Profit Maximization of Location Selection for Inbound Collection System of Crude Palm Oil Industry

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Abstract: In crude palm oil industry, raw material collection system is an important part within the supply chain. In order to collect sufficient raw material for production, a collection station is a key driver. It serves as an intermediary between the suppliers and the millers. First in First out (FIFO) concept is employed for the operation at the collection station. The objective of this research is to maximize profit for inbound collection system of crude palm oil industry in cooperatives at Krabi province. A profit maximization model which presents an integrated distribution and pricing strategy for inbound collection system is constructed. Each collection station should makes it's decision on the basis of the pricing incentive offered by the miller. There are two main steps involved in this research; studying the existing system, and designing an appropriated inbound collection system. To maximize profit of the inbound collection system, the proper amount of raw material deliver to each collection station under pricing strategy is computed. In addition, the result of a proposed model suggests that four collection stations are opened at Aoleuktai, Aoleuknuea, Lamthap and Thaithong. Whereas the collection stations in existing system are opened at Khiriwong, Klongya and Khaokaen. In addition, the profit of inbound collection system of the proposed model is increased by approximately 7.7% (2,016,088 Bath). Consequently, better understanding the logistics system and pricing strategy for inbound collection system of palm-oil industry will be a useful tool in management regarding the profit of all stakeholders.

Keywords: Logistics, collector, inbound collection, Mixed-Integer Linear Programming

1. Introduction.

There is no argument that energy is one of the essential things for everyday live. As the economy rapidly grows, the demand for energy increases while the amount of worldwide energy remain finite, especially petroleum which are non-renewable energy. At present the world thrives on the use of petroleum. Almost all transport uses it, from cars and trucks to trains and planes. In the exploration, the worldwide petroleum could run out in the next 30-40 years. Therefore, several countries interested in renewable energy plants for alternative energy used. The one of renewable energy that appropriate for Thailand is “Biodiesel” because it is an alternative energy from vegetable oil. Although, biodiesel can be produced from various plants, palm oil is the most important plant for biodiesel production in Thailand. This is because its production yield is higher than others. Moreover, the south of Thailand is suitable area for palm farm.

According to Thai government strategy, the biodiesel will be used as alternative energy in the future. Therefore, during the past five years, the demand of palm oil is continuously increased. Once the palm oil demand increased, raw material collection system within the supply chain will be more competitive as the amount of raw material is not sufficient to produce palm oil for renewable energy. Therefore, the internal supply chain management under the guidance will reduce the costs of palm oil. This situation leads to increase in competition among palm oil industry. In contrast, if the production cost is high, the palm oil industry must pay additional costs and will lose the completion ability.

In palm oil industry, the raw material collection system is an important part within the supply chain. In order to get adequate amount of raw material for production, the collecting raw material from the supplier is a key process. When the amount of fresh fruit bunch(FFB) is less than the demand, the raw material price will be increased. Different purchasing strategies are used by the miller to collect the FFB. The step – price policy approach is one of an important strategy used in this industry. The collector will gain more price rate if they supply more FFB to the miller. Therefore each collector station has to make its decision on the basis of the pricing incentive offered by the miller.

2. Supply Chain Network

Supply chains are the critical infrastructure for the production, distribution, and consumption of goods as well as services in our globalized network economy. Supply chains, in their most fundamental realization, consist of manufacturers and suppliers, distributors, retailers, and consumers at the demand markets. A supply chain system is a network of facilities and distribution options that perform the functions of obtaining raw materials, the transformation of these raw materials into intermediate and finished products, and the distribution of these finished products to customers. Each enterprise will be different in the complexity of the chain due to its size. A supply chain network can be separated into five important units. They are (1) raw material supplier units, (2) inventory stocking units, (3) production units, (4) distribution center units, and (5) customer units.

The flow of materials in each unit is operated by a diversity of means. The inputs to each production unit are comprised of raw materials and/or work-in-process materials that can be supplied by different vendor units or other production units. Raw materials and/or work-in-process materials will be transformed or assembled into finished goods by production process. Then the outputs of finished goods from the production unit can be held in finished goods inventory or shipped to a distribution center unit. Lastly, the flow of materials, which are finished goods, are distributed through a distribution network to the retail market in order to satisfy the demand of customers, as shown in Figure 1. In supply chain management system, there are four major decision areas: (1) location, (2) production, (3) inventory, and (4) transportation (distribution). Therefore, total costs in supply chain network or total system-wide costs can be regarded as the aggregate of the cost of each category mentioned previously.

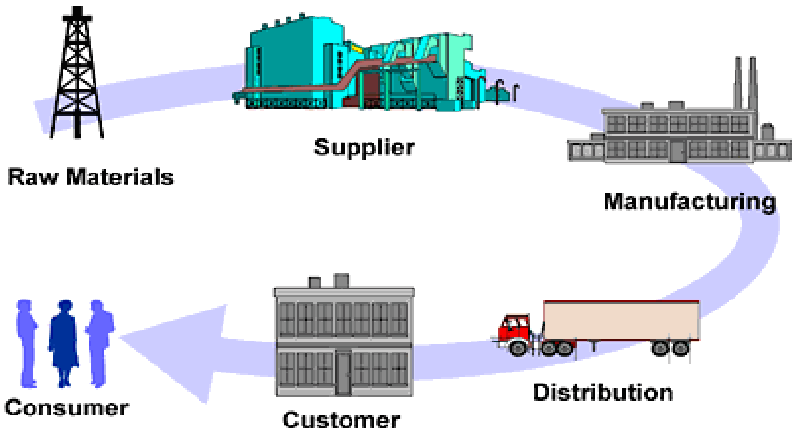

Figure 1: Flow of Materials in Supply Chain Network.

Facility Location in Supply Chain system

Supply chain management entails not only the movement of goods but also decisions about (1) where to produce, what to produce, and how much to produce at each site, (2) what quantity of goods to hold in inventory at each stage of the process, (3) how to share information among parties in the process and finally, (4) where to locate plants and distribution centers. Location decisions may be the most critical and most difficult of the decisions needed to realize an efficient supply chain. Transportation and inventory decisions can often be changed on relatively short notice in response to changes in the availability of raw materials, labor costs, component prices, transportation costs, inventory holding costs, exchange rates and tax codes. Goal of making facility location and capacity allocation is to maximize overall profitability of the resulting supply chain network, while providing customer with the appropriate responsiveness. Revenues come from the sale of product, whereas costs arise from facilities, labor, transportation, material, and inventories.

Actually the supply chain or the logistics network has multiple members, considering from upstream to downstream. The same as general supply chain, the supply chain network in this research can be illustrated, as shown in the following Figure 2.

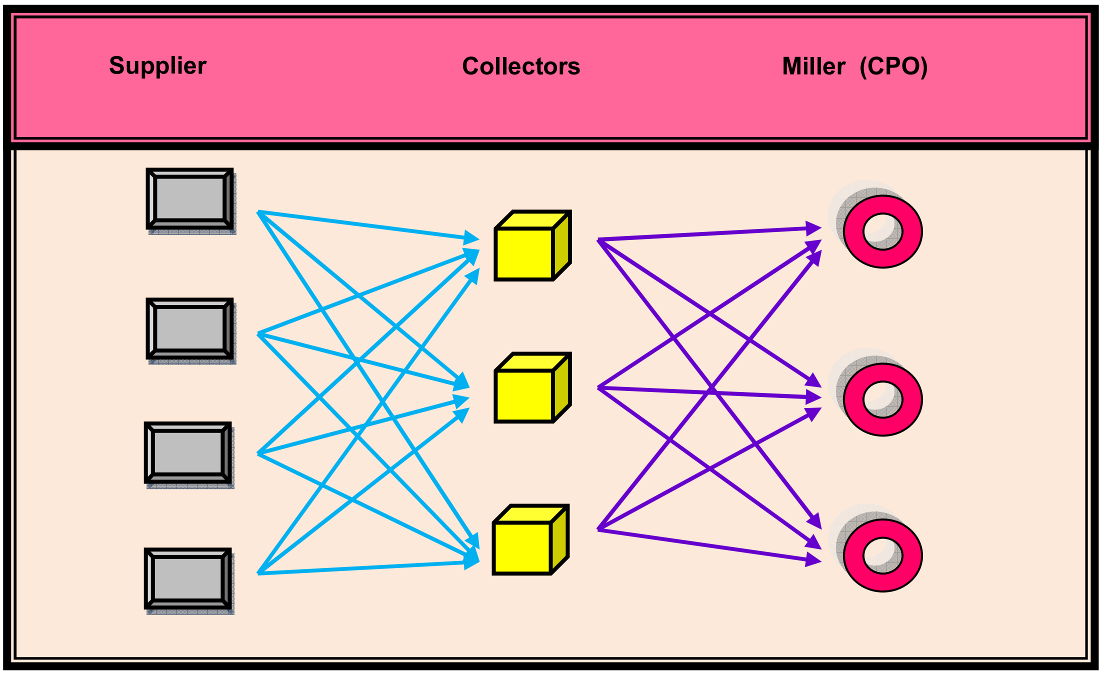

Figure 2: Supply Chain Network in this research

3. Literature review

The literature on the problem of locating facilities with profit-maximizing is not new to the operations research community. Many researchers have extensively studied location allocation models covering formulations which range in complexity from simple linear, single stage, uncapacitated, deterministic models to non–linear probabilistic models. Algorithms include local search and mathematical programming based approaches. Previous research study was well surveyed by Auckara-aree Kanya (2007) which presented the multi–location allocation problem in which maximize profit under step–price policy requirement. In addition, they propose the solution steps in order to find the solution of the considered problem, and also present a numerical example as a demonstration of the proposed procedure. In the problem, assume that there is no shortage occurs for collecting raw material and inventory consideration is also ignored. In a numerical example, observe that the step–price policy affects the decision of the model. Adding one supplier in the model, total collected quantity has been increased but the profit value may increase or decrease depending on step–prices.

Jose Fernandez et.al. (2007) presented solving a huff-like competitive location and design model for profit maximization in the plan that consider to set up a single new facility in a planar market where similar facilities of competitors. In this paper, researcher consider a single facility location problem on the plane, with static competition and inelastic demand, having probabilistic behavior, based on an attraction function depending on both the location and the quality of the facility to be located. In the model, the objective is to maximize the profit obtained by the chain, to be understood as the income due to the market share captured by the chain minus its operational costs.

Necati Aras et.al. (2007) proposed to the problem of locating collection centers of a company that aims to collect used products from product holders. The remaining value in the used products that can be captured by recovery operations is the company's motivation for the collection operation. In this study, researcher formulated a mixed-integer nonlinear facility location-allocation model which proposes a new facility location-allocation model to find the optimal locations of a predetermined number of collection centers as well as the optimal incentives offered by the company to product holders depending on the condition of their used items. In this model, consider a pick-up scenario in which the company collects the used products from the premises of the product holders and all the collection-related costs, i.e., cost of operating the vehicles and transportation cost of used products are incurred by the company.

Zuo-Jun Max Shen (2006) presented a profit-maximizing supply chain design model in which a company has flexibility in determining which customers to serve. The company may lose a customer to competition if the price charges is too high. In mathematical model, propose to a profit maximizing supply chain which a company can choose whether to satisfy a customer's demand. By consider a company that produces a single product. In this research, two models are created: flexible model and serve-all model. The aim of first model is to find out the impact of service flexibility on total profit, while the last model is to find ranges of values for holding cost and location cost that impact the optimal supply chain structure.

4. Research methodology

4.1. Model Input

In this research, the model is compared to existing system model and proposed model. Since, we consider the multi–location allocation problem in which profit through the inbound collection system is maximized under step–price policy requirement. Facility location decisions represent an important aspect of strategic planning for supply chain management. These decisions are instrumental in the determination of the sets of locations for facility. It focus on the application of mathematical programming models in the strategic design for maximize profit and to study location allocation problem for facility. Hence, the comparison of them can identify the appropriate location of collection station with advice for collecting the FFB in system.

In this step, the required data for network modeling are collected as the following: 1) location of the millers, the collection stations and the suppliers, 2) fix cost of collection stations, 3) annual demand of each miller, 4) capacity of the suppliers and the collection stations, 5) transportation rates and (6) price per unit under requirement of the millers.

After that, we assume that the supplier is visited only once. For the transportation between collection stations and the factories, it is set that vehicles have limited capacity and may be more than one trip of delivery, if collected raw material at a collection station is larger than capacity of vehicles. Inbound collection system, there is no shortage or delay occurs in the system and inventory consideration is also ignored. In this study, the number and location of opened collection stations under step-price policy which maximum the profit of supply chain is considered. In order to maximize profit of collection system, collectors must decide where and how many FFB should be collected from farms distributed to the millers.

4.2. Formulated Model

In order to explain the system, a mathematical model is developed. The model investigated in this study is considering the selection of suppliers and optimal number of collection stations. The aim of the model is to optimize inbound collection system in which the profit throughout the system is expected to maximize. In the mathematical model, the objective function can be written as shown in (1) and the restrictions are explained in (2)-(7) as follows.

OBJECTIVE FUNCTION:

$$Maximize \left\{ \sum_{j=1}^{n}\sum_{k=1}^{o}\sum_{g=1}^{l} P_{jkg}X_{jkg} - \left[\left(\sum_{j=1}^{n} F_j W_j \right) + \left(\sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij} \right) + \left(\sum_{j=1}^{n}\sum_{k=1}^{o} C_{jk}X_{jk} \right) \right] \right\} \quad (1)$$

CONSTRAINTS:

$$\sum_{j=1}^{n} X_{ij} \leq S_i \qquad \text{for } i = 1, 2, 3, \ldots, m \quad (2)$$

: the total amount shipped from a supplier cannot exceed the supplier's capacity

$$\sum_{k=1}^{o} X_{jk} \leq Z_j W_j \qquad \text{for } j = 1,2,\ldots, n \quad (3)$$

: the total amount shipped from a collection station cannot exceed the its capacity

$$\sum_{i=1}^{m} X_{ij} - \sum_{k=1}^{o} X_{jk} = 0 \qquad \text{for } j = 1,2,\ldots,n \quad (4)$$

: the amount shipped out of a collection station cannot exceed the quantity of received from supplier

$$\sum_{j=1}^{n} X_{jk} \leq D_k \qquad \text{for } k = 1,2,\ldots, 0 \quad (5)$$

: the amount shipped to the millers cannot exceed its capacity

$$\sum_{j=1}^{n}\sum_{g=1}^{l} X_{jkg} - \sum_{j=1}^{n} X_{jk} = 0 \quad \text{for } k = 1,2,\ldots,n \tag{6}$$

: the amount shipped out of a collection station under requirement of the millers cannot exceed the total quantity of collection station

$$W_j \in \{0,1\} \tag{7}$$

: each collection station is either open or closed

$$X_{ij}, Y_{jk}, X_{jkg}, X_{jk} \geq 0$$

: sets of variables are non–negativity

where

i	=	number of the suppliers (i = 1,2,3,…,m)
j	=	number of the collection station (j = 1,2,3,…,n)
k	=	number of the millers (k = 1,2,3,…,o)
g	=	number of requirement g of crude palm oil plant (g = 1,2,3,…,l)
X_{ij}	=	quantity shipped from supplier i to collection station j
X_{jk}	=	quantity shipped from collection station j to the millers k
X_{jkg}	=	total collected quantity from collection station j to the millers k under requirement g
W_j	=	1 if collection station is located at site j, 0 otherwise
S_i	=	supply capacity at supplier i
Z_j	=	capacity of collection station j
D_k	=	annual demand from the millers k
P_{jkg}	=	raw material price per unit under requirement g of the millers k
F_j	=	fixed cost of locating collection station at site j
C_{ij}	=	cost per unit from supply source i to collection station j
C_{jk}	=	cost per unit from collection station j to the millers k

The objective function (Equation 1), maximizes the profit which is the revenue minus the sum of Inbound cost, outbound cost and collection station set up cost. An inbound cost is the sum of raw material cost and transportation cost between the suppliers and collection stations. An outbound cost is included of wage and transportation cost between collection stations and the miller. Constraint (2) – (7) is a condition to calculate the most profitable in the system.

4.3 Model Output

After formulating the model in the previous section, it is solved with mathematic program to obtain for the maximum profit of inbound collection system in crude palm oil industry. The fixed costs are calculated with the two alternatives whether they should be opened or not. The result is summarized in the following Tables 1 and 2.

Tables 1: The comparison of profit, revenue and cost function for two model type (baht)

	existing system	propose model
Profit	26,160,181.46	28,176,270.00
Revenue	410,621,190.00	410,621,190.00
Fix Cost	256,831.44	48,003.60
Inbound Cost	375,930,437.04	374,189,133.97
Outbound Cost	8,273,760.70	8,207,729.94

Tables 2: Compare location of collection station for two model type.

Model	Collection Station			
existing system	Khiriwong	Klongya	Khaokaen	
propose model	Aoleuktai	Aoleuknuea	Lamthap	Thaithong

5.Conclusion

The inbound collection system of crude palm oil industry in Krabi is discussed in this reserach. There are two main steps involved in this research; studying the existing system, and designing an appropriated inbound collection system. The main objective of the model is to determine the appropriated location for collection stations and allocation problem for the inbound collection system. To maximize profit, the appropriated amount of raw material deliver to each collection station under pricing strategy is computed. The result of the proposed model suggests that the four collection stations are opened at Aoleuktai, Aoleuknuea, Lamthap and Thaithong. Whereas the collection stations in the existing system are opened at Khiriwong, Klongya and Khaokaen. In addition, the profit of inbound collection system of the proposed model is increased by approximately 7.7% (2,016,088 Bath). As well, the collectors can apply operation and management for setting up of an inbound collection system under different step-price policy requirement. In the future, we plan to improve the performance of the solution procedure, and to apply to a real life problems.

6.Acknowledgements

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