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The distribution-free newsboy problem with resalable returns ☆

Julien Mostard[a,*], René de Koster[b], Ruud Teunter[c]

[a]Faculty of Economics and Business Administration, Room 3A-33, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands
[b]Rotterdam School of Management, Erasmus University Rotterdam, P.O. Box 1738, Rotterdam 3000 DR, The Netherlands
[c]Faculty of Economics, Erasmus University Rotterdam, The Netherlands

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Abstract

We study the case of a catalogue/internet mail order retailer selling style goods and receiving large numbers of commercial returns. Returned products arriving before the end of the selling season can be resold if there is sufficient demand. A single order is placed before the season starts. Excess inventory at the end of the season is salvaged and all demands not met directly are lost. Since little historical information is available, it is impossible to determine the shape of the distribution of demand. Therefore, we analyze the distribution-free newsboy problem with returns, in which only the mean and variance of demand are assumed to be known. We derive a simple closed-form expression for the distribution-free order quantity, which we compare to the optimal order quantities when gross demand is assumed to be normal, lognormal or uniform. We find that the distribution-free order rule performs well when the coefficient of variation (CV) is at most 0.5, but is far from optimal when the CV is large.

Keywords: Inventory; Distribution-free newsboy problem; Product returns

1. Introduction

In many countries, customers have the legal right to return unused purchases within a specified number of days after purchase, especially in the case of distant selling. The original purchase cost is then partially or fully reimbursed. As a result of this right, retailers selling products via mail order or over the internet generally have to deal with large volumes of returns. Because the sales process is remote, customers cannot see, feel and try the actual product, which often leads to a wrong decision. We will concentrate on the example of a mail order/internet retailer selling fashion products, since these have particularly high return rates. However, the model that we propose and our findings are generally applicable to other types of style goods as well (e.g., toys, personal computers or consumer electronics). Common reasons for returning fashion products are a wrong

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*Corresponding author. Tel.: +31 20 4446194; fax: +31 20 4446005.
E-mail address: jmostard@feweb.vu.nl (J. Mostard).

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size, a change of mind (remorse) or the fact that the actual color differs slightly from the displayed one.

The presence of return flows changes inventory control significantly (Fleischmann et al., 1997). First, the retailer has little control over the return flow in terms of quantity, quality and timing. Second, ordering decisions and processing of returned products have to be coordinated, since returned products can be resold in most cases. The higher the return rates, the more important these factors become. In the case of a mail order/internet retailer that we consider, return rates are usually larger than 18% and can be as high as 74% for specific fashion products (Mostard and Teunter, 2005).

The management of return flows has received growing attention in the past decade. The whole of logistic activities to collect, disassemble and recover (parts of) used products or materials for the purpose of recapturing value or proper disposal is known as reverse logistics (Revlog Website, 1999; Rogers and Tibben-Lembke, 1999).

Much research in this field has been dedicated to the implications of return flows for the areas of distribution planning, inventory control and production planning. Fleischmann et al. (1997) have performed a review of the mathematical models that have been proposed in this context. However, the vast majority of the proposed inventory control models for reverse logistics concentrate either on returns that need extensive recovery (e.g., repair or remanufacturing) or on end-of-life products destined for recycling. In our case, the returned products are generally in an as-good-as-new condition and can be resold directly after testing and possibly repackaging provided there is enough demand and they are returned before the end of the selling season (in the case of seasonal products).

We consider the inventory control problem for the case of a mail order/internet retailer selling fashion products. Besides the high return rates, seasonality, large supply lead times and lack of data are three important factors in this case that complicate inventory control. These are all related to the type of product, fashion clothing. We will next discuss each factor separately.

Fashion products are seasonal: Fisher and Raman (1996) note that most fashion apparel companies introduce a completely new product line every season which must be designed and produced in time to be sold during a concentrated retail selling season. They also point out that the costs of excess inventory that must be sold below purchase cost at the end of the season and of lost sales due to stockouts are high in the apparel industry because of unpredictable demand and a complex supply chain.

The supply lead times of fashion products are usually long: Therefore, retailers have to settle their entire season's order quantities well before they have an opportunity to observe actual sales performances (Mantrala and Raman, 1999). Because of this single-order opportunity, it is natural to use a newsboy-type model for analyzing our problem. However, the standard newsboy model does not allow for returns.

Only recently, Vlachos and Dekker (2003) first studied ordering policies for single-period products with returns. They extend the newsboy problem while making two simplifying assumptions. First, they assume that products can be resold only once. Second, they assume that a fixed percentage of sold products is returned and resalable. Considering several different return options, based on different handling of the returned products, they derive optimal order quantities for the various models resulting from these options. By numerical experiments, they show that the optimal classical newsboy quantity is far from optimal when return rates are high.

In a following study, Mostard and Teunter (2005) argue that the two assumptions underlying the model of Vlachos and Dekker lead to a suboptimal order quantity. In practice, products can be returned and resold several times during a season, which contradicts the first assumption. Moreover, due to the second assumption, part of the variability in the number of (resalable) returns, given gross demand, is ignored. Mostard and Teunter drop these assumptions. Taking a net demand approach, they derive a simple closed-form equation that determines the optimal order quantity given the gross demand distribution, the probability that a sold product is returned, and all