IJE TRANSACTIONS B: Applications Vol. 31, No. 5, (May 2018) 759-769

International Journal of Engineering

Journal Homepage: www.ije.ir

Optimal Decisions in a Dual-channel Supply Chain for the Substitute Products with Special Orders under Disruption Risk and Brand Consideration

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PAPER INFO

Paper history:
Received 24 July 2017
Received in revised form 12 October 2017
Accepted 09 March 2018

Keywords:
Pricing
Three Echelon Supply Chain
Game Theory
Disruption Risk
Special Order
Brand Value; Substitute Product

ABSTRACT

In this paper, a three-echelon supply chain model, including two producers, distributor and retailer was considered, which both producers produce one kind of goods in different brands and qualities. Each manufacturer has its own channel that the retailer can offer exclusively its manufacturer's product and receives a discount on the purchase of the goods from the distributor (exclusive market) or offers the goods of both manufactrers (non-exclusive market). In this work, pricing decisions for the same substitute products were developed with different brands in the exclusive and non-exclusive markets. Customers are divided into two categories of loyal customers and indifferent customers whom the demand for products depends on the distance from the brand and the distance of the product prices from the ideal product prices. In this model, the retailer sells the required goods from the distributor, there may be a risk of discontinuity between the retailer and the distributor, in which case only a percentage of the retailer's order quantity can met by the distributor and the unsatisfied orders are directly purchased from the manufacturer on a special order. The purpose of this research is to maximize the total supply chain profit by application of game theory, which determines the optimal sales price in each supply chain. Finally, application of the model is illustrated by numerical examples and then sensitivity analysis was conducted on its important parameters.

***doi**: 10.5829/ije.2018.31.05b.11*

1. INTRODUCTION

Profitability and ensuring the profitability are some of the main reasons of creating a supply chain. Each chain seeks to maximize the benefit of the entire chain instead of increasing its own profits. In fact, pricing a single item or multiple items in a system hasa great importance. Most of the papers published in pricing domain were about the substituted products; while, increase in the use of the product, the use of others are reduced. However, a few researchers have pointed out the substitute products with different brands. The users of these products are usually divided into two groups of indifferent and loyal customers. Since the type of products manufactured is the same in both companies, loyal customers use their own brand in each case; but the distance between the customer's position and the place of supply of the product is important to the indifferent customers. In the competitive market of the substitute products with different brands, if the product doesn't exist in the market, after a while it would be out of the market competitionand since there are different risks, retailers who deliver products to their customers may not be able to meet all the orders of upper level. Therefore, the retailers must think carefully to meet the final customer demand. In general, application of the game theory in the supply chain is incorporated to the interaction between the members of the supply chain. Supply chain members may have conflicting goals so that each chain hope to maximize their profits, and this may lead to a reduction in the overall supply chain profit. For this reason, most models in the supply chain seek to interact with the supply chain members so that the total supply chain profit is maximized and the profit or loss in the supply chain is shared across all the supply chain.

Literature review is divided into two parts:

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Please cite this article as: A. MohsenzadehLedari, A. ArshadiKhamseh, Optimal Decisions in a Dual-channel Supply Chain for Substitute Products with Special Orders under DisruptionRisk and Brand Consideration,International Journal of Engineering (IJE),IJE TRANSACTIONS B: Applications Vol. 31, No. 5, (May 2018) 759-769

1. Reviewing researches on the pricing of substitute and complementary products and the game theory in the supply chain. 2. Reviewing researches related to the disruption risk in the supply chain and special order. Moorthy [1] showed that in the competitive market between different trading companies, the results did not depend solely on the company's own performance and decision, but depended on how other companies used their strategy to seize the market. Taleizadeh and Noori-daryan [2] proposed a three-echelon supply chain consisting of multi-suppliers, a manufacturer, and a few retailers with reworking operation in an integrated and non-integrated structure to optimize the chain's profit in both cases by setting the optimal price and production policy which uses the Stackelberg model between the chain members. There are extensivestudies on pricing of substitute products, such as: Karakul and Chan [3] examined the analytical and management effects of substitute products on pricing and procurement decisions. Their model is single-period with two products: an old product and a new one, the new product replaces an old one, if there is a shortage. Karakul and Chan [4] presented a single-period model for substitute products as a combination of pricing products and supplies for substitute products, in which each product requiring logistic time and the demand for substitute products are random. Chen et al. [5] provided a pricing policy in a supply chain with substitute products, in which the manufacturer sells its products directly and through the internet. The retailor sells the substitute product which is produced by another producer. Zhaoet et al. [6] identified the problem of pricing substitute products with a producer and two retailers. The consumer demand and producer costs are uncertain with a centralized and three decentralized pricing models. Rasouli and NakhaiKamalabadi [7] presented a new mathematical model towards a joint pricing and inventory control for seasonal and substitutable products in a competitive market over a finite time planning horizon. It is assumed that the two substitute products belong to two different rival firms. Ahmadi Yazdi and Honarvar [8] presented a new model for designing integrated forward/reverse logistics based on pricing policy in direct and indirect sales channel. The proposed model includes producers, disposal center, distributers and final customers. Unlike pricing on a substitute product, few studies have been conducted on complementary products, which some of them are discussed as follows: Esmaeilzadeh and Taleizadeh [9] presented the optimal price of two complementary products in a two-level supply chain in two modes. The supply chain at each level includes a retailer and two manufacturers. In the first case, they assumed that, the costs of producing complementary products at each level are the same, while in the second case it was assumed that the costs of production are different and depends on the demand. Arshadi Khamseh et al. [10] provided a pricing model for substitute products in the fuzzy supply chain with two manufacturers and a retailer with four pricing models. In most of the supply chain models, demand for products is considered constant, or demand is a random variable, and the utility demand function is used in a limited number of researches. Wong and Eyers[11] Xia and Rajagopalan [12] used the utility function for customer demand, which is considered as the function of product price, logistic time, and customer distance from the brand. Xiao et al. [13] developed the game theory model including a manufacturer and a retailer; in which the proposed model the interaction between procurement time and price was examined. The proposed model includes a custom product in an order-based production system and the demand of the product depends upon the time of preparation and the selling price. The supply chain may be at risk due to various factors. One of the important risks that threatens the supply chain is the disruption risk in the supply chain. Xanthopoulos et al. [14] presented the Newsvendor model with two channels of supply, in which there is a possibility of disruption risk between the distributor and the retailer in each channel that in the event of disruption risk, only a percentage of the order quantity will be met by the distributor. MohsenzadehLedari et al. [15] presented a Newsvendor model in a multi-level supply chain with two supply channals that allows for the disruption risk between the retailer and the distributor in each of the supply channels. In that case, the event of disruption risk, the percentage of order will not be met and the retailer would deliver the amount of unsatisfied orders as special order and directly order from the manufacturer. Qi [16] presented a model in which retailers offer the possibility of supplying products from two suppliers and the first source provides the product at low prices, without the guarantee (there is a possibility of disruption risk occurrence); the second supplier provides the product at a higher price and complete reliability (there is no possibility of interruption risk occurrence).

In this paper, three-level supply chain model was developed with the possibility of disruption risk occurrence between the retailer and distributor and special ordering in the event of disruption risk, which uses the Stackelberg model for interaction between the supply chain members in both cases of the exclusive and non-exclusive markets. Thus, in exclusive market, each retailer only sells the product of the same channel manufacturer, but in non-exclusive market, retailers can offer the products of both manufacturers with different brands.

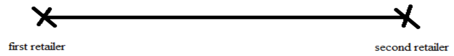
We proposed some innovations and contributions as follows, which distinguishes our investigation from previous work:

- ✓ Providing a three-level supply chain that two manufacturers present the same product with different brands.
- ✓ The possibility of occurring disruption risk between the retailer and the distributor, which forced us to have special order in the case of disruption.
- ✓ Examination of exclusive and non-exclusive markets.
- ✓ Defining utility function based upon price and distance for demands.

Reminder of this paper is organized as follows: Insection 2, problem description and assumptions are described. In section 3 notations and mathematical models are presented. A numerical example is presented toillustrate the effectiveness of the model in section 4. Finally conclusions from this research and future research are discussed in section 5.

2. PROBLEM DESCRIPTION

This paper presents a three-level supply chain that its chain members include a manufacturer, distributor and retailer. In order to supply products to the market there are two channels of supply from different manufacturers with different brands that compete with each other. Both manufacturers provide the same product, but with different brands so that products supplied in the market are replaceable and these two producers are looking for increase in their share on the market. The market is exclusive, will receive a benefit of discount percentage from distributor. Otherwise, no discount will be given. If the market is exclusive all products of a particular brand will be offered at the retail location. If the market is not exclusive, the percentage of products with a particular brand will be at the retail location and the rest will be offered at the retail location related to the competitor manufacturer.The performance of the supply chain is that the distributor buys the product from the manufacturer and sells the retailer(s). In this case due to political problems, equipment failure, natural disasters, a percentage of retail demand (s) of the retailer(s) may be not met by the distributor(s). The possibility of such case is probable that is called the disruption risk and in the case of occurrence, a percentage of demands are met. Since all demand of the market should be met by the retailer (s) and the shortage is not allowed. A percentage of the retailer(s) demands which has not satisfied by distributor (s), will be fulfilled and met in the form of a special order directly from the manufacturer of the same product at a higher price than the price of distributor. As previously mentioned, the products of both producers are interchangeable and it means that customers can use any of these products. Therefore, the tendency to buy will be related to the price of competing products, distance from theideal price of product and customer's distance from the product supply location. Finally, for each product demand, a utility function of the ideal price, sensitive to the distance and the brand is provided so that customers divided into loyal customers and in different customers and uniformly distributed. Also, *"d"* is the distance between the two retailers.



$$U_j = r - \alpha_{jk}.r_{jk} - t.x_j \tag{1}$$

2. 1. Model Assumptions

1. For supplying two substituted products, the value of the barand is taking into account.
2. The disruption risk will be accured between the distributor, the retailer and in the case of occurence the disruption risk, we will have special ordering.
3. Using both exclusive and non-exclusive markets in the study.
4. When have two type of customers: loyal and ordinary customers; also using the utility function for these two types of demands.
5. The shortage and lead time are not permitted.

3. MODEL DEFINITION

This section presents the mathematical model of the exclusive and non-exclusive markets; then the concave objective function related to each chain in the supply chain is described using Hessian matrix.

Parameters:

r : The ideal price of the product

α_{jk} : Percentage of the product j to the retailer k

c_j : Sales price of the product j by the manufacturer to the distributor

a_j : The production cost of j th product

U_j : Utility function related to the demand of j th product

t : The sensitivity of the customers to the brand

x_i : Customer location (customer distance from the desired brand)

p_i : Disruption risk in the ith distributor

y_i : A percentage which is met by the distributor

λ_i : Discount rate by the distributor i.

Decision variable:

r_{jk} : The price of the j thproduct at the kth retailer

w_{ji} : The price of the j th product by the ithdistributor

T_{jk} : The price of the sale of the j[th] product by the manufacturer to the retailer k

d_j : The demand for theproduct j

3. 1. The Problem Model in the Exclusive Market

In the exclusive market, each channel only provides the products of its manufacturer to the final customer and receives a discount. In the state of exclusive market with discount the profit of retailer1are as follows:

$$\pi_{R1}=(1-p_1).((r_{11}-(1-\lambda_1).w_{11})).d_1+ p_1.((r_{11}-(1-\lambda_1).w_{11}).y_1.d_1+(1-y_1).d_1.(r_{11}-T_{11})) \quad (2)$$

Profit of retailer 2 is as follow:

$$\pi_{R2}=(1-p_2).((r_{22}-(1-\lambda_2).w_{22})).d_2+ p_2.((r_{22}-(1-\lambda_2).w_{22}).y_2.d_2+(1-y_2).d_2.(r_{22}-T_{22})) \quad (3)$$

Profit of distributor 1 is as follow:

$$\pi_{D1}=(1-p_1).(((1-\lambda_1).w_{11}-c_1).d_1)+p_1.((1-\lambda_1).w_{11}-c_1) \quad (4)$$

Profit of distributor 2 is as follow:

$$\pi_{D2}=(1-p_2).(((1-\lambda_2).w_{22}-c_2).d_2)+p_2.((1-\lambda_2).w_{22}-c_2) \quad (5)$$

Profit of manufacturer 1 is as follow:

$$\pi_{M1}=(c_1-a_1).d_1+p_1.(T_{11}-a_1).(1-y_1).d_1 \quad (6)$$

Profit of manufacturer 2 is as follow:

$$\pi_{M2}=(c_2-a_2).d_2+p_2.(T_{22}-a_2).(1-y_2).d_2 \quad (7)$$

Profit of the total chain is as follow:

$$\pi_{total}=\pi_{R1}+\pi_{R2}+\pi_{D1}+\pi_{D2}+\pi_{M1}+\pi_{M2} \quad (8)$$

Utility function of demand for the product 1 is as follow:

$$u_1=r-r_{11}-t.x_1 \quad (9)$$

Utility function of demand for the product 2 is as follow:

$$u_2=r-r_{22}-t.x_2 \quad (10)$$

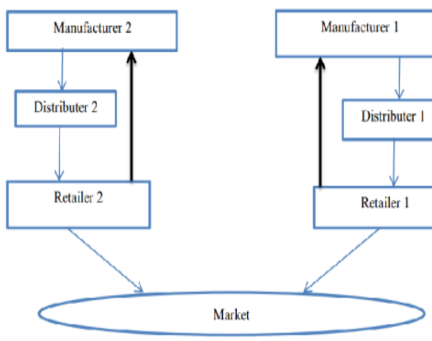


Figure 1. Exclusive market

The demand for the first and the second product is the total demand of loyal and indifferent customers to any of these products. The demand of the loyal customers is calculated by putting the utility function equeals to zero for that product and the demand of the in different customer is equal to equivalence of the two utility function in such a waythat the following expression should be considered:

Loyal customer demand functions for the first product are as follows:

$$r-r_{11}-t.x_1=0 \quad (11)$$

$$x_1=\frac{r-r_{11}}{t} \quad (12)$$

In different customer demand for the first product are as follows:

$$r-r_{11}-t.x_1=r-r_{22}-t.(d-x_1) \quad (13)$$

$$x_1=\frac{r_{22}-r_{11}+t.d}{2t} \quad (14)$$

Total demand of the first product is as follows:

$$d_1=\frac{r_{22}-r_{11}+t.d}{2t}+\frac{r-r_{11}}{t} \quad (15)$$

Loyal customer demand for the second product is as follows:

$$x_2=\frac{r-r_{22}}{t} \quad (16)$$

Indifferent customer demand for the second product is as follows:

$$r-r_{11}-t.(d-x_2)=r-r_{22}-t.x_2 \quad (17)$$

$$x_2=\frac{r_{11}-r_{22}+t.d}{2t} \quad (18)$$

The total demand of second product is as follows:

$$d_2=\frac{r_{11}-r_{22}+t.d}{2t}+\frac{r-r_{22}}{t} \quad (19)$$

Hessian matrix is used to illustrate the concavity of the utility function for each chain in the supply chain as follows:

$$H_{R1}=\begin{bmatrix}\frac{\partial^2\pi_{R1}}{\partial r_{11}{}^2} & \frac{\partial^2\pi_{R1}}{\partial r_{11}\partial r_{21}}\\ \frac{\partial^2\pi_{R1}}{\partial r_{21}\partial r_{11}} & \frac{\partial^2\pi_{R1}}{\partial r_{21}{}^2}\end{bmatrix} \quad (20)$$

$$H_{R1}=\begin{bmatrix}-\frac{3(1-p_1)}{t}+p_1(-\frac{3y_1}{t}-\frac{3(1-y_1)}{t} & 0\\ 0 & 0\end{bmatrix} \quad (21)$$

As shown in the Hashin matrix of the first retailer, the profit function of the first retailer is concave.

$$H_{R2}=\begin{bmatrix}\frac{\partial^2\pi_{R2}}{\partial r_{12}{}^2} & \frac{\partial^2\pi_{R2}}{\partial r_{12}\partial r_{22}}\\ \frac{\partial^2\pi_{R2}}{\partial r_{22}\partial r_{12}} & \frac{\partial^2\pi_{R2}}{\partial r_{22}{}^2}\end{bmatrix} \quad (22)$$

$$H_{R2}=\begin{bmatrix}0 & 0\\ 0 & -\frac{3(1-p_2)}{t}+p_2(-\frac{3y_2}{t}-\frac{3(1-y_2)}{t}\end{bmatrix} \quad (23)$$

As it is clear from the Hessian matrix of the second retailer, the profit function of the second retailer is concave. The profit functions of the distributors and producers are linear based on the sale price. Therefore, they areconcave and also convex, and if we use Hessian matrix, all members of Hessian matrix will be zero. In order to obtain the product sales price at retail, following equations should be solved and the amount of the obtained sale price should be entered into the profit of the distributor chains to obtain the sales price at the distributor chain.

$$\begin{cases}\frac{\partial\pi_{R1}}{\partial r_{11}}=0\\ \frac{\partial\pi_{R2}}{\partial r_{22}}=0\end{cases} \quad (24)$$

$$\begin{aligned}r_{11}&=\frac{2}{5}r+\frac{6}{35}t.d+\frac{18}{35}w_{11}-\frac{18}{35}w_{11}.\lambda_1-\frac{18}{35}w_{11}.p_1+\frac{18}{35}w_{11}.p_1.\lambda_1\\&+\frac{18}{35}p_1.w_{11}.y_1-\frac{18}{35}p_1.w_{11}.y_1.\lambda_1+\frac{18}{35}p_1.T_{11}-\frac{18}{35}p_1.T_{11}.y_1+\frac{1}{35}t.d\\&+\frac{3}{35}w_{22}-\frac{3}{35}w_{22}.\lambda_2-\frac{3}{35}w_{22}.p_2+\frac{3}{35}w_{22}.p_2.\lambda_2+\frac{3}{35}p_2.w_{22}.y_2\\&-\frac{3}{35}p_2.w_{22}.y_2.\lambda_2+\frac{3}{35}p_2.T_{22}-\frac{3}{35}p_2.T_{22}.y_2\end{aligned} \quad (25)$$

$$\begin{aligned}r_{22}&=\frac{2}{5}r+\frac{1}{35}td+\frac{3}{35}w_{11}-\frac{3}{35}w_{11}.\lambda_1-\frac{3}{35}w_{11}.p_1+\frac{3}{35}w_{11}.p_1.\lambda_1\\&+\frac{3}{35}p_1.w_{11}.y_1-\frac{3}{35}p_1.w_{11}.y_1.\lambda_1+\frac{3}{35}p_1.T_{11}-\frac{3}{35}p_1.T_{11}.y_1+\frac{6}{35}td\\&+\frac{18}{35}w_{22}-\frac{18}{35}w_{22}.\lambda_2-\frac{18}{35}w_{22}.p_2+\frac{18}{35}w_{22}.p_2.\lambda_2+\frac{18}{35}p_2.w_{22}.y_2\\&-\frac{18}{35}p_2.w_{22}.y_2.\lambda_2+\frac{18}{35}p_2.T_{22}-\frac{18}{35}p_2.T_{22}.y_2\end{aligned} \quad (26)$$

By replacing the optimal sales price of the product in retailat the distributor's profitand solving the below equations, the optimal sale price at the distributor chain will be obtained.

$$\begin{cases}\frac{\partial\pi_{D1}}{\partial w_{11}}=0\\ \frac{\partial\pi_{D2}}{\partial w_{22}}=0\end{cases} \quad (27)$$

$$w_{11}(A)+w_{22}(B)=C \quad (28)$$

$$w_{22}.(E)+w_{11}.(M)=F \quad (29)$$

$$w_{11}=\frac{CE-BF}{AE-BM} \quad (30)$$

$$w_{22}=\frac{CM-AF}{BM-AE} \quad (31)$$

By replacing the optimal sales price of the product in distributor at the producer's profitand solving the following equations, the optimal sale price at the manufacturer chain in the case of special order are obtained stated as follows:

$$\begin{cases}\frac{\partial\pi_{M1}}{\partial T_{11}}=0\\ \frac{\partial\pi_{M2}}{\partial T_{22}}=0\end{cases} \quad (32)$$

$$\begin{aligned}T_{11}&=(-p_1.(1-y_1).(-a_1).(-\frac{3}{7}p_1+\frac{3}{7}p_1.y_1)-(c_1-a_1).(\frac{\frac{-18}{35}p_1+\frac{18}{35}p_1.y_1}{t}+\frac{\frac{-3}{7}p_1+\frac{3}{7}p_1.y_1}{2t}))\\&/(p_1.(1-y_1).(\frac{\frac{-18}{35}p_1+\frac{18}{35}p_1.y_1}{t}+\frac{\frac{-3}{7}p_1+\frac{3}{7}p_1.y_1}{2t}))\end{aligned} \quad (33)$$

$$\begin{aligned}T22&=(-p2.(-a2).(1-y2).(\frac{\frac{-18}{35}p2+\frac{18}{35}p2.y2}{t}+\frac{\frac{-3}{7}p2+\frac{3}{7}p2.y2}{2t})-(c2-a2).(\frac{\frac{-18}{35}p2+\frac{18}{35}p2.y2}{t}+\\&\frac{\frac{-3}{7}p2+\frac{3}{7}p2.y2}{2t}))/(p2.(1-y2).(\frac{\frac{-18}{35}p2+\frac{18}{35}p2.y2}{t}+\frac{\frac{-3}{7}p2+\frac{3}{7}p2.y2}{2t}))\end{aligned} \quad (34)$$

3. 2. TheProblemModel in the Non-exclusive Market

In the non-exclusive market, each retailer can offer both products and there is no restriction and discount for retailer. In the non–exclusive market, equations are:

Profit of retailer 1 is as follows:

$$\begin{aligned}\pi_{R1}&=(1-p_1).((r_{11}-w_{11}).\alpha_{11}.d_1)+(1-p_2).((r_{21}-w_{21}).\alpha_{21}.d_2)\\&+p_1.((r_{11}-w_{11}).\alpha_{11}.y_1.d_1+(r_{11}-T_{11}).\alpha_{11}.(1-y_1).d_1)+\\&p_2.((r_{21}-w_{21}).\alpha_{21}.y_2.d_2+(r_{21}-T_{21}).\alpha_{21}.(1-y_2).d_2)\end{aligned} \quad (35)$$

Profit of retailer 2 is as follows:

$$\begin{aligned}\pi_{R2}&=(1-p_2).((r_{22}-w_{22}).\alpha_{22}.d_2)+(1-p_1).((r_{12}-w_{12}).\alpha_{12}.d_1)+\\&p_2.((r_{22}-w_{22}).\alpha_{22}.y_2.d_2+(r_{22}-T_{22}).\alpha_{22}.(1-y_2).d_2)\\&+p_1.((r_{12}-w_{12}).\alpha_{12}.y_1.d_1+(r_{12}-T_{12}).\alpha_{12}.(1-y_1).d_1)\end{aligned} \quad (36)$$

Profit of distributor 1 is as follows:

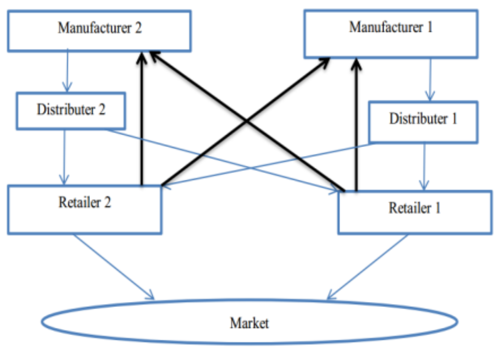


Figure 2. Non-exclusive market

$$\pi_{D1} = (1-p_1).((w_{11}-c_1).\alpha_{11}.d_1 + (w_{12}-c_1).\alpha_{12}.d_1) + p_1((w_{11}-c_1).\alpha_{11}.y_1.d_1 + (w_{12}-c_1).\alpha_{12}.y_1.d_1) \quad (37)$$

Profit of distributor 2 is as follows:

$$\pi_{D2} = (1-p_2).((w_{22}-c_2).\alpha_{22}.d_2 + (w_{21}-c_2).\alpha_{21}.d_2) + p_2((w_{22}-c_2).\alpha_{22}.y_2.d_2 + (w_{21}-c_2).\alpha_{21}.y_2.d_2) \quad (38)$$

Profit of manufacturer 1 is as follows:

$$\pi_{M1} = (c_1-a_1).d_1 + p_1.(T_{11}-a_1).(1-y_1).d_1.\alpha_{11} + p_1.(T_{12}-a_1).(1-y_1).d_1.\alpha_{12} \quad (39)$$

Profit of manufacturer 2 is as follows:

$$\pi_{M2} = (c_2-a_2).d_2 + p_2.(T_{22}-a_2).(1-y_2).d_2.\alpha_{22} + p_2.(T_{21}-a_2).(1-y_2).d_2.\alpha_{21} \quad (40)$$

The total profit of supply chainis as follows:

$$\pi_{total} = \pi_{R1} + \pi_{R2} + \pi_{D1} + \pi_{D2} + \pi_{M1} + \pi_{M2} \quad (41)$$

Utility function of demand for the first product is as follows:

$$u_1 = r - \alpha_{11}.r_{11} - \alpha_{12}.r_{12} - t.x_1 \quad (42)$$

Utility function of demand for the second product is as follows:

$$u_2 = r - \alpha_{22}.r_{22} - \alpha_{21}.r_{21} - t.x_2 \quad (43)$$

Loyal customer demand for the first product is as follows:

$$r - \alpha_{11}.r_{11} - \alpha_{12}.r_{12} - t.x_1 = 0 \quad (44)$$

$$x_1 = \frac{r - \alpha_{11}.r_{11} - \alpha_{12}.r_{12}}{t} \quad (45)$$

Indifferent customer demand for the first product is as follows:

$$r - \alpha_{11}.r_{11} - \alpha_{12}.r_{12} - t.x_1 = r - \alpha_{22}.r_{22} - \alpha_{21}.r_{21} - t.(d - x_1) \quad (46)$$

$$x_1 = \frac{\alpha_{21}.r_{21} + \alpha_{22}.r_{22} + t.d - \alpha_{11}.r_{11} - \alpha_{12}.r_{12}}{2t} \quad (47)$$

The total demand of first product is as follows:

$$d_1 = \left(\frac{\alpha_{21}.r_{21} + \alpha_{22}.r_{22} + t.d - \alpha_{11}.r_{11} - \alpha_{12}.r_{12}}{2t}\right) + \left(\frac{r - \alpha_{11}.r_{11} - \alpha_{12}.r_{12}}{t}\right) \quad (48)$$

Loyal customer demand for the second product is as follows:

$$r - \alpha_{22}.r_{22} - \alpha_{21}.r_{21} - t.x_2 = 0 \quad (49)$$

$$x_2 = \frac{r - \alpha_{22}.r_{22} - \alpha_{21}.r_{21}}{t} \quad (50)$$

Indifferent customer demand for the second product is as follows:

$$r - \alpha_{11}.r_{11} - \alpha_{12}.r_{12} - t.(d - x_2) = r - \alpha_{22}.r_{22} - \alpha_{21}.r_{21} - t.x_2 \quad (51)$$

$$x_2 = \frac{\alpha_{11}.r_{11} + \alpha_{12}.r_{12} - \alpha_{21}.r_{21} - \alpha_{22}.r_{22} + t.d}{2t} \quad (52)$$

Total demand of the second product is as follows:

$$d_2 = \left(\frac{\alpha_{11}.r_{11} + \alpha_{12}.r_{12} - \alpha_{21}.r_{21} - \alpha_{22}.r_{22} + t.d}{2t}\right) + \left(\frac{r - \alpha_{22}.r_{22} - \alpha_{21}.r_{21}}{t}\right) \quad (53)$$

Hessian matrix is used to illustrate the concavity of the utility function of each chain in the supply chain as follows:

$$H_{R1} = \begin{bmatrix} \dfrac{\partial^2 \pi_{R1}}{\partial {r_{11}}^2} & \dfrac{\partial^2 \pi_{R1}}{\partial r_{11} \partial r_{21}} \\ \dfrac{\partial^2 \pi_{R1}}{\partial r_{21} \partial r_{11}} & \dfrac{\partial^2 \pi_{R1}}{\partial {r_{21}}^2} \end{bmatrix} \quad (54)$$

$$H_{R1} = \begin{bmatrix} \begin{array}{l} -\frac{3(1-p_1).\alpha_{11}^2}{t} + \\ p_1(-\frac{3\alpha_{11}^2.y_1}{t} - \frac{3\alpha_{11}^2.(1-y_1)}{t} \end{array} & \begin{array}{l} \frac{1}{2}.\frac{(1-p_1).\alpha_{11}.\alpha_{21}}{t} + \frac{1}{2}.\frac{(1-p_2).\alpha_{21}.\alpha_{11}}{t} \\ +\frac{1}{2}.p_1.(\frac{\alpha_{11}.y_1.\alpha_{21}}{t} + \frac{\alpha_{11}.(1-y_1).\alpha_{21}}{t}) \\ +\frac{1}{2}.p_2.(\frac{\alpha_{21}.y_2.\alpha_{11}}{t} + \frac{\alpha_{21}.(1-y_2).\alpha_{11}}{t}) \end{array} \\ \begin{array}{l} \frac{1}{2}.\frac{(1-p_2).\alpha_{11}.\alpha_{21}}{t} + \\ \frac{1}{2}.\frac{(1-p_2).\alpha_{21}.\alpha_{11}}{t} \\ +\frac{1}{2}.p_1.(\frac{\alpha_{11}.y_1.\alpha_{21}}{t} + \frac{\alpha_{11}.(1-y_1).\alpha_{21}}{t}) \\ +\frac{1}{2}.p_2.(\frac{\alpha_{21}.y_2.\alpha_{11}}{t} + \frac{\alpha_{21}.(1-y_2).\alpha_{11}}{t}) \end{array} & \begin{array}{l} -\frac{3(1-p_2).\alpha_{21}^2}{t} + \\ p_2.(-\frac{3\alpha_{21}^2.y_2}{t} - \frac{3\alpha_{21}^2.(1-y_2)}{t}) \end{array} \end{bmatrix} \quad (55)$$

$$H_{R2} = \begin{bmatrix} \dfrac{\partial^2 \pi_{R2}}{\partial {r_{12}}^2} & \dfrac{\partial^2 \pi_{R2}}{\partial r_{12} \partial r_{22}} \\ \dfrac{\partial^2 \pi_{R2}}{\partial r_{22} \partial r_{12}} & \dfrac{\partial^2 \pi_{R2}}{\partial {r_{22}}^2} \end{bmatrix} \quad (56)$$

$$H_{R2} = \begin{bmatrix} \begin{array}{l} -\frac{3(1-p_1).\alpha_{12}^2}{t} + \\ p_1(-\frac{3\alpha_{12}^2.y_1}{t} - \\ \frac{3\alpha_{12}^2.(1-y_1)}{t} \end{array} & \begin{array}{l} \frac{1}{2}.\frac{(1-p_2).\alpha_{22}.\alpha_{12}}{t} + \\ \frac{1}{2}.\frac{(1-p_1).\alpha_{12}.\alpha_{22}}{t} \\ +\frac{1}{2}.p_2.(\frac{\alpha_{22}.y_2.\alpha_{12}}{t} \\ +\frac{\alpha_{22}.(1-y_2).\alpha_{12}}{t}) \\ +\frac{1}{2}.p_1.(\frac{\alpha_{12}.y_1.\alpha_{22}}{t} \\ +\frac{\alpha_{12}.(1-y_1).\alpha_{22}}{t}) \end{array} \\ \begin{array}{l} \frac{1}{2}.\frac{(1-p_2).\alpha_{22}.\alpha_{12}}{t} + \\ \frac{1}{2}.\frac{(1-p_1).\alpha_{12}.\alpha_{22}}{t} \\ +\frac{1}{2}.p_2.(\frac{\alpha_{22}.y_2.\alpha_{12}}{t} + \\ \frac{\alpha_{22}.(1-y_2).\alpha_{12}}{t}) + \\ \frac{1}{2}.p_1.(\frac{\alpha_{12}.y_1.\alpha_{22}}{t} + \frac{\alpha_{12}.(1-y_1).\alpha_{22}}{t}) \end{array} & \begin{array}{l} -\frac{3(1-p_2).\alpha_{22}^2}{t} + \\ p_2.(-\frac{3\alpha_{22}^2.y_2}{t} - \\ \frac{3\alpha_{22}^2.(1-y_2)}{t}) \end{array} \end{bmatrix} \quad (57)$$

As Hessian matrix of the first retailer profitshows, its first minor determinant is negative and the second minor determinant which is the determinant of Hessian matrix is equal to $\frac{8\alpha_{11}^2.\alpha_{21}^2}{t^2}$; that is a positive value. Therefore, Hessian matrix of the retailer profit is concave. The profit function of the distributors and producers is linear based on the sale price, so it is concave and convex as well and if we use Hessian matrix, all members of the Hessian matrix will be zero. In order to obtain the product sale price at retail, following equations should be solved and the amount of the obtained sale price should be entered into the profit of the distributor chains to obtain the sales price at the distributor chain.The equations are as follows:

$$\begin{cases} \frac{\partial \pi_{R1}}{\partial r_{11}} = 0 \\ \frac{\partial \pi_{R1}}{\partial r_{21}} = 0 \\ \frac{\partial \pi_{R2}}{\partial r_{12}} = 0 \\ \frac{\partial \pi_{R2}}{\partial r_{22}} = 0 \end{cases} \tag{58}$$

Optimal values of retailer prices are as follows:

$$\begin{aligned} r_{11} = {} & (2r + d.t + 4\alpha_{11}.w_{11} - 2\alpha_{12}.w_{12} + 4T_{11}.\alpha_{11}.p_1 - 2T_{12}.\alpha_{12}.p_1 \\ & -4\alpha_{11}.p_1.w_{11} + 2\alpha_{12}.p_1.w_{12} + 4\alpha_{11}.p_1.w_{11}.y_1 - 2.\alpha_{12}.p_1.w_{12}.y_1 \\ & -4T_{11}.\alpha_{11}.p_1.y_1 + 2T_{12}.\alpha_{12}.p_1.y_1) / 6\alpha_{11} \end{aligned} \tag{59}$$

$$\begin{aligned} r_{21} = {} & (2r + d.t + 4\alpha_{21}.w_{21} - 2\alpha_{22}.w_{22} + 4T_{21}.\alpha_{21}.p_2 - 2.T_{22}.\alpha_{22}.p_2 \\ & -4\alpha_{21}.p_2.w_{21} + 2\alpha_{22}.p_2.w_{22} + 4\alpha_{21}.p_2.w_{21}.y_2 - 2.\alpha_{22}.p_2.w_{22}.y_2 - \\ & 4T_{21}.\alpha_{21}.p_2.y_2 + 2T_{22}.\alpha_{22}.p_2.y_2) / 6.\alpha_{21} \end{aligned} \tag{60}$$

$$\begin{aligned} r_{12} = {} & (2r + d.t - 2\alpha_{11}.w_{11} + 4\alpha_{12}.w_{12} - 2T_{11}.\alpha_{11}.p_1 + 4T_{12}.\alpha_{12}.p_1 + 2\alpha_{11}.p_1.w_{11} - 4\alpha_{12}.p_1.w_{12} \\ & -2\alpha_{11}.p_1.w_{11}.y_1 + 4.\alpha_{12}.p_1.w_{12}.y_1 + 2T_{11}.\alpha_{11}.p_1.y_1 - 4T_{12}.\alpha_{12}.p_1.y_1) / 6\alpha_{12} \end{aligned} \tag{61}$$

$$\begin{aligned} r_{22} = {} & (2r + d.t - 2\alpha_{21}.w_{21} + 4\alpha_{22}.w_{22} - 2T_{21}.\alpha_{21}.p_2 + 4T_{22}.\alpha_{22}.p_2 + 2\alpha_{21}.p_2.w_{21} \\ & -4\alpha_{22}.p_2.w_{22} - 2\alpha_{21}.p_2.w_{21}.y_2 + 4\alpha_{22}.p_2.w_{22}.y_2 + 2T_{21}.\alpha_{21}.p_2.y_2 - 4T_{22}.\alpha_{22}.p_2.y_2) / 6\alpha_{22} \end{aligned} \tag{62}$$

By replacing the optimal sales price of the product in the retailerat the distributor's profit and solving the below equations, the optimal sale price at the distributor chain will be obtained.Optimal values of distributer prices are as follows:

$$\begin{cases} \frac{\partial \pi_{D1}}{\partial w_{11}} = 0 \\ \frac{\partial \pi_{D1}}{\partial w_{12}} = 0 \\ \frac{\partial \pi_{D2}}{\partial w_{22}} = 0 \\ \frac{\partial \pi_{D2}}{\partial w_{21}} = 0 \end{cases} \tag{63}$$

$$\begin{aligned} w_{11} = w_{12} = {} & (14r + 18\alpha_{11}c_1 + 18\alpha_{12}c_1 + 3\alpha_{21}c_2 + 3\alpha_{22}c_2 + 7dt - 17T_{11}\alpha_{11}p_1 \\ & -17T_{12}\alpha_{12}p_1 + 3T_{21}\alpha_{21}p_2 + 3T_{22}\alpha_{22}p_2 - 18\alpha_{11}c_1p_1 - 18\alpha_{12}c_1p_1 - 3\alpha_{21}c_2p_2 \\ & -3\alpha_{22}c_2p_2 + 18\alpha_{11}c_1p_1y_1 + 18\alpha_{12}c_1p_1y_1 + 3\alpha_{21}c_2p_2y_2 + 3\alpha_{22}c_2p_2y_2 + \\ & 17T_{11}\alpha_{11}p_1y_1 + 17T_{12}\alpha_{12}p_1y_1 - 3T_{21}\alpha_{21}p_2y_2 - 3T_{22}\alpha_{22}p_2y_2) / 35(\alpha_{11} + \alpha_{12} \\ & -\alpha_{11}p_1 - \alpha_{12}p_1 + \alpha_{11}p_1y_1 + \alpha_{12}p_1y_1) \end{aligned} \tag{64}$$

$$\begin{aligned} w_{21} = w_{22} = {} & (14r + 3\alpha_{11}c_1 + 3\alpha_{12}c_1 + 18\alpha_{21}c_2 + 18\alpha_{22}c_2 + 7dt + 3T_{11}\alpha_{11}p_1 \\ & +3T_{12}\alpha_{12}p_1 - 17T_{21}\alpha_{21}p_2 - 17T_{22}\alpha_{22}p_2 - 3\alpha_{11}c_1p_1 - 3\alpha_{12}c_1p_1 - 18\alpha_{21}c_2p_2 \\ & -18\alpha_{22}c_2p_2 + 3\alpha_{11}c_1p_1y_1 + 3\alpha_{12}c_1p_1y_1 + 18\alpha_{21}c_2p_2y_2 + 18\alpha_{22}c_2p_2y_2 - \\ & 3T_{11}\alpha_{11}p_1y_1 - 3T_{12}\alpha_{12}p_1y_1 + 17T_{21}\alpha_{21}p_2y_2 + 17T_{22}\alpha_{22}p_2y_2) / 35(\alpha_{21} + \alpha_{22} \\ & -\alpha_{21}p_2 - \alpha_{22}p_2 + \alpha_{21}p_2y_2 + \alpha_{22}p_2y_2) \end{aligned} \tag{65}$$

By replacing the optimal sales price of the product in the distributor at the producer's profit and solving the following equations, the optimal sale price at the manufacturer chain in the case of special order is obtained. Optimal values of manufacturer prices are as follows:

$$\begin{cases} \frac{\partial \pi_{M1}}{\partial T_{11}} = 0 \\ \frac{\partial \pi_{M1}}{\partial T_{12}} = 0 \\ \frac{\partial \pi_{M2}}{\partial T_{22}} = 0 \\ \frac{\partial \pi_{M2}}{\partial T_{21}} = 0 \end{cases} \tag{66}$$

$$\begin{aligned} T_{11} = T_{12} = {} & (578a_1 + 51a_2 - 578c_1 - 51c_2 + 518r - 569\alpha_{12}c_1 \\ & -569\alpha_{11}c_1 + 51\alpha_{21}c_2 + 51\alpha_{22}c_2 + 259dt + 578a_1\alpha_{11}p_1 + \\ & 578a_1\alpha_{12}p_1 + 51a_2\alpha_{21}p_2 + 51a_2\alpha_{22}p_2 + 569\alpha_{11}c_1p_1 + 569\alpha_{12}c_1p_1 \\ & -51\alpha_{21}c_2p_2 - 51\alpha_{22}c_2p_2 - 578a_1\alpha_{11}p_1y_1 - 578a_1\alpha_{12}p_1y_1 - 51a_2\alpha_{21}p_2y_2 \\ & -51a_2\alpha_{22}p_2y_2 - 569\alpha_{11}c_1p_1y_1 - 569\alpha_{12}c_1p_1y_1 + 51\alpha_{21}c_2p_2y_2 + \\ & 51\alpha_{22}c_2p_2y_2) / (1147(\alpha_{11}p_1 + \alpha_{12}p_1 - \alpha_{11}p_1y_1 - \alpha_{12}p_1y_1)) \end{aligned} \tag{67}$$

$$\begin{aligned} T_{21} = T_{22} = {} & (51a_1 + 578a_2 - 51c_1 - 578c_2 + 518r + 51\alpha_{11}c_1 + 51\alpha_{12}c_1 \\ & -569\alpha_{21}c_2 - 569\alpha_{22}c_2 + 259dt + 51a_1\alpha_{11}p_1 + 51a_1\alpha_{12}p_1 + 578a_2\alpha_{21}p_2 \\ & +578a_2\alpha_{22}p_2 - 51\alpha_{11}c_1p_1 - 51\alpha_{12}c_1p_1 + 569\alpha_{21}c_2p_2 + 569\alpha_{22}c_2p_2 - \\ & 51a_1\alpha_{11}p_1y_1 - 51a_1\alpha_{12}p_1y_1 - 578a_2\alpha_{21}p_2y_2 - 578a_2\alpha_{22}p_2y_2 \\ & +51\alpha_{11}c_1p_1y_1 + 51\alpha_{12}c_1p_1y_1 - 569\alpha_{21}c_2p_2y_2 - 569\alpha_{22}c_2p_2y_2) / (1147(\alpha_{21}p_2 \\ & +\alpha_{22}p_2 - \alpha_{21}p_2y_2 - \alpha_{22}p_2y_2)) \end{aligned} \tag{68}$$

4. NUMERICAL EXAMPLE

Five numerical examples are solved to demonstrate the functionality and performance of the proposed models. In all examples data were randomly generated. In each instance, it was shown that by changing the important parameters of the problem, the sales price of the product per chain of the supply chain, the demand for each product and the supply chain profit will be changed.

4. 1. Numerical Example in the Exclusive Market

For the different values of the parameters, the values of the decision variables are listed in Table 1. It has shown that how the changes in the important parameters affect the decision variables as well as the total profit of the chain.

In examples 1, 2 and 3 it has shown that by a corresponding increase of $c_1, c_2, a_1, a_2, p_1, p_2, y_1, y_2$; the amount of selling pricesarealso increased in all chains of the supply chain and rising prices lead to reduce the demands for both products. Thus, the profits of the entire chain are reduced. In examples 4 and 5 only the cost of producing and the manufacturer's selling price (c_1, c_2, a_1, a_2) are increased that cause increasing the average of selling price in all chains of the supply chain whereas the demand for both products and profitability are reduced. As shown in the above table, with a simultaneous increase in $c_1, c_2, a_1, a_2, p_1, p_2, y_1, y_2$; the selling prices are increased in all the chains of the supply chain and rising prices lead to reduce the demands for both products. Thus, the profits of the entire chain are reduced and also in cases where only c_1, c_2, a_1, a_2 increase, the selling prices increase in all the chains, the demands for both products and the profits decrease. In Table 3, the up arrow is an increase sign and the down arrow is a decrease sign that show the summary results in Figure 3.

TABLE 1. Parameters for the model in the exclusive and non-exclusive market

Parameters	Case 1	Case 2	Case 3	Case 4	Case 5
r	40	40	40	40	40
t	16	16	16	16	16
d	1	1	1	1	1
α_{11}	0.5	0.5	0.5	0.5	0.5
α_{12}	0.5	0.5	0.5	0.5	0.5
α_{21}	0.5	0.5	0.5	0.5	0.5
α_{22}	0.5	0.5	0.5	0.5	0.5
c_1	7	9	12	14	21
c_2	6	8	10	12	18
a_1	5	6	8	10	15
a_2	4	5	7	8	12
p_1	0.2	0.4	0.7	0.2	0.2
p_2	0.3	0.6	0.65	0.3	0.3
y_1	0.7	0.8	0.9	0.7	0.7
y_2	0.75	0.85	0.9	0.75	0.75
λ_1	0.15	0.15	0.15	0.15	0.15
λ_2	0.14	0.14	0.14	0.14	0.14

TABLE 2. Optimum values of the decision-variables in the exclusive market

Decision variables	Case 1	Case 2	Case 3	Case 4	Case 5
r_{11}	34.5744	35.3454	36.1777	36.9423	39.3103
r_{22}	34.3715	35.0929	35.8236	36.5367	38.7018
w_{11}	31.1240	32.5775	34.3373	35.1173	39.1106
w_{22}	30.6660	32.1605	32.7144	34.0820	37.4980
T_{11}	13.7254	18.9705	18.1512	27.4509	41.1764
T_{22}	10.9803	13.7254	19.7285	21.9607	32.9411
d_1	0.8327	0.78300	0.7278	0.6784	0.5209
d_2	0.8581	0.8145	0.7720	0.7291	0.6001
Total profit	50.9193	47.8989	43.1172	39.4669	29.22463

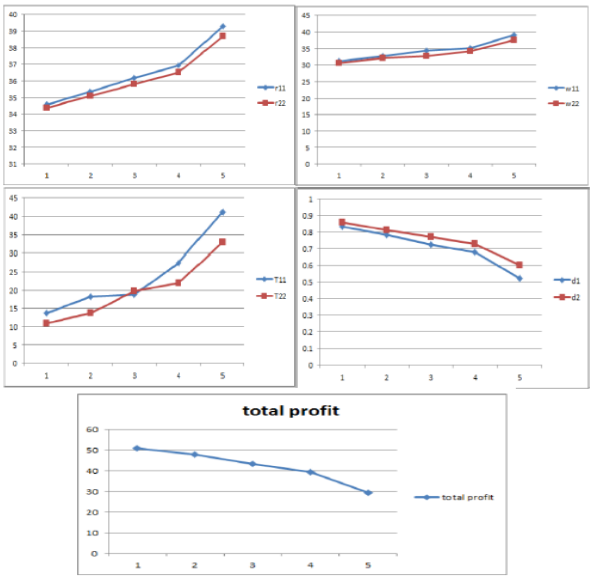


Figure 3. The impactsof changing parameters on the decision variables and benefit of supply chain

TABLE 3. The impacts of changing parameters on the decision variables and benefit of supply chain

Change of parameters								Impact on the decision variables								
c_1	c_2	a_1	a_2	p_1	p_2	y_1	y_2	r_{11}	r_{22}	w_{11}	w_{22}	T_{11}	T_{22}	d_1	d_2	**Total profit of supply chain**
↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↓	↓	↓
↑	↑	↑	↑	-	-	-	-	↑	↑	↑	↑	↑	↑	↓	↓	↓

4. 2. Numerical Examples in the Non-exclusive Market For the different values of the parameters, the values of the decision variables were obtained and results are shown in Table 4. In fact, it has shown that how the changes in the important parameters affected on the decision variables as well as the total profit of the chain. In examples 1, 2 and 3 it has shown that by a corresponding increase of $c_1, c_2, a_1, a_2, p_1, p_2, y_1, y_2$, the amount of selling prices were also increased in all chains of the supply chain and rising prices lead to reduce the demand for both products and thus the profits of the entire chain are reduced. In examples 4 and 5 only the cost of producing and the manufacturer's selling price (c_1, c_2, a_1, a_2) are increased that caused increase in the manufacturer's selling price in all chains of the supply chain whereas the demand for both products and profitability were reduced.

As shown in the above table, with a simultaneous increase in $c_1, c_2, a_1, a_2, p_1, p_2, y_1, y_2$, the selling prices are increased in all the chains of the supply chainand rising prices lead to reduce the demand for both products. Thus, the profits of the entire chain are reduced and also in cases where only c_1, c_2, a_1, a_2 increased, the selling prices increased in all chains, the demand for both products and the profitability also decreased. In Table 5, the up arrow is an increase sign and the down arrow is a decrease sign; these arrows show the summary results in Figure 4.

TABLE 4. Optimum values of the decision variables in the non-exclusive market

Decision variables	Case 1	Case 2	Case 3	Case 4	Case 5
r_{11}	43.2251	43.3140	43.5239	43.7148	44.2045
r_{12}	43.2251	43.3140	43.5239	43.7148	44.2045
r_{21}	43.1623	43.2575	43.4670	43.5896	44.0160
r_{22}	43.1623	43.2575	43.4670	43.5891	44.0160
w_{11}	17.1075	19.1409	21.5955	23.0140	28.9205
w_{12}	17.1075	19.1409	21.5955	23.0140	28.9205
w_{21}	16.4351	18.3907	19.5735	21.4874	26.5398
w_{22}	16.4351	18.3907	19.5735	21.4874	26.5398
T_{11}	204.155	206.9709	293.239	157.137	225.1883
T_{12}	204.155	206.970	293.239	157.137	225.188
T_{21}	189.3009	243.7934	247.6904	153.3157	198.5546
T_{22}	243.7934	189.3009	247.6904	198.5546	153.3157
d_1	0.2964	0.2911	0.27790	0.2638	0.2313
d_2	0.30431	0.2981	0.2850	0.2796	0.2548
Total profit	23.3314	22.4198	20.4044	18.9952	15.1143

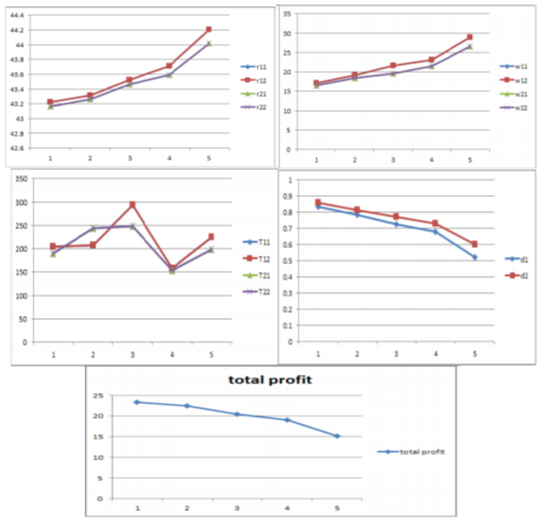


Figure 4. The impact of parameter changing on the decision variables and the benefit of the supply chain

TABLE 5. The effect of changing parameters on the decision variables and the profit of the supply chain

Change of parameters								Impact on the decision variables					
c_1	c_2	a_1	a_2	p_1	p_2	y_1	y_2	r_{jk}	w_{ji}	T_{jk}	d_1	d_2	**Total profit of the supply chain**
↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↓	↓	↓
↑	↑	↑	↑	-	-	-	-	↑	↑	↑	↓	↓	↓

5. CONCLUSION

In this paper, a three-echelon supply chain problem for the pricing of substitute products taking into account the brand value and the disconnection risk between the distributor and the retailer was developed in two states of exclusive and non-exclusive markets; in which the event of disruption risk, the retailer provides its required products by special order and directly from the manufacturer. We showed that in both cases, when the cost of production in the manufacturer chain increases, it causes an increase in the price of the products in the chains of the distributor and retailer which reduces the demand and profitability. In addition, production costs, when the possibility of the disruption risk rises, the product price also increases which causes reduction in the demand and also supply chain profitability in both cases of the exclusive and non-exclusive markets. In this work, the utility function of the demand was used to determine the demand for products. In future research we can use random variable for demand function and the lack of lag and lost sales when the shortage occurs. Based on the obtained results, it can be concluded that in the competitive market, where the competition is on the quality and price, manufacturer selection has the great importance and the retailers can offer several products from these manufacturers to optimize their benefits.

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Optimal Decisions in a Dual-channel Supply Chain for the Substitute Products with the Special Orders under DisruptionRisk and Brand Consideration

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PAPER INFO

Paper history:
Received 28April 2017
Received in revised form 15September 2017
Accepted 02October 2017

Keywords:
Pricing
Three Echelon Supply Chain
Game Theory
Disruption Risk
Special Order
Brand Value; Substitute Product

چکیده

در این مقاله یک زنجیره تامین سه سطحی شامل دو تولید کننده ، توزیع کننده و خرده فروش ارائه شده که هر دو تولید کننده یک نوع کالا با کیفیت و برندهای متفاوت را تولید می کنند. هر تولید کننده، کانال مخصوص به خود را دارد که خرده فروش می تواند به صورت انحصاری کالای مربوط به تولید کننده خود را ارائه و از درصدی تخفیف در خرید کالا از توزیع کننده برخوردار شود(بازار انحصاری) و یا کالا هر دو تولید کننده را ارائه کند(بازار غیر انحصاری). در این مقاله تصمیمات قیمت گذاری کالاهای جایگزین یکسان با برند های متفاوت در بازار انحصاری و غیرانحصاری توسعه داده شده است. مشتریان به دو دسته مشتریان وفادار و مشتریان بی تفاوت تقسیم می شوند که تقاضا کالا برای مشتریان به فاصله از برند و فاصله قیمت محصول تا قیمت ایده آل بستگی دارد. در این مدل خرده فروش کالا مورد نیاز خود را از توزیع کننده خریداری می کند، ممکن است به دلایلی بین خرده فروش و توزیع کننده ریسک انقطاع بوجود آید که در اینصورت تنها درصدی از میزان سفارش خرده فروش توسط توزیع کننده قابل برآورده سازی می باشد و مقدار سفارش برآورده نشده به صورت سفارش ویژه به صورت مستقیم از تولید کننده خریداری می شود. هدف از این تحقیق بیشینه سازی سود کل زنجیره تامین بر اساس نظریه بازیهاستکه مقادیر بهینه قیمت فروش در هر یک از حلقه های زنجیره تامین تعیین شود. در انتها کاربرد مدل با مثال عددی و سپس تحلیل حساسیت روی پارامترهای مهم آن نمایش داده شده است.

doi*: 10.5829/ije.2018.31.05b.11*