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Inventory rationing and sharing in pre-sell distribution with mobile communication technologies

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Abstract

In pre-sell distribution, the uncertain customer demands are revealed by the company's sales representatives who visit the customers and arrange delivery quantities on the spot, prior to physical execution of deliveries. Given a periodic base-stock of a distributed product, we consider allocation of the product to the customers in two different settings: with and without utilization of mobile communication technologies. There are two performance measures considered: the customer-average fill rate, and the sales profit under service level constraints. The mobile setting is shown to enable a generally better system-wide performance, featuring the capability of inventory pooling. To observe the magnitude of this advantage we determine the optimal allocation policies by means of stochastic dynamic programming. Computational examples for selected configurations and demand distributions are presented.

Keywords: Inventory pooling; Inventory rationing; Pre-sell; Mobile communication technologies; Stochastic programming

1. Introduction

Distribution of goods is realized in many industries by means of field representatives who travel through assigned territories, discover the customer demand, and execute sales. A predominant role in such distribution practice has been traditionally played by the so called *route-sell* method, which assumes that a number of vehicles loaded at the depot are sent on tour to meet uncertain customer demands: each vehicle carries the goods on board and distributes (sells) them to the geographically dispersed customers as it follows its route. This distribution mode has been extensively studied in the past decades by the research community in the context of the vehicle routing problem and its stochastic extensions (Baldacci et al., 2004; Bertsimas and Simchi-Levi, 1996; Golden and Assad, 1988; Laporte et al., 2002).

The presented research deals with an alternative distribution method designated commonly as *pre-sell*. In pre-sell distribution the sales are arranged with the customers by salespersons in advance, prior to the physical execution of deliveries. These advance salesmen are typically travelling through assigned territories on a regular basis and visit predetermined customers—like manufacturers, wholesalers and retailers—in order to assess their requirements and "to sell any quantity and every

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item that might be appropriate" (Makadok, 1993; Anily and Federgruen, 1990; Golden and Wasil, 1987; U.S. Bureau of Labor Statistics, USA, 2006). They are often assigned to promote products to the customers, check stock on-site, negotiate the sales, and estimate delivery dates (California Employment Development Department, USA, 1995; U.S. Bureau of Labor Statistics, USA, 2006).

Comparing to route-sales, the advance fixing of delivery quantities provides pre-sell with several potential advantages (Makadok, 1993; Puric and Schreib, 2002): (a) delivery trucks are stocked to accurately match the orders; (b) no stock-outs will occur on the trucks; (c) the trucks carry no excess stock, saving fuel costs; (d) they return empty, therefore no product unloading and handling back at the depot, what saves labor costs and reduces breakage; (e) knowing zero demands in advance means less stops; (f) the routes can be scheduled with more certainty and customers' time windows better met; (g) fewer trucks might be needed. The well-known industries that employ pre-sell are, e.g. the beverage, soft drink, and consumer goods.

Though the route-sell mode had previously been dominating over pre-sell (Anily and Federgruen, 1990; Golden and Wasil, 1987), the evidence of the recent years shows pre-sell to win more popularity than before (Goldberg, 2003), and not least due to novel opportunities enabled by mobile communication technologies. They deliver new attractive capabilities: remote access to the CRM and ERP systems; taking customer orders on-site and transmitting them immediately to the CRM or ERP back-end; tracking roaming employees and assets; communicating customer orders, instructions and data to the right employees in the field (Makadok, 2003). These capabilities result in several new advantages for the enterprise (MEI Computer Technology Group Inc., 2007; Puric and Schreib, 2002; TechRepublic, Inc., 2006): (a) a greater speed and accuracy of data collection and transmission; (b) more efficient resource allocation by utilizing real-time data from the field; (c) performance improvements due to a better sourcing of mobile workers with the up-to-date corporate data; (d) a better job assignment.

Convinced by ever growing adoption of mobile solutions (Krebs, 2004) and their potential impact on pre-sell distribution, we take in this paper a closer look at the above advantages (b) and (c). For that we consider a company which pre-sells a single good to a number of customers. We show that mobile technologies may act as a means of *inventory pooling* in pre-sell. Besides that, we let the company use an *inventory rationing* policy for matching its limited stock against customer demands.

Both pooling and rationing represent important dimensions in inventory management. The concept of *inventory pooling* has received a remarkable attention in the literature since the publication of the work by Eppen (1979), who has shown how consolidation of inventories and aggregation of stochastic demands can reduce the expected holding and penalty costs. Since then many authors have studied pooling strategies in various settings. Alfaro and Corbett (2003) give a recent overview for uncapacitated inventory systems. As they point out, much of the literature on such systems assume normally distributed demands. They make then a detailed analysis of the impact of demand correlation on the value of pooling in an uncapacitated setting with a computational study for some selected non-normal demands. Corbett and Rajaram (2006) generalize Eppen's (1979) results to non-normal dependent demands. Research on pooling in capacitated systems has been recently advanced by Benjaafar et al. (2005). Typically the analysis of such systems is based on considering Poisson arrivals of unit demands.

Whereas pooling is likely to be a strategic decision, *inventory rationing* deals with the following, rather operational, problem (de Véricourt et al., 2002). If one distinguishes between customer demands of different priority, then one must decide how to allocate the stock to the incoming demands when it runs low: it can sometimes be more rational to stop filling the demands of low priority classes in order to save the stock for meeting possible demands of higher priority—i.e. to ration the inventory. Much of the studies focus namely on determining stationary inventory levels $r_1, \ldots, r_n$ such that filling the ith class demand stops when the on-hand inventory drops to or below r_i. Recent reviews of rationing research can be found in Deshpande et al. (2003) and Arslan et al. (2005).

There also exists research that considers both dimensions of pooling and rationing together. However, this body of research is essentially smaller than that on pooling or rationing only. de Véricourt et al. (2002) consider rationing in a production–inventory system with backorders and characterize the optimal policy. They then enable inventory pooling in a system with two demand streams and show that ignoring the stock rationing dimension