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Evaluation of Marketing-Pricing Decisions in a Two-Echelon Supply Chain

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This paper discusses the interaction between one manufacturer and a single retailer in a channel in which both are willing to optimize their profit by adjusting pricing and advertising decisions. The manufacturer produces and sells a product at wholesale price to the retailer who in turn distributes it to consumers with retail price. The market demand is simultaneously affected by retail price, brand advertising of the manufacturer, and local advertising of the retailer. A Cobb-Douglas demand function is used to demonstrate the relationship between the parameters. Decision variables are two firms' prices and their advertising investments. The problem is modelled under integrated policy and Stackelberg game. Also, we examine Retail Fixed Markup (RFM) policy and investigate its performance on supply chain. Then, the solution under three policies compared by numerical study, and the Pareto-efficient strategy is derived. We found numerically that a properly designed RFM policy improves each member's profit and leads to Pareto improvement over Stackelberg policy. Besides, it improves the total supply chain's profit by 600% in average comparing to Stackelberg policy.

Keywords: *marketing, pricing, price-dependent demand, retail fixed markup, supply chain.*
JEL Classification: L06, L11, M03, M31, M37, R32

Introduction

In recent years a considerable amount of research has been conducted on different aspects of supply chain such as pricing, marketing, production, distribution, purchasing, inventory management, etc. The retailer–manufacturer interaction problem is one of the classical research areas in the supply chain literature. (a) How should the members of supply chain behave in order to manage their costs/profits? (b) How can the manufacturer take advantages of his leadership in order to increase his profit and the retailer's? Answering these questions is our purpose in this research.

To answer question (a), one approach is known as centralized/integrated policy. It ignores the competition between the members with the aim of maximizing the total system profit. But it may be impractical and undesirable in many cases due to incentive conflicts. Another approach is decentralized policy, in which each member independently chooses his strategy in a way that the overall system efficiency couldn't necessarily be optimized. In other words, this approach often causes lost profits for the whole system comparing to centralized approach.

To answer question (b), we know that different decentralized approaches leads to different system efficiency. In the other hand, each member prefers an approach which cause more profit to him. In this research we examine two approaches: Stackelberg and RFM. In Stackelberg policy, the leader of the game (manufacturer) sets his wholesale price and national advertising investment first, and then the follower (retailer) observes this decision and chooses his retail price and local advertising. While in RFM policy, the manufacturer chooses his decisions similar to Stackelberg, but the retailer only decides on local investment. Since, he receives a fixed markup; and, choosing the wholesale price by manufacturer is equivalent to setting the retail price. It is shown that RFM policy not only improves the total channel's profit, but also, improves each member's profit. So, RFM policy leads to Pareto improvement over Stackelberg policy.

In this paper, we consider a two-echelon supply chain including one manufacturer in the upstream and a single retailer in the downstream of the channel. Optimal advertising investments and pricing decision is discussed in this supply chain. The manufacturer and retailer want to maximize their profit by adjusting Marketing and Pricing decisions. The market demand is simultaneously affected by retail price, and advertising efforts, and, is a decreasing and convex function of the price, but an increasing and concave function of the retailer's and manufacturer's advertising investment. Both firms use advertising programs to encourage customers to purchase the product. The manufacturer promotes the product by brand advertising, while the retailer supports the manufacturer's product by local advertisement. We model the problem under integrated policy, and as a Stackelberg game in which the manufacturer is the leader. Then, we consider Retail Fixed Markup (RFM) policy discussed by Liu *et al.* (2006), and, examine its performance on the retailer's, manufacturer's, and total channel's profit. In RFM policy, the manufacturer sets the wholesale price first, that is equivalent to setting the retail price. The decision variables are wholesale and retail prices and advertising investments of the retailer and manufacturer.

We don't claim that RFM can coordinate the channel. In contrast, our results show that RFM does not coordinate the channel. We say one policy can coordinate the channel if it improves all the members' profit comparing to other possible decentralized policies, and leads to equal total profit comparing to centralized/integrated policy.

This supply chain can be considered either "Competitive" or "Cooperative". Since, each member of the channel is willing to optimize his own decisions and objectives. In the other hand, the both members contribute to the advertising cost in order to increase the demand and their profit.

The reminder of the paper is organized as follows. The next section reviews the related literature. Section 3 describes the notations, assumptions, and the two firms' objective functions. Then we develop integrated, Stackelberg, and Retail Fixed Markup policies for the problem in section 4. We present a numerical study and the corresponding sensitivity analysis for some parameters with the purpose of evaluating the influence of these parameters on profits, the two firms' decision and evaluating Pareto-improving region in section 5. Finally, section 6 summarizes the results and covers the concluding remarks.

Literature review

Many papers in the recent years have been published in the different aspects of supply chain. Our research is related, at least in spirit, to channel coordination in supply chain. Here, we review some related papers that consider marketing-pricing decisions, Retail Fixed Markup, and coordination mechanisms.

In Stackelberg game setting, Eliashberg and Steinberg (1987) consider production activities and their relation to marketing strategies such as pricing policies. Some other authors study similar problem for a two-echelon supply chain with deterministic price-dependent demand curve, either liner or Iso-elastic. (e.g. Arcelus and Srinivasan, 1987; Li *et al.* 1995; Ertek and Griffin, 2002). Other papers analyze multi-echelon inventory systems by appling Stackelberg game (e.g. Lau and Lau, 2004; 2005; Yang and Zhou, 2006; Chu *et al.* 2006; Liou *et al.* 2006).

There have been extensive researches that investigate the coordinating of a supply chain. Qin *et al.* (2007) study the problem in which the vendor offers a price discount in a system with price-sensitive demand. Cachon and Zipkin (1999) examine some incentive contracts to coordinating the two-echelon supply chain. Viswanathan and Piplani (2001) study a coordination problem in which the vendor offers a price discount to persuade the buyers to replenish only at the specific time periods. Cachon and Lariviere (2005) consider some coordination mechanisms such as revenue sharing, price-discount, buy-back, quantity discounts, franchise fee, quantity-flexibility, and sales-rebate contracts. Huang *et al.* (2011) study coordinating pricing, inventory decisions, and supplier selection in a supply chain in which demand is price dependent.

Some recently published papers consider coordination problem with marketing-pricing decisions in a two echelon supply chain in which the market demand simultaneously affected by price and advertising efforts of both firms: Yue *et al.* (2006) investigate the price discount scheme in order to achieve coordinating the channel. Karray and Martín-Herrán (2008) study a three-stage game-theoretic model; they proceed to study an advertising and pricing competition between national and store brands in Karray and Martín-Herrán (2009). He *et al.* (2009) model this problem as a stochastic Stackelberg differential game; Szmerekovsky and Zhang (2009) model it as a Stackelberg game in which the manufacturer is the leader. Xie and Wei (2009) consider cooperative and Stackelberg game. Xie and Neyret (2009) and SeyedEsfahani *et al.* (2011) investigate this problem with different demand functions by applying four game-theoretic models including cooperative, Nash, Stackelberg-retailer and Stackelberg-manufacturer games; Kunter (2012) applies cost and revenue sharing mechanism to coordinate the channel.

There is sufficient evidence that RFM exists in practice. Many industries operate by using fixed Mark-ups such as gasoline dealers, grocers, and electronics industry. In addition, RFM is also considered in marketing literature. For example see (Bresnahan and Reiss, 1985; Kadiyali *et al.*, 1996; 1999). Liu *et al.* (2006) consider a RFM policy and examine the behavior of a retailer and a single manufacturer in a decentralized channel under price-dependent demand. They also formulate the problem under price-only contract, and, show that RFM leads to Pareto improvement over the price-only contract. Li and Atkins (2002) introduce a model similar to Liu *et al.* (2006)'s, but for marketing and operation sections in a single firm. Although, RFM policy in our model and Liu *et al.* (2006)'s model does not achieve channel coordination, Ha (2001) propose one policy similar to RFM under price-dependent demand that is capable to coordinate the channel.

Model formulation

Notation and assumptions

In this paper, we use a notation for representing the parameters and the decision variables to model the Marketing-Pricing problem in a two-echelon supply chain. A one manufacturer and a single retailer channel is considered, in which the manufacturer sells the product to consumers through a retailer. The manufacturer has a fixed production cost ($c_M \geq 0$) per unit product and the retailer has a fixed distribution cost ($c_R \geq 0$) per unit. Also, the manufacture sells the product with wholesale price ($w > c_M$) to the retailer who in turn sells it with the retail price ($p > w + c_R$) to the customers. The manufacturer decides on the National advertising expenditures *m*, and wholesale price *w*. On the other hand, the retailer decides on the local advertising investment *r*, and retail price *p*. The market demand is simultaneously affected by retail price, advertising investment of the retailer and manufacturer. The manufacturer's advertising investment planned for influencing potential consumers to consider the product's brand. However, the retailer's one is to motivate customers' buying behaviour.

Suppose that the total market demand is a decreasing and convex function of the price, but an increasing and concave function of the retailer's and manufacturer's advertising investment. We use a Cobb-Douglas demand function to demonstrate the relationship between the parameters. A Cobb-Douglas demand function represent the relationship of the market demand to the price, retailer's and manufacturer's advertising investments with their elasticity parameters. Note that this function is concave/convex, continuous and has a constant elasticity. It is widely used in economics, for example Goyal and Gunasekaran (1995) propose a model in which demand is a function of price and number of times that the product advertised. We will use this demand function similar to Yu *et al.* (2009). Assume that the demand function is specified by $D(r,m,p) = Kr^{\alpha}m^{\beta}/p^{\gamma}$ where *k* is a positive constant characterizing the market scale, and *p*, *r* and *m* represent the price, retailer's and manufacturer's advertising investment, respectively. Besides, α, β and γ stand for the elasticity of *r*, *m* and *p*, respectively. It is necessary to assume $\gamma > 0$ in order to guarantee the convexity of $D(r,m,p)$ in p. in addition, $0 < \alpha < 1$ and $0 < \beta < 1$ to ensure the concavity of demand function in *r* and *m*.

Furthermore, $\prod_{i}^{j}$ represent the firm's *i* profit function at policy *j* where $i \in \{R, M, T\}$ and $j \in \{I, S, F\}$. *R*, *M*, and *T* stand for the retailer, manufacturer, and total supply chain respectively. And *I*, *S*, and *F* correspond to Integrated, Stackelberg, and Retail Fixed Markup (RFM) policies, respectively. We consider three policies: Centralized/Integrated, Decentralized with Stackelberg game, and Retail Fixed Mark up (RFM) policy.

Two firm's objective function

The objective function of each firm has two parts: one is the revenue from selling the product and another is the cost from advertising investment. In this case the manufacturer's profit is $(w - c_M)D(r,m,p) - m$, and the retailer profit is $(p - w - c_R)D(r,m,p) - r$. Each firm is willing to optimize his profit. The decision variables are the retail price (*p*), wholesale price (*w*), retailer's advertising investment (*r*), and manufacturer's advertising investment (*m*).

Policies

Integrated policy

In the integrated or centralized policy, the manufacturer together with the retailer considered as a one single firm, so, the goal is maximizing the whole supply chain's profit. The integrated profit is an upper bound for RFM and Stackelberg policies' profit. Here, there are three decision variables to determine, and there is no wholesale price to optimize. We denote integrated solution by (p^*, m^*, r^*). The objective function is the sum of two firm's profit:

$$\prod_T^I = (p - c_M - c_R)D(r,m,p) - r - m;\quad D(r,m,p) = Kr^{\alpha}m^{\beta}p^{-\gamma} \tag{1}$$

Proposition 1

(I) Integrated retail price and two firm's advertising investment are:

$$p^* = \frac{\gamma}{\gamma - 1}(c_M + c_R),$$
$$m^* = \sqrt[1-\alpha-\beta]{\frac{k\beta^{1-\alpha}\alpha^{\alpha}}{(c_M + c_R)^{\gamma-1}} * \frac{(\gamma-1)^{\gamma-1}}{\gamma^{\gamma}}},$$
$$r^* = \sqrt[1-\alpha-\beta]{\frac{k\alpha^{1-\beta}\beta^{\beta}}{(c_M + c_R)^{\gamma-1}} * \frac{(\gamma-1)^{\gamma-1}}{\gamma^{\gamma}}}$$

(II) And, Integrated profit is:

$$\prod_T^I = \frac{(1 - \alpha - \beta)}{\alpha} r^*$$

Proof: by considering $\partial D/\partial p = -\gamma D(r,m,p)/p$, $\partial D/\partial r = \alpha D(r,m,p)/r$ and $\partial D/\partial m = \beta D(r,m,p)/m$, the first order conditions are:

$$\begin{aligned} \frac{\partial \prod_T^I}{\partial p} &= D(r,m,p)\left[1 - \frac{\gamma}{p}(p - c_M - c_R)\right] = 0 \\ \frac{\partial \prod_T^I}{\partial r} &= \frac{\alpha}{r}D(r,m,p)(p - c_M - c_R) - 1 = 0 \\ \frac{\partial \prod_T^I}{\partial m} &= \frac{\beta}{m}D(r,m,p)(p - c_M - c_R) - 1 = 0 \end{aligned} \tag{2}$$

By solving the above equations, we get the optimal solution as in part (I). The Hessian matrix is negative definite. Since $H_{11} < 0$, $H_{11}H_{22} > 0$ and $H_{11}(H_{22}H_{33} - H_{23}H_{32}) < 0$. So, $\prod_T^I$ is concave in *p*, *r*, and *m* and have maximum:

$$H = \begin{bmatrix} \frac{\partial^2 \prod_T^I}{\partial p^2} & \frac{\partial^2 \prod_T^I}{\partial p \partial r} & \frac{\partial^2 \prod_T^I}{\partial p \partial m} \\ \frac{\partial^2 \prod_T^I}{\partial r \partial p} & \frac{\partial^2 \prod_T^I}{\partial r^2} & \frac{\partial^2 \prod_T^I}{\partial r \partial m} \\ \frac{\partial^2 \prod_T^I}{\partial m \partial p} & \frac{\partial^2 \prod_T^I}{\partial m \partial r} & \frac{\partial^2 \prod_T^I}{\partial m^2} \end{bmatrix} = \begin{bmatrix} \frac{-(\gamma-1)^3}{\gamma(c_M + c_R)^2}\frac{r}{\alpha} & 0 & 0 \\ 0 & -\frac{1-\alpha}{r} & \frac{\alpha}{r} \\ 0 & \frac{\alpha}{r} & -\frac{1-\beta}{m} \end{bmatrix} \tag{3}$$

Part (II) can be proved by considering EQ (1) and EQ (2).

According to part (I), if $0 < \gamma < 1$, then the price has a negative value, and will lead to negative profit. So, we focus only on situation where $\gamma > 1$. Furthermore, according to part (II), it is necessary to $1 - \alpha - \beta$ to have a positive value.

Stackelberg policy

In the Stackelberg (Stag) approach, players are classified as leader and follower. The leader chooses his strategy first, and then the follower observes this decision and makes his own strategy. It is necessary to assume that each enterprise is not willing to deviate from maximizing his profit. In other words, each player chooses his best strategy. Here, the manufacturer is the leader, and the retailer is the follower. The manufacturer determines his wholesale price and advertising investment and acts as a leader by announcing it to the retailer in advance, and the retailer acts as a follower by choosing his retail price and advertising investment based on the manufacturer strategy. We denote Stag solution by (w_S, p_S, m_S, r_S). The objective functions for the retailer and manufacture are as below:

$$\begin{aligned} &\Pi_R^S = (p - w - c_R)D(r,m,p) - r, \\ &\Pi_M^S = (w - c_M)D(r,m,p) - m; \\ &D(r,m,p) = Kr^\alpha m^\beta p^{-\gamma} \end{aligned} \tag{4}$$

Proposition 2

(I) The optimal decisions in Stag policy are:

$$w_S = \frac{1-\alpha}{\gamma-1}c_R + \frac{\gamma-\alpha}{\gamma-1}c_M$$

$$p_S = \frac{\gamma-\alpha}{\gamma-1}\times\frac{\gamma}{\gamma-1}(c_R+c_M)$$

$$m_S = \sqrt[1-\alpha-\beta]{\frac{k\alpha^\alpha\beta^{1-\alpha}}{(c_R+c_M)^{\gamma-1}}\times\frac{(\gamma-1)^{2\gamma-\alpha-1}}{\gamma^\gamma(\gamma-\alpha)^{\gamma-\alpha}}}$$

$$r_S = \sqrt[1-\alpha-\beta]{\frac{k\alpha^{1-\beta}\beta^\beta}{(c_R+c_M)^{\gamma-1}}\times\frac{(\gamma-1)^{2\gamma+\beta-2}}{\gamma^\gamma(\gamma-\alpha)^{\gamma+\beta-1}}}$$

(II) The two firms' profits at Stackelberg policy are:

$$\Pi_R^S = \frac{1-\alpha}{\alpha}r_S, \quad \Pi_M^S = \frac{\gamma-1}{\gamma-\alpha}\times\frac{1-\alpha-\beta}{\alpha}r_S$$

Proof: the first order conditions for the retailer are as follows by considering $\partial D/\partial p = -\gamma D(r,m,p)/p$ and $\partial D/\partial r = \alpha D(r,m,p)/r$:

$$\begin{aligned} &\frac{\partial \Pi_R^S}{\partial p} = D(r,m,p)\left[1 - \frac{\gamma}{p}(p - w - c_R)\right] = 0 \\ &\frac{\partial \Pi_R^S}{\partial r} = \frac{\alpha}{r}D(r,m,p)(p - w - c_R) - 1 = 0 \end{aligned} \tag{5}$$

Solving the above equations, we get the optimal solution for given *w* and *m* as follows:

$$\begin{aligned} &p = \gamma(w + c_R)/(\gamma - 1) \\ &r = \sqrt[\alpha-1]{\frac{\gamma^\gamma}{(\gamma-1)^{\gamma-1}}\times\frac{(w+c_R)^{\gamma-1}}{\alpha k m^\beta}} \end{aligned} \tag{6}$$

Bear in mind that the Hessian matrix is a negative definite matrix, so Π_R^S is concave in *p* and *r*, and have a maximum value.

$$\begin{bmatrix} \frac{\partial^2\Pi_R^S}{\partial p^2} & \frac{\partial^2\Pi_R^S}{\partial p\partial r} \\ \frac{\partial^2\Pi_R^S}{\partial r\partial p} & \frac{\partial^2\Pi_R^S}{\partial r^2} \end{bmatrix} = \begin{bmatrix} \frac{-(\gamma-1)^3 r}{\gamma\alpha(w+c_R)^2} & 0 \\ 0 & -\frac{1-\alpha}{r} \end{bmatrix} \tag{7}$$

By substituting obtained values for *p* and *r* in the manufacturer's function, we get the following equation which is a function of only *w* and *m*:

$$\Pi_M^S = (w - c_M)\times(w + c_R)^{\frac{\gamma-\alpha}{\alpha-1}}\times m^{\frac{-\beta}{\alpha-1}} \times \sqrt[\alpha-1]{\frac{\gamma^\gamma}{\alpha^\alpha k}\left(\frac{1}{\gamma-1}\right)^{\gamma-\alpha}} - m \tag{8}$$

Then, the first order conditions for the manufacturer are:

$$\begin{aligned} &\frac{\partial \Pi_M^S}{\partial w} = D(r,m,p)\left[1 + \frac{w-c_M}{w+c_R} * \frac{\gamma-\alpha}{\alpha-1}\right] = 0 \\ &\frac{\partial \Pi_M^S}{\partial m} = (w - c_M)\frac{\beta}{1-\alpha}\frac{D(r,m,p)}{m} - 1 = 0 \end{aligned} \tag{9}$$

Solving the above equations together with EQ (6), part (I) will be proved. Similarly, Π_M^S is concave in *w* and *m*, because the Hessian matrix is a negative definite matrix.

$$H = \begin{bmatrix} \frac{\partial^2\Pi_M^S}{\partial w^2} & \frac{\partial^2\Pi_M^S}{\partial w\partial m} \\ \frac{\partial^2\Pi_M^S}{\partial m\partial w} & \frac{\partial^2\Pi_M^S}{\partial m^2} \end{bmatrix} = \begin{bmatrix} \frac{-(\gamma-1)^3 m}{\beta(\gamma-\alpha)(1-\alpha)(c_M+c_R)^2} & 0 \\ 0 & -\frac{1-\alpha-\beta}{m(1-\alpha)} \end{bmatrix} \tag{10}$$

Also, Part (II) can be proved in the same way as we proved in proposition 1.

Retail Fixed Markup (RFM) policy

In this policy, the manufacturer sets his wholesale price first. Next the retailer chooses his advertising investment. Here, similar to Stackelberg policy the manufacturer sets his decisions by considering that the retailer will choose his best strategy. The retailer receives a fixed markup ($\theta = 1 - w/p$). So, choosing the wholesale price by manufacturer is equivalent to setting the retail price. We denote integrated solution by (w_F, p_F, m_F, r_F). By Substituting $w = (1-\theta)p$ to EQ (4), we get the objective functions of two firms under RFM as below:

$$\begin{aligned} &\Pi_M^F = [(1-\theta)p - c_M]D(r,m,p) - m, \\ &\Pi_R^F = (\theta p - c_R)D(r,m,p) - r; \\ &D(r,m,p) = Kr^\alpha m^\beta p^\gamma \end{aligned} \tag{11}$$

Proposition 3

(I) The optimal retail price is one of the roots of the following equation:

$$\theta(1-\theta)(\gamma-1)p_F^2 + \gamma c_R c_M + [(1-\alpha-\gamma)(1-\theta)c_R - \theta(\gamma-\alpha)c_M]p_F = 0$$

(II) Other optimal variables are:

$$w_F = (1-\theta)p_F$$

$$m_F = \sqrt[1-\alpha-\beta]{k\alpha^\alpha\beta^{1-\alpha}\left[\frac{(1-\theta)p_F - c_M}{1-\alpha}\right]^{1-\alpha}\frac{(\theta p_F - c_R)^\alpha}{p_F^\gamma}}$$

$$r_F = \sqrt[1-\alpha-\beta]{k\alpha^{1-\beta}\beta^\beta\left[\frac{(1-\theta)p_F - c_M}{1-\alpha}\right]^\beta\frac{(\theta p_F - c_R)^{1-\beta}}{p_F^\gamma}}$$

(III) The two firms' profit at RFM policy is:

$$\Pi_R^F = \frac{1-\alpha}{\alpha}r_F$$

$$\Pi_M^F = \frac{(1-\alpha-\beta)}{\alpha(1-\alpha)}\left[\frac{(1-\theta)p_F - c_M}{\theta p - c_R}\right]r_F$$

Proof: the retailer's investment for given *m* and *p* is obtained from:

$$\frac{\partial \Pi_R^F}{\partial r} = \frac{\alpha}{r}(\theta p - c_R)D(r,m,p) - 1 = 0 \tag{12}$$

By substituting obtained value for r in the manufacturer's function and differentiating it respect to p and m, we get the following two equations:

$$D(r,m,p) * \left\{1-\theta+\frac{[(1-\theta)p_F-c_M]}{\alpha-1}\left[\frac{\gamma}{p}-\frac{\theta\alpha}{\theta p-c_R}\right]\right\}=0$$
$$[(1-\theta)p_F-c_M]\left[\frac{\beta r}{\alpha(1-\alpha)(\theta p-c_R)m}\right]-1=0 \quad (13)$$

Solving the above equations results part (I) and (II). Furthermore, Part (III) can be proved in the same way as we proved in proposition 1.

Numerical study

We perform a numerical study to quantify our analytical results and concepts from the previous sections to achieve some managerial insights. We present a base case to compare the results of different policies. Then, we illustrate the Pareto-improving region through a numerical study. Finally, we present a sensitivity analysis of results by changing the values of some parameters. We applied MAPLE 12 for evaluating the problem.

Base case

In our numerical study, we consider the same base-case values which used in YU et.al (2009). Values for input parameters presented in Table 1.

Table 1

Parameter values of the base-case

Parameter	α	β	γ	c_M	c_R	k
Value	0.43	0.39	1.3	20	20	350

Table 2 summarizes the solutions of three policies for the base-case values. In RFM policy it is assumed that θ is equal to 0.54. As shown in the table, the retailer's and manufacturer's profit at RFM policy is higher than those of Stag policy. The manufacturer's, retailer's, and total supply chain's profit increased by 1843%, 369%, and 516%, respectively at RFM policy comparing to Stag policy.

Table 2

Solutions of two approaches for the Base-case Example

	Integrated	Stackelberg	RFM(0.54)
w^*	-	96	81.3
p^*	173.3	502.6	176.7
$r^*(10^5)$	438	7.4	34.6
$m^*(10^5)$	397	2.3	44.8
$\Pi_M(10^5)$	-	1.06	20.6
$\Pi_R(10^5)$	-	9.79	45.9
$\Pi_T(10^6)$	18.3	1.08	6.66

Lemma 1: the manufacturer's profit (Π_M^F) and the retailer's profit (Π_R^F) are concave in θ and have a maximum value.

Proof: Due to complexity of the problem, we show the concavity of the profit functions numerically. Figure 1 illustrate the two firm's profit respect to θ. There exist θ_1, and $\theta_2$such that maximize the retailer's and manufacturer's profit, respectively. As shown in the figure, both the profit functions are concave. We know that sum of two concave function will be concave. Consider that $\theta_1 = 0.58$ and $\theta_2 = 0.45$, we can say that the value of θ that maximize whole system's profit at RFM policy is between 0.45 and 0.58. Here, when$\theta^* = 0.54$, the total channel's profit is maximized.

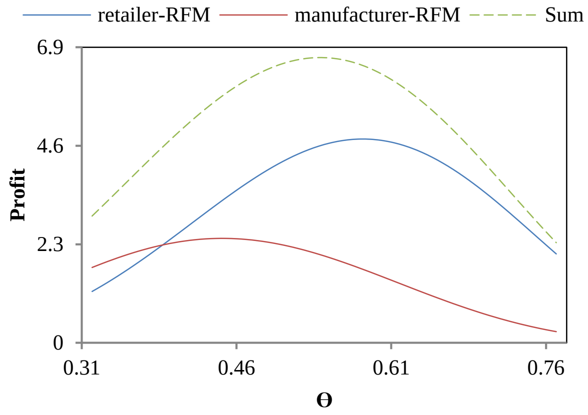

Figure 1. Two firms' and supply chain's profit in θ

Figure 2 illustrates the retailer's and manufacturer's profit functions with respect to θ under the RFM and Stackelberg policies. As shown in the figure, the retailer will prefer RFM policy to Stag policy if θ is between 0.31 and 0.82, similarly the manufacturer will benefit from RFM policy if θ is between 0.12 and 0.81. So, $\theta \in (0.31, 0.81)$ is a Pareto-Efficient strategy.

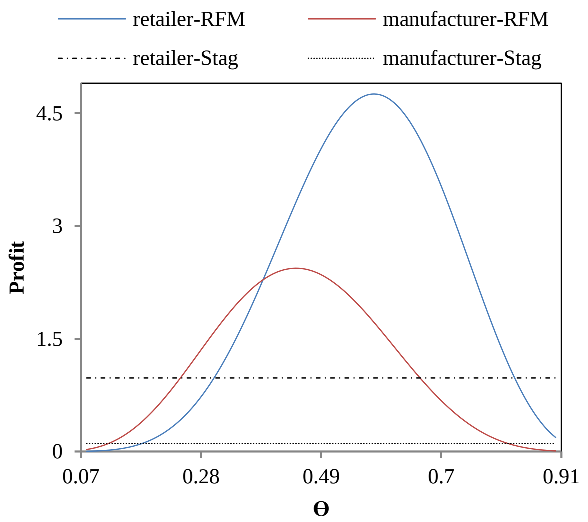

Figure 2. Two firms' profit at Stag and RFM policies respect to θ

Lemma 2: RFM policy with $\theta \in (\underline{\theta}, \overline{\theta})$ leads to Pareto improvement over the Stag policy if θ satisfies the both following constraints:

$$r_F \geq r_S, \quad \frac{(1-\theta)p-c_M}{(\theta p-c_R)(1-\alpha)} r_F \geq \frac{\gamma-1}{\gamma-\alpha} r_S \quad (14)$$

We investigate this Lemma numerically. RFM (θ) will be a Pareto-efficient strategy if both the retailer and manufacturer can benefit from it comparing to Stag policy, in other words, we should have $\Pi_R^F \geq \Pi_R^S$ and $\Pi_M^F \geq \Pi_M^S$

which are equivalent to EQ (14). It can be proved easily from simultaneously using part (II) of proposition (II) and part (III) of proposition (III). From Lemma 2, for base case data $\theta \in (0.31, 0.81)$ is a Pareto-efficient strategy. We investigate this interval numerically. We found that, the interval $(\underline{\theta}, \overline{\theta})$ is absolutely less sensitive to α and k for $\alpha \in (0.35, 0.55)$ and $k \in (300,400)$. Figure 3 and 4 illustrate the variations of this region with respect to γ and c_R, respectively.

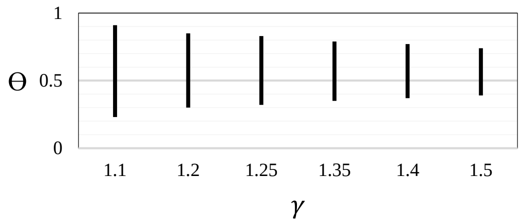

Figure 3. Pareto-improving region in γ

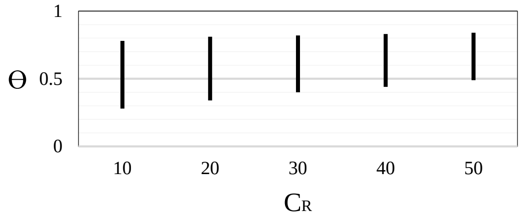

Figure 4. Pareto-improving region in c_R

Sensitivity analysis

In this subsection, we perform a sensitivity analysis by changing the values of major parameters in the base-case. We define ρ as the supply chain's percentage improvement at RFM policy comparing to Stag policy. Table 3 shows the Sensitivity analysis of total supply chain profit at Stag and RFM policies and percentage improvement of RFM policy. Consider that θ^* at RFM policy maximize the total supply chain's profit. Also, Table 4 shows the variations of decision variables at three policies.

Table 3

Solutions under variation of Base-Case Parameters

Solutions→		Stag	RFM(θ^*)		
Parameters↓		$\prod_T^S(10^5)$	θ^*	$\prod_T^F(10^5)$	ρ
α	0.35	0.12	0.51	0.48	300
	0.45	71	0.55	517	628
β	0.3	0.14	0.58	0.35	150
	0.4	23.7	0.54	171	621
γ	1.2	144	0.54	1270	782
	1.5	0.06	0.54	0.27	350
k	300	4.6	0.54	28	508
	400	22.8	0.54	140	514
c_R	0	34.5	0.42	205	494
	50	4.2	0.59	26	519
c_M	5	23.8	0.61	144	505
	50	4.3	0.49	26	504

Table 4

Decision variables under variation of Base-Case Parameters

Solutions→		Integrated			Stag				RFM(θ^*)			
Parameters↓		P	r(10^5)	m(10^5)	w	p	r(10^3)	m(10^3)	w	p	r(10^3)	m(10^3)
α	0.35	173	1.2	1.34	107	549	5.6	1.9	85	174	16	26
	0.45	173	4690	4070	93	491	5260	1600	80	177	30000	36500
β	0.3	173	0.96	0.67	96	503	9	2.2	77	183	17	14
	0.4	173	1300	1210	96	503	1620	520	81	177	9050	12000
γ	1.2	240	8330	7560	134	924	10000	2370	112	245	65700	86200
	1.5	120	1.78	1.62	66	256	4.1	1.7	56	122	14	18
k	300	173	186	168	96	503	314	98	81	177	1470	1900
	400	173	920	833	96	503	1550	485	81	177	7270	9400
c_R	0	87	1390	1260	58	251	2340	733	58	100	10300	14900
	50	303	170	156	153	880	290	91	117	285	1350	1770
c_M	5	108	957	868	53	314	1600	506	38	98	7440	9870
	50	303	172	156	183	880	290	91	169	331	1340	1780

Furthermore, we solve 1000 problems and drive conclusions about the results. To evaluate the RFM policy, we set $= \theta^*$, and other parameters generated randomly as: $\alpha \in (.38, .45)$, $\beta \in (.38, .45)$, $\gamma \in (1.2, 1.4)$, $k \in (300,400)$, $c_R \in (10,30)$, $c_M \in (30,50)$.

Solving the problems, we found that both the retailer and manufacturer can benefit from RFM (θ^*) comparing to Stag policy in all problems. Then, we examine the percentage improvement of this policy comparing to Stag policy. Table 5 shows the results. The manufacturer's and retailer's profit increased at least by 900% and 156% respectively. Also, The Stag policy's average efficiency is about 6% of that of integrated policy, while increased to 37% at RFM (θ^*) policy.

Figures 5, 6, 7 and 8 illustrate the influence of α or γ on prices, demand and total profit. We set $\theta = \theta^*$ at RFM policy in which the total supply chain's profit maximized. It is obvious that the retail price at Stag policy is much greater than those of other policies, so, much more demand will be lost in this policy because of higher retail price. The retail and wholesale prices are decreasing in γ, while, they are not considerably changed by changing the value of α.

Table 5

Percentage improvement of RFM comparing to Stag policy

	Manufacture	Retailer	Total
Average	2395	440	615
Minimum	900	156	252
Maximum	11370	1870	2420
Mode	2135	286	567

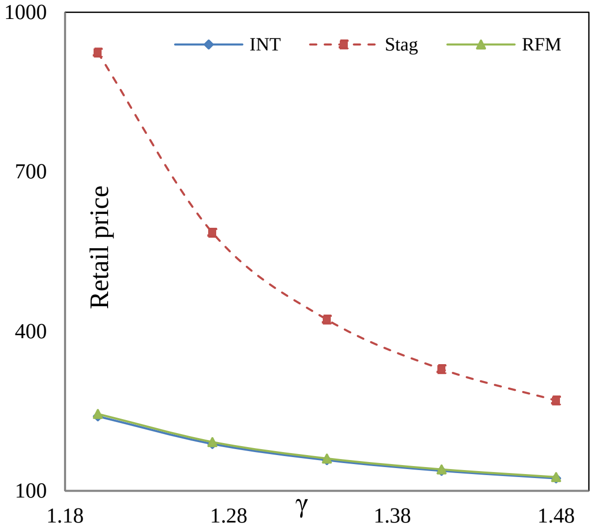

Figure 5. The impact of γ on Retail price

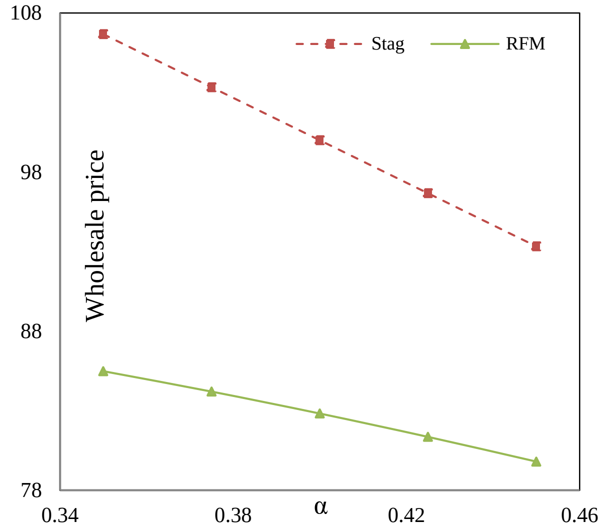

Figure 6. The impact of α on Wholesale price

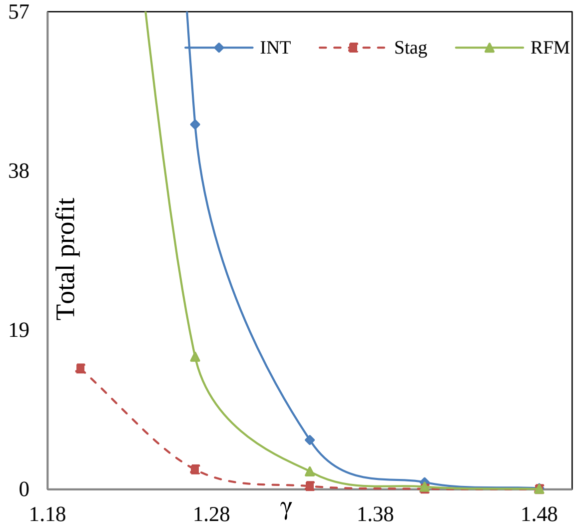

Figure 7. The impact of γ on Total profit

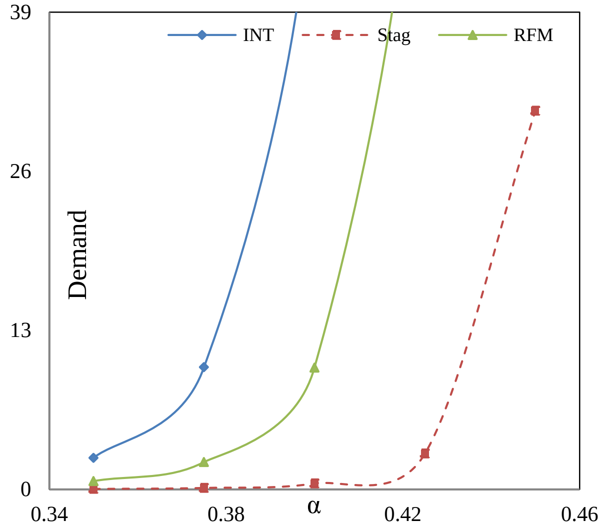

Figure 8. The impact of α on Demand

Conclusions

This paper has studied the retailer-manufacturer problem in which the market demand is a decreasing and convex function of the retail price, but an increasing and concave function of advertising investment of two firms. Both firms are willing to optimize their profit by adjusting pricing and advertising decisions. We compare the problem under integrated and Stackelberg policies. Then, we examine Retail Fixed Markup (RFM) policy and investigate its performance on supply chain.

We found numerically that: (a) a properly designed RFM improves each member's profit and leads to Pareto improvement over Stackelberg policy. The manufacturer's and retailer's profit increased at least by 900% and 156% respectively comparing to Stackelberg policy. Besides, it improves the total supply chain's profit by 600% in average comparing to Stackelberg policy. (b) Both the manufacturer's and the retailer's profit are concave in Retail Fixed Markup rate and have a maximum value. Consequently, the total channel's profit is concave and has a maximum. (c) The Pareto-improving region is less sensitive to some parameters such as investment's elasticity and scale *k*, while other parameters such as price's elasticity, production and distribution costs have considerable effect on the region. (d) RFM policy's average efficiency is 37% of that of integrated policy. So, there is an opportunity to achieve higher channel efficiency than this.

Our research has some limitations for future research. We consider a channel with one manufacturer and a single retailer that is not in accordance with real world supply chains. So, a more general model with multiple retailers or multiple manufacturers will produce interesting results. In addition, one can adopt a more general demand function to investigate the problem.

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Dvipakopės tiekimo grandinės įvertinimas priimant sprendimus dėl kainų nustatymo

Santrauka

Pastaraisiais metais buvo atlikta daug tyrimų, susijusių su įvairiais tiekimo grandinės aspektais: kainų nustatymu, rinkodara, gamyba, paskirstymu, pirkimu, turto valdymu, ir t. t. Mažmenininko ir gamintojo tarpusavio sąveikos problema yra viena iš klasikinių tyrimo sričių, kuri yra analizuojama mokslinėje literatūroje apie tiekimo grandines. Šiuo tyrimu siekiama atsakyti į keletą klausimų: „Kaip turėtų elgtis tiekimo grandinės dalyviai norėdami valdyti savo pelną?" ir „Kaip gamintojas gali panaudoti savo lyderystės privalumus, norėdamas padidinti savo ir mažmenininko pelną?"

Šiame darbe nagrinėta dvipakopė tiekimo grandinė, kurioje yra vienas gamintojas ir vienas mažmenininkas. Abu grandinės nariai nori maksimizuoti savo pelną. Gamintojas priima sprendimus dėl išlaidų nacionalinei reklamai ir didmeninių kainų, o mažmenininkas priima sprendimus dėl investicijų vietinei reklamai ir mažmeninių kainų. Abi įmonės naudoja reklamos programas, norėdamos paskatinti vartotojus pirkti konkretų gaminį. Gamintojo investicijos, skirtos reklamai, yra nukreiptos norint padaryti įtaką galimam vartotojui vertinant prekės ženklą. O mažmenininko investicijos reklamai yra skirtos paskatinti vartotojo pirkimo elgesį.

Šią tiekimo grandinę galima laikyti arba „konkurencine", arba „kooperacine", nes kiekvienas grandinės dalyvis nori optimizuoti savo sprendimus ir tikslus. Antra vertus, abu dalyviai prisideda prie reklamos kaštų, norėdami padidinti poreikį ir savo pelną. Mūsų tyrimą paskatino teorinių modelių, kuriuose rinkos poreikiui tuo pačiu metu įtaką daro mažmeninė kaina ir dalyvių reklamos pastangos, stoka. Mes nagrinėjame fiksuoto mažmeninio antkainio (FMA) (plg. angl. Retail Fixed Markup - RFM) politiką, kurią aptarė Liu ir kt. (2006). Jie teigia, kad rinkos poreikiui įtaką daro tik kaina.

Norėdami atsakyti į pirmąjį klausimą, mes modeliuojame problemą pagal centralizuotą ir decentralizuotą politikas: Stackelberg žaidimas su gamintoju lyderio pozicijoje, ir fiksuoto mažmeninio antkainio (FMA) politika. Integruotoje arba centralizuotoje politikoje gamintojas kartu su mažmenininku laikomi viena įmone, todėl tikslas yra maksimizuoti visos tiekimo grandinės pelną. Integruotas pelnas yra viršutinė riba FMA ir Stackelberg politikų pelnui. Integruota politika, dėl paskatų konflikto, daugeliu atveju gali būti nepraktiška ir nepageidaujama. O decentralizuotoje politikoje, kiekvienas dalyvis savarankiškai pasirenka savo strategiją taip, kad bendras sistemos efektyvumas nebūtinai bus optimizuotas. Kitaip tariant, šis metodas dažnai sukelia visos sistemos pelno nuostolius.

Norint atsakyti į antrąjį klausimą, pirmiausia reikia prisiminti, kad dėl skirtingų decentralizuotų metodų yra ir skirtingas sistemos efektyvumas. Kiekvienas dalyvis renkasi metodą, kuris suteikia daugiau pelno jam. Stackelberg metode žaidėjai yra klasifikuojami į lyderį ir sekėją. Lyderis pirmasis renkasi savo strategiją, o sekėjas seka jo sprendimu ir kuria savo strategiją. Būtina manyti, kad kiekviena įmonė nenori nukrypti nuo savo pelno maksimizavimo. Kitaip tariant, kiekvienas žaidėjas pasirenka savo geriausią strategiją. Gamintojas (lyderis) nustato savo didmeninę kainą ir reklamos investicijų dydį ir iš anksto paskelbia tai mažmenininkui, o mažmenininkas veikia kaip sekėjas, pasirinkdamas savo mažmeninę kainą ir reklamos investicijų dydį, remdamasis gamintojo strategija. FMA politikoje gamintojas pasirenka savo sprendimus panašiai kaip Stackelberg metode, o mažmenininkas priimą sprendimus tik dėl vietinio investavimo. Kadangi jis gauna fiksuotą antkainį, gamintojo pasirinkta didmeninė kaina yra tolygi mažmeninės kainos nustatymui. Tai parodo, kad abu dalyviai gali pagerinti savo pelną, pereidami prie FMA politikos.

Siekiant išreikšti skaičiais analitinius rezultatus ir koncepcijas, kad būtų galima padaryti kai kurias valdymo įžvalgas, buvo atliktas skaitmeninis tyrimas Šiame straipsnyje pateiktas pagrindinis atvejis, kad būtų palyginti skirtingi politikos rezultatai. Taip pat pailiustruota Pareto-pagerinimo sritis, panaudojant skaitmeninį tyrimą. Keičiant kai kurių parametrų vertes pateikta rezultatų jautrumo analizė.

Remiantis statistiškai atliktos analizės duomenimis, galima teigti, kad tinkamai sudarytas FMA pagerina kiekvieno dalyvio pelną kartu pagerindami ir Pareto (lyginant su Stackelberg politika). Gamintojo ir mažmenininko pelnas atitinkamai padidėja mažiausiai 900 % ir 156 %, lyginant su Stackelberg politika. Be to, tai pagerina bendrą tiekimo grandinės pelną vidutiniškai 600 % lyginant su Stackelberg politika; ir gamintojo, ir mažmenininko pelnas yra įgaubtas fiksuoto mažmeninio antkainio koeficiente ir turi maksimalią vertę. Todėl bendras kanalo pelnas yra įgaubtas ir yra maksimalus. Pareto-pagerinimo sritis yra ne tokia jautri kai kuriems parametrams, tokiems kaip investavimo lankstumas ir skalė k, o kiti parametrai, tokie kaip kainos lankstumas, gamybos ir paskirstymo kaštai daro žymią įtaką sričiai; FMA politikos vidutinis efektyvumas sudaro 37 % integruotos politikos vidutinio efektyvumo. Taigi egzistuoja galimybė pasiekti didesnį grandinės efektyvumą už gautą.

Šis tyrimas yra ribotas, nes nagrinėta grandinė su vienu gamintoju ir vieninteliu mažmenininku. Tai neatitinka tiekimo grandinės reikšmės tikrame pasaulyje. Todėl, gerokai gausesnis modelis analizuojant daugiau mažmenininkų arba daugiau gamintojų, pateiks įdomių rezultatų. Be to, problemai tirti galima panaudoti daug bendresnę poreikio funkciją.

Raktažodžiai: *rinkodara, kainų nustatymas, nuo kainos priklausantis poreikis, fiksuotas mažmeninis antkainis, tiekimo grandinė.*

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