



Joint product assortment, inventory and price optimization to attract loyal and non-loyal customers



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ARTICLE INFO

Article history:

Received 20 December 2012

Accepted 9 February 2014

Processed by B. Lev

Available online 17 February 2014

Keywords:

Assortment planning

Inventory management

Pricing

Limited shelf space

Heterogeneous customers

ABSTRACT

In this paper, we analyze the emerging retail practice of carrying a combined product assortment consisting of both regular “standard” products and more fashionable and short-lived “special” products. The purpose of this practice is to increase store traffic by attracting heterogeneous classes of customers, which drives up sales of standard products due to the potential cross-selling effect. Customers who are primarily attracted by special products will also buy some standard products. In this context, we analyze three decisions that are crucial for a retailer’s commercial success: the product assortment, the inventory levels and the pricing. We propose an optimization model and an iterative heuristic to analyze the trade-offs between the combined product assortment, the inventory level and the price per product when there is limited shelf space. Using numerical experiments, we show that our heuristic can be trusted and that its accuracy improves when the number of products increases. Our findings indicate that to attract more customers for standard products, a retailer may benefit from carrying low priced special products which, if considered in isolation, would be non-profitable. As the cross-selling effect decreases, a retailer should focus more on the standard assortment by increasing its size and decreasing the prices. However, introducing special products and ignoring the cross-selling effect may decrease a retailer’s profitability. We show that the introduction of special products involves more than just choosing the right specials for non-loyal customers but impacts the global assortment planning, the standard products and the products pricing.

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1. Introduction

Product assortment, inventory and price planning are mutually dependent strategic decisions of crucial importance for a retailer’s commercial success. A retailer needs to consider these decisions jointly, with the purpose of attracting more customers, satisfying their demand and, ultimately, maximizing his profit subject to various constraints, such as limited shelf space for displaying products.

Recently, the retail practice of combining “standard” and “special” products in the total assortment has emerged and been

adopted by an increasing number of retailers. The assortment of standard products is relatively stable over time, which means that customers expect to find them every time they shop. This type of products may also be called “fixed products” [6]. The main objective of the standard assortment is to support the positioning and profitability of a retailer [38]. Standard assortment items also serve as a strategic tool to attract and retain loyal customers, i.e. customers who regularly visit the store for their customary shopping and grow accustomed to a certain product range [12]. Accordingly, in general, the price of a standard product is stable and balances its attractiveness with the long-term profit it should generate.

Special products, by contrast, are offered only temporarily, in limited quantities and usually at very attractive prices. Alternative names for this type of products are “loss leaders” or “variable products” [6]. They are typically replaced by a new collection of items within a short period (a few weeks or less). Although special products may provide retailers with slim profits (or potentially be

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loss making if considered in isolation), they are critically important because they help increase overall store traffic by attracting non-loyal customers to a store. Non-loyal customers do not regularly visit the same store but are rather opportunistic and are occasionally attracted by special offers. This increased store traffic can also boost sales of standard products, resulting in increased overall sales and profits. The demand flow generated by non-loyal (respectively loyal) customers for standard (respectively special) products is called the cross-selling effect. The pricing of special products is thus an essential element and should above all aim to attract non-loyal customers and eventually increase the cross-selling effect. Moreover, studies show that customers drawn to promotions not only enjoy shopping but also gain a sense of achievement by buying items on special offer [28]. For retailers, providing customers with this sense of achievement by rotating special assortment items might be preferable to promoting standard assortment items, since it allows retailers to maintain a steady sell-through of standard items and avoids the erosion of established price points.

The practice of carrying a combined assortment is especially widespread in the grocery industry. Walmart, for example, offers a wide range of standard product categories – from food and clothing to home electronics – as well as a limited number (around 1% of the total assortment) of weekly “special buys” in order to create excitement [28]. Lidl and Aldi, two of the most successful discount retailers, compete effectively with a very narrow product assortment, consisting of standard products such as tooth-paste and orange juice, to which special assortment items are constantly added (called “surprise buys” or “special items”). Aldi’s special assortment, for example, consists of non-food, very diverse products introduced twice per week for 1-week intervals. These products may be electrical items, clothing, sports equipment or pet toys and are rotated throughout the year according to the season (e.g. “back to school” special items or ski wear) with the aim of keeping the shopping experience in the store interesting [41,21]. The number of these “special items,” however, varies substantially in percentage terms between the two retailers (approximately 9% for Lidl versus 4% for Aldi).

In this paper, we devise a stylized mathematical model to address the integrated product assortment, pricing and inventory optimization problem taking into consideration the role of both standard and special assortments in generating store traffic when the available shelf space is limited. The proposed integrated approach explicitly models the interdependence between the total assortment decision, the pricing, and the number of customers attracted to the store and the demand per product. In general, a broader product assortment would attract more customers, thus increasing demand for products, but would it also increase operational and inventory cost in a limited shelf space configuration. Product price is another significant factor that has a direct impact on customers’ product choice and consequently on demand for a product. It cannot be considered in isolation from comprehensive combined assortment planning including standard and special items. According to McKinsey and Company study [31] “for most companies, better management of pricing is the fastest and most cost-effective way to increase profits”. For instance, during the economic recession in 2009 when customers became more price sensitive, Lidl was able to drive down the prices of its products compared with other supermarkets in the UK [35]. Although the marginal profit per product decreased, Lidl experienced an increase in its market share from 2.2% to 2.4% [36] due to the increased demand. The importance of considering assortment, pricing and inventory decisions jointly is illustrated in the case of JCPenney. The department store chain received the 2004 Fusion Award in supply chain management for “its innovation in integrating downstream to merchandising and allocation systems and

then upstream to suppliers and sourcing.” A JCPenney vice president attributes the company’s success to the fact that, “assortments, allocations, markdown pricing are all linked and optimized together” [26].

The rest of the paper is organized as follows. In Section 2, we review the related literature. In Section 3, we present the problem and the mathematical model. In Section 4, we propose a heuristic solution procedure for our problem, and assess its accuracy on instances with 5–15 products. In Section 5, we present and discuss illustrative examples and insights on larger problem instances (60 products). In Section 6, we conclude our study.

2. Related literature

Product assortment, pricing and inventory optimization are critically important retailing decisions that have a substantial impact on retailers’ profitability. Yet these decisions have been examined somewhat independently due to the increased complexity that their joint optimization entails. Furthermore, researchers from different fields, operations management and marketing in particular, have been interested in assortment planning and these three decisions. Maddah et al. [26] offer a very good review of representative works in assortment planning. They discuss the various decisions at hand, and refer to contributions in the fields of operations management as well as of marketing. In this section, we review the scientific literature in assortment planning, focusing on the operations management literature and on the three decisions that we aim to jointly analyze in our work: products assortment, pricing and inventory.

Kök et al. [20] provide a detailed review of the product assortment and inventory planning literature. One of the first papers in the operations research literature that integrates inventory management into the product assortment planning problem is by van Ryzin and Mahajan [37]. They study the trade-off between product variety benefits and inventory costs using a Multinomial Logit (MNL) model. The MNL model is a widely used utility-based model where each consumer chooses the product with the highest utility out of the set of available choices ([5]). In the model presented by van Ryzin and Mahajan [37], customers have homogeneous expected utilities and can substitute if their favorite variant is not carried (assortment-based substitution). The sale is lost if their favorite variant is carried but temporarily unavailable (no stock-out-based substitution). In the same research stream, Li [22] studies a joint product assortment and inventory optimization problem for a single period and differs from van Ryzin and Mahajan [37] in that he allows different cost parameter values across products. Both studies share the same limitation: they assume that consumers are homogeneous with respect to their preferences. Our research is focused on “customer type” heterogeneity (loyal and non-loyal customers), which results in the so-called latent-class logit assortment problem. Méndez-Díaz et al. [29] also study this problem, but compared to our work they do not consider the retail space constraint and product pricing optimization together.

The product selection problem becomes even more challenging when limited shelf space is included. The shelf space constraint plays a key role in our work, since it has an impact on both the product assortment problem and the accompanying inventory decisions. The impact of the space constraint on product selection is studied by Kök and Fisher [19]. They note that the constrained shelf space implies that average inventory per stock keeping unit (SKU) is inversely related to the breadth of the assortment. They consider stock-out and assortment-based substitution using an exogenous demand model that specifies a priori the demand for each product and the probability that customers will substitute.

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