



A decision support model for determining the level of product variety with marketing and supply chain considerations



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ARTICLE INFO

Article history:

Received 1 May 2014

Received in revised form

7 March 2015

Accepted 8 March 2015

Available online 21 March 2015

Keywords:

Product variety

Integer programming

Optimization

Supply chain

ABSTRACT

We develop a decision support model to determine the optimal product variety for a manufacturer by accounting for both the marketing and supply chain perspectives. While the marketing perspective tends to focus on variety's salience to consumers, the supply chain perspective tends to focus on inventory management and distribution factors such as order fulfillment rates, fill rates, and related costs. In general, the supply chain costs increase as product variety increases, but this overall trend may be arrested to some extent by advanced manufacturing techniques such as modularization. These techniques often generate an irregular cost function that poses a modeling challenge. We address this issue by developing a piecewise ILP (integer linear program) model, and demonstrate its utility by applying it in a systematic managerial simulation study. The simulation examines how the optimal level of product variety and the corresponding selection of products depend on the revenue and cost characteristics of products.

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1. Introduction

Determination of the optimum number of variants in a product line is an important strategic issue for both manufacturers and retailers. According to a survey by the Food Marketing Institute, between 1996 and 2008, the number of items in a typical supermarket went up by 50% (Brat et al., 2009). This dramatic increase in variety is being driven by a belief amongst many retailers that consumers value variety, a belief that has been fostered over the years by recurring stories in the popular media about mega-stores such as Wal-Mart driving out small incumbent neighborhood stores (Barrison, 2011). Yet, intriguingly, according to the Spring 2013 Retailer Expansion Guide, currently one of the fastest growing supermarket chains in the country is Aldi (Chainlinks, 2013), a chain known for its limited product variety. The simultaneous success of both Wal-Mart and Aldi suggests that the issue of product variety is not such a simple one. Even amongst manufacturers such as Procter and Gamble, Campbell Soup, Clorox, ConAgra Foods, and Church and Dwight, the current trend seems to be shifting towards fewer items in a product line (Brat et al., 2009). This appears to be quite different from the trend in 1990s, when manufacturers focused on producing an increasing number of variants of products (Brat et al., 2009).

The optimal level of variety should be the one that maximizes profit which is of course the difference between benefits and costs. When marketing researchers look at benefits and costs, they look at them from the perspective of consumers (Baumol and Ide, 1956). For instance, they tend to focus on costs that are salient to consumers such as time costs (Kuksov and Villas-Boas, 2010), psychological costs of overchoice (Gourville and Soman, 2005) and regret (Toffler, 1984). While marketing research has been focused on consumer-related issues, there has been a parallel development of an equally rich literature in the operations area that looks at the issue of product variety from the supply chain perspective. This literature tends to focus on the different costs in the supply chain that increase as product variety increases. Both of these research streams are important which suggests that integrating them would lead to an improvement of the relevant decision models. This is also increasingly supported by current industry trends where cross-disciplinary work is becoming the norm. Researchers have responded by including both consumer and supply side costs. For instance, Corstjens and Doyle (1981) developed a decision support model to determine the optimal shelf space in a retail store. Their model examines the issue from the consumer perspective only. This model was then extended by Baronet et al. (2011) to include supply chain costs. This strongly suggests that cross-disciplinary research is necessary to bring our theoretical models closer to business reality where decision makers have to look at the overall picture and not just the marketing or the supply side.

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Normally, once all the relevant benefits and costs have been determined, the determination of the optimal level of variety should be a relatively straightforward application of classical optimization. However, the classical approach assumes that revenue and costs curves are regular (concave/convex respectively). In the problem studied here, the cost trend is potentially irregular, due to advancements in supply chain techniques, such as modularization. In addition, product variety may be altered in discrete fashion by the firm. To address these difficulties, we develop a piecewise ILP (integer linear program) model of product variety. This model may be solved iteratively to (i) precisely determine the optimal level of product variety, (ii) identify which products to produce and, (iii) decide the production level (quantity) of each selected product. This makes the model a powerful decision support model.

Such decision support models have been developed extensively in the marketing literature for shelf space design (Corstjens and Doyle, 1981; Baron et al., 2011), salesforce territory design (Zoltners and Sinha, 2005), department-level promotion-mix planning (Allaway et al., 1987), seasonal merchandizing planning (Smith et al., 1998), potential franchise sites for their impact on distribution system revenue and on existing outlets (Ghosh and Craig, 1991), potential retail location sites for their impact on market share (Drezner, 1994). In fact, the 2004 ISMS practice design award was given to a decision support model that was developed 30 years earlier for salesforce territory design (Zoltners and Sinha, 2005). We demonstrate the use of our model in a managerial simulation, details of which are provided in Section 4. The managerial simulation is used to show how the model can be used by practitioners. In Section 5, we provide some concluding remarks.

2. Literature review

The issue of product variety has implications for both marketing and supply chain researchers. Here, we look at both the perspectives in order to evaluate the potential form of the firm's revenue and cost functions of product variety.

2.1. Marketing perspective

Marketers' interest in the issue of product variety arises from its perceived importance to customers who value high levels of variety in a product line for a number of reasons. As product variety increases, a consumer is more likely to find a product variant that closely matches his/her preferences. In product categories where consumer preferences are highly heterogeneous, a firm with higher variety will capture a larger market share due to the greater probability of a match occurring between customer needs and the firm's product assortment (Lancaster, 1990; Baumol and Ide, 1956). In some product categories, due to satiation, consumers are known to seek variety in successive shopping trips. In these categories, higher product variety is preferred as it leads to a greater likelihood of satisfying customers in successive trips (Kahn, 1998). Consumers also perceive products offered by firms with high product variety to have higher quality (Berger et al., 2007). These considerations suggest that the sales revenue of a firm will increase with higher product variety.

Increasing product variety is not necessarily always beneficial to the consumers. As the number of alternatives offered to a customer increases, he/she has to spend more time evaluating them to find the product variant that best fits his/her preferences. This increases the consumer's search effort which, beyond a point, may become so high that the consumer avoids making a purchase altogether (Kuksov and Villas-Boas, 2010). This was confirmed in a field experiment study in which it was found that participants were less likely to make a choice when the number of flavors of

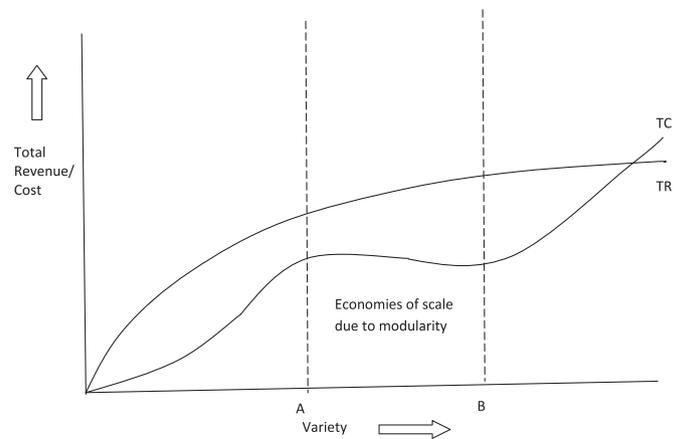


Fig. 1. Total revenue and cost forms (in continuous form for visual ease).

jam offered to consumers was increased (Iyengar and Lepper, 2000). Interestingly, reducing the assortment size in an online grocery store was found to increase sales (Boatwright and Nunes, 2001). Increasing variety can blur the competitive differences between brands, and thereby confuse consumers (Matzler et al., 2011). At higher levels of variety, the potential for regret (buyer's remorse) experienced by a consumer for not making the right choice also increases. The problems associated with too much variety were famously termed 'overchoice' by Alvin Toffler in his classic book "Future Shock" (Toffler, 1984). However, the challenges associated with overchoice arise at relatively high levels of variety (Gourville and Soman, 2005). From these considerations, we can conclude that the total revenue of a firm increases with greater product variety but at a decreasing rate (Please see Fig. 1). It should be noted that we view Fig. 1 as a visualization tool that captures concepts nicely rather than the depiction of an actual product variety instance. We view product variety forms (i.e., functions) as discrete and, accordingly, develop a discrete model in Section 3.

2.2. Supply chain perspective

Research on product variety in the supply chain area tends to focus more on variety's impact on costs. Much of this research suggests that increasing product variety leads to higher operations and supply chain costs. For instance, Hayes and Clark (1986) find that product variety increases the complexity in the operating environment in a factory. As variety increases, different variants are produced in smaller numbers leading to the loss of economies of scale and increasing per unit production cost (Alfaro and Corbett, 2003). In a detailed study of the auto industry, it was empirically found that greater product variety has a significant adverse effect on total labor hours per car, overhead hours per car, assembly line downtime, minor repair and major rework, and inventory levels (Fisher and Ittner, 1999). Higher levels of product variety often require bigger inventories (due to the presence of multiple items). These, in turn, increase the chances of stockouts (Smith et al., 1980), leading to higher stockout costs. We conclude from this research that per unit production costs generally tend to increase at an increasing rate with higher product variety.

At the same time, there is some literature in the supply chain area that suggests that firms occasionally contain the general trend of increasing product variety-related costs (at least in some limited range) through the application of advanced manufacturing techniques. These include achieving economies of scale through the use of common modules in products, also known as modularization (Fisher and Ittner, 1999), sharing of components (Heese and Swaminathan, 2006), and assembly postponement (Lee and Tang,

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