Simulation of Refinery-Supplier Relationship

Fitra Lestari, Kamariah Ismail, Abu Bakar Abdul Hamid, Eko Supriyanto, Wahyudi Sutupo

***Abstract*—The relationship between refinery and their supplier is an important issue to achieve the effective collaboration. Therefore, the refinery requires maintaining and evaluating a mutually beneficial relationship with supplier. The aim of this study is to evaluate a set of the performance attributes using discrete event simulation that supports the stakeholder for measuring the refinery-supplier relationship. This paper concentrates on analyzing four case studies on oil palm refinery in Malaysia. Then, measuring the performances is employed through the Arena simulation software. The finding shows that performance attribute of responsiveness and quality optimal to implement in push strategy than pull strategy. Indeed, simulation result shows that it supports the decision making process in evaluating the refinery-supplier relationship.**

***Index Terms*— Performance measurement, refinery-supplier relationship, discrete event simulation, oil palm refinery**

I. Introduction

Oil palm refinery is one of the oil palm industries which focus on advance processing to provide derivative products into the market. This industry requires the crude oil in form of Crude Palm Oil (CPO) and Crude Palm Kernel Oil (CPKO) from the supplier to produce the finished product. In addition, the suppliers are supported by transportation service provider such as lorry to deliver the crude oil to the refinery. Thus, as an entity of business process, the refinery needs for implementing the effective collaboration with their supplier in order to increase productivity [1].

Todeva and Knoke [2] reviewed the research on strategic alliances and model collaboration. They found that the collaboration between entities of business process was affected by ability the entity to build and maintain successful relationships with partners. Furthermore, it was also caused by the behavior among partners that affecting current and future relationship [3]. Thus, the refinery-supplier relationship is an important issue among researchers and practitioners that need to evaluate. Moreover, Kannan and Tan [4] revealed that evaluation of the relationship between entities was done by measuring the performance. They have proven performance measurement is used for optimizing the relationship with the partners.

This paper focuses on measuring the relationship between refinery and supplier through simulation modeling. There is an approach in simulation modeling such as discrete event simulation (DES) that is employed for measuring performance based on the specific event and the point in time [5]. Thus, objective of this study is to evaluate a set of the performance attributes by developing the simulation modeling that supports the stakeholder for analyzing the refinery-supplier relationship. Furthermore, the paper is arranged as follows the literature review focus on investigating the gap of research related to the supplier - buyer relationship and discrete event simulation. Then, Refinery-supplier relationship presents the processing data collection. Performance measurement shows the output of simulation and discusses the analysis of the result. Finally, the conclusion shows implication of study and further research.

II. Literature Review

The relationship between supplier and buyer is an important issue in business process because both of them want to maximize their resources for competing in the market. McQuaid [6] revealed each entity required to sustain a mutually beneficial relationship to push the success of one partner helps the success of the other. In addition, to develop and subsequently maintain the positive supplier-buyer relationship, entities should regularly address to concern the strategic of their partners. Thus, it needs to conduct the following guidelines to evaluate the successful relationship among partners.

Evaluation of the relationship between entities serves for analysis of how well the relationship works. Therefore, it supports the stakeholder in the decision making process to change, continue or terminate the relationship. To consider this term, it needs to measure the relationship which it is done by measuring its performance. Olsen et al. [7] revealed performance measurement easily adopted to analyze the relationship between entities for improvement.

This paper considers the issue on the supplier and buyer of how to evaluate the relationship and what kind of measurement tools. Previous research has mentioned technique to measure performance of the relationship. Poureisa et al. [8] measured the performance to evaluate relationship in order to win the competitive advantage through a new tool of Balanced Scorecard based on cause and effect relationship. This method provides quick and comprehensive examinations for top manager's perspective.

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Cousins et al. [9] implemented structural equation model using a sample size of manufacturing and service firms to test the hypothesis model for measuring the performance strategic buyer-supplier relationships. Moreover, Lestari et al. [10] evaluated the supply chain strategy which it consists of relationships between industries through employing the software architecture. The software was required for measuring performance attributes at runtime are specified event and time using discrete event simulation of simulation modeling.

Above methods have proven to provide the solution for measuring the performance based on the relationship between entities. The case in this study requires evaluating the relationship in technical part which it considers measuring the performance based on an event that occur with the behavior of the entities. Thus, simulation modeling is proposed in this case. Jadrić et al. [11] reviewed discrete event simulation tools in an academic environment. They found that this method able to represent the real system, evaluate the behavior of entities and measure performance based on specifying point as a discrete event. Finally, this paper toward to conduct on measuring the performance supplier-buyer relationship using simulation modeling approach.

III. Refinery-supplier Relationship

The case study in this paper describes the relationship between the refinery and the supplier which it is conducted in oil palm industry in Malaysia. Main supplier of crude oil delivers CPO from milling industry and CPKO from crushing industry to the refinery. Then, these are processed through the stages of refining, bleaching and deodorization. The finished products of this process in form of Olein, Stearin and Palm Fatty Acid Distillate (PFAD). Refinery process is an important step for producing edible oil and fat products. Therefore, The purpose of this process removes impurities and components that affect the quality of the final product [12].

Furthermore, the case study analysis four oil palm refinery in Malaysia. Then, the type of relationship each refinery is generalized into strategies which converted to simulation modeling software. In addition, data collecting of the refinery-supplier relationship is employed based on structural, operational and numerical data.

A. Structural Data

Structural data necessary to describe the flow of raw material to be finished product that occurs between supplier and refinery. Thus, the relationship among entities is represented by the physical flows among of them. In addition, this data is constructed based on activities in the business process.

Structural data in this study represented the model of supply and demand between the refinery and the supplier. Refinery required the crude oil from suppliers through ordering process based on the schedule production activities. Then, the supplier developed the schedule product delivery of CPO and CPKO. The crude oil was arrived using the lorry and then verified before loading into the silo. If crude oil had quality suitable with the standards than the lorry loaded into the silo. While the crude oil does not fulfill the standard of quality, it was returned back to the supplier. Moreover, Supplier clerk submitted the invoice of delivering crude oil. The detail structural data can bee seen in Fig. 1 which it shows the event graph of the relationship between oil palm refinery and the supplier.

B. Operational Data

Moreover, the phase to measure the performance done by transforming the relationship between entities into a model which it converted the structural data into operational data Therefore, operational data related with the operational strategy among the entities.

This study categorized the strategy of relationship between oil palm refinery and supplier based on four case studies. It found that there were two types of relationship stratgey involving push and the pull stratgey. The push strategy arranged the fulfillment order based on annual forecasting of refinery demand. Thus, the supplier delivered the crude oil based on the time period that was decided by the oil palm refinery. In this case, it represented the strategy make-to-stock which the lorry delivered crude oil through exponential distribution in average 60 minutes of time arrival. On the other hand, the pull strategy represented delivery product from supplier to refinery following direct ordering process which adopted the stratgey of make-to-order. It represented on scheduling with average arrival rate 5 days.

C. Numerical Data

The next phase defines numerical data which it break-down into the simulation modeling software. There were 16 operations that represented the relationships between refinery and supplier in the real system. In this study, each operation was covered by resource that service the entities such as lorry, QC operator, supplier clerk, pump oil and regulator. Furthermore, the resource that was done by operator represented by the expression of triangular distribution because it shown uncertainty of time working activity operator or clerk [13]. Furthermore, lorry of suppliers was described by the exponential distribution because it represented times whenever lorry arrive into the system which this expression described duration activity into minimum, mode and maximum [14]. Moreover, the simulation also shown there were more than one loading point in the refinery. Table I shows the detail numerical data based on the case study.

IV. Performance Measurement

The performance measurement aims to evaluate the model through attributes that have been designed. The model is measured using the Arena simulation software which it represents the refinery-supplier relationship. There are several steps should be followed to find results of simulation modeling. They are determination of problem formulation, conceptual modeling, verification and validation, experimentation and analysis the result.

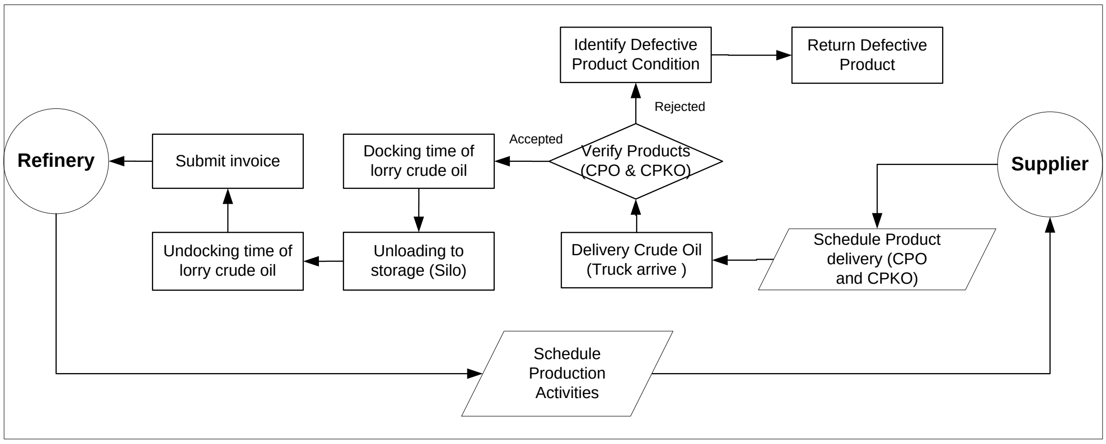

Fig. 1. Structural data

TABLE I
NUMERICAL DATA

Operation	Resource	Expression	Time	Item
Arriving lorry crude oil based on annual forcasting	Lorry	Exponential	60 minute	
Arrivalal rate lorry crude oil based order crude oil	Lorry	Average	5 day	
Verify crude oil	QC operator	Triangular	(5, 8, 12) minute	
Crude oil suitable with standard?	QC operator			Accept (Yes : 95%), Reject (No : 5%)
Returning defective product	Lorry	Average	10 minute	
Distance lorry unloading	Lorry	Average	5 + (2*(4-n)) minute	Pump number (n)
Docking time of lorry	Supplier clerk	Triangular	(2, 5, 8) minute	
Unloading capacity crude oil	Lorry	Average	30 ton	
Speed rate unloading	Pump oil	Average	10 ton/hour	Capacity silo storage (10000 ton)
Undocking time of lorry	Supplier clerk	Triangular	(3, 4, 7) minute	
Submit invoice	Supplier clerk	Triangular	(0.5, 2, 3) minute	
Distance exit	Lorry	Average	10 minute	
Pump crude oil 1	Regulator	Average	30 ton/hour	
Pump crude oil 2	Regulator	Average	30 ton/hour	
Pump crude oil 3	Regulator	Average	30 ton/hour	
Pump crude oil 4	Regulator	Average	30 ton/hour	

A. *Problem Formulation*

The relationship between refinery and supplier is formulated into three main performance attributes involves responsiveness, utilization and quality. These attributes are measured using discrete event simulation technique based on pull and push strategy.

1) Responsiveness described the time fulfillment of crude oil from the supplier to the refinery which explored the strategy of the average amount of time between the moment an intention to purchase of crude oil was declared and the moment the purchase order was received by refineries. In the detail, it included, the receiving product cycle time per hour (T_{rc}), verifying product cycle time per hour (T_{vp}), transferring product cycle time per hour (T_{tp}) and submitting invoice cycle time per hour (T_{ss}).

$$\text{Responsiveness} = T_{rc} + T_{vp} + T_{tp} + T_{ss} \quad (1)$$

2) Utilization described the resource of supplier to complete order of the refinery. This attribute measured the supplier's ability to fill orders completely in terms of product shipped (P_{sh}) and quantity ordered during a definite period of time (Q_{od}). In addition, product shipped represent the capacity and number of lorry loading within the system.

$$\text{Utilization} = \frac{(P_{sh})}{(Q_{od})} x\, 100\% \quad (2)$$

3) Quality described the satisfaction of shipping accuracy from the supplier to the refinery. This attribute measured the percentage of stock keeping units (SKUs) that were represented by number of lorries that were shipped without error out (LCO_{FP}) of all lines during a defined period of time (LCO_{in}).

$$\text{Quality} = \frac{(LCO_{FP})}{(LCO_{in})} x\, 100\% \quad (3)$$

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B. Conceptual Modeling

Conceptual modeling as preliminary models is necessary ways to represent of a system in developing simulation modeling into the software. In this section, structural, operational and numerical data are compiled into the simulation model. To run the simulation, it requires model logic because it describes flow processing based on the modules within the software. Fig. 2 shows the logic relationship between refinery and supplier. Then, Fig. 3 shows the model translation through Arena software.

C. Verification and Validation

Verification is used with debugging the simulation software to ensure the model working properly and the operational logic is correct. This study is supported by the Arena simulation software. Thus, the verification of the software was done by pressing F4 or by selecting the command *check model* on the menu *run* and shown the notification. Therefore, verification is the technique to compile the data in order to check whether there is any error in the model Arena. The validation using simulation is done to compare output from simulation modeling with a record within the actual system to consider the model correctly. Thus, the solutions can be applied to real systems. Furthermore, this result is discussed with stakeholders in order to validity the model.

D. Experimentation, Result and Analysis

The simulation runs during 30 days and 24 hours per day. This study adopted type of simulation in term of terminating method to analyze the simulation output. Therefore, the parameters defined relative to specific initial and stopping conditions that were part of the model. In addition, to obtain the desired level of accuracy in simulation modeling, this study adopted Paired-t confidence interval to match the samples and determine the number of replications.

Therefore, replication serves to accurate the statistical result, in order to measure of average model performances and ensuring reliable data. Hoad et al. [15] advised that the default value for the number replication is set at five. More replications were created to get the greater precision until a confidence interval feels satisfied to be achieved.

Arena simulation software shown that this case study runs on three replications in order to obtain the best precision of statistical data. Then, result from the relationship between refinery and supplier in term of push and pull strategies are converted into performance attributes. Table II shows the summary of the comparison of result between push and pull stratgey based on the relationship refinery to the supplier.

TABLE II
COMPARISION OF RESULT BETWEEN PUSH AND PULL STRATGEY

Activity in Simulation	Report Section	Push Strategy	Pull Strategy
Average lorry crude oil spend in the model	Total Time (entity), Average	0.164 day	1.51day
Total lorry in	Total Number (entity), Value	754 lorry	843 lorry
Total lorry out	Total Number (entity), Value	752 lorry	753 lorry
Total lorry reject	Total Number (entity), Value	38 lorry	39 lorry
Total lorry FG	Total Number (entity), Value	714 lorry	714 lorry
Total lorry WIP	Total Number (entity), Value	2 lorry	90 lorry
Total quantity added of crude oil	Total Number (entity), Crude oil	21448 ton	21481ton
Pump crude oil 1	Total Number (entity), Crude oil	5490 ton	5356 ton
Pump crude oil 2	Total Number (entity), Crude oil	5100 ton	5350 ton
Pump crude oil 3	Total Number (entity), Crude oil	5250 ton	5347 ton
Pump crude oil 4	Total Number (entity), Crude oil	5608 ton	5428 ton

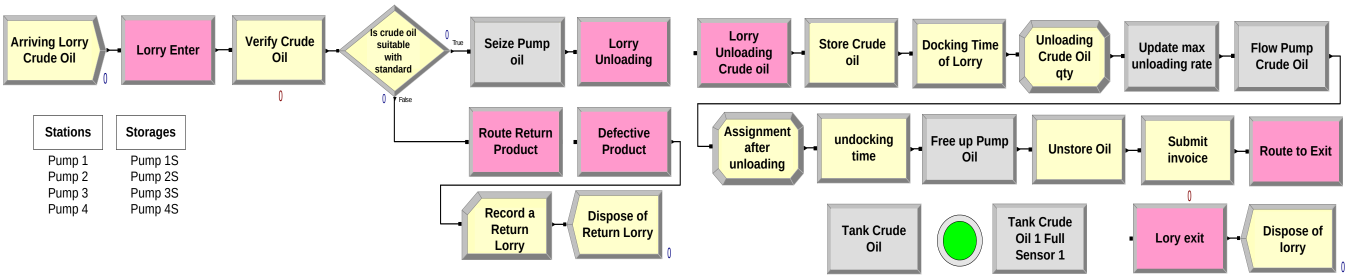

Fig. 2. Model logic refinery-supplier relationship

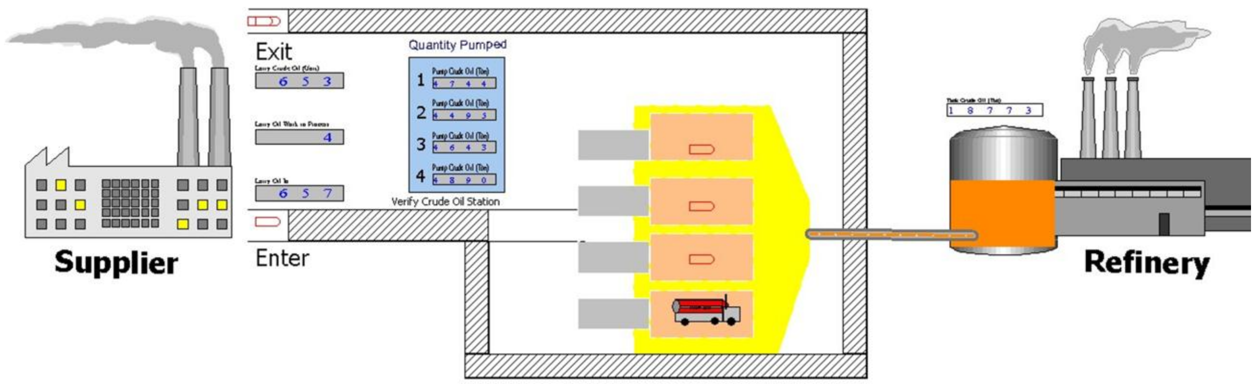

Fig. 3. Model translation through Arena software

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The above formulations are calculated after obtaining the result of simulations in order to analyze the performance attribute for both of strategy. The detail result of performance attribute between refinery and supplier can be seen in Table III.

TABLE III
SUMMARY OF ANALYSIS THE RESULT

Performance attribute	Push	Pull	Optimization
Responsiveness (hour)	3.9	36.2	Push
Utilization (%)	95.07%	95.09%	Pull
Quality (%)	94.69%	84.70%	Push

Finding of performance measurement using Arena simulation software showed that push strategy more optimal in term of responsiveness and quality than pull strategy that represents the relationship between refinery and supplier. Nevertheless, attribute of utilization showed that the pull strategy achieved more optimal. Therefore, in push stratgey, average lorry crude oil spent in the modeled shorter than pull strategy because the suppliers had the fixed schedule to deliver crude oil based on annual forecasting of demand in the oil palm refinery. Thus, it affected lead time of supply crude oil more optimal. In addition, this stratgey provided the best quality as satisfaction of the refinery on supply crude oil by the supplier in term of accuracy of shipping. On the other hand, utilization in pull stratgey better than push stratgey; nevertheless, it showed that the difference of the percentages both of them is not crucial.

V. CONCLUSION

The simulation modeling in this study is adopted based on the case study oil palm refinery in Malaysia in order to define the relationship between refinery and their supplier. Result of performance attribute show that this is an initial study to identify the collaborative behavior of the refinery and the supplier. Therefore, the finding gives implication to leverage measuring the relationship using simulation modeling. Furthermore, it can be applied to any industry that decide the effective relationship with the partners of business involving the supplier, distributor and the buyer. Further research is proposed to extend the scholar's knowledge for considering the power of position that influenced the relationship between entities in business process. Therefore, most of the oil palm industry in Malaysia runs the business process are affected by the policy of the holding company for operating the business from upstream to downstream sector.

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