Perishable Items in Multi-Level Inventory Systems
(Summary)

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Inventory control is nowadays recognized as a crucial activity to succeed in a lot of businesses. To perform well in inventory control indeed enables you to reach a high reactivity and so on to give a high service level to your customers. Moreover, this can be a way to decrease cost keeping less items in stock and for a shorter time. The main problem in inventory control is that these two facts are pushing in opposite ways regarding to inventory policy. On one hand, the uncertainty in the demand requires to keep enough stock to avoid shortage. One the other hand, the cost incurred by the capital tied up in inventories must be cut down by lowering inventory levels. The optimum solution is often not easy to find even in very simple cases. When the situation becomes more complicated, it often does not exist any theoretical result to find the optimum.

In this thesis, we focused on multi-echelon (or multi-level) inventory systems, where several stocks are linked somehow. For instance, a purchasing center supplying a supermarket can be modeled as a multi-echelon inventory system. The purchasing center holds a stock and the supermarket too. These two inventories are linked as the supermarket is supplied by the purchasing center. This problem is difficult to study as every modification in the inventory policy at one location has implications at the other location. Increasing the number of inventories linked makes the problem much harder. Nevertheless, the field of multi-echelon inventory theory has a wide range of practical applications, as the majority of the supply chain systems can be modeled as multi-echelon systems.

The majority of the work in the inventory control theory assumes that the products can be hold in stock as longer as needed i.e. that the products keep all their usability whenever they are sold. In practice, this is obviously not the case for some products like provisions, photographic films, medicine or blood. We can include in this list all the products that will loose value due to the trend as cell phones or clothes. From a theoretical point of view, almost every item will become unusable after a certain amount of time. From a practical point of view, only the products with short shelf life or product which will become unsaleable soon will be considered as perishables. For example, perishables stand for almost one third of the sales of the supermarket industry according to Broekmeulen and Van Donselaar (2007). The major characteristic of a perishable inventory system is that once the product lifetime is reached, the product must be discarded from the stock. In the supermarket industry, around 15% of the perishables are lost due to spoilage according to Lystad and Ferguson (2006). It is
therefore important to study the perishable case to understand how to handle with perishable items into practice.

The goal of this master thesis is to study multi-echelon inventory systems for perishable items. It is important to notice that this kind of inventory system is very complicated to study. We therefore decided to focus on simulation to get some understanding about general behaviours of the system. Our main goal was to find good inventory policy for a range of problems and to evaluate if significant savings can be achieved by considering the items as perishable. Moreover, we searched for some trends and general behaviour of multi-echelon systems when considering the items as perishable.

This master thesis studies a two-echelon distribution system for perishable items with two non identical retailers. One central warehouse supplies two retailers with different characteristics. Each location is managed following a standard continuous (R, Q) ordering policy. This means that a batch of Q items is ordered as soon as the inventory position declines to or below R. The demand occurs solely at the retailers and follows independent Poisson processes. Customers are backordered when the retailer is out of stock. Whenever a retailer is out of stock and a customer arrives, this one wait for a new item to arrive at the retailer. The items are considered as fixed lifetime perishables. Whenever an item perished, it is discarded from the stock. The model includes fix transportation time and the allocation policy at the central warehouse is a First-Come-First-Serve one: The order that occurs the first at the central warehouse is supplied in first.

This kind of system is very complicated and therefore hard to study. In this master thesis, we focused on a simulation study of 48 different problems with both a FIFO (First In First Out: the first item arriving in the inventory will be sold first) and a LIFO (Last In First Out) issuing policy at the retailers. The goal of this study is to optimize the values of the reorder points R at every location, to decrease the average global supply chain cost considering that the items are perishables. We also tried to find some general behaviour of the system and we compare the FIFO and the LIFO best found solution.

We used a discrete event computer program called Extend to carry out the simulation study. More than 1000 hours of computer-time were used. For every problem, we conducted an optimization process to find better values of the reorder points at every location. For the FIFO
case, an average cost reduction of more than 20% was found. It exists a good opportunity in
term of cost savings while taking into account the perishable characteristic of the items.
Another finding of our study is that the LIFO case has good performance comparing to what
expected. On average, the costs increase is only 7% while considering a LIFO issuing policy
instead of a FIFO one. Moreover, the values of the reorder points for the FIFO best found
solution are still the same than the LIFO best found solution in 70% of the problems studied.

This master thesis was made at the division of Production Management in the department of
Industrial Management and Logistics at Lund Institute of Technology. This project is a
starting point in the general study of the multi-echelon perishable inventory systems.