Obsolete Inventory Reduction

Erick Jones, Tim Farnham

University of Nebraska, 175 Nebraska Hall, Lincoln, NE 68588, USA

ABSTRACT

This paper considers an inventory problem faced by municipality. A methodology was developed to evaluate items to be ordered in large quantities then stored or ordered in a system based on Just-in-Time. The ratio shows when warehousing becomes inefficient due to overcapacity or obsolescence. This paper presents an efficient ratio to determine when a Just-in Time supply chain is favorable to a multi-echelon inventory system where obsolete inventory is present. This methodology was used to reduce obsolete inventory in a supply chain and reduce operating costs.

1.1 Introduction

This paper considers a consumable goods inventory problem faced by a city department and shows how inefficient warehousing can become if inventory is not periodically checked for obsolescence. The department purchases and distributes consumable items used by offices spread through the city. To support the service process, the department operates several warehouses in the city. Furthermore, the warehouses orders large quantities of goods at a negotiated price and stores the items until an office places an order for a relatively smaller quantity then the warehouse orders. If the order quantity is on hand, the items in the orders are then picked by warehouse employees and delivered to the offices. If the warehouses do not have the item on hand, the item is placed on backorder and is delivered when it becomes available. Any stock out is very costly.

This paper will continue in the following manner. The next section will discuss the carrying costs associated with two-echelon inventory handling. Then a one-echelon system utilizing Just-in-Time will be discussed. After the one-echelon JIT system we will introduce the municipality cost ratio model, followed by a case study that used the municipality cost ratio to make decision.

1.2 The Two Echelon model

Several aspects of Caglar's (2003) model are very useful when optimizing two-echelon models. The model has been verified by using several cases referred to in his original article. This section will show how his model can be modified to fit this system. First we will consider a two-echelon multi-consumable goods inventory system consisting of a central distribution center and multiple customers that require service illustrated in Fig. 1.

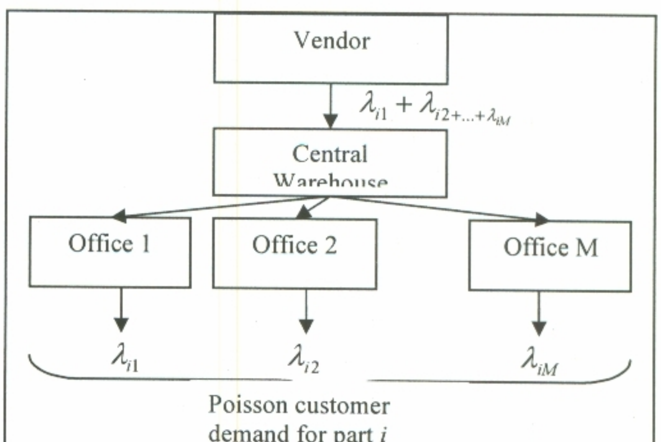

Figure 1: Two echelon inventory chain

Each office acts as a smaller warehouse. This is because they each supply many customers and maintain a stock level S_{iM} for each item. So each office consists of a set *I* of *n* items that are used with at a mean rate. When an item is used by a customer the customer replenishes itself by taking item i from the office *M* supply stock if the item is in stock. If the item is not in stock the item is back ordered and the customer has to wait for the item to become available at the office.

The goal of this paper is to make a decision of supply chain type based on basic purchasing and holding cost information, while maintaining an average response time that will not negatively impact the customers. This may include the elimination of the central warehouse.
We use the notation listed in Table 1 in all of the models:

Table 1: Notation for Models

Notation	Meaning
A_w	Annual fixed cost of warehouse operation;
C_I	Total cost of holding inventory;
C_{Lj}	Labor cost at warehouse j:
C_{Vj}	Cost of vehicles and maintenance at office j;
C_{Uj}	Cost of utilities at office j:
C_W	Lease price or depreciation and cost of capitol of warehouse;
C_{Mj}	Annual property maintenance for warehouse j;
$J = \{1, 2, \ldots, M\}$	Set of offices;
K_j	Customer at office j;
l_i	Demand rate of item i;
L_{JITij}	JIT lead time for an expedited order of item i at office j;
$\lambda_{ij} = K_j l_i$	Demand rate for item i at office j;
θ_c	Organizations cost of capitol;
θ_{Oij}	Obsolescence rate for item i at office j;
θ_S	Shrinkage rate based on total inventory in system;
P_{Wi}	Purchase price using warehouse system of item i;
P_{JITi}	Negotiated JIT purchase price for item i;
S_{ij}	Base stock level for item i at office j;
SS_{ij}	Safety stock of item i at office j;
V_{Wj}	Value of warehouse j;
W_{ij}	Waiting time for a customer ordering item i from office j;
W_j	Waiting time for a customer ordering from office j;

Using the notation in Table 1, a model of the cost of operating a warehouse and implementing a JIT system was derived. This information can then be used to determine if the organization benefits from operating the warehouse.

As most managers know, there are many operating costs associated with warehouse management. These include fixed costs such as lease or tied up capital, racking, utilities, labor, vehicle fleet maintenance, property maintenance, and property depreciation. Let A_W be all periodical fixed costs that the savings of purchasing in large quantities have to justify in order to minimize the total cost of the operation. We calculate the annual costs using equation 1.

$$A_w = \sum_{j \in J} C_{Wj} + C_{Uj} + C_{Lj} + C_{Vj} + C_{Mj} + \theta_c V_{Wj} \quad (1)$$

These fixed costs in addition to item associated costs make up the total cost of having a warehouse in operation. Many of these costs are hidden and are frequently overlooked when procurement managers decide the level of quantities to purchase. Shrinkage in the form of lost items, stolen items, or damaged items, obsolescence, and the cost of capital on the inventory is typically among these hidden costs. These costs can be modeled as a percentage of total inventory on hand.

1.3 The One-echelon model

The second model used for reference is the common one-echelon JIT system. JIT requires better planning of demand from customers and can sometimes make management feel uneasy of the extra procurement cost of items on a per unit basis, but there are many cases where the elimination or significant downsizing of a warehouse can save money without sacrificing service to the customer.

The JIT system in this model works by items ordered going directly from the vendor to the office, where a smaller stock level is used versus the warehouse. One-echelon systems will differ in that there is no intermediary between the vendors and the offices. This system is shown in Figure 2.

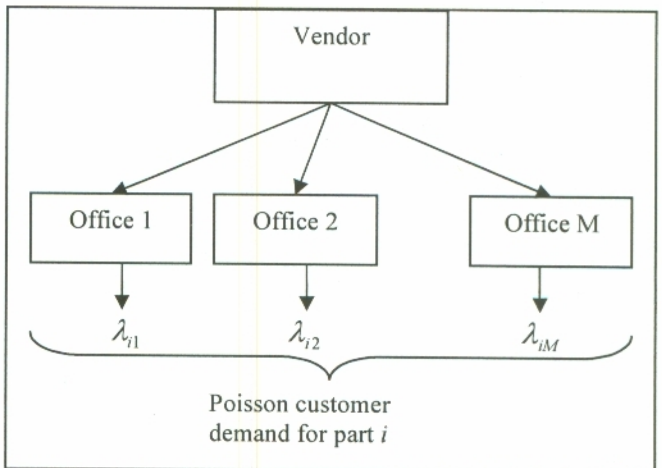

Figure 2: One echelon inventory chain

The JIT contracts that will need to be made with the vendors will need to be established based upon demand rate λ_{ij}. We determine the expected time of backorders of item *i* in office j by using equation 2:

$$W_{ij} = E\left[L\left(S_{ij}\right)\right] = \sum_{j\in J}\sum_{i\in I}\left(L_{JITij} * \left(1 - \sum_{i=0}^{SS_{ij}}\left(\frac{\lambda_{ij} L_{JITij}}{n!}\right)^{n} \exp\left(\lambda_{ij} L_{JITij}\right)\right)\right) \quad (2)$$

In this case, items are delivered to the offices at the same rate the items are being used. The symbol t_{ij} represents time in-between deliveries for item *i* at office *j*. Therefore, by substitution, $\lambda_{ij}t_{ij}$ is also the order quantity. This is shown in equation 3.

$$S_{ij} = \lambda_{ij}t_{ij} + SS_{ij} \quad (3)$$

Keeping the expected wait time for the customer for each system the same will allow for a comparison of costs without changing the response time to the customer.

Costs associated with the JIT system will contain all of the fixed costs of the system as well as additional costs of requiring more service from vendors. In some instances, the per unit price can remain constant by ordering a couple large quantity orders or several small quantity orders. However shipping rates for the several smaller orders may increase. Due to this, it may be important to select vendors that are close to the offices. After factoring in a possible increase in purchase price and shipping increases, the total cost for the JIT system is calculated by using equation 4 when the obsolescence, shrinkage, and cost of capital costs are given by equation 5:

$$C_{JIT} = \sum_{i\in I}\sum_{j\in J} P_{JITi}\lambda_{ij} + C_I \quad (4)$$

When,

$$C_I = \sum_{i\in I}\sum_{j\in J}\left(I_{ij} * \left(\theta_C + \theta_S + \theta_{Oij}\right)\right) \quad (5)$$

Once again, in many situations the data needed to use this optimization may not be available in the time frame allotted to the project. This is where out simplified carrying cost ratio simplifies the decision to move to a two-echelon

2.1 The Municipality Ratio Model

The model focuses on comparing the two systems and selecting the best choice for the scale of the operation. As long as the total cost for the purchasing, storing, and delivering items to the customer is accounted for, we can determine which system is a better choice with our decision model.

The ratio simply compares the total cost of the purchased inventory to the amount of money spent holding and delivering it to the offices. An evaluation system for analyzing supply chain costs for operations which rely on inventory delivery from a supplier. The purpose is to provide a methodology for determining cost incurred over the supply chain process from the time an inventory item is loaded on a truck from the original vendor to the time an operation sells/makes use of the item for their business. The merits of understanding these incurred costs include: 1) An understanding of the cost of each item, 2) Knowledge of the cost the operation would be required to overcome these costs, and 3) Guidelines for what actions an operation can take to decrease the cost/dollar spent ratio.

The cost of inventory plus the fixed costs make up the total cost of the warehouse operation and is shown in equation 6.

$$\text{Total Warehouse Cost} = A_w + C_I \quad (6)$$

After identifying the stock levels using the above mentioned formulas or current accounting information, the next step is to develop a ratio to determine which system is better for the operation. This ratio is the model for which this paper is based on. Put simply, equation 7 is a ratio of the total cost of maintaining the inventory by the total inventory purchase price, and is the key metric for performance.

$$\mu_W = \frac{A_W + C_I}{\sum_{i \in I} C_{Wi}} \qquad (7)$$

This formula develops a baseline for the financial efficiency of the operation. This unit less number is a ratio of total dollars spent maintaining inventory versus the total purchase price of all the items in the inventory.

Most JIT contracts will increase purchase prices between 15-25%. Thus if an organization's carrying cost ratio is above this target, JIT one-echelon options needs to be considered.

Table 2 shows a widely cited break down of holding costs associated with warehousing merchandise (Johnson, 1999). So if the ratio is above this baseline for any particular contribution, focus can be turned to that area. In the event that the storage facilities is above the baseline, lowering facilities cost by elimination of facilities in conjunction with a JIT system is recommended.

Table 2: General Handling Cost

Cost Source	% of Purchase Price
Insurance	0.25%
Storage Facilities	0.25%
Taxes	0.50%
Transportation	0.50%
Handling	2.50%
Depreciation	5.00%
Interest	6.00%
Obsolescence	10.00%
	25.00%

3.1 Results: Case Study

This system was used in the analysis of the "City of X" health and human services (CoXHHS) department that had its own distribution network to service 30 offices. An analysis was then done to determine inefficiencies in the supply chain (slow inventory turn items, inefficient racking, etc.), and this data was then used to create cash flow analysis for which actions would be useful in reducing cost/dollar purchased. This system can be very beneficial in determining which actions will yield the most positive results in reducing costs and/or increasing net profits for an organization.

The above relationship defines the total cost determined over the course of the supply chain. It combines the cost of delivering an item with the cost incurred during the process of holding that item in inventory. This equation is the ratio of warehouse cost per item to purchase price per item. This effectively demonstrates the ratio of money a supplier spends storing and shipping an item to the actual monetary investment put in to each inventory item, represented by the ratio (C_{System})/ C_P. This ratio, when combined with holding cost, can be extremely effective in determining the efficiency of a supply chain as well as providing an indicator of the inventory turn rate for the entire system. For this project, our primary focus was the eventual calculation of this ratio.

3.2 Facilities Costs

The second element of the holding cost calculation involved compiling the total facilities cost for each of the warehouses involved in the operation's supply chain. This data is included in Table 3.

Table 3: Facilities Cost

WH j	Labor Cost	Util & Supplies	Lease Cost	Facility Total Cost
WH 1	123	356	0	480
WH 2	30	50	78	158
WH 3	26	74	0	100
WH 4	26	62	0	89
WH 5	12	28	0	40
Total	217	570	78	867

Additionally, CoXHHS was only leasing the WH 2, at a price of $78,000 a year. This incremental price was another possibility for removal, as all the other warehouse facilities were owned by the city. These issues would be an important factor in determining which actions to take in the options analysis.

3.2 Purchasing Costs

With facilities costs and individual item turn rates in hand, it was possible to proceed to a more in depth analysis of the data. A first step was to calculate an average turn rate for each facility in the CoXHHS supply chain. The desired result is that each facility would have at least a turn rate of 1.0, indicating that the inventory in each warehouse was overturned once a year. The results are summarized in Table 4.

Table 4 shows the only facility which demonstrated a desired average turn rate was WH 2. The other buildings, especially the WH 3, featured extremely low turn rates. The most likely cause of this was the presence of vast amounts of obsolete inventory in each facility. The low receipts for the WH 5 shows that they were not ordering any items, a fact which is consistent with its role as an intermediary building in the supply chain. Thus their low turn rate is acceptable given the building's role. However, the Rankin and BARC facility each sent out a large number of orders but contained an unacceptably low turn rate.

Table 4: Purchasing Cost

Warehouse #	Turns / Year	Tot. Recipts
WH 1	0.36	$48,065.62
WH 2	2.18	$501,062.43
WH 3	0.07	$34,541.00
WH 4	0.49	$531,931.75
WH 5	0.15	$25,475.21
Total Purchases		$1,141,076.01

3.3 The Carrying Cost Ratio

The total cost incurred per item was calculated for the entire CoXHHS supply chain and compared back to the total purchase cost; resulting in the warehouse cost per dollar spent. This calculated value was also exceptionally high, netting an average of $0.97 per dollar purchased being spent to store and transport each inventory item. Lowering this ratio could be accomplished through a variety of methods including consolidating inventory, increasing efficiency by standardizing procedures and optimizing storage use, and most importantly through elimination of obsolete inventory items from each facility. Table 5 shows the calculations for the CoXHHS carrying cost ratio.

Table 5: Carrying Cost Ratio of CoXHHS

Costs	Facilities	Shrinkage	Fleet	Sum
Annual	867	127	87	1081
Purchases	1115			1115
			μ=	0.97

3.4 Inventory Turn Analysis

The ratio showed that the facilities cost of the system was well above 0.25% of the total purchase price. So in order to eliminate facilities and implement JIT inventory turns data was needed.

Inventory turns are defined as the average number of items kept in stock divided by the annual usage of the item and is shown in equation 8.

$$T = \frac{S_{ij} + S_{i0}}{\lambda_{ij}} \quad (8)$$

The ABC analysis compares all the items ordered and prioritizes them according to use. ABC Analysis, with results indicated in Table 6.

Order policy for each type of movers are set by movement category. Items that are deemed as "A" movers were placed on continual review for reordering. "B" movers have a review quarterly. "C" movers are reviewed annually.

Table 6: ABCD Analysis of Inventory

Category	Number of Items
A	104
B	150
C	476
D	2,262
Total	2,992

3.5 The Decision

After determining that the current carrying cost ratio for the CoXHHS was above the expected 15%-25% procurement cost increase, a decision was made to switch from a two-echelon system to a one-echelon system. The switch had an EBIT of $250,000 with at ROI of just over 1 year. The carrying cost ratio was reduced from 97% to 30%. Ordering policies were simplified and managed by each office, eliminating the need for a centralized logistics system. However, much of the savings was due to lowering the total volume of obsolete inventory in the warehouses. This reduction in obsolete inventory produced a 75% reduction in racking requirements.

4.1 Conclusion

There are many organizations that operate warehouses in order to reduce costs. However, over time these warehouses become bloated with inventory that is no longer needed or is needed at a much lower demand. Unless managers periodically analyze the contents of their warehouse, the carrying cost of all items purchased can outweigh savings from procurement when purchasing in bulk.

Johnson's estimate on holding costs puts the holding cost ratio at 25% (Johnson, 1999). This indicates that procurement must 20% lower through the warehouse method for it to be actually saving money over a JIT system with higher item costs. In this case study, where the actual ratio was 97% of procured cost, it was clear that it was an inefficient system. In today's fast pace business plans, quick decisions need to be made. This carrying cost ratio makes easy to find data easily shows when a warehouse system is inefficient. This model speeds up the process and thereby speeds change and cost savings in a company.

However there are some limitations to this model. One limitation would be very large systems where JIT contracts would be too complicated. Organizations with a large service range such as a regional or larger retailer may not benefit from this ratio as is. But, for a smaller company or a city, this model can be very effective at recognizing overcapacity or inefficiencies in a supply chain.

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