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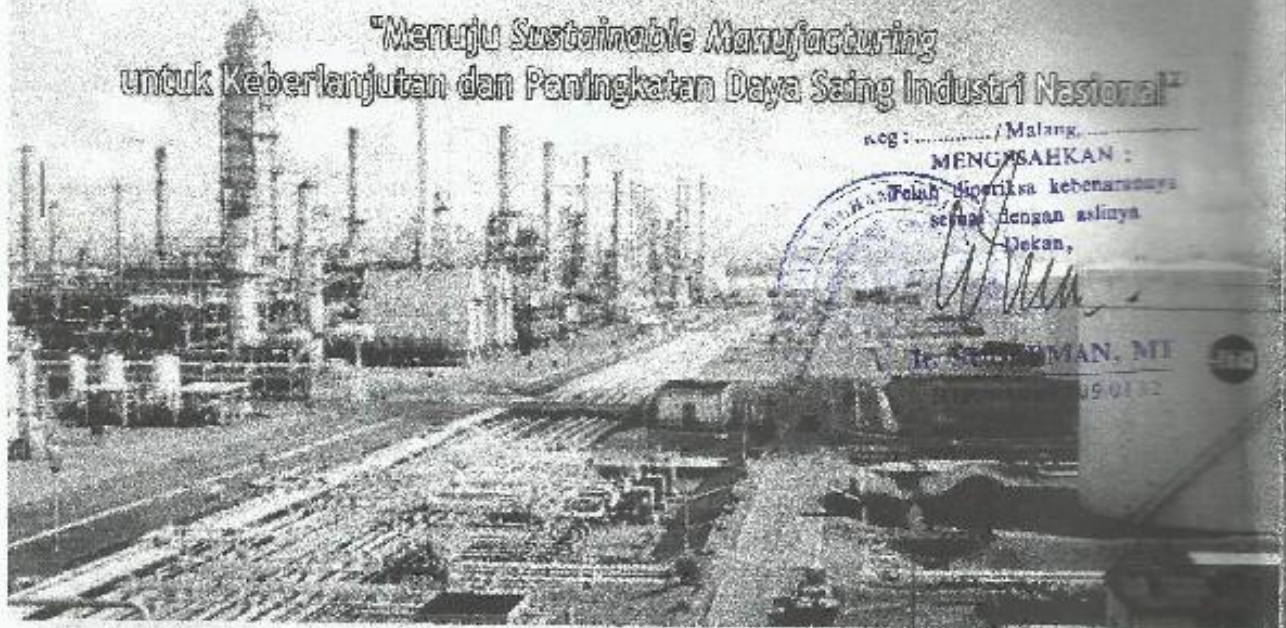
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## TRADE-OFFS BETWEEN DISTRIBUTION COSTS AND CUSTOMER SERVICE IN CENTRALIZED AND DECENTRALIZED WAREHOUSING SYSTEM

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### Abstrak

*This paper attempts to investigate the advantages and disadvantages applying centralized and decentralized warehousing systems. Literature review is used to explore the factors affecting these two warehousing systems. There are some factors considered when deciding centralized and decentralized warehousing system. Service level, transportation and inventory costs are the main affecting factors of determining these two distribution systems. The decentralized warehousing system has ability to respond well to customer needs; however has higher inventory and transportation costs than centralized warehousing system. Centralized warehousing system require more efficient distribution costs and provide diverse product line but produce lower service level and higher potential risks in case the warehouse inaccessible.*

*Keywords:* warehouse, centralized, decentralized

### INTRODUCTION

In the global business, warehousing is one of the main key in the flow of supply chain management which cost a lot of money in providing the warehouse itself, inventory (work in process or finished goods) and other facilities. However, warehousing strategy could be the effective way to reach and service the customers, even a company can save millions of dollar in logistic costs and improve the level of service simultaneously by managing the effective number, size and location of warehouses to replenish the retail or customers demand [12]. There are two options of warehousing strategy in term of the degree of controlling the inventory level and customer service levels; those are centralization and decentralization [10][13]. The two types of those warehousing strategy give very different results in the business of inventory level and the ability in covering customer's demand.

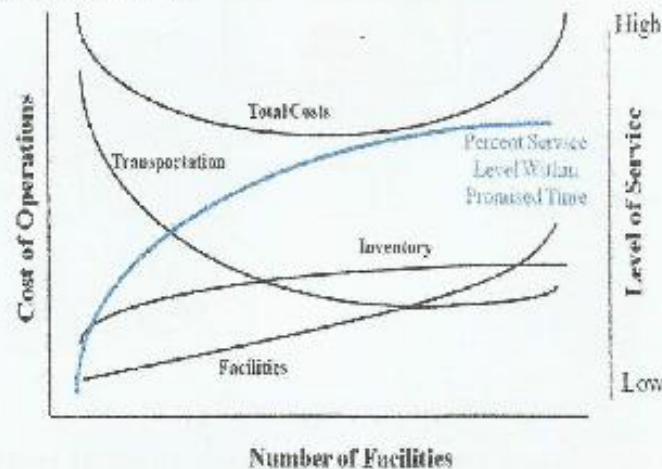
This paper studies the contradictory benefit in determining the centralized and decentralized warehouse in term of inventory level and customer service especially in multi-echelon system, in other words, what are the implications of warehouse strategies to inventory cost and customer service?

This paper tries to discuss how the centralized and decentralized warehousing strategy affects the inventory level and the level of customer service by giving some facts, evidences and case study concerning the conflict of these two. This paper will be divided into three main parts such as introduction which consist of the background of the problem, research statement and also the structure of the research. The second part is the body which consists of the discussion, evidence, and arguments of the impact of warehousing to inventory and service level. In this section also explain briefly the other factors impact in making decision of the recommended warehousing strategy and their risks when choosing each strategy. The last part of this paper is conclusion, in which this part will conclude the discussion session and also recommend the better way to choose the warehousing system.

### THE ROLE OF WAREHOUSE

A warehouse is originally a place to store inventory, but in current logistic system development, the role of warehousing has been changed in term of leveling the productivity and the flowing of raw material, parts and finished goods as well as the consolidation terminals such as break bulk and cross-dock facilities [1][13].

A key success factor in some big wholesalers and retailers of their warehousing activities is how to meet the customers' expectation and warehouse management including the cost involved. The most appropriate example success in managing efficiently the warehouses is Sara Lee, North Carolina. This company re-lays out and automates the warehouse, reducing the lead time from warehouse to customers (customer service) and lower the cost associated [5]. They stated that the warehouses also give several value adding roles in logistic system such as transportation consolidation, product mixing, and service and safety stock. It means that the add value of warehousing system is more beneficial than cost to a product. Some big wholesalers or retailers warehousing will avoid the interruption of product, semi finished product or raw materials flow from company to customers or from suppliers to plants. However, some of them consider about just in time (JIT) or zero inventory (non stocks) concept that minimize the number of warehouse where they will store items only if they are required. This is important because the number of warehouses will impact directly to the cost involved in warehousing such as transportation cost, inventory cost, cost of lost sale (service level) and warehouse cost, therefore the best way to decide the number of warehouses is by trade-cost evaluation. According to Coyle, Bardi and Langley [4] [5] when the number of warehouses increase the inventory cost will increase too whereas the lost sale cost decrease. The Figure 1 below shows how the number of warehouses impacts the other costs:



Source: *The Management of Business Logistic* [5]

Figure 1. Logistic cost related to the number of warehouse

The Figure 1 explains that the number of warehouses will affects four basic warehousing costs such as inventory cost, warehousing/facility costs, transportation costs and also service costs (service level). In this paper, we will concentrate on the three of them: inventory cost, transportation costs and service level. As shown on the figure above, the more number of facilities or warehouses, the more inventories provided. As consequences, the increasing warehouse numbers will decrease the costs incorporating with customer service or in the other words the customer service level will increase as the number of warehouses increases. The increasing of service level is determined by the increasing of the delivered promised order percentage and less stock out. The total logistic cost also depend on the transportation cost which individually affected by how many number of warehouse should be served, the more number of warehouses served the more expensive transportation cost.

#### CENTRALIZED AND DECENTRALIZED WAREHOUSING SYSTEM VERSUS INVENTORY COST IN MULTILEVEL DISTRIBUTION

The basic function of warehouse is storage or holding goods inventory for periods of time. The most fundamental problem in warehousing system is the high cost of holding finished goods for long time periods [4] [5]. It is not just hold the finished goods (the high value products) but also the movement of product or inventory turnover such as consolidation break bulk or cross docking. All





These activities are usually costly and risky in terms of damage, loss and obsolesces besides the opportunity cost when the capital of inventory invested to other more beneficial areas.

One of the most important tasks of managing warehouse is how to decide to provide warehouses in the system. The centralized warehouse in the echelon system could be the choice to control the inventory. Inventory carrying cost become substantial effect in this strategy as the inventory carrying cost could be 2.5 percent of sales, which is a significant proportion for firms [10]. In the centralization strategy, inventory can be centralized at production facility or central warehouse where the central warehouse could be a consolidation of purchasing point or even as a part of production facility. The figure of the centralized warehousing process in multi echelon system is explained briefly from the Figure 2 below.

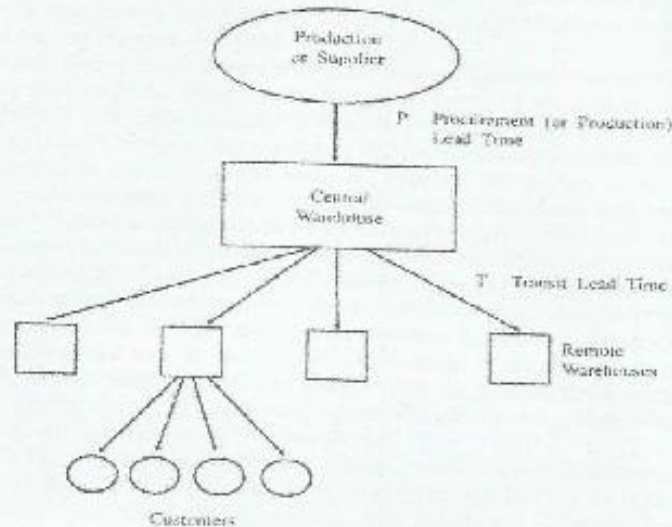


Figure 2. Two echelon warehousing system

In the Figure 2 above, it can be described that on the centralized warehouse which used push system, the inventories included the safety stocks are located in the central warehouse and cover the entire system to anticipate the variation of production lead time. This is the main point why the centralized carry much money in inventory cost. The inventory level will increase in this push centralized warehouse system when the number of remote warehouses increases. The other inventory occurs in warehouse when replenish its inventory from external source such as supplier or other production plants and there is also a holding cost counted per unit time inventory in remote warehouses or retailers [12][13][14]. They also said that in overall, the profit of firms which used the centralized warehouses may lower than decentralization since the grass root (customer level) or local conditions are uncertain such as the uncertain customer's quantity demand, uncertain lead time of supplier replenishment, local tax regulation, or local transportation cost fluctuation.

On the other hand, decentralized warehousing system which focuses on the pull of inventory control implies that remote warehouses make orders to the central warehouse. The quantity demand from customers becomes the quantity to make order to the central warehouse. The problem rise in term of the replenishment of orders from the central warehouse in remote warehouses when it can not be done on the time because the individual remote warehouse demands are not controlled centrally [10] which cause the high variation of replenishment from central warehouse to remote warehouses, therefore the procurement quantities in this system are based on the separate order quantities of the different system modeling of remote warehouse location or there will be a flexibility in replenishing the order to remote warehouses (retailers). This will sometimes affect the total inventory in both the remote warehouses and central warehouse where there will be a high risk for central warehouse to





stock out and there will probably a longer lead time for the remote warehouses or retailers to receive their orders due to the central warehouse must cover all the remote warehouse order with different replenishment time.

#### CENTRALIZED AND DECENTRALIZED WAREHOUSING SYSTEM VS. SERVICE LEVEL

In warehousing, the customer service is the "true value" where people are willing to pay for availability, therefore warehouse managers currently realize that warehousing strategies are paid more attention as a "customer service weapon" [6]. That customer service level can be measured by the level of product availability that is provided by available inventory in warehouses. The warehousing strategy can use a high level of product availability to improve the responsiveness to customers but in fact it requires a large number of inventories, therefore logistic should balance the level of product availability and the cost of inventory [3][16].

In the logistic flow, the push system in the multi echelon, warehouses has some benefits in term of providing the products to the customers that is provided by stocks and product availability. In an independent system or centralized warehouse system which is demand controlled from end up to down side, the inventory stocks in the central warehouse will protect the whole system from the demand variation of production and procurement lead time, whereas the product stocks in the remote warehouses or retails will protect the low level system against the transit lead time [2][15]. The protective stocks in central warehouse as also a part of customer service in term of providing safety stocks to the retails or wholesalers' demand because the retails and wholesalers (remote warehouses) are the first customers which have to served well. Moreover, the stocks in the remote warehouses are the most important stocks must be maintained due to it interacts to the end-customers directly. The central warehouse is serving the entire market because remote warehouse and retails are treated like customers, therefore when there is an increase in percentage of the market served directly, the inventory in the central warehouse will not increase [10]. In general, if the market covered by warehouse is larger, the centralized warehousing system with push system is more effective in term of total inventory converting in proportion of market served.

There is a big different between the centralized warehousing and decentralized warehousing system in term of how the decision made, in the centralized warehousing the decision making is centralized from top to down, while the decentralized allow each location of warehouses to make their own decision based on the information available to them [8]. Therefore, in the decentralized (pull system) strategy actually enable the remote warehouses, retailers or even the central warehouse to serve the customers optimally because they have authority when to make order to central warehouse or supplier, how many inventory they stock and how much they order. In the decentralized and centralized warehouse strategy, there are other factors affecting the choice of this warehouse system related to market service such as the number of remote warehouse, sales volume and transshipment cost.

In centralized warehousing problem, the number of warehouse has a significant influence in the total inventory in all warehouses. As the number of warehouse increases, the local safety stock in each warehouse will decrease because the safety stock is distributed to more location. In this warehousing system, inventories in any warehouses consists of cycle stocks and safety stocks where the total cycle stocks in whole system will not change when the number of warehouse increases because of the quantity of cycle stocks in that specific warehouse is usually averaging in half a cycle time supply [10]. That ensures the demand can be covered securely because there are enough extra stocks when the supply received late (constant demand is assumed rarely occurred in the real world). The obvious result of this, is probably the optimized customer services by reducing the lost sales when there are a very high variations in customer's demands but there is still an extra inventory can be released to cover the unpredictable customer's demand.

On the other hand, the increase number of warehouses in the pull system means that there are more customers' demand variations which affect the accuracy of order replenishment from central warehouse to retailers or remote warehouses. This probably impacts the level of stocks in each retailer or remote warehouse in term of product availability. It is explained clearly in the textbook "*The Management of Business Logistic*" [5] in the figure 1 (the trade-off between the number of warehouses and the cost of lost sale-service level) in which the more number of warehouses, the less cost of lost





sale or we can say that the customer service level will be good, however the more number of warehouses also reflect the more demand variations in each remote warehouses and retailers that means the central warehouse (plant) in the decentralized warehousing system will have serious problems in covering all those warehouses' fluctuated demands in different quantities, different lead times and different distances, or in other words that the probability of failure to replenish the product's orders in this system is higher than the centralized warehousing policy.

The decision of choosing the warehouse strategy whether centralization or decentralization also depend on the kind items sold if fast-selling items or slow-selling items. When the items sold are fast selling, the warehousing strategy which stocks plenty of inventories such as centralized system, there is no influence in term of increasing the safety stock especially in the remote warehouses [19]. This is happened because of the large stocks which enter into warehouses are balanced by the fast selling stocks sold or we can say that the high turnover of in and out stocks will not impact significantly on the increase of the inventory stocks in this warehousing system. On the other hand, the slow-selling items are more suitable for the decentralization system in the business of products availability. The independent remote warehouse which its stocks are not supplied regularly cause the lack of inventory when serving the fast selling items, the obvious impacts of this are increasing the back order activity and even worse, lost sale. The high back order and lost sale level will automatically increase the total cost of logistic.

High product sales turnover which is relevant with the number of warehouse is could be the reason to choose centralized warehousing system [9]. That is because most firms pushing their product sales or turnover to large number of retailers rather than keeping the product in their firms or supplier. In centralized warehousing system, the high product turnover is due to the improvement of utilization inside the warehouse and maximization of the space of the warehouse is more possible than in decentralized warehousing system [12]. Moreover, high product sales are also caused by diversity of product line in the warehouse so that could increase the sales volume.

The other factor influence the decision in warehousing is about the transshipment and transportation issue because transportation or transshipment from plant or central warehouse to remote warehouses related to the delivery time and the replenishment [7][16]. In the centralized warehousing system, the transshipment will be done periodically based on the central warehouse/plant decision, while in the decentralized warehousing system, the order transshipment will be done based on the remote warehouses or retailers demand condition (independent) so that there will be probably imbalanced inventories among the remote warehouses/retailers which definitely affect the transportation/transshipment cost in term of strategy to cover the delivery of whole remote warehouses/retailers. In conclusion, the decentralized warehousing system requires more expensive in transshipment or transportation cost because of imbalance inventories or we can say that the higher cost of transportation (the longer distance of transshipment), the centralized warehousing system is more favorable than decentralized warehousing system.

## CONCLUSION AND RECOMMENDATION

The warehousing strategy such as centralized and decentralized system in a multi echelon warehousing problem affected by two aspects simultaneously: inventory level and service level. In the push system of warehousing problem which all warehouses' stocks are covered by central warehousing system, the inventory level will increase in term of the number of remote warehouses increase [12]. This increase because of the remote warehouses' or retailers' inventories is not independently managed by their selves but from the central warehouse or plant so that the overall stocks are relatively high. However, the product availability means that the customer service can be maintained well in order to the amount of inventories. On the other hand, in the decentralized warehousing problem, the inventories in remote warehouses can be minimized based on the customers' demand. The condition will be risky in the fluctuated customers' demand in term of limited inventories while the order replenishment (transit lead time) from central warehouses is not in time. The risks of this are obvious: back order or lost sales.

There are some aspects before choosing the favorable warehousing strategy (centralized or decentralized system) such as sales volume and transshipment cost. The fast and slow selling items influence these strategies in term of the inventory turnover; the faster items sold the more favorable centralized warehousing system because of the plenty of inventory stocks. Furthermore, the





imbalanced inventory because of fluctuated demand in many remote warehouses impact the product transshipment time where the delivery time will not be precisely delivered by central warehouse. Therefore, the shorter distance of transshipment, the decentralized warehousing is more favorable than centralized warehousing system.

Based on the discussion above, there are some recommendations that could be taken in the business of choosing the warehousing strategy whether push or pull system. When the firms concern about the customer service level while the customer demands are remaining constant, the centralized warehousing system is more recommendal to use. However, when the company concern to minimize the inventory level while the customers' demands are fluctuated, the decentralized warehousing system is more favorable than the other one. These recommendations are also definitely influenced by the other factors that mentioned before such as volume of sales (turnovers), transportation cost and the number of warehouses. These firm factors give significant impact on inventory level in term of replenishing orders, leveling safety stocks and determining the transshipment lead time, therefore the factors should be considered as constraints before making decision whether using centralized or decentralized warehousing strategy.

## REFERENCES

- [1] Bowersox, J.D., and Close, J.D., 1986. *Logistical Management. The Integrated Supply Chain Process*. McGraw-Hill Companies, Inc.
- [2] Caron, F. and Marchet, G. 1996. The Impact of Inventory Centralization/Decentralization on Safety Stock for 2 Echelon System. *Journal of Business Logistics* 17 (1). Retrieved March 6, 2007, from ABI/INFORM Trade& Industry.
- [3] Chopra, S. and Meindl, P. 2001. *Supply Chain Management: Strategy, Planning, and Operation*. Prentice-Hall, New Jersey.
- [4] Coyle, J.J., Bardi, J.E., Novack, A.R. 1996. *Transportation 5<sup>th</sup> ed.* South-Western College Publishing, Ohio.
- [5] Coyle, J.J., Bardi, J.E., Novack, A.R. 1992. *The Management of Business Logistics 6<sup>th</sup> ed.* West Publishing Company, Minneapolis.
- [6] Daly, F. 1993. Warehousing: The Strategic Weapon For Customer Service. *Industrial Engineering* 25 (5). Retrieved March 19, 2007, from ABI/INFORM Trade& Industry.
- [7] Hidaka, K. and Okano, I. 1997. Simulated-Based Approach to the Warehouse Location Problem for a Large Scale Real Instance. *Proceeding of the 1997 Winter Simulation Conference*. Retrieved March 6, 2007, from ABI/INFORM Trade& Industry.
- [8] Hurncourt, L. 2001. Mixups in The Warehouse: Centralized & Decentralized Multi-Plant Firms. *Economic Inquiry* 39 (4). Retrieved March 6, 2007, from ABI/INFORM Trade& Industry.
- [9] McKinnon, A. 1989. *Physical Distribution Channel*. Billing & Sons, Ltd. NY
- [10] Rosenfield, B.D., and Pendrock, E.M. 1986. The Effect of Warehouse Configuration Design on Inventory Level and Holding Cost. *Sloan Management Review* 21 (4). Retrieved March 6, 2007, from ABI/INFORM Trade& Industry.
- [11] Somburanasit, p. 2012. Centralized warehouse vs. decentralized warehouses. *TPoint semester*, issues 11, September 2012.
- [12] Teo, C. and Shu, J. 2004. Warehouse-Retailer Network Design Problem. *Operations Research* 52 (3). Retrieved March 6, 2007, from ABI/INFORM Trade& Industry.
- [13] Tersine, R.J. 1994. *Principles of inventory and materials management*, 3rd edn. Prentice-Hall International, London
- [14] Towill, D. R. 1981. Supply chain dynamics. *International Journal of Computer Integrated Manufacturing*, 4, 197-208.
- [15] Van Roy, T. 1989. 'Multi-level production and distribution planning with transportation fleet optimization', *Management Science*, vol. 35, no. 12, pp. 1443-1453.
- [16] Vidal, C. J. & Goetschalckx, M. 1997. Strategic production-distribution models: A critical review with emphasis on global supply chain models. *European Journal of Operational Research*, 98, 1-18.
- [17] Ya Peng, Z. & Yi Zhong, D. 2007. Optimization model for closed-loop logistics network design in manufacturing and remanufacturing system. *IFFE*.