Receiving and Shipping Management in a Transshipment Center

CHYUAN PERNG AND ZIH-PING HO*
Department of Industrial Engineering and Enterprise Information, Tunghai University, Taiwan

ABSTRACT

This research discusses how to apply the concept of the extra supply chain cost to managing an operational problem in a transshipment center. We set four scenarios. Scenario 1 is: goods will be sent to the transshipment center until there is no free space. Scenario 2 is: goods will be sent to the transshipment center and a temporary space. Scenario 3 is: Scenario 1 without free space reorganization. Scenario 4 is: Scenario 2 without free space reorganization. In all the four scenarios, we create an extra supply chain cost equation to validate the results. The extra supply chain cost consists of renting temporary space, transportation, reorganization and returned goods. We used empirical data gathered from some transshipment centers in central Taiwan to simulate our research problem. In conclusion we show that the larger the transshipment center, the lower the extra cost. The extra cost will be minimized if the transshipment center returns the superfluous goods directly because of high space and reorganization cost. If the transshipment center is full: first the return of the goods should be considered; secondly, the renting of temporary space should be considered, with the reorganization of space being the final consideration.

Key words: dynamic layout problem, supply chain cost problem, dynamic space control, allocation problem, reorganization management.

1. INTRODUCTION

Facility layout problems (FLPs) have been investigated in depth by researchers in many engineering fields (Lee & Elsayed, 2005). A transshipment center in this research is defined as the shipment of goods to an intermediate destination, and then onwards to a further destination. The dynamic layout problem of transshipment center space is one such FLP. The FLPs in a transshipment center are important issues in supply chain management. For different methods of transportation, there are corresponding dynamic layout alternatives. This research utilizes a simulation method for receiving and shipping management in a transshipment center.

This paper contributes a novel approach to the strategic planning of receiving and shipping in a limited transshipment center space while unlimited temporary space can be rented. In this study, the goods have to be arranged in the transshipment center regardless of space capacity. If the transshipment center is full, temporary space will be obtained for storing the extra goods. The consideration of transportation and reorganization costs will also be included.

Simulating receiving and shipping problems with space constraint in a transshipment center is extremely complex. Previous research has seldom discussed this issue. The transshipment center unit changes dynamically over time. The traditional method is not feasible for handling a problem which involves receiving

* Corresponding author. E-mail: c8880@ms21.hinet.net

and shipping goods concurrently. Under inefficient configuration management of a transshipment center, we are forced to increase costs by renting temporary space. The goods have to be set down in sequence, adjacent to the next receiving number. The goods are of various shapes and sizes. To solve these problems, we have to minimize the rental of transshipment center space, transportation, reorganization and returned goods costs.

2. LITERATURE REVIEW

Previous research has shown that the transshipment center problem is important in supply chain management. Most of the relevant existing research focuses on networking, and does not consider the dynamics of the configurations in transshipment center units. Hoppe and Tardos (2000) concluded that the transshipment problem is defined by a dynamic network with several sources and sinks. There are no polynomial-time algorithms known for most of these problems. In their paper, they gave the first polynomial-time algorithm for the quickest transshipment problem. Their algorithm provided an integral optimum flow. Qi (2006) presented a logistics scheduling model for two processing centers that are located in different cities. Each processing center has its own customers. When the demand in one processing center exceeds its processing capacity, it is possible to use part of the capacity of the other processing center subject to a job transshipment delay. Lee and Elsayed (2005) noted that space shortage occurred when the demand exceeds the warehouse storage capacity. The additional space requirement is satisfied by considering leasing storage space. The warehouse storage capacity problem is then formulated as a non-linear programming model to minimize the total cost of owned and leased storage space. Aghezzaf (2005) proposed strategic capacity planning to solve warehouse location problems in supply chains operating under uncertainty. He used a special Lagrangian relaxation method in which the multipliers are constructed from dual variables of a linear program.

Herer and Tzur (2001) contemplated a system consisting of two locations which replenish their stock from a single supplier; and where transshipments between the locations are possible. Their model included fixed (possibly joint) and variable replenishment costs, fixed and variable transshipment costs, as well as holding costs for each location and transshipment costs between locations. In their research, transshipment costs can be proposed for evaluating the performance of transshipment space. Petinis and Tarantilis (2005) presented the formulation and the solution of a multi-product warehouse sizing problem. The optimal warehouse inventory level and the order points are determined by minimizing the total inventory ordering and holding costs for a specific time period. The problem is formulated as an appropriate mathematical model of NLP nature and solved using appropriate numerical optimization techniques. They offered a numerical case study where the sensitivity of the model parameters involved is given through appropriate figures.

Heragu, Du and Schuur (2005) and Meng, Heragu and Zijm (2004) stated that the two primary functions of a warehouse are (1) temporary storage and protection of goods; and (2) providing value added services such as fulfillment of individual customer orders, packaging of goods, after-sale services, repairs, testing, inspection and assembly. To perform the above functions, the warehouse is divided into several functional areas such as reserve storage area, forward (order collation) area and cross-docking. They used a mathematical model and a heuristic algorithm that jointly determined the product allocation to the functional areas in the warehouse as well as the size of each area using data readily available to a warehouse manager. Melachrinoudis, Messac and Min (2005) found that to effectively re-configure a warehouse network through consolidation and elimination, a physical programming (PP) model can enable a decision maker to consider multiple criteria (i.e., cost, customer service and intangible benefits) and to express criteria preferences not in traditional forms of weights, but in ranges of different degrees of desirability. The proposed model is tested with real data involving the reconfiguration of an actual company's distribution network in the United States and Canada.

In summary, we need a simulation for determining strategic planning for receiving and shipping in a limited transshipment center space while unlimited temporary space can be rented.

3. PROBLEM STATEMENT

Transshipment center management is the allocation of goods in a transshipment center, and is an important issue in supply chain management. The transshipment center in this research is x units in length, and y units in width, with n orders of goods entering the transshipment center continuously. The goods are allocated adjacent to the next receiving number in sequence. There is a staging time (time for transferring goods) recorded for each item received. If the staging time expires, they have to move the goods out of the transshipment center. In addition, all new goods received have to be placed immediately into the transshipment center. Usually, if there are no free spaces in the transshipment center, we have to rent temporary space in order to arrange these goods. On the other hand, if there are enough free spaces, but there are no integrated free spaces, then we have to reorganize the free spaces. For example (see Figure 1), the transshipment center fills with goods. Each serial number represents the received number of goods.

5	5	5	5	5
5	3	3	3	3
3	3			9
9	9	9	2	
	4	4	4	

Figure 1. The original allocation.

If the goods need 4 units of staging space, but there are no integrated free spaces, we ought to reorganize the free space. There are four kinds of costs in our problem. One is the rental of temporary space. Second is the transportation cost. Third is the cost of reorganization. Lastly is the returned goods cost.

4. EXTRA COST EQUATION

In formulating the extra cost equation, the following notation is used.

Extra Cost =
Rent of temporary space cost (RTSC) + Transportation cost (TRC) +
Reorganization cost (REC) + Returned goods cost (RGC) (1)

where

RTSC = price per unit grid of temporary space $\times$ used spaces, (2)

TRC = price per unit space of truck $\times$ used space, (3)

REC = price of reorganization cost per time $\times$ times, (4)

RGC = price of returned goods per job $\times$ jobs. (5)

The rental cost of temporary space has to be minimized because the more unit grids rented, the higher the price. This is reasonable because it indicates that the manager must always be on the look out for more free space in order to arrange any unexpected goods received. The transportation cost is also counted due to the fact that trucks must be rented in the real world for transportation. If the transshipment center space is rearranged, the reorganization cost must be paid because of the cessation of receiving and shipping. If a transshipment center must return goods, it has to pay the cost. The extra cost is the summation cost of rental of temporary space, transportation, reorganization, and returned goods, and the objective is to minimize the extra cost.

5. SYSTEM DEVELOPMENT CONCEPT

The system development concept (see Figure 2) shows that when goods are received, the system will clear the overdue goods. Any expired goods stored in the transshipment center will be released. Next, the goods will be put into the transshipment center. Then, we set four scenarios. Scenario 1 is: goods will be sent to the transshipment center until there is no free space; Scenario 2 is: goods will be sent to the transshipment center and temporary space. Scenario 3 is: Scenario 1 without free space reorganization. Scenario 4 is: Scenario 2 without free space reorganization. The system will calculate the maximum integrated free spaces. If there are integrated free spaces, then the system will fill these with goods. For scenarios 1 and 2, if there are enough free spaces but there is a lack of integrated free space, then the system will reorganize the free space. Therefore, the default procedure is to move the goods into the transshipment center. Temporary space will be rented if superfluous goods are shipped to the transshipment center. The system will also check whether all goods are completed. If the answer is no, then the expired goods will be deleted and the process will be repeated. After that, the procedure is to count the number of reorganizations. Finally, the system will calculate any extra cost.

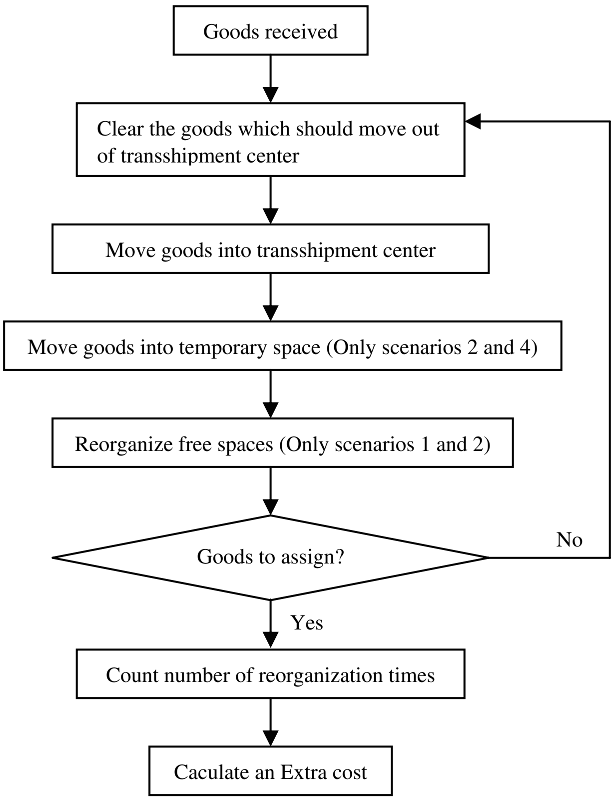

Figure 2. System development concept.

There are three kinds of random numbers in our computer program. These are job size (1-35 units of space), received day (1-90 days), and storage day (1-14 days). We applied the simulation 100 times to the four scenarios. We use three sets of data to simulate and compare the shape of the transshipment center, which are x (length) = 20, y (width) = 10; x = 15, y = 10; and x = 10, y = 10. Furthermore, we have computed the extra cost for the four scenarios.

This simulation is a case study. Therefore, we set the price per unit grid of temporary space at $26 (USD). The transportation cost per unit space is $1. The penalty of returned goods per job is $220. The reorganization cost per time in a transshipment center is $730. These values were obtained in 2006 from actual companies in central Taiwan.

6. SYSTEM VALIDATION

The system adopts a website structure design. The results can be viewed on the Internet. There is a three-layer structure, which includes the PHP language, an access database, and an Apache server in our system. The hardware environment is a Pentium IV computer. All algorithms are coded with the PHP language. The results were obtained over a period of two days of simulation.

The major findings of this study are listed in Tables 1-3. It is obvious that the larger the transshipment center, the lower the extra cost. For each scenario, the larger the transshipment center, the lower the total costs. In this case study, the lowest extra cost will be achieved if the transshipment center returns the superfluous goods directly. But in the long term, it will decrease the reputation of the transshipment center. It is not a good idea to return the superfluous goods in all situations. In Tables 1-3, Scenario 1 is lower than Scenario 4 due to the free space reorganization cost and the lack of rented temporary space. At the same time, Scenario 2 is higher than Scenario 4 because of the added factor of free space reorganization cost. It is an interesting result that means because of the high reorganization costs, reorganization of the transshipment center on a regular basis should not occur. In all the scenarios except Scenario 3, if goods are continuously entering into the transshipment center, rented temporary space should be kept at a minimum because of the high rent of temporary space cost. Therefore, from the results in this case study, if the transshipment center is full, we should return the goods first, followed by rental of temporary space, and lastly proceed to space reorganization.

Upon completing the analysis, it is found that the highest cost will be incurred if RGC is 4 times the original amount, RTSC and TRC is 1.2 times higher, or REC is 2 times higher than the current price.

7. CONCLUSIONS

In the busy business environment, the transshipment center problem is an important issue in supply chain management. This paper contributes the application of the extra cost concept. Using this concept, we are able to determine strategic plans for receiving and shipping in a limited transshipment center space, while unlimited temporary space can be rented. Under inefficient configuration management of the transshipment center, we are forced to increase costs in supply chain management. The factors that make up the extra cost are the rental of temporary space, transportation, reorganization, and the return of goods. We also set four scenarios to validate our cost function. Scenario 1 is that goods will be sent to the transshipment center until there is no free space; Scenario 2 is that goods will be sent to the transshipment center and temporary space. Scenario 3 is Scenario 1 without free space reorganization. Scenario 4 is Scenario 2 without free space reorganization.

Table 1. *The Extra Costs in Transshipment Center (20x10)*

Cost Type	Scenario 1	Scenario 2	Scenario 3	Scenario 4
RTSC	0	1346	0	2069
TRC	0	52	0	80
REC	1044	1044	0	0
RGC	466	0	669	0
Total	1510	2442	669	2149

Note. Unit = US dollar.

Table 2. *The Extra Costs in Transshipment Center (15x10)*

Cost Type	Scenario 1	Scenario 2	Scenario 3	Scenario 4
RTSC	0	3098	0	4034
TRC	0	119	0	155
REC	1628	1628	0	0
RGC	1173	0	1377	0
Total	2801	4845	1377	4189

Note. Unit = US dollar.

Table 3. *The Extra Costs in Transshipment Center (10x10)*

Cost Type	Scenario 1	Scenario 2	Scenario 3	Scenario 4
RTSC	0	5837	0	6473
TRC	0	225	0	249
REC	2037	2037	0	0
RGC	2193	0	2321	0
Total	4230	8099	2321	6722

Note. Unit = US dollar.

Based on the results, we show that a larger transshipment center will induce a lower extra cost. In this case study, the extra cost will be the least if the transshipment center returns the superfluous goods directly. Because of high reorganization costs, we should not reorganize the transshipment center on a regular basis. If goods are continuously entering the transshipment center, we should rent the least amount of temporary space due to the high cost of renting temporary space. To sum up the case study, if the transshipment center is full, we should return the goods first, then rent the temporary space, and lastly proceed to space reorganization.

We suggest that other costs, such as the cost of reputation lost, should be added in future long term studies.

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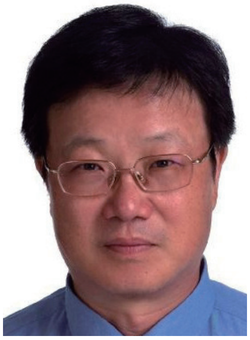

Chyuan Perng is an Associate Professor in the Department of Indutrial Engineering and Enterprise Information at Tunghai University, Taiwan. He received his Ph.D. degree in industrial engineering from Texas Tech University, USA. He is a part-time Associate Professor in the Department of International Business in Asia University. He has also participated in several industrial and governmental projects in Taiwan.

Zih-Ping Ho is a fourth-year Ph.D. student in the Department of Industrial Engineering and Enterprise Information at Tunghai University, Taiwan. He also teaches courses in the Department of Management and Information in Nan-Jeon Institute of Technology.