Chapter 19

Optimal Control of the Integrated Marketing–Production Planning Problem

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ABSTRACT

We consider in this paper the integrated marketing–production planning problem and propose an optimal control approach to derive the optimal solution. The state variables are the inventory level and the stock of goodwill and the control variables are the production rate and the advertising rate. Both cases where the firm adopts a continuous-review and a periodic-review policy are considered. The optimal states and controls are obtained explicitly. Illustrative examples are presented. Sensitivity analysis shows the effect of some system parameters on the optimal solution.

INTRODUCTION

Many manufacturing enterprises use a production-inventory system to manage fluctuations in consumer demand for the product. Such a system consists of a manufacturing plant and a finished goods warehouse to store those products that are manufactured but not immediately sold, thus incurring incremental costs. The optimization problem is to balance the benefits of production smoothing versus the costs of holding inventory. Organizations have adopted periodic or continuous review methods to track inventory for purchasing and accounting purposes according to the needs of the business, based on criteria such as general rates of sale (slow versus fast-moving goods), or number of employees involved in the process, and the degree to which external environmental factors may affect the business operations, such as competitor activities.

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The challenge is exacerbated when promotional marketing campaigns are executed that generate short-term surges in product demand en route to long-term business growth. Marketers have long sought to optimize the “4Ps” of Product, Price, Place, and Promotion (which includes advertising), as a strategic management tool to drive consumer demand and thus secure sustainable, profitable long-term growth for their branded products and, thereby, their business. While the key design elements of the Product and its Place distribution channels form the bedrock of marketing strategy, Price and Promotion may also be used tactically to accelerate sales or respond to external market situations, in the shape of opportunities or threats (MacDonald & Rasmussen, 2009).

Given the widely accepted premise that the ultimate goal of advertising is sales (Naccarato & Neuendorf, 1998; Ogilvy, 1983), it is critical that the marketing and supply chain functions of the organization are closely aligned. The lack of product availability may cause more damage to the brand’s reputation than any poorly executed campaign. Equally, excess inventory levels may stimulate a rapid price adjustment policy that undermines the organization’s planned image-building pricing strategy. Therefore, tracking inventory is an essential component of business management for any company selling tangible goods, especially those within highly competitive industries, or with a short product shelf-life, such as perishable goods (Bakker, Riezebos, & Teunter, 2012; Nahmias, 1982; Raafat, 1991; Xu & Zhuo, 2016), or fashion items (Liu, Bi, Chen, & Li, 2014), or technologies subject to obsolescence (Goyal & Giri, 2001). Moreover, the dramatic increase in the number of internet users has helped accelerate the response time between marketing actions and consumer purchase, and so added further pressure on the supply chain process (Kumar & Sethi, 2009).

Management research has long documented the silo tendencies of large organizations, partly as a result of the different operational approaches by the Marketing (medium to long term focus; demand pull orientation) and Supply Chain (short to medium term focus; demand push orientation) departments, despite their interdependency for the overall success of the organization (Felin & Powell, 2016; Krackhardt & Hanson, 1993; Lawrence & Lorsch, 1967). This is supported by the personal experiences of one of the authors, gained during a 20-year career in multinational blue-chip organizations across diverse industries. Indeed, the interests of long-term sustainable business growth for the organization are best served by a coordinated effort between both parties in an increasingly complex marketplace. While there exists a plethora of research in production planning and inventory management, many of the related works focus on either the marketing field, or the operations management field (Xu & Zuo, 2016). Therefore, the goal of this paper is to begin to address this gap by integrating the production planning problem and the marketing problem into a single problem.

The following background section provides an overview of the scope of research in inventory management related to consumer demand fluctuations, to highlight the multiplicity of the dimensions imposing on the problem outlined above. The authors then seek to provide a solution model for both the continuous-review and periodic-review policies adopted by companies, which includes the analysis yielding the optimal solutions and an illustrative example in each case. The paper concludes with a summary of the benefits of the models presented for practitioners and suggestions for further research in this field to enrich the models presented.
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