Int. J. Production Economics 143 (2013) 627–632

Contents lists available at SciVerse ScienceDirect

Int. J. Production Economics

journal homepage: www.elsevier.com/locate/ijpe

Exploratory analysis of free shipping policies of online retailers

Tonya Boone, Ram Ganeshan *

Mason School of Business, The College of William and Mary. Williamsburg, VA 23187-8795, United States

ARTICLE INFO

Available online 24 August 2011

Keywords:
Free shipping
Inventory models
Online retail

ABSTRACT

Online retailers (or Internet divisions of brick and mortar retailers) often offer shipping discounts (for example "free shipping on orders above $150") to entice customers. The premise is that the retailer will attract more customers and these customers will likely buy more per order to avail the shipping discount, increasing total revenues and profits. In parallel, the retailer must also plan the replenishment of items sold during the free shipping promotion. This paper provides an exploratory model that analyzes (a) what form a retailer should use the free shipping promotion, and in parallel, (b) how the retailer should plan for replenishment from their suppliers.

1. Introduction

Online retailers (or the Internet divisions of brick and mortar retailers) often offer free shipping promotions to attract and retain customers. Saks Fifth Avenue, an upscale department store on its saksfifthavenue.com web site has a "FREE SHIPPING on orders of $150 or more with code: AUGSHIP10".[1] Vitaminshoppe.com, a purveyor of vitamins and supplements, has a "FREE SHIPPING on $99+ orders"[2] promotion.

Many studies have shown (see PayPal, 2008) that one of the biggest issues facing online retailers is the "abandonment" of online shopping carts. Abandonment refers to customers who "add" products to the shopping cart but when it comes time to pay and checkout, they simply leave the web site. Surveys estimate (PayPal, 2008; Mulpuru et al., 2010) that the top reasons customers abandon their shopping carts are due to high shipping costs (about 25% of all those who abandon do it due to shipping costs). Free shipping promotions are primarily designed to capture those customers who are sensitive to shipping costs.

However, there does not seem to be any consensus on *how* these shipping promotions should be run. Some retailers have free shipping irrespective of what or how much is ordered. Some ship free to members of their loyalty club (Amazon's Prime service or Overstock.com's Club O). By far, the most common form of promotion is free shipping if the order value exceeds a certain threshold amount (Barry, 2010), just like Saks Fifth avenue of Vitaminshoppe mentioned earlier. However, a quick survey of net retailers indicates that this threshold is wildly variable—anywhere from $25 to over $250 (see Istobe.com, 2010).

1.1. Model context

The context of this paper is a retailer who is offering free shipping if the customer spends more than a predetermined threshold value. The premise of the promotion is that it will give an incentive to those customers who would otherwise abandon their shopping carts to proceed and compete the checkout process. Additionally, if this retailer has the same prices on similar products as its competitors, it may attract some customers who may otherwise shop elsewhere. In other words, the promotion will likely produce more orders (Lewis, 2006; Tedeschi, 2007). The promotion will also provide incentives to customers to buy more so they can avail the free promotion, increasing the average value of a customer order (Lewis et al., 2006). The conventional wisdom is that increased customer order combined with the increased value per order will increase the overall revenue for the retailer during the promotional period.

The benefits of increased revenue are countered by multiple costs. One, the retailer now has to bear the cost of shipping to those customers who meet the threshold value. Second, retailers typically sign procurement contracts with suppliers that also outline frequency of shipments. These procurement contracts are signed prior to running promotions. If retailers do not sufficiently plan for the increased revenue from free shipping promotions, they run the risk of stocking-out, not fully taking advantage of the promotion. On the other hand, if they order too much, they run the risk of holding too much inventory. So planning inventory for the promotion may entail higher procurement levels, ordering more often from suppliers, and holding more in inventory. Third, if the profit margins are low, the retailer may never make up the cost of the free shipping promotion.

* Corresponding author.
E-mail addresses: tonya.boone@mason.wm.edu (T. Boone), ram.ganeshan@mason.wm.edu (R. Ganeshan).
URL: http://operationsbuzz.com (R. Ganeshan).

[1] Website accessed August 19, 2010.
[2] Website accessed August 19, 2010.

0925-5273/$ - see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.ijpe.2011.08.008

The model in this paper explores the relevant costs and benefits of running a successful free shipping promotion. Specifically, we model the number of orders and the average customer order value as a function of the threshold value—as the threshold decreases, the number of orders and the average order value increase as does the total revenue. On the other hand, decreasing the threshold increases the cost of shipping and the cost of maintaining the inventory policy needed to support the promotion. This model is unique since it encompasses total logistics costs on both the supplier and the customer side. On the customer side, the increased revenues compete with the increased cost of transportation and holding inventory. On the supply side, the cost of ordering competes with the cost of holding inventory. We construct an optimization model that gives the retailer insights on how to set threshold values for the free shipping promotion, and simultaneously, how to set order size with suppliers in planning inventory.

A second contribution of the paper comes from the fact that we model customer order value as a random variable—so when the promotion is run there is uncertainty on the total revenues. The paper constructs a simulation model based on the optimization model to provide insights into how a retailer can assess the risks of a free shipping promotion.

The remainder of the paper is organized as follows: Section 2 introduces the notation; develops the optimization model that computes the optimal threshold and inventory policy; and makes observations on model assumptions and structure. Section 3 presents a numerical illustration, introduces the simulation model, and provides insights into risks involved in running a free shipping promotion. Finally in Section 4, we present a summary and some thoughts on further research.

2. Model development

2.1. Notation

Decision variables:

- Q = order size from supplier (in $'s).
- T = threshold value. If the value of the order is above this threshold value, then shipping of the order is free.

Variables and constants:

- A = value of order, normally distributed with mean μ_T and standard deviation σ. The mean value of the order, μ_T is a function of T. For the purposes of this paper, we assume that $\mu_T = \mu_o + \alpha T^{-\beta}$, where μ_o, α, and β are positive constants.
- N_T = number of orders during the promotion period. For the purposes of this paper, we assume that $N_T = N_o + \gamma T^{-\delta}$, where N_o, γ, and δ are positive constants.
- S = ordering cost.
- h = inventory cost per dollar of inventory.
- m = profit margin on procurement cost. The procurement cost includes the product cost and the cost of transportation from the supplier to the retailer.
- p = proportion of orders that qualify for free shipping.
- r = transportation cost to the customer.
- k = safety factor for computing safety stocks.

2.2. Model

The expected profit over the course of the "free shipping" promotion as a function of the supplier order size (Q) and the Threshold value (T) can be represented as

$$E(P) = \mu_T N_T m - Q/2h - \mu_T N_T(1-m)/QS - k\sigma N_T(1-m)h - pN_T r \quad (1)$$

The first term in the equation is the total profits less ordering cost to suppliers, holding costs of inventory, and shipping costs to the customer. The total revenue over the course of the promotion is $\mu_T N_T$. This multiplied by m gives the profits made on procurement. The second term in the profit function is the cost of holding inventory. The average inventory, $Q/2$, multiplied by the cost of inventory h gives the cost of inventory holding during the promotion. The third term is the cost of ordering replenishments from the suppliers. The total number of orders during the promotional period is $\mu_T N_T(1-m)/Q$. Therefore multiplying the number of orders by the cost per order S is the total ordering costs. The fourth term in the expected profit is the cost of holding safety inventory. The standard deviation of revenue at cost (this is a surrogate for demand) is $\sigma N_T(1-m)$. The retailer chooses k so that a desired level of uncertain demand can be satisfied (see Silver et al., 1998). For example, $k=1.96$ would cover 95% of demand. The final term in the profit function is the cost of shipping to the customer. The proportion of orders that qualify for free shipping, $p = P(A = a > T)$. Since r is the cost of shipping per shipment, the total shipping cost to customers is $pN_T r$.

As the threshold value T decreases, it increases both μ_T and N_T and therefore the profits (the first term in (1)). A decrease in T also increases the number of orders, the cycle and safety inventory, and the cost of customer shipping. The optimal T will balance the increases in profits with the increases in the cost of maintaining inventory and the customer shipping costs. Numerical techniques can be used to compute the Q and T that maximize $E(P)$. In this paper, we focus on the optimization of the expected profit. Since the average value of the order is normally distributed the profits will also be distributed around $E(P)$. The explicit assessment of risk of the free shipment promotion is outside the scope of this paper. However, the numerical illustration in Section 4 provides insights on how the retailer can assess the risk of the promotion.

2.3. Observations on how T impacts revenue and shipping costs

The following three observations explore the impact of threshold price on the customer-side economics. These observations are based on the assumed functional forms of μ_T and N_T.[3]

A1. The average value of an order is a decreasing function of T, with a minimum at μ_o.
A2. The number of orders during the promotion period is a decreasing function of T, with a minimum at N_o.
A3. The proportion of orders that qualify for free shipping is a decreasing function of T.

2.4. Proof

A1. Since $\lim_{T\to\infty}\mu_T = \mu_o$, μ_o represents the average value of the order without the promotion. The "free shipping" promotion increases the average value of the order to a value above μ_o. The parameters α and β control, for a given T how much the average value of the order increases beyond μ_o. Since $\partial\mu_T/\partial T < 0$, (a) follows. The point elasticity (wrt T) of the average order value for a given T is $-\alpha\beta T^{-\beta}/\mu_T$. This elasticity increases with T but is

[3] As one referee pointed out, this paper does not formally validate the functional form of μ_T and N_T by empirical data or case-based data. It is based on the authors' experience with multiple retailers – that μ_T and N_T are decreasing functions with a lower bound.