CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Stevens (1989) explained that in a traditional supply chain, each "player" is responsible for his own inventory control and production or distribution ordering activities. According to De Toni *et.,al.,* (2005), all players in a traditional supply chain (such as retailers, distributors, manufacturers, must solve a fundamental problem which is "how much to order the production system to make (or the suppliers to supply) to enable a supply chain echelon to satisfy its customers' demands". Each player in the supply chain basing his production orders or delivery orders solely on his sales to his customer, on his inventory levels and, sometimes, on WIP targets. This condition, makes each echelon in the supply chain only has information about what their customers want and not on what the end customer wants. This caused the suppliers hard to gain any insight into what their customers are ordering to cover their own Customer Service Level (CSL), the cost requirements and what the customers are ordering to satisfy immediate customer demand. Finally, this lack of visibility of real demand can and does cause a number of problems in a supply chain.

Facing the problem at the traditional supply chain, several theories propose to re-plan the supply chain. Kurnia *et.al.,(*1998) had explained the re-plan can be applied on the various area such as the area of promotions (efficient promotion), assortments (efficient assortment), development and introduction of new products (efficient new product introduction), and logistics that considers replenishment processes (efficient replenishment).

One concept to re-plan the supply chain is Vendor–Managed Inventory (VMI) concept. According to Archetti *et.al.,* (2005), VMI is a system in which the supplier is

responsible to monitors and decides the inventory policy in each retailer. In other words, the supplier will acts as a central decision–maker for all inventory control problem. The application of a VMI policy with respect to the traditional retailer–managed inventory policies raised advantages which rely in a more efficient utilization of the resources. The supplier can reduce and optimize its level of inventories while in line with maintaining the same or even increase the level of service. On the other hand, there is a guarantee that no stock-out will occur in the retailers.

VMI has become more popular in the grocery sector in the last 15 years due to the success of retailers such as Wal-Mart. Disney *et.al.*,(2001) have implemented VMI in a supply chain using data available from a popular ERP system and a spreadsheet based decision support system. Moreover, VMI is not a new strategy. It was discussed by Magee (1958) in a presentation of a conceptual framework for designing a production control system. Magee (1958) explained that one player in the supply chain give information of what the maximum and minimum demands on the stock unit will be; the other has the responsibility of keeping the stock unit replenished but not overloaded as long as demand stays within the specified limits. Cottrill (1997) and Holmstrom (1998) analyze the application of VMI technique in apparel, food and grocery sector. But this technique is potential to be applied in other sector as well. De Toni *et.,al.*, (2005) had studied the VMI which applied in household electrical appliance sector. While in this research, the VMI will be applied in an oil company for optimizing its company replenishment policy.

2.2 Inventory Management

A successful inventory management process translates techniques into daily tactical responses to customer demands and business needs. Inventory management will be proper if it is able to decide properly how and where to locate all inventory items

(Greene, 1997). The strategies for inventory management are efficient store assortment which attempts to optimize the productivity of inventories and store space at the costumer interface, efficient replenishment which attempts to optimize time and cost in the replenishment system, efficient promotion which attempts to maximize the total system efficiency of trade and customer promotion, and efficient product introduction which attempts to maximize the effectiveness of new product development and introduction activities (Silver *et.al.*, 1998).

Tersine defined inventory is a priceless asset that can be replaced by the more inexpensive called information. To able replacing it, the information must be correct in time, accurate, and consistent. If this happens, so the inventory will be less, reduce cost, and faster in distributing the product to the consumer.

The objective of the inventory management is to replace the expensive assets that called inventory with a more inexpensive assts that called information. Inventory management answers the question about how much inventory that needs to be stock in case when facing the forecast fluctuation, costumers demand and supplier.

The main reason the needs of inventory management are:

1) To maximize the service to the costumer
2) To maximize the buying efficiency and production
3) To maximize the profit
4) To minimize the inventory stock, but ensure to avoid the stock out

2.2.1 Inventory

The inventory can be categorized into five basic types, which are:

1) Raw material; consist of all elements and direct material that buying for produce the end product.

2) The half-end material; is an inventory from assembling process to the end process.
3) The end material; is an inventory that ready to be distributing to the distribution centre, retailers, distributor, or directly to consumer.
4) Distribution stock; is an inventory that being keep on a point or location where it is as close as possible to the consumer.
5) The maintenance material, improvement and operation (MRO Supplies); this inventory is including the office writing tools and also other things that need to the operational and service.

As theoretical, the inventory can be divided into 2 kind of inventory component, as stated below:

1) Round inventory consist of the most active components that available in stock (move fastest)
2) Safety stock (finished material, or often called inventory stock support that being used to protect the company from the demand fluctuation)

The inventory was being done because there is a demand, where the demand was divided into two kinds, which are independent demand and dependent demand. Independent demand is a method to manage the product which demand was affected by costumer demand or demand from other that out of company control. While the dependent demand is a demand for all components that needed to fulfill the independent demand (Tersine, 1994).

Narasimhan (1995) defines the objective of inventory management is to have the appropriate amounts of materials in the right place, at the right time, and at low cost. Inventory control is a critical aspect of successful management. With high carrying cost, companies cannot afford to have any money tied up in excess inventories. The objective of good customer service and efficient production must be met at minimum inventory

levels. In order to obtain a good inventory control, a company must match the timing of demand and supply so that the inventory goes on the elf just in time (Narasimhan, 1995).

2.2.2 Properties of inventory

Basically, the properties of inventory are universal. Tersine (1994) classifies the properties of inventory that are the most commonly cited as:

1) Demands are units taken from inventory. It can be categorized according to their size, rate and pattern. Demand size refers to magnitude of demand and has the dimension of quantity. The demand rate is simply the demand size per unit time. Demand patterns refer to how units are withdrawn from the inventory.
2) Replenishment is units put into inventory. It can be categorized according to their size, pattern, and lead time. Replenishment size refers to the quantity or size, pattern and lead time. Replenishment size refers to the quantity or size of the order to be received. The replenishment pattern refers to the units are added to inventory. Replenishment lead time is the length of time between the decision to replenish an item and its actual addition to stock and can be constant or variable.
3) Constraints are limitations placed on the inventory system.

2.2.3 Vendor Managed Inventory

Vendor Managed Inventory (VMI) is a concept in which the buyer of a product provides certain information to a supplier of that product and the supplier takes full responsibility for maintaining an agreed inventory of the material (De Toni *et.al.*, 2005). As a symbiotic relationship, VMI makes it less likely that a business will unintentionally become out of stock of a good and reduces inventory in the supply chain. One of the

fundamental elements of VMI concept is the integration of information between each echelon in supply chain to create a good decision.

2.2.4 Inventory Replenishment Policies

A replenishment policies consist of decision regarding when to reorder and how much to reorder (Narasimhan, 1995). There are many different types of replenishment policies, of which below are commonly used: the periodic review, order-up-to policy and the continuous review reorder point, order quantity model. Replenishment policies may take any of several forms. We restrict attention to two types:

1) Continuous review

   Inventory is continuously tracked and an order for a lot size Q is placed when the inventory declines to the reorder point (ROP). So, the size of the order does not change from one order to the next. The time between orders may fluctuate given variable demand.

2) Periodic review:

   Inventory status is checked at regular periodic intervals and an order is placed to raise the inventory level to a specified threshold. So, the time between orders is fixed. The size of each order however can fluctuate given variable demand.

   In periodic review policies, inventory levels are reviewed after a fixed period of time T and an order is placed such that the level of current inventory plus the replenishment lot size equals a pre-specified level called the order-up-to level (OUL). The review interval is the time T between successive orders. Observe that the size of each order may vary, depending on the demand experienced between successive orders and the resulting inventory at the same

time of ordering. Periodic review policies are simpler for firms to implement because they do not require that the firm have the capability of monitoring inventory continuously.

2.3 Algorithm

Algorithm is a finite list of well-defined instructions for accomplishing some task that given an initial state and will terminate in a defined end-state. The origin of algorithm is come from the name of Muslim scientist named Abu Ja'far Muhammad bin Musa Al-Khwarizmi (780 – 846 M) that published masterpieces in mathematics, geography and music (Wahid, 2004)

Algorithms are essential to the way it process information, it tells what specific steps to perform and in what specific order in order to carry out a specified task, such as calculating employees' paychecks or printing students' report cards. Typically, when an algorithm is associated with processing information, data are read from an input source or device, written to an output sink or device, and/or stored for further processing. Stored data are regarded as part of the internal state of the entity performing the algorithm. In practice, the state is stored in a data structure, but an algorithm requires the internal data only for specific operation sets called abstract data types.

For any such computational process, the algorithm must be rigorously defined: specified in the way it applies in all possible circumstances that could arise. That is, any conditional steps must be systematically dealt with, case-by-case; the criteria for each case must be clear.

Because an algorithm is a precise list of precise steps, the order of computation will almost always be critical to the functioning of the algorithm. Instructions are usually assumed to be listed explicitly, and are described as starting 'from the top' and going 'down to the bottom', an idea that is described more formally by flow of control.

So far, this discussion of the formalization of an algorithm has assumed the premises of imperative programming. This is the most common conception, and it attempts to describe a task in discrete, 'mechanical' means. Unique to this conception of formalized algorithms is the assignment operation, setting the value of a variable.

2.4 Vendor Managed Inventory in Chevron Pacific Indonesia Company

Vendor-Managed Inventory is a supply chain strategy where the vendor or supplier is given the responsibility to manage the customer's stock. According to De Toni *et.al.,* (2005), VMI comes in many different forms where it depends on sector application, ownership issues and scope of implementation. Familiar names are Quick Response (QR), Synchronized Consumer Response (SCR), Continuous Replenishment (CR), Efficient Consumer Response (ECR), Rapid Replenishment (RR), Collaborative Planning, Forecasting and Replenishment (CPFR) and Centralized Inventory Management (CIM).

In this company, VMI's form that will be applied is Continuous Replenishment (CR). CR reorganizes the traditional system of ordering and replenishment characterized by the transfer of purchase orders from the retailer to the supplier/manufacture/vendor. The supplier himself decides the quantity to be delivered on the basis of information about sales and the stock level in the retail centre, taking into account the orders already acquired by outlets and following a pre-established program of replenishment. The retailer, on the other hand, has to guarantee a continuous flow of information to enable the supplier to formulate realistic order proposals and make reliable provisions.

In this research, the VMI will be applied in an oil company for optimizing its company replenishment policy by using algorithm which based on VMI concept; continuously shared information. The Oil Company is Chevron Pacific Indonesia (CPI) which located in Riau, Sumatera. Their "supplier" term is referring to their oil production

field under production system department which produces the constant amount of crude oil continuously in 24 hours. And their "retailer" term is referring to their inventory management area that consist of 16 storage tanks for keeping the crude oil that came from the oil production field continuously also for 24 hours. Vendor that placed in Production System Department will create a replenishment policy for crude oil replenishment in inventory management area. The replenishment policy is the best scheduling of filling system which will decide how much the crude oil to be filled into the correct tank by using the integration of information between vendor, retailer and costumer in order to overcome the stock out while the crude oil must aligned with the shipping schedule.

2.4.1 Production System

Production System in CPI is started from the oil production field where the crude oil is being pumped from the earth continuously for 24 hours. There are two type of crude oil that being pumped, which is Sumatera Light Crude Oil and Duri Crude Oil. After being pumped, the crude oil directly being sent to the inventory management area where the storage tank is located (Department of Hydrocarbon Transportation CPI, 2002).

2.4.2 Filling and Loading System

The process of inventory management in CPI is started at the filling system. The filling system is similar to the replenishment activity in inventory term. Crude oil that had gathered from the production field is WIP inventory in filling and loading system. While the loading activity is the activity that taking the crude oil from the storage tank to meet the demand.

In create a filling planning, it is needed to have a loading or shipping plan. Because the unfulfilled largest loading or shipping plan at current day (XL_m) will become

an input in developing the filling planning in order to cover all shipping schedule at current day.

The loading plan to develop the filling planning is start with determine the tank which can cover the current day loading. To select the tank, it is need a consideration based on the tank's condition. The integration of information about the tank condition is needed here. The tank/s which available and operable is the tank/s which is not in maintenance schedule, performs loading activity, and performs filling activity. After that, Tank which has the fixed Pumpable amount that can cover the XL_m will be selected for being loaded. Formula (1) below will determine the fixed amount of oil inside the storage tank which can be load because each tank has its own unpumpable amount. The oil will not be able to be loaded if it is reach the unpumpable amount limit, which is determined by the company.

$$Fp_x = Cs_x - Up_x \qquad \dots (1)$$

Where;

Fp_x = Fixed Pumpable stock on **x** tank; **x** = 1,2,…**y**

Cs_x = Current stock on **x** tank; **x** = 1,2,…**y**

Up_x = Unpumpable stock on **x** tank; **x** = 1,2,…**y**

XL_m = The largest loading or shipping plan at **m** day that unfulfilled; **m**=1,2,…n

In developing filling planning, it is need to rank the priority of which tank to be filled first by finding the difference amount between XL_m that need to be fulfilled, Cs_x and Up_x using formula (2) below:

$$\Delta F_x = XL_m - Cs_x + Up_x \qquad \dots (2)$$

Where;

ΔF_x = Filling amount of **x** tank in cover XL_m

The tank chosen to become the first priority to be filled (P_i) is the tank which has the lowest ΔF_x. Because, the lowest ΔF_x means need less filling time in achieving the target (XL_m), and can soon perform loading activity.

In defining the require amount of oil to be filled in to the chosen tank (R_{ix}), use the formula (3) below.

$$R_{ix} = (20\%^* XL_m) + P_i \qquad \ldots (3)$$

Where;

R_{ix} = Required amount of **i** priority of **x** tank based on ΔF_x value; **i** = 1, 2, ..**j**

P_i = Filling amount of **i** priority tank based on ΔF_x value; **i** = 1, 2, ..**j**

Based on formula above, the required amount to be filled into the chosen tank is covering the XL_m with additional 20% to prevent any unpredictable things during loading activity.

After it gets the required amount, the integration information about the estimation of crude oil received in current day is being considered in developing the filling planning. Because the total required amount will be equivalent or less than the estimation crude oil received, as present in formula (4) below:

$$\sum_{i=1}^{j} F \leq E_{OIL};\ i = 1, 2, ..j \qquad \ldots (4)$$

Where;

E_{OIL}= Estimation of oil will be received at current day

From formula (4), the filling amount based on the availability of oil estimation will be as formula (5) below:

$$F_i = \begin{cases} R_{ix}, & R_{ix} \leq E_{OILi} \\ E_{OILi}, & R_{ix} \geq E_{OILi} \end{cases}; \mathbf{i} = 1, 2, ..\mathbf{j} \qquad \ldots (5)$$

Where;

E_{OILi} = Estimation of oil will be received at current day which available to provide Filling **i**.

Then, the duration of each activity is determined by the amount over the rate, as formula (6)

$$\text{Duration} = \frac{\text{Require Amount}}{\text{Require Rate}} + \text{Preparation time} \qquad \ldots (6)$$

In loading activity, require amount will be used as long as it is not bigger than the maximum capacity of rate that the company can handles and the minimum capacity of rate that the company can tolerates. While the preparation time is the time needs for setup and other pre loading activity. There is a strong relationship between fillings with loadings activity. If the filling is improper, the loading will be interrupt caused by the insufficient amount of crude oil stock.