MODELING WAREHOUSING SYSTEM TO IMPROVE CUSTOMER RESPONSIVENESS

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ABSTRAK

As a potential wide-separated island market, Indonesian logistics firms require a complex warehousing structure in distributing their products to entire part of areas. The problem raise when not all part of market areas receive the products with the same price and availability as the other places received. The product availability (customer responsiveness) in the multi echelon warehosing network depend on the optimum warehouse/distribution centre location determination Rosenfield and Pendrock (1986) have researched about the conflict between inventory level and customer service on the firms which practiced the centralized warehousing strategy. This research attempts to optimize the integrated strategies in implementing the warehousing policy, how to model the warehousing system effectively using the concept of warehousing location layout and the concept of centralized-distributed warehousing system with accommodating the probability of changes of the logistic elements like transportation-distribution, sales volume and the distance.

The case study result shows that the optimum warehouse location should be located in the city of Pasuruan at the grid 514.2 horizontally and 143.8 vertically. From that case, the firm automatically could deliver the products in the huge scale to gain the unit cost reduction (economic sacle) which finally could raise the customer responsiveness (product avaliability). The sensitivity analysis also shows that the distance (from source to market) of determined warehouse location affect the transport rate.

Key words: warehouse, location, customer, distribusi

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 retails or customers demand (Theo and Shu, 2004, 396). 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 (Rosenfield and Pendrock, 1986, 23). 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.

Most of the inventory system used by industries in Indonesia have problem in the business of providing their products to the entire market areas especially in the distributed market location with the same level of availability. The distance is too far between the production sources and warehouses, will force the companies to stock their products in a huge numbers in particular warehouses/ distribution centers that will increase the logistics cost especially on the inventory costs. Automatically, the selling price will rise as well. On the other hand, some warehouses have a very low inventory that means the product availability

is low and will impact on the high backorder, lost sale and lost customers.

From the problems above, the reserah will be designed into three stages. In detail will be described by the following explanation:

Research stage I: Determining the warehouse location optimally by considering the aspects such as, Geographical Condistion, Market Areas, Source/ production plant

Research stage II: Some significant influences of the logistics' elements changes to the total logistics cost from the designed warehouse location model. In this stage will be followed by sensitivity analyzing of changes of, The distribution-transportation cost, The distance and The sales volume / demand

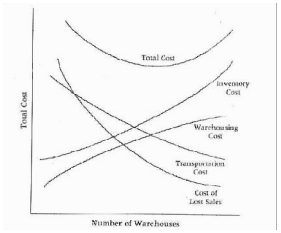
Research stage III: Determining the pull-push system on the designed warehouse models with the parameters: Inventory level, Cutomer service level, Back order and lost sale

Literature Review

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 (Bowersox and Closs, 1986).

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 (Coyle, Bardi and Langley, 1992, 14). They stated that the warehouses also give several value-adding roles in logistic system such as transportation consolidation, product mixing, 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 (1992) if the number of warehouses increase the inventory cost will increase too whereas the lost sale cost decrease. The figure below shows how the number of warehouses impacts the other costs:



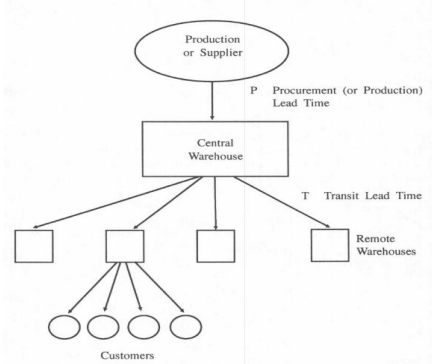
Picture 1. The number of warehouses will affects four basic warehousing cost

The figure describes that the number of warehouses will affects four basic warehousing costs such as inventory cost, warehousing cost, transportation cost and the lost sale cost (service cost). In this research we will concentrate the two of them: inventory cost and service level. As shown on the figure above, the more number of warehouses, the more inventories and the warehouse numbers will decrease the cost of lost sale or in the other words the customer service level will increase. 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 Warehouse versus the Inventory in 2 echelon system

The basic function of warehouse is storage or holding goods inventory for periods of time. Coyle, Bardi and Langley (1992) said that the most fundamental problem in warehousing system is the high cost of holding finished goods for long time periods. 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 basically costly and risky in term 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, like Rosenfield and Pendrock (1986) example on the self distribution network, the inventory carrying cost could be 2.5% of sales, a significant proportion. 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 centralized warehousing process in 2 echelon systems is explained briefly from the figure below:



Picture 2. The centralized warehousing

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 (Teo and Shu, 2004). Teo and Shu 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's cost fluctuation.

In the other hand, decentralized warehouse 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 to remote warehouses when it can not be done on the time because the individual remote warehouse demands are not controlled centrally (Rosenfield and Pendrock, 1986) 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 stocking 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.

Warehouse and Inventory in 2 echelon

One of the most important tasks of managing warehouse in a two echelon system is how to decide to provide inventory in the system. Inventory carrying cost become substantial effect in the warehousing strategy implemented. Rosenfield and Pendrock (1986) example on the self distribution network that the inventory carrying cost from the plant to the lower level of warehouses could be 2.5 percent of sales, a significant proportion. Two echelon warehousing system inventory flow from 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 how two echelon warehousing system flow the inventory is explained briefly from the figure 2. The inventories included the safety stocks are located in each warehouse level to anticipate the variation of production lead time. The 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 (Teo and Shu, 2004).

Number of Warehouse

In the centralized warehouse problem, the number of warehouse has a significant influence in the total inventory in all warehouses. If the number of warehouse increases, the local safety stock in each warehouse will decrease because the safety stock is distributed to more location. According to Rosenfield and Pendrock (1986, 26), 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. That ensure the demand can be covered securely because of there is an extra stock 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 by Coyle, Bardi and Langley (*The Management of Business Logistic, 1992, pg. 60)* in the figure (the trade-off between the number of warehouses and the cost of lost sale) that 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 a huge difficulties in covering all those warehouses' fluctuated demand in different quantity (lot size), different lead time 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.

Sales Volume

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 (Rosenfield and Pendrock, 1986). 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 in 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.

Transshipment Cost

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 (Hidaka and Okano, 1997). 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 will require 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.

Warehousing and Customer Service

Customer service is the main key in warehousing activities in term of adding value to products which stored in storage and it should be continuously measured and monitored within the warehouse (Daly, 1993). The review of customer service improvement can be evaluated trough the warehouse activities such as customer order fulfillment, pick and store the right materials and pack and ship to right address. Daly (1993) found that the level of customer service can be measured by using some measurements based on the customers requirements and factor impacted. The following table figures out how warehouse can impact customer service and what measurement used to measure:

Table 1.Same meansurement based on customer reguirement and factor impacted

Customer Requirements	Factors	Measurements
Correct Product	• Operator Errors • Location Control • SKU Identification • Picking Document	☑ Returns ☑ Stock-outs
Correct Quantity	• Operator Accountability • Inventory Levels • Procedures & Training	☑ Accuracy ☑ Fill Rate ☑ Backorder Rates
Good Condition	• Packing Specifications • Storage Capacity • Equipment Condition • Facility	☑ Complaints ☑ Damage Sales
On Time Figure 1	• Throughput Capacity • Order Scheduling • Pick Management • Traffic/Carrier Relations	☑ Shipments - Orders ☑ Promises Kept

Source: Daly, 1993.

THE RESEARCH METODOLOGY

This research will be designed into three stages to overcome the problems to determine the final model of the distribution system by determining the optimum warehouse location and to explore the impacts of the changes of the transportation rates,

capacity and the distance of warehouse location and finally by analyzing how the push-pull inventory policy in the multi echelon could be implemented in the designed distribution network model particularly its effect to the inventory level and customer responsiveness. Research will be conducted in some industries at eastern Java especially in industries which have well developed multi echelon distribution network structure.

The qualitative data such as the current warehouse structure, distribution network, the number and location of warehouses and the company's market areas will be gathered together with the quantitative data as logistics' costs (transportation and inventory cost) and demand fulfillment rate. The research is a case study research (inductive research) which uses case study as the main data to form the opinion/general conclusion (Eisenhardt, 1989) about how to model warehousing strategy of multi echelon company and its impacts to the designed model from logistic aspects and impact of inventory policy (push-pull system) to the level of inventory, the availability level and customer service level. Thus, in the inductive research will require empiric data from the single/multi sources.The parameters will be used in this research as the pivot data in the first and second research stage are the cover-age ability of the market area and total logistic cost that will be measured by the changes of other logictics' elements such as transportation-tranship ment cost, capacity-demand and the distance between sources-market areas. Some metrics will be used to measure the impact in the third research stage (push-pull system or centralized-distributed system) are the inventory level in which correlate to inventory carrying costs, safety stock and on hand inventory and other parameters like customers service level that correlated to the customer demand responsiveness, back order level and lost sale. The proposed problem solving to solve the logistic problem is divided into some research steps:

Stage I

- Step 1: Current logistics strategy observation
  In this step, the field observation will be held by observing the company's distribution activity network especially company's strategy in distribution process, distributor location and covered market area.
- Step 2: Determining the problems
  From the information gathered in the previous step, the next step is determining the problem faced b the firms. In this step, will be focused on the determining the outbound logistic. Brain storming with some expertise in logistics such as the logistics manager and CEO will be conducted to formulate problems.
- Step 3: Identifying alternatives
  After formulating the problems, the next step is identifying some alternatives in solving problems. The proposed alternatives related to company's distribution strategy (location and the number of distribution centres). The technique will be used in this step is grid technique. Moreover, to support the problem solving process, software and hardware will be prepared for pilot run. The output of this stage is a design of warehouse layout.

Stage II

- Step 4 - 5: Evaluation and sensitivity analysis.
  From pilot run and the output of stage I will be evaluated (sensitivity analysis) by analyzing the impact of changes of some logistics elements such as transportation-distribution cost, capacity and distances. The output of the stage II is an impact to designed warehouse location when the variables above changes.

Stage III

- Step 6-7: Inventory policy Analysis and final design model of warehousing.
  From the output stage II, there will be an analysis of inventory policy which can be implemented to manage the inventory level with push and pull technique (centralization and distribution strategy). Once the inventory policy is found, the next step is making the final model of distribution/warehousing.
- Step 8: Conclusion and Recommendation
  In this step of stage III, the result of this research will be focused on the generalising the logistics concept especially on the warehousing strategy and distribution on general. Because of this research is inductive rsearch so the bottom-up process will be held carefully in this step.

RESEARCH RESULT

The coverage of the market area is around East Jave that concentrated on the several cities within this Eatern Java province. The method used to determine the optimum warehouse location in this research would use the map as the main source to develop the distribution channel aroud the market areas. By using grid centre technique, the distribution centre will be located optimally by calculating the chosen cordinates uses by dividing the total numerator value of each vertical and horizontal section by the total denominator value of each vertical and horizontal section respectively. The following shaped table informs how the grid centre determined:

Table 2. The distribution centre will be located optimally by calculating the chosen cordinates

Source /Market Area	Rate Rp/pc/km (A)	Load (B)	Grid Coordinat		Calculation	
			Hor	Vert	AxBxHor (000)	AxBxVer (000)
Malang (S)	1,000	900	400	100	360,000	90,000
Market:						
Surabaya (M)	1200	125	420	260	63,000	39,000
Blitar (M)	1000	100	270	70	27,000	7,000
Situbondo (M)	2000	525	800	160	840,000	168,000,
Bojonegoro (M)	2000	150	195	185	58,500	55,500
	Total				1,348,500	359,500
					Hor	Vert
Numerator – Sources: SUM (rate*load*Cordinate)					360,000	90,000
Numerator – Markets: SUM (rate*load* Cordinate)					925,500	269,500
Total					1,285,500	359,500
Denominator – Sources: SUM (rate*load)					900	900
Denominator – Markets: SUM (rate*load)					1,600	1,600
Total					2,500	2,500
Grid Centre: Total Numerator / Total Denominator					514.2	143.8

The final calculation shown the locaton cordinate is located at the 514.2 horizontally and 143.8 vertically. It means that based on the grid method, the location should be around the city had that such cordinate above (around the city of Pasuruan).

Discussion

Review of the Result

The firm's distribution distribution problem was the unefective product distribution which distributed directly by salesman to the customers or retailers. To solve the problem by determining the warehouse location optimally is expected that the distribution centre have functions to store the products as stocks. This will help firm to produce their products maximally (economic scale) to be stored at distribution centre and also help to cover the fluctuated demand.

The optimal warehouse location is located around the City of Pasuruan will lead the company

to cover the whole market areas such as Situbondo (see the map). The demand prospect shows that the most potential market is Situbondo that had the biggest product demand (525 packs). The warehouse is also projected to help to cover the product demand from Bojonegoro and other new prospect area at the northern cities.

The warehouse should be functioned to stock point to subject the economic scale when the firm transports the product to. This will automatically decrease the transportation cost, stock out cost and cost of shortage that will lead the decrease of total distribution cost.

To step the next stage (distribution policy – centralized or distributed), the final result of determining the optimal warehouse location will be used as input to analyse how the policy of product distribution should be.

The Implication for the Customer Service

By locating the warehouse at the determined location around Pasuruan will impaact on the customer servce performance in the buseness of product availability. Based on prior condition, in some potential market areas such as Surabaya and Situbondo complained that there were often stockout because of supplies problem. This is definitely caused by the distance between source (Malang) and the markets.

The other advantages by locating the warehouse at Pasuruan is concerning with continues plan to expand the product market areas and the new potential markets are the areas which have a tropic climate such as Gresik, Lamomgan, Probolinggo, Jember dan the other eastern areas.

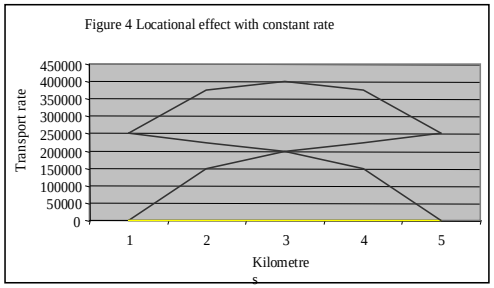
The other implication if locating the warehouse at Pasuruan is decreasing the cost of transportation regarding the economic scale of product transport. In the business of product shipment, the more products carried the cheaper cost of transportation per unit. Warehouse could be the solution for the firm to deliver the products in a huge scale to gain the unit cost reduction. And again, by reducing the cost of transportation means the product price per unit is reduced as well.

Senstivity Analysis: Locational Effects of Tapering Rates

The distance (from source and to market) of the determined warehouse location affect the transport rate. The closer warehouse built from the source the transport rate will be cheaper. However, the transporr rate will be more expensive when the warehouse is located far away to the market. In summary, the total transport rate will be reached at the top (the most expensive) in the position where the graph line of *From Source* line and *To Market* line crossed in the optimal distance of them.The locational effects of determined location based on the constant transport rate assumption could be drawn as follow:

Table 3. The locational effects of determined location based on the constant transport rate assumption

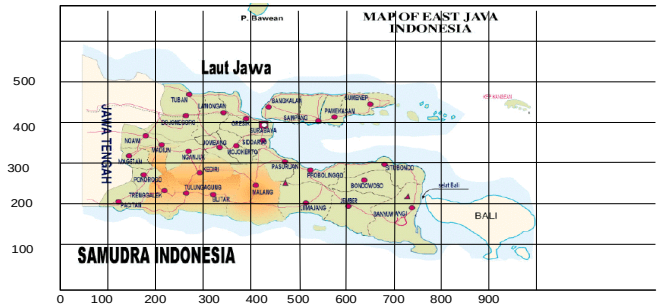
Km from Source	Transport Rate from Source (Rp)	Km to Market	Transport Rate to Market (RP)	Total Transport Rate (Rp)
0	0	250	250,000	250,000
100	150,000	200	225,000	375,000
150	200,000	150	200,000	400,000
200	225,000	100	150,000	375,000
250	250,000	0	0	250,000



Picture 3. The figure below describes the graph of locational effect based on the constant transport rate.

CONCLUSSION

Location is a significant consideration in the business of expanding the sales volume with the minimum cost. More optimum location tobe located as distribution centre, more minimum cost of distributed market coverage. From the collected data of the case study found that the required dictribution centre should be located at the grid 514.2 horizontally and 143.8 vertically (514.2; 143.8). Based on the Jawa Timur map used in the research, the cordinate are located at around the city of Pasuruan. The following figure shows where the detail dictribution location should be located for the markets area



Picture 4. The Chosen Location as Distribution Centre: Pasuruan

REFERENCES

Bowersox, JD and Closs, JD 1996, *Logistic management :the integrated Supply chain process*, McGraw-Hill, USA

Caron, F. and Marchet, G. 1996. The Impact of Inventory Centralization/Decentralization on Safety Stock for 2 Echelon System. *Journal f Business Logistic 17 (1)*. Retrieved March 6, 2007, from ABI/INFORM Trade& Industry.

Chopra, S. and Meindl, P. 2001. *Supply Chain Management: Strategy, Planning, and Operation*. Prentice-Hall. New Jersey.

Coyle, J.J., Bardi, J.E., Novack, A.R. 1996. *Transportation 5th ed*. South-Western College Publishing. Ohio.

Coyle, J.J., Bardi, J.E., Novack, A.R. 1992. *The Management of Business Logistic 6th ed*. West Publishing Company. Minneapolis.

Daly, 1993. Warehousing: The Strategic Weapon For Customer Service, *Industrial Engineering Journal*, Vol. 25, No. 5, pg.61. Retrieved September 5, 2007, from ABI/ INFORM Trade& Industry.

Eisenhardt, K. M. 1989, 'Building theories from case study research', *Academy of Management Review*, vol. 14, no. 4, pp. 532-550.

Hidaka, K. and Okano, H. 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.

Ho, P. and Perl, J., 1995. Warehouse Location Under Service-Sensitive Demand. Journal of Business Logistic, Vol. 16, No. 1, pg. 133-164. Retrieved September 5, 2007, from ABI/INFORM Trade& Industry.

Hunnicutt, L. 2001. Mixups in The Warehouse: Centralized & Decentralized Multi-Plant Firms. *Economic Inquiry 39 (4)*. Retrieved August 19, 2007, from ABI/INFORM Trade& Industry.

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 August 19, 2007, from ABI/INFORM Trade& Industry.

Teo, C. and Shu, J. 2004. Warehouse-Retailer Network Design Problem. *Operation Research 52 (3)*. Retrieved August 19, 2007, from ABI/INFORM Trade& Industry.