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Solving an Integrated Sales-Leasing Problem With Remanufacturing and Inventory Shortage Using Differential Evolution

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ABSTRACT

In this article, an integrated sales and leasing company is considered. This company remanufactures leased products at the end of operating lease contracts to make them as good as new ones and sell them to the customers. In order to satisfy customers' demand, required products are provided from a third-party when the company meets inventory shortage. Non-linear competitive demand functions are used which are sensitive to manufacturer suggested retail price (MSRP) and inflation rate. A mixed integer non-linear mathematical model (MINLP) is developed to determine optimal price of selling products, optimal amount of monthly payments in leasing contracts, and optimal inventory control planning, i.e. the optimal amount of manufacturing and remanufacturing products and optimal inventory levels. The main objective is to maximize net profit of the company. Small, medium and large-scale sizes of the model are solved to show the applicability of the model. To solve the large-scale problem, differential evolution (DE) algorithm is applied as a meta-heuristic solution approach. Numerical results show high sensitivity of model to demands. Also, optimal trend behaviors of some main variables of the problem seem similar to the competitive behavior of demands.

KEYWORDS

Differential Evolution, Inflation, Inventory Shortage, Leasing, Mixed Integer Non-Linear Mathematical Model, Pricing, Production Planning, Rebate, Remanufacturing

1. INTRODUCTION

Nowadays, there are companies that not only prepare goods to sell them to their customers, but also present options for durable goods for receiving predetermined monthly payments. These kinds of commercial contracts are called leasing contracts in which there are at least two parties, the party who lends the asset (lessor) and the party who rents it (lessee). Toyota provides this option for its used cars and calls it purchasing or leasing Toyota Certified Used Vehicles (TCUVs). The deal holds only when only the product is within six years of the current model year and has 85,000 miles or less on the odometer. The same happens in a variety of products in the retail industry especially when

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the customers do not need the product permanently and just want to use it for a specific range of time. In other words, maintaining a product after the relevant need has been fulfilled can be costly and annoying for customers.

Two main types of leasing are financial lease and operating lease (considered in this study). Financial lease is a long-term obligation in which the sum of the regular payments is approximately equal to the product's purchase cost, leasing that is not financial is an operating lease (Contino, 2002).

Leasing companies are developing due to the advantageous that leasing creates for the both customers and companies. Leasing is less capital-intensive than purchasing and it is suitable for customers who can't afford their necessary goods. On the other side, leasing company enjoys a monotonous financial process that is a result of regular payments paid by customers. Also, since the real ownership of the leased product is the lessor, the leasing company can derive a benefit of tax deduction (Attorney & Fred, 2005). In other words, depreciation costs are incorporated in the regular payments and thus, tax saving for the leasing company occurs.

In an integrated sales and leasing company, the board should always decide on selling or leasing a product in order to maximize total benefits and respond to customers' demand. Manufacturer suggested retail price and inflation rate are two parameters that their impacts on operating lease demand functions are analyzed. Most demand functions are price sensitive, hence, in order to investigate the impacts of the mentioned parameters we should join pricing and production planning decisions in the problem of joint revenue management of selling and leasing.

Until 1955, pricing and production planning (inventory control) were considered separately. For the first time, Whithin (1955) focused on these two fields simultaneously. It helps the company design a plan for leasing or selling goods in order to maximize its benefits.

In marketing, there are different attractions to stimulate customers buy or lease a specific product. Rebate is a prevalent sales promotion strategy which means that the manufacturer will return back a percentage of the sales price to the customer who fills the special form of the purchased product and sends it to the manufacturer (Keyhanian & Rabbani, 2014).

When capacity of manufacturing and remanufacturing products is limited, it is plausible that the company meets lack of inventory to satisfy customers' demand. In this case, the company may cover required products through outsourcing in order to reduce cost of backorder and lost sales which are incurred due to inventory shortage.

As mentioned, changing the price of a product may change customers' demand. In economic markets, there are different prices for a product. One of these prices is MSRP which is an initial price recommended by manufacturer to retailers and it usually can be seen on the product tag or label (Yang et al., 2010; Keyhanian & Rabbani, 2015). The selling price of the product is usually lower than MARSP to entice more customers.

Another parameter that may change customers' demand is inflation. It can affect the willingness of customers for purchasing or leasing a product. For example, high rates of inflation may reduce purchasing demand in the market remarkably and lead customers to leasing. Changing the rate of tax may alter the amount of tax payments, therefore, it can affect decisions in the leasing market (Hochman & Rabinovitch, 1984). Singh and Bhatia's work is a recent example in literature in which inflation has been considered along with time value of money in a vendor buyer model, (Singh & Bhatia, 2011).

In this study, an integrated sales and leasing company in which leased products are remanufactured at the end of leasing contracts and are sold to the corresponding customers is considered. Also, when inventory levels of new and remanufactured products are not sufficient, the company will compensate its shortage by purchasing products from a third-party supplier. Non-linear demand functions for purchasing new or remanufactured products and leasing new products are presented which are sensitive to MSRP and inflation rate. Rebate is permitted as a strategy to raise customers' demand and it has been modeled in a unique way in order to not disturb the effect of the other parameters in the model. A mixed integer non-linear mathematical model is developed to determine optimal number of products that should be sold or leased to maximize total profit with regards to the pricing problem

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