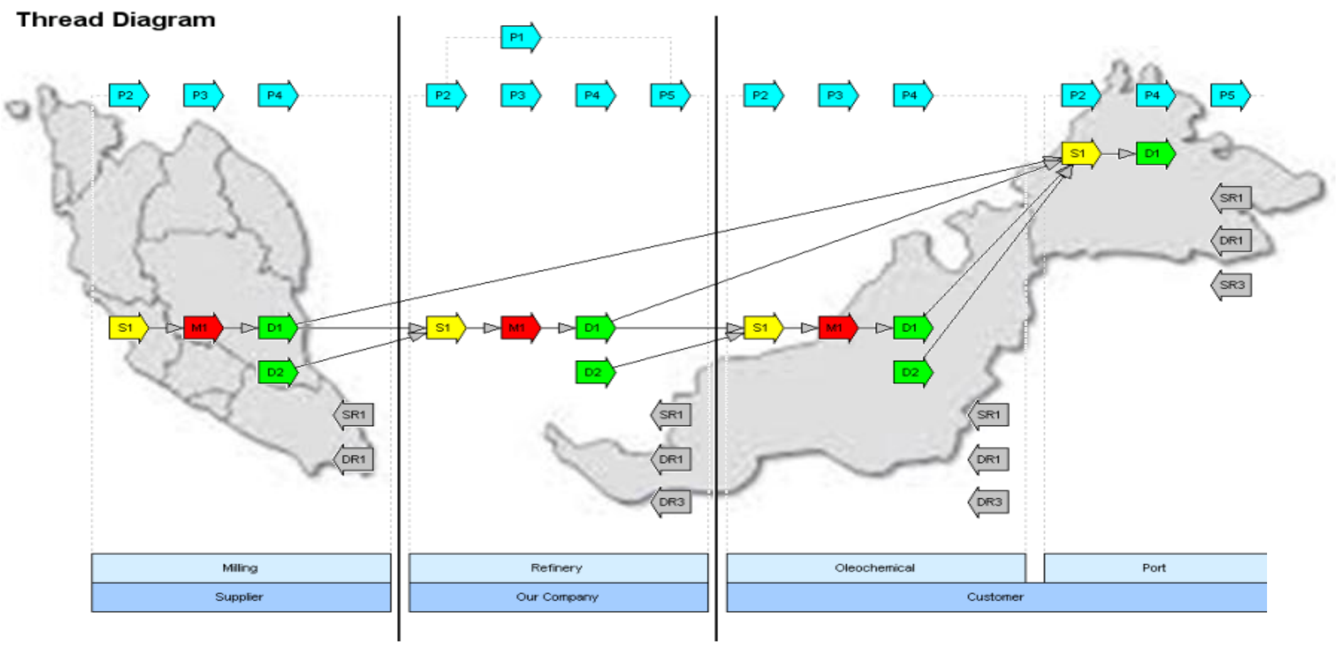

Fig. 2. SCOR model into four scenarios

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In Deliver, transportation models based on type of lorry, capacity and delivery cost which are used to distribute the products to destinations such as the movement of products between industries and ports. In this case, transportation can be divided into four categories. They are transportation cost from milling to the port, milling to the local industry, local industry to the port and between the local industries. Return, it means the activities related with returning of product that are caused by the quality of the product, defects, reject and complaint customer.

Overall process categories in SCOR models will be adopted as parameters to measure performance system that has been built. Conceptual of SCOR models is simulated using discrete event simulation that can be seen in figure 3. Then, to ensure that the model represents the real system it requires to verification and validation.

Verification is used with debugging the simulation software to ensure the model working properly and the operational logic is correct. The software represents the entity with block diagram that is shown by animation using routing of flow product to calculate variable cost. Furthermore, Validation aims to provide an accurate model in representing the real system. Output from simulation will compare with record within actual system. Thus, this result can be discussed to stakeholders in order to validity the model.

C. Simulation Result and Analysis

Results of the hybrid SCOR model and discrete event simulation show there are enhancing the value added of derivative products from FFB in the milling process into various downstream industries based on four scenarios that has been made. The value added of the product is obtained by running simulations on supply chain configuration with dividing the profit in downstream industry and total number of FFB on the milling process. In addition, the simulation software shows a replication length during one year. The results of simulation indicate that the determination of the value added in the palm oil downstream industry in Scenario I is 61 times, scenario II is 81 times, scenario III is 85 times and scenario IV is 101 times. There is a tendency to increase from Scenario I - IV in determining the added value of derivative products in which it can be seen in figure 4.

The highest value added of CPO obtained in scenario IV where this scenario simulates 100% of CPO is processed on refinery process. Then, all products of refinery processed in local industry such as oleochemical. Thus, the results of the local industry will be exported in the form finished product to the end customer. Indeed, simulation results show that the profit of this business will be greater if Malaysia is able to export the final product or palm oil derivative products.

However, when compared with the existing system, Malaysia is still concerned about running palm oil business based on scenarios II and III, which it is still a small amount of the finished products is exported. This shows that there are many semi-finished products are exported to developed countries for an advanced processing into finished products. This result also may give consideration to stakeholder for the decision making process in order to invest in the palm oil business is more toward the industrial development of derivative products based on quality of product or technology processing of palm oil.

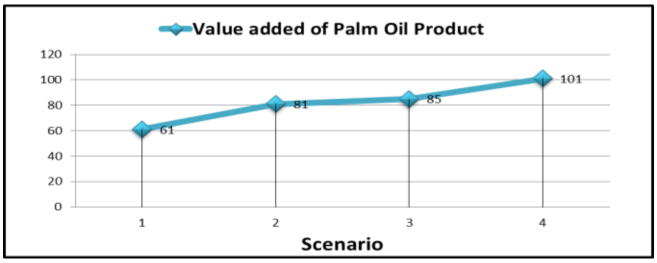

Fig. 4. The value added of palm oil derivative products into four scenarios

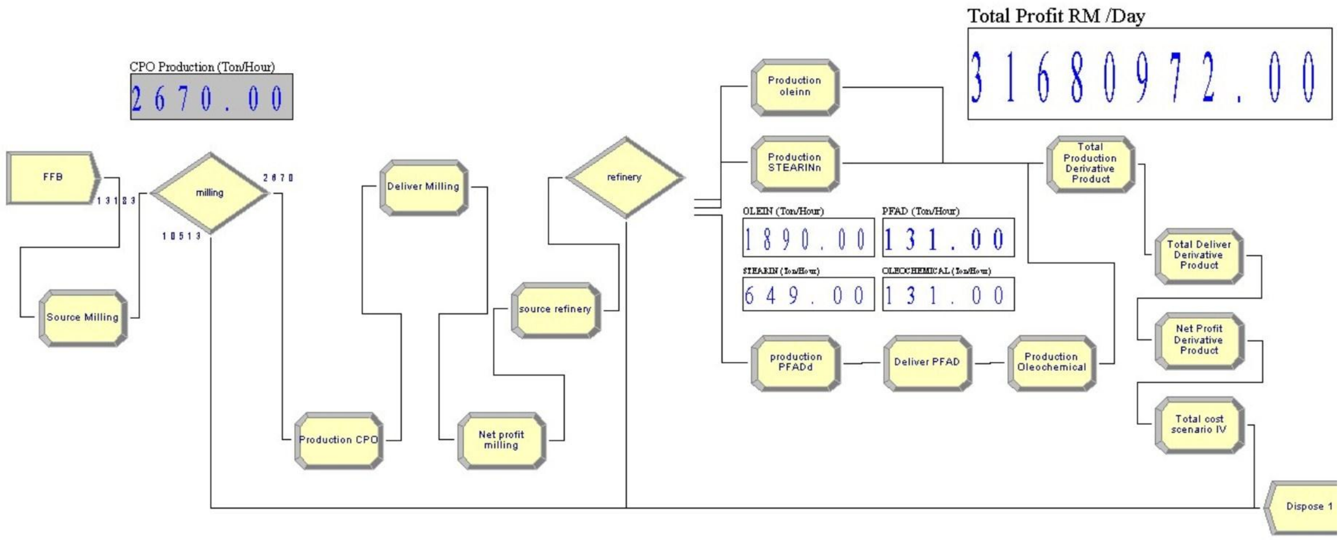

Fig. 3. The conceptual SCOR model is simulated using discrete event simulation for scenario IV

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V. Conclusion

The model that has been developed in this study can be used as a consideration to stakeholders in the Malaysian palm oil industry. This model is the result of hybrid SCOR model and discrete event simulation that can determine enhancing value added of CPO if it is processed by palm oil downstream industry. Thus, the main contribution of this paper is to propose a technique for determining value-added derivative products by performing a simulation of the business process in the palm oil downstream industry including process of millings, refiners and oleochemicals. Simulation approach is built on relationships between supplier, manufacturing and customer into stages of the Plan, Source, Make, Deliver and Return. The simulation results showed that the highest value added of the derivative products will be achieved when palm oil downstream industry is able to produce finished products that will be used by the end customer.

Furthermore, further research is suggested to consider uncertainty demand into system dynamic and try to compare results of supply chain simulation with other methods like goal programing.

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