Chapter 14
The Use of Optimal Control Theory as a Benchmarking Tool in Production–Inventory Systems

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ABSTRACT

This chapter addresses some issues related to some Optimal Control Theory (OCT) problems (for example, impossible analytical solution because of an unsolvable integral, or punctual parameters that were unrealistic). It is proposed the use of OCT as a benchmarking tool to analyze inventory control systems to enhance parameters. In addition, the application of methods and heuristics in solving these problems is also described. These methods are discussed and applied in calculating the production and inventory functions using data of accounting variables of USA and Brazil companies, available in the Economatica software data base. Eventually, the results are compared and some recommendations about the advantages and disadvantages of each method are accomplished.

INTRODUCTION

Motivation

Effective inventory management is critical for a company's success. In general, a business spends more than a quarter of its budget just in inventory costs, and those that manage their inventory ineffectively can spend considerably more, incurring unnecessary costs, lower profits, and even increased the risk of bankruptcy.

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Inventory control models can be used to support decision making, for example, determining the order or production quantities, the inventory level to be held, etc. A diversity of production and inventory control models have been developed by other researchers, using several different techniques, as shown in Bag, Chakraborty, and Roy (2009), Hsieh and Dye (2013), Maddah, Yassine, Salameh, and Chatila (2014), Moori, Marcondes, and Avila (2002), Varyani, Jalilvand-Nejad, and Fattahi (2014), Sana (2010), Segic, Marinovic, and Potokar (2007), Thornhill and Naim (2006), Wee and Widyadana (2013), among others.

Optimal control theory (OCT) has been widely applied in inventory control. For example, Ignaciuk and Bartoszewicz (2012) studied the optimal inventory control of products that can be considered perishable in a periodic review system. Keblis and Feng (2012) studied optimal inventory control in a make-to-assembly system, but with make-to-stock components. Oliva (2005) considered the transportation costs to make the decision on how much to buy to stock. Rosa (2010) proposed a model with dynamic networks using stochastic dynamic programming (used in stochastic optimal control) to obtain an optimal policy for inventory control at places with demand to be satisfied and to get the cost. Many other authors, such as, Ceryan, Duenyas, and Koren (2012), Federgruen and Zheng (1992), Hwang and Koh (1992), Lahmar and Kulkarni (2006), Lototskii and Mandel (1979), Sana (2010), Sethi and Thompson (2006) and Song (2009) have also studied this topics.

In addition, in Zhu (2013) is studied a model for joint decision under uncertainty of demand and supply. Nowadays, with the risk of supply interruption, many companies hold a safety stock, affecting the selling price and the price-sensitive demand. A model that combines price and inventory was studied by Zhu (2013) and a concern is shown by the fact that the reliable supply had more significant impact on profit than the demand variability. Thus, companies should not use all raw material inventories because it would increase the quantity and the necessity to resupply, affecting negatively on earnings in case of interruption. Therefore, at least a minimum inventory or safety stock is required.

One way to solve this problem is using Optimal Control Theory (OCT) in an inventory control model taking into account the safety stock to avoit the stockout problem. Some of the common formulation of an optimal control inventory can be seen at Holt, Modigliani, Muth, and Simon (1960) and Sethi and Thompson (1980). Some other models can be found in Sethi and Thompson (2006).

Few OCT problems can be solved analytically or with an analytical solution from Variational Calculus (Chilan& Conway, 2015). Many of them will lead to unsolvable integrals or it will lead to a good solution, but with an unworkable computational time.

Since there are some methodologies issues in solution of OCT and parameter estimation problems, in this chapter is addressed some topics related about them. Moreover, the use of OCT solution is performed in an entire sector as benchmarking tool to enhance punctual parameters that were unrealistic.

Contribution

This research proposes the use of optimal control theory as a benchmarking tool to analyze inventory control systems. The results are compared with other similar companies (e.g. companies from the same sector) to confront the parameters and solutions of each company, including results of two models. In addition, an easy way to solve optimal inventory control problems is recommended, and it is applied to companies of a sector using financial reports data, so the companies could compare themselves to benchmarking companies instead to just the optimal solution (depending on parameters). The problem is modeled as OCT and its solution is accomplished using metaheuristics, such as genetic algorithm, discretization, and numerical methods, such as finite difference.