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A SIMULATION INVESTIGATION ON VENDOR MANAGED INVENTORY MODEL VERSUS TRADITIONAL INVENTORY SYSTEM

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Abstract- There is two different points of view toward supply chain (SC) for information sharing and inventory managing which this research has focused on them. This paper investigated on two inventory policy model which called proposed Vendor Managed Inventory (VMI) and a Traditional Inventory Model (TIM). The VMI is supposed based on information sharing and maintaining the inventory on a min level. However, the policy of inventory in traditional model is considered on max inventory without any information sharing tools. The data were supposed for three members of supply chain in automotive industry for 12000 hours which is equivalent by 34 working months. It should not be forgotten to say that the proposed supply chain model is strategized by "Make to Order" policy. The models were compared with two key performance indicators (KPI's) such as system efficiency and average inventory level. The results reveal that in the proposed VMI model in comparing with TIM, the efficiency of the system has been increased by 5% and the averages inventory level have been decreased by 37% for manufacturer (raw material inventory), 29% for manufacturer (final product inventory). The improvement on KPI's is due to properly information sharing through Electronic Data Interchange (EDI) into VMI model.

Keywords - Vendor Managed Inventory (VMI), Supply Chain (SC), Electronic Data Interchange (EDI), Simulation, Traditional Inventory Model (TIM).

I. INTRODUCTION

Supply chain (SC) is described as a system whose constituent parts include material suppliers, production facilities, distribution services and customers linked together via the feed forward flow of materials and the feedback flow of information [1]. A SC is generally complex and is characterized by numerous activities spread over multiple functions and organizations, which pose interesting challenges for effective supply chain coordination. To meet these challenges supply chain members must work and coordinate with each other [2], therefore, Supply Chain Management (SCM) becomes crucial and plays an important role in the business environment. SCM involves managing integrated information about product flow, improving customer satisfaction and reducing cost of inventories [3].

Although storing inventory has lot of advantages for SC member, it is important to be careful about the level of inventory which must be stocked. Nowadays, managers attempt to store the stock down as long as they are able to meet their customer satisfaction. Reducing inventory level without affecting the availability of product is one of the essential goals in SCM [4]. Moreover, the most successful supply chain is the chain which has closer coordination and relationship among its members. Previously, companies considered information as a power source for organization and there was no necessity for sharing information among chains. Nowadays, this attitude has changed and information sharing, coordination between members of chain became highlighter [5]. Since information sharing increases chain's visibility and is used for material flow coordinating [6], therefore, it can be a optimum solution to remedy the bullwhip effects and improve SC performance [7, 8, 9]. Based on the research of Cachon and Fisher, the benefits of information sharing along the SC become obvious [10]. Yao et al. [11] concluded that information sharing in SC can reduce safety stock; thereby the average inventory level is reduced. In the other hand, information sharing lets the customer's demand shine through the chain and all parties be aware of demand for reacting faster to the customer's need, in this way the customer satisfaction and performance of chain will increase. Hence information sharing among chain's member becomes an important issue in supply chain. There are two different points of view toward SC for information sharing and inventory managing which this paper has focused on them. The first one is Traditional Inventory Model (TIM) and the second one is Vendor Managed Inventory (VMI). The first model (TIM) is based on inventory management in pull based supply chain and it has no information sharing among its member but the second model (VMI) contains information sharing among the whole members of pull SC and also it contains close cooperation for its inventory managing. These two proposed model will be explained clearly in the following section.

II. REVIEW ON VENDOR MANAGEMENT INVENTORY (VMI) LITERATURE

VMI is a recent approach for information sharing in SC that customer allows its supplier to access to the inventory

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level and the sale data (point-of-sale for retailer). The supplier uses this information to plan and manage its customer's inventory. This means the supplier takes its customer's inventories into account in addition to its own inventories when making its inventory plan and replenishment. Suppliers can calculate inventory levels, deliveries rates and minimize the costs by implementing VMI in a system [12]. On the other hand, VMI is defined as a process where the order is generated by the supplier for the customer based on the demand information which is sent by the customer (Hall, 1998). The most important attribute of VMI is that supplier can be aware of incoming demand, correlate it with the previous year's demand, and replenish inventory without system stock outs [13]. Based on the shared information, supplier decides when and what quantity must send to its customer. Indeed, Information sharing between buyer and vendor can be considered as a useful strategy for remedy the bullwhip effects and increase supply chain performance [8, 9,15] .

Nowadays, many attentions go toward to the new concepts of VMI, information sharing and cooperation among chain's members after there were applied by the industry leaders such as Wal-Mart, K-Mart and Proctor & Gamble [16,17,18]. Ireland and Crun [19] cited that for creating new revenue opportunities, efficiencies and loyalty of customer, it is necessary to have more consideration on collaboration in SC. Marques et al. [18] concluded that for improving collaboration among chain's members, it is necessary to increase demand visibility. As Soroor et al. [6] explained, information sharing along the chain provides higher visibility for members in order to coordinate the material flow, but Smaros et al. [20] stated that one of the main challenges in SCM is lack of demand visibility which leads to inefficient capacity utilization, poor product availability and high stock levels. Information sharing can be a good strategy for increasing the visibility of demand along the entire chain. Challener [21] clarified the organizations employing VMI are able to have capital reductions around 20-30% in inventory and receivables. With the mathematical model of Yao et al. [11] , it is understood that, implementing the VMI is caused to lower inventory carrying cost.

Jung et al. revealed that using VMI strategy in SC may reduce total inventory cost and analyze how different parameter such as capacity, demand variance and cost parameters affect on this reduction [22]. Also, applying VMI approach in SC leads to total cost reduction along the chain, and level of cost reduction depends on types of VMI implementation [23]. Tang explained that the VMI objectives are insuring the consumer service level and lower inventory cost [24]. IKEA as one of the biggest home furnishing companies in the world uses VMI in order to increase service level and decrease the SC's inventory [25]. In this context, the most researchers agree to employ VMI and transfer the inventory managing responsibility from customer to supplier [24,26,27, 29].

III. Material and Methods

As mentioned previously, there are two different points of views toward SC as information sharing and inventory managing which this investigation has focused on them. The first one is Traditional Inventory Model (TIM) and the second one is Vendor Managed Inventory (VMI).

The first model (TIM) is based on inventory management in pull based supply chain and it has no information sharing among its member but the second model (VMI) contains information sharing among the whole members of "Make to Order" based supply chain and also it contains close cooperation for its inventory managing. therefore this paper firstly, propose two models based on the combination of information sharing and inventory management policies, and also then simulate the models for 12,000 hours to investigate the system efficiency and average inventory level of proposed models to find out that which model has higher efficiency.

To have a better overview from the proposed supply chains for this research, authors depicted the chins, member and the flow or supply on the material and the product in Figure 1.

IV. TRADITIONAL INVENTORY MODEL

The proposed structure for TIM in this paper is based on "Make to Order" strategy. Indeed, moving from "Make to Stock" in SC and implementing "Make to Order" is difficult but it is considered as a lean thinking in order to increase the customer satisfaction. Based on applied strategy in TIM, the production is not started in the system until the retailer's order comes to the system and reaches to the distributor's hand, when the retailer's order comes to the system, the system will start its production based on the retailer's requirement, and therefore, the retailer satisfies because they receive the product within specification. On the other hand, in this model, the material flow is triggered when the downstream member pulls the material from its upstream partner. Since, storing much inventory at warehouse is meant to keep higher payment which may be expired or became obsolete and not suitable to sell. In fact, while the number of production is strictly varied and depends to the number of orders which comes to the system, so that the proposed strategy for this model helps chains members to maintain inventory obsolescence and other problems.

Definitely, this point of view is as a good contribution of this model. In this model, each member of chain is responsible for its inventory managing and replenishing. The information directly is sent by the downstream member to upstream partner of chain based on the coming orders. Demand from the downstream partner leads to shipments of goods and pull the products from the upstream member in supply chain. There is no information sharing among the chain's member in this model and the upstream members use replenishment information from immediate downstream member to respond incoming orders. Furthermore, in the proposed traditional model of this investigation, the maximum inventory replenishment is proposed for each member by evaluating its own inventory level. Based on this inventory policy, while remained inventory at each echelon of chain meets Re-Order Point (ROP) level, managers place orders to fulfill the warehouses and reach the level of inventory to the maximum initial inventory.

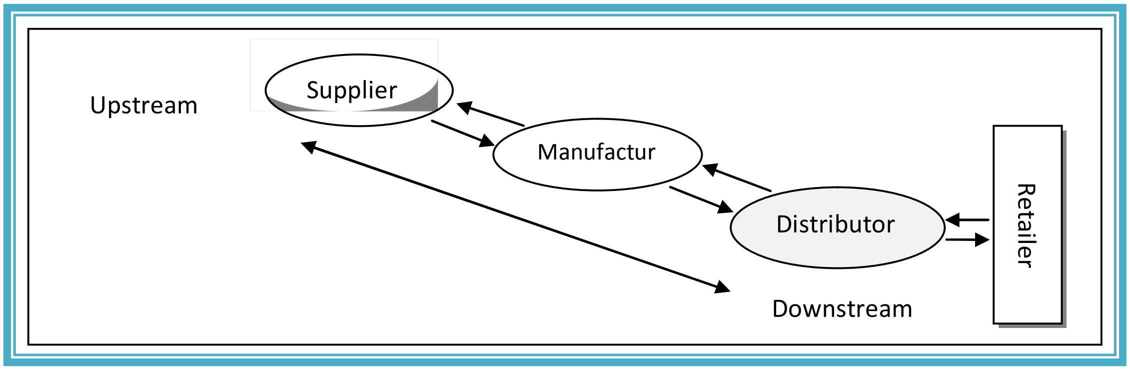

Fig 1 Proposed supply chain model for this research

V. VENDOR MANAGED INVENTORY

Since this paper interest to make more collaboration and closer understanding between the chain's members and improve the SC performance, the internet communication and information sharing are used for second proposed model which is called VMI. In proposed VMI model of this paper which is based on "Make to Order" SC, information is shared between all members of chain in contrast with previous models which shared information were just between two members of chain. The proposed VMI model shares the information (inventory level, demand data) between chain's members via Electronic Data Interchange (EDI). Also, via the defined information sharing between the whole members of chain, each member is responsible for the inventory managing and replenishing of its downstream member. For instance, based on the each updating of raw material inventory level in manufacturer, the updated inventory level will be shared with supplier, also the production planning of manufacturer will be shared with supplier.

Hence, based on this information sharing, supplier becomes responsible to check the raw material inventory level of manufacturer and decide whether the inventory level of raw material in the manufacturer level need to be replenished and also will decide about the quantity which must be replenished. On the other hand, the main feature of VMI is inventory managing of customer by its vendor, in the proposed VMI model, this inventory managing responsibility which is done by vendor has been defined during the whole chain and between the whole members of SC. In contrast, the previous VMI models just defined this responsibility between two echelons of SC. Therefore, the proposed VMI model contains the information sharing and also the inventory managing by vendor through chain and between all members. Furthermore, to design the proposed VMI model of this research, maintaining ROP inventory level was employed for its inventory managing policy. This strategy is used by each upstream member of SC for deciding whether needs to replenish inventory, fulfil the gap and increase the inventory to the ROP level and try to keep it at that level for their downstream partner. To sum up, in the proposed VMI structure, the downstream member of chain allows the upstream member to be aware of demand information and inventory level via the EDI. Upstream member uses this information for their planning and inventory managing.

VI. RESULTS AND DISCUSSION

As implementing the systems in actual world is very costly and timely, therefore simulation modeling is utilized for determining system's behaviors. However, simulation modeling can be considered as a useful tool for investigation on the system behavior. Simulation modeling provides the opportunity for managers to test and evaluate the proposals without running the risk of actual implementing for new approaches and absorb the cost associated with expensive errors [30]. Hence, in the field of SCM, simulation can be employed to support SC design decisions or to evaluate the supply chain policies [31]. To simulate the model for this investigation, Arena software (version 13) has been applied as the powerful simulation software for simulation researches. Each proposed model is simulated five times over a simulated time period of 12000 hours with the warm up period of 500 hours. As this paper investigates on two KPIs which are system efficiency and average inventory level, so that the Arena records the defined KPIs and reports as follows:

A. System Efficiency

In this paper, the incoming orders by the retailers to the system are considered as system input and the responded orders are defined as the output of system. The objective of this part is to calculate the system efficiency for clarifying which model has better performance. For this purpose, both models run in the same condition with the same number of inputs. Based on the results of simulation, the total entry

Orders are 63546 units. According to assumed redundancy in simulation environment, the number of orders which have been responded in VMI model is calculated as 53544 units as well as for Traditional model by 50373 units. Table 1 represents the efficiency of the both models.

Table 1 Comparison of system efficiency among proposed models

Model	Input	Output	Efficiency
VMI	63546	53544	84%
TIM	63546	50373	79%

Table 1 represents that the number of responded order in proposed VMI is more than TIM, therefore, the performance of VMI accordingly is better than TIM.

Figure 2 shows that the system efficiency of VMI model is 84% while 79% for TIM. It can interpret that, proposed VMI has more ability to satisfy the retailer's order in comparison to TIM. Greater system efficiency represents higher customer satisfaction level in the services organization, and in manufacturing organization, it can represent less wasting.

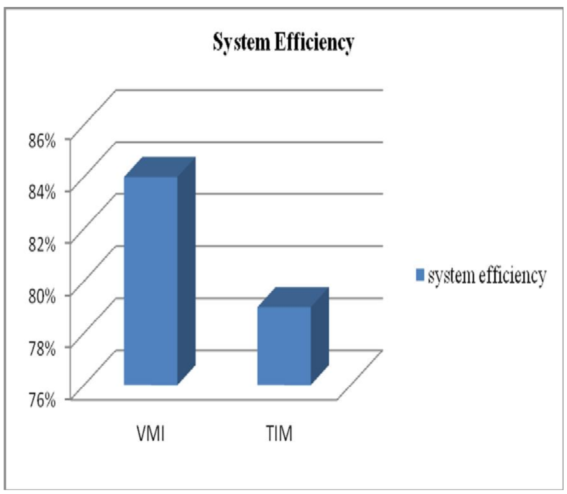

Fig 2 Comparison of system efficiency among proposed models

B. Inventory Level

Another criterion for the models comparison in this paper is inventory level. The simulation results for inventory level of members [Manufacturer inventory (Raw material), Manufacturer inventory (Final product), Distributor inventory] are reported by Arena after its 5 replications and explained here. The simulation results for Manufacturer inventory level (Raw material) are averagely shown as Table 2.

Table 2 Comparison of Manufacturer Inventory (Raw material)

Model	VMI	TIM
Manufacturer inventory level (Raw material)	2093	2866

According to Figure 3 and Table 2, the inventory level of manufacturer (Raw material) in supply chain under TIM is 2867 units and in VMI condition is 2093 units. Manufacturer inventory level (Raw material) in VMI condition is less than TIM. In the other word, implementing proposed VMI model leads to keeping fewer inventories for manufacturer (Raw material). Although the inventory level of manufacturer (Raw material) is decreased in VMI model, simultaneously the efficiency of system is increased, therefore, it can be a positive point for VMI model.

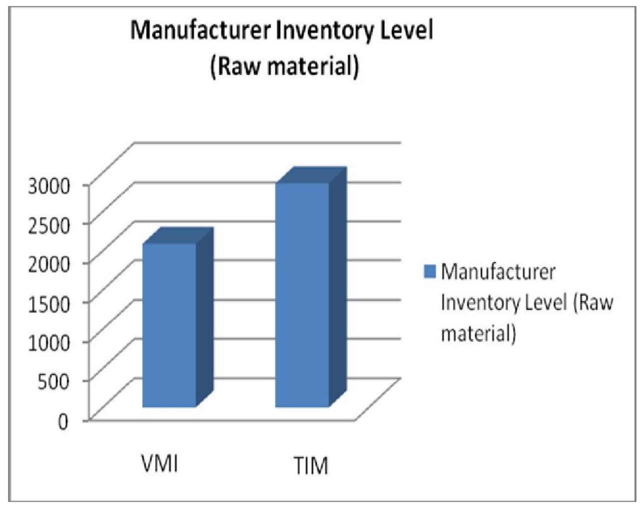

Fig3 Comparison of Manufacturer Inventory (Raw material)

Manufacturer has another warehouse which is for its final product and is called Manufacturer inventory (Final product). The average inventory level of Manufacturer is shown in table 3 and figure 4.

Table 3 Comparison of Manufacturer Inventory (Final Product)

Model	VMI	TIM
Manufacturer inventory level (Final product)	1637	2119

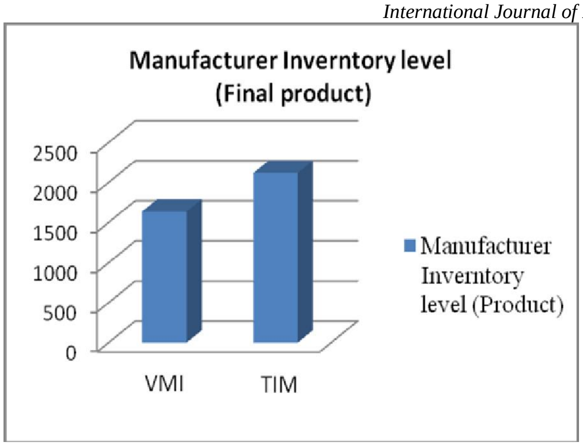

Fig 4 Comparison of Manufacturer Inventory (Final product)

The simulation results by Arena show that the average inventory level of Manufacturer (Product) in proposed VMI model is less than TIM. By implementing TIM, the average inventory level for Manufacturer (Final product) is 2119 units while implementing proposed VMI model decrease it to 1637 units. Using information sharing and "Make to Order" strategy in making the VMI model are the main reasons for its inventory reduction. Distributor is another member of chain which the inventory level of that has been reported by Arena. Table 4 and Figure 5 show the average inventory level of Distributor.

Table 4 Comparison of Distributor Inventory

Model	VMI	TIM
Distributor Inventory Level	542	1020

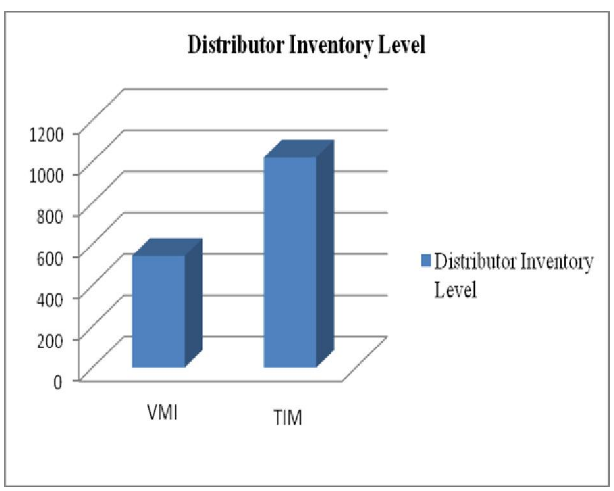

Fig 5 Comparison of Distributor Inventory

According to Figure 5 and Table 4, the inventory level of distributor in SC under TIM is 1020 units and in proposed VMI condition is 542 units. Distributor inventory level at VMI condition is less than TIM. Therefore, VMI structure helps the distributor to keep fewer inventories in comparison to TIM.

In conclusion, although keeping inventory is necessary in the organization for preventing stock out, the important issue is trying to keep minimum inventory in order to decrease the inventory cost, avoid from product obsolescence and market's demand changes. Reduction in inventory level is satisfactory until the efficiency of system has not been decreased. The structure of proposed VMI model of this paper helps the chain's members to keep less inventory level rather than TIM and fortunately it can control and increase the efficiency of the system simultaneously. Indeed, the reasons of this positive point are information sharing, good cooperation and coordination which are defined among the whole members of chain.

VII. CONCLUSION

The research can be concluded from different view of points. Firstly, the fact is that, rapid growth of internet forces organization to have information sharing along supply chain. Sharing information between the whole members in proposed VMI model of this research bring greater efficiency and less inventory level for the system rather than proposed traditional model. This information sharing cause to more collaboration among the chain's members, therefore, by implementing proposed VMI model although the inventory level is decreased, the numbers of responded orders are increased, and totally system efficiency is increased.

This is a strength point of proposed VMI model which simultaneously can have inventory reduction and system efficiency increscent. Hence, sharing information along the whole members of chain can be a success factor for proposed VMI model.

As far as decision makers are looking for decision support, the results of this paper can be employed by decision makers in construction of effective decisions. It furnishes them to propose their policy about implementing proposed VMI versus TIM in their SC to promote the efficiency and productivity to the chains. Differences that make VMI model more efficient than traditional model are information sharing and better inventory managing system which exists in VMI model, also, coordination among players is a key to success.

The input orders from retailer to distributor was same (Input= 63546) for both VMI and TIM models. Although the output of two models were not equivalent (VMI output=53544, TIM output= 50374). It can be concluded that the more successful response on output orders from two system have a significant changes which reveals the improvement through using VMI comparing with TIM policies.

From the results of the inventory averages of members, it can be observed that all of the member's inventory levels were gradually decreased. To investigate into VMI model, it was observed that decreasing inventory on downstream member has received more attention into whole supply chain proposed simulated model. As it is observed in simulation result, the average inventory level of distributor feels the most decreasing along the chain which is from 1020 to 542 units by implementing the proposed VMI model and this change in average inventory level is greater than the other partners of chain. Further researches also can be conducted issued by this research. Firstly, this research concentrated on two KPIs and evaluated the proposed models based on them, beside this, other KPIs such as inventory cost, total inventory of supply chain can be investigated as further research. For the second concern, the proposed conceptual models have concentrated on supply chain of automotive industry; it also can be developed by considering supply chain of other industries.

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