Service Inventory Management

Bijvank, M.

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Summary

Customer satisfaction is an important differentiation strategy for retailers and other companies. Due to the globalization of the market and the growth of internet as a distribution channel, the number of brands for similar products has increased and the amount of competition is huge. It is important for a business to keep customer satisfied. Consequently, there is a shift in supply chains from a focus primarily on manufacturing and costs to a focus that increasingly includes a services management element. Truly focusing on end customer needs requires excellent forecasting or an extremely responsive supply chain. Inventories are kept at all parties of the supply chain to incorporate flexibility against uncertainties.

Traditionally inventory management tends to look for cost-based improvements, rather than focusing on customer service. This shift towards customer focus should also be reflected in inventory management. The goal of this thesis is to develop inventory models and to design related solution approaches which resolve around customer service. We call this *service inventory management*. Current trends from practice that have to be dealt with are tight delivery schedules, efficiency and cost reductions, service constraints, increased competition and the influence it has on customer behavior. Current solution techniques do not address these issues sufficiently. Therefore, new approaches and techniques are required to control inventory levels more accurately. In this thesis we have studied three different settings. Each setting is a part of my thesis.

In part I, we considered an after-sales service where customers' requests consist of multiple items. When a product or machine fails, customers expect to get a good after-sales service. This means that they request a quick and adequate repair. When a technician wants to repair the failed product, enough spare parts should be available. Otherwise, the entire repair is cancelled. The inventory control in this setting can be seen as a *multi-item* inventory problem, since the service to a customer depends on the availability of all required spare parts. Inventory models in which the demand follows this *all-or-nothing* strategy, is hardly studied in literature. In this thesis, a new expression is derived to compute the service perceived by customers. Furthermore, a solution technique is developed to support decisions regarding the inventory levels. With the use of a case study, we show that the solution procedure can improve current practices significantly (31% service level improvement against current holding costs).

In part II, a *single-item* inventory system is investigated. For this type of systems it is common in literature to assume that customers wait for a new order

to arrive in case the inventory level is zero. This is called *backordering*. In practice, customers are not willing to wait. In fact, they will either buy a substitute product or they visit a different store. Either way, the original demand is lost. This is called *lost sales*. Inventory systems with this property are difficult to analyze. In this thesis we show that a new type of replenishment policy should be used in such systems. It is more efficient not to order many products when the inventory position is low after a period with many customer demands. Such periods do not occur regularly. There is also no reason to replenish extra items for the demand that will be lost due to the low inventory levels. Consequently, in a lost-sales setting the order sizes do not have to raise the inventory position as much as in a backorder setting when the on-hand inventory level is low.

We developed new models for such new type of policies for periodic review inventory systems. We have considered systems without and with fixed order costs, and we have relaxed assumptions regarding the lead time. We compared the performance to well-known replenishment policies such as order-up-to policies and fixed order size policies. Numerical experiments show that such policies with delay result in near-optimal costs for periodic review models.

The difficulty with exact models in a lost-sales context is the computational complexity. Therefore, we also proposed an approximation model in which the steady-state behavior of the inventory systems is approximated. Such approximation procedures are very useful to determine near-optimal order quantities. The performance of such procedures is illustrated for models with a cost objective and a service level objective. In particular, we considered a case study in which the inventory levels at hospitals have to be determined. Because of specific characteristics we derived a simple and efficient inventory rule to make near-optimal replenishment decisions. The heuristic rule can easily be implemented in a spreadsheet-based program, and is therefore very appealing to be used in practice.

In part III, we do not assume to know the customers' behavior towards stock outs. In case of excess demand a customer can either make a reservation (i.e., backorder), look for substitute products, go to another store or the demand is lost. Since the behavior of customers towards stock-out occurrences depend on the inventory levels of the available items, it becomes rather complex to develop an exact mathematical model. Therefore, we propose a simulation model to analyze such inventory systems. However, simulation is not recommended when optimization decisions have to be made on the inventory levels for such systems. Therefore, a heuristic procedure is proposed to approximate the performance of the inventory system. The assortment problem is used to illustrate the performance of this heuristic model.

Based on this study we conclude that models become rather complex when to model the customers behavior towards stock-out occurrences besides a backorder

assumption. However, it is necessary to include this behavior to guarantee high service levels and keep customers satisfied. In order to use any of the models in practice, we recommend the usage of our approximation procedures. Such procedures result in near-optimal stock levels without large computation times.