Effect of Slotting Allowances on Pricing and Shelf Space Allocation in the Supply Chain with Different Channel Power Structures

Ya-zi WANG, Di REN and Guo-hua SUN*

School of Management Science and Engineering, Shandong University of Finance and Economics, Jinan 250014, China
*Corresponding author

Keywords: Slotting allowances, Supply chain, Shelf space, Pricing.

Abstract. Whether the supplier offering slotting allowances to the retailer is reasonable has always been the focus of attention. The paper investigates the effects of slotting allowances on the two-echelon supply chain consisting of a supplier and a retailer in which the demand facing the retailer is both price and shelf-space sensitive. The results show that the slotting allowances have different effects on the supply chain with different power structures. In the supplier Stackelberg supply chain, the retail price and shelf space are not affected by the slotting allowances, hence the product sales are also not affected. In the retailer Stackelberg supply chain, the retailer will reduce the retail price and allocate more shelf space as the slotting allowance rate increases. The numerical simulation result shows that in the retailer Stackelberg supply chain, the profits of the retailer and the total supply chain increase with the slotting allowance rate and the profit of the supplier increases only when the slotting allowance rate is below a certain threshold. Therefore it does good to the retailer Stackelberg supply chain when proper slotting allowances are paid by the supplier to the retailer.

Introduction

With the rapid development of economics, supermarkets play an important role in commodity circulation. As an important resource of the supermarket, shelf space has an important effect on the products' sales. The large amount of goods displayed on the shelves can stimulate consumers' desire to buy, but if too much, it will bring negative influence to both employees and consumers [1]. To display their own products on the retailer's shelf space, suppliers usually pay some slotting allowances to the supermarket. However, the conflicts between the supplier and the retailer caused by slotting allowances become more fierce in recent years. In 2003, Carrefour was boycotted by Shanghai and Nanjing Roasted Food Association due to the excessive slotting allowances. In 2006, Mengniu company removed their products from Carrefour with the same reason. Refusing to pay slotting allowances, Gree, Midea, Haier and other well-known home appliance companies choose to set up their own sales channels.

There is a lot of controversy over whether the supplier should pay slotting allowances to the retailer in reality. Someone agree that it is reasonable for the supplier to pay slotting allowances, since it can help the retailer allocate the limited shelf space more reasonably. Sullivan believed that slotting allowances can balance the contradiction between the development of new products and consumers' choice of products [2]. Li et al. concluded that the presence of slotting allowances is reasonable with a multiple case study method [3]. Zheng et al. discussed the possibility, existence and rationality of slotting allowances with a three-stage dynamic game model and give some suggestions for slotting allowances from the perspective of consumer welfare [4].

Someone disagree that the supplier should offer slotting allowances to the retailer, since slotting allowances can push up the final prices of the commodity and harm interests of the consumer. Marx and Shaffer concluded that the small manufacturers were often unable to obtain widespread distribution for their products because of slotting allowances [5]. Wang built a general game model and found that charging slotting allowances can raise the retail prices and bring down both consumers' and social total welfare [6]. The above research mainly focus on the rationality of slotting allowances.
from the perspectives of market power and market efficiency, and does not consider the impact of shelf space on demand.

The mentioned literatures considered the effect of shelf space on the demand of products but didn't consider the effect of slotting allowances on the decisions of shelf space allocation. In this paper, how the slotting allowances affect the optimal decisions of members in the supply chain with different power structures are studied.

Problem Description

A supply chain composed of a supplier and a retailer is considered. The products produced by the supplier need to be displayed on the shelf space of the retailer. The unit production cost incurred by the supplier is $c_s$ and the unit shelf space cost incurred by the retailer is $h$.

The demand facing the retailer is both price and shelf-space sensitive and the demand function is:

$$q(p, S) = \alpha p^{-\beta} S^\gamma$$

where $\alpha (>0)$ is the basic demand in the market, $p$ is the retail price, $S$ is the shelf space allocated to the product, $\beta (>1)$ and $\gamma (\in [0,1))$ are the elasticities of retail price and shelf-space.

The supplier offers slotting allowances to the retailer. Slotting allowances is linearly related to sales volumes. Suppose the slotting allowance rate is $\phi$, the supplier shall pay $\phi \omega$ to the retailer for each unit of product sold, in which $\omega$ is the wholesale price charged by the supplier.

Supplier Stackelberg Supply Chain

In the supplier Stackelberg supply chain, the supplier acts as the Stackelberg leader and the retailer acts as the follower. The supplier first set the wholesale price $\omega$. The retailer then decides the unit retail margin $m$ and the shelf space $S$ according to the supplier's decision.

The game process between suppliers and retailers is as follows:

Phase I: $\max_{\omega} \pi_s^\omega(\omega) = [(1-\phi)\omega - c_s]q(p, S)$ \hspace{1cm} (1)

Phase II: $\max_{m,S} \pi_r^S(m, S | \omega) = (m + \phi \omega)q(p, S) - hS$. \hspace{1cm} (2)

By backward induction, the optimal wholesale price of the supplier is: $\omega^*_s = \frac{(\beta - \gamma) c_s}{(\beta - 1)(1-\phi)}$. \hspace{1cm} (3)

The retailer's optimal unit retail margin retail price, shelf space and product sales are:

$$m^*_r = \frac{(1-\beta \phi)(\beta - \gamma)c_s}{(\beta - 1)^2(1-\phi)}$$

$$p^*_r = \frac{\beta(\beta - \gamma)c_s}{(\beta - 1)^2}$$

$$S^*_r = \left\{ \frac{\gamma\alpha(\beta - 1)^{2(\beta - 1)}}{h\beta^\beta [(\beta - \gamma)c_s]^{\beta - 1}} \right\}^{\frac{1}{1-\gamma}}$$

$$q^*_r = \frac{h}{\gamma(\beta - \gamma)c_s} \left\{ \frac{\gamma\alpha(\beta - 1)^{2(\beta - 1)}}{h\beta^\beta [(\beta - \gamma)c_s]^{\beta - 1}} \right\}^{\frac{1}{\gamma}}$$ \hspace{1cm} (4)

Retailer Stackelberg Supply Chain

In the retailer Stackelberg supply chain, the retailer acts as the Stackelberg leader and the supplier acts as the follower. The retailer first decides the unit retail margin $m$ and the shelf space $S$. The supplier then decides the wholesale price $\omega$ according to the retailer's decisions.

The game process between suppliers and retailers is as follows:
Phase I: \[ \max_{m,S} \pi^s_r(m,S) = (m + \phi_0)c(q(p,S) - hS) \]  

(5)

Phase II: \[ \max_{\omega} \pi^s_r(\omega|m,S) = [(1 - \phi)\omega - c_s]q(p,S) \]  

(6)

By backward induction, the optimal wholesale price of the supplier is:

\[ \omega^s_r = \frac{\beta(\beta - 1) + 1 - \phi}{(\beta - 1)(1 - \phi)(\beta + \phi - 1)}c_s. \]  

(7)

The retailer's optimal unit retail margin, retail price, shelf space and product sales are respectively:

\[ m^r_v = \frac{(1 - \phi - \beta)\gamma}{(\beta + \phi - 1)(1 - \phi)}c_s, \quad p^r_v = \frac{\beta^2}{(\beta - 1)(\beta + \phi - 1)}c_s, \quad S^r_v = \left[ \frac{\gamma\alpha(\beta - 1)^{\beta - 1}(\beta + \phi - 1)^{\beta - 1}}{h\beta^2c_s^{\beta - 1}} \right]^{\frac{1}{1 - \gamma}}, \quad q^r_v = \frac{h}{\gamma}(\beta - 1)^{\beta - 1}(\beta + \phi - 1)^{\beta - 1} \left[ \frac{\gamma\alpha(\beta - 1)^{\beta - 1}(\beta + \phi - 1)^{\beta - 1}}{h\beta^2c_s^{\beta - 1}} \right]^{\frac{1}{1 - \gamma}}. \]  

(8)

**Model Analysis**

Property 1 In the supplier Stackelberg supply chain, the optimal retail price and shelf space are not affected by slotting allowances; accordingly, the sales quantity are also not affected by slotting allowances.

Property 2 In the retailer Stackelberg supply chain, the slotting allowance rate increases, the optimal retail price decreases and the shelf space increases; accordingly, the sales quantity increases.

From Property 1 and 2, it is easy to conclude that slotting allowances have more impact on the retailer Stackelberg supply chain. In the supplier Stackelberg supply chain, the slotting allowances have no effect on product sales because the supplier can effectively control the retailer’s decisions by adjusting his wholesale price. In the retailer Stackelberg supply chain, retailers have the motivation to reduce the retail price and allocate more shelf space as their income is closely related to slotting allowances. It supports that why retailers are more inclined to charge slotting allowances to small and medium-sized suppliers.

Property 3 The wholesale prices of the supplier in the supply chains with different power structures satisfy: (1) when \( 0 \leq \phi \leq \frac{1 + \gamma + \beta\gamma}{1 + \gamma + \beta} \), \( \omega^s_r \leq \omega^p_r \); (2) when \( \frac{1 + \gamma + \beta\gamma}{1 + \gamma + \beta} < \phi \leq 1 \), \( \omega^s_r \geq \omega^p_r \).

Property 4 The retail prices of the retailer in the supply chains with different power structures satisfy: (1) when \( 0 \leq \phi \leq \frac{\gamma(\beta - 1)}{\beta - \gamma} \), \( p^r_v \leq p^p_r \); (2) when \( \frac{\gamma(\beta - 1)}{\beta - \gamma} < \phi \leq 1 \), \( p^r_v \geq p^p_r \).

Property 5 The shelf spaces allocated by the retailer in the supply chains with different power structures satisfy:

(1) when \( 0 \leq \phi \leq 1 - \beta \left[ 1 - \left( \frac{\beta - 1}{\beta - \gamma} \right)^{\beta - 1} \right] \), \( S^r_v \geq S^p_r \); (2) when \( 1 - \beta \left[ 1 - \left( \frac{\beta - 1}{\beta - \gamma} \right)^{\beta - 1} \right] \leq \phi \leq 1 \), \( S^r_v \leq S^p_r \).

Property 6 The sales quantities in the supply chains with different power structures satisfy:

(1) when \( 0 \leq \phi \leq 1 - \beta \left[ 1 - \left( \frac{\beta - 1}{\beta - \gamma} \right)^{\beta - 1} \right] \), \( q^r_v \geq q^p_v \); (2) when \( 1 - \beta \left[ 1 - \left( \frac{\beta - 1}{\beta - \gamma} \right)^{\beta - 1} \right] \leq \phi \leq 1 \), \( q^r_v \leq q^p_v \).

From Property 3 and 6, it’s found that when the slotting allowance rate is low, in the supplier Stackelberg supply chain, the supplier charges a lower wholesale price and the retailer is also inclined to give a lower retail price and allocate more shelf space which promotes the product sales. On the
contrary, when the slotting allowance rate is high, in the retailer Stackelberg supply chain, the wholesale price and retail price are lower, the shelf space allocated is larger, and the corresponding product sales is larger. It is easy to conclude that the slotting allowances have a positive effect on the product sales of the retailer Stackelberg supply chain.

**Numerical Example**

Suppose the demand function is: \( q = 1000p^{-2}s^{0.5} \). The unit production cost is \( c_i = 3 \) and the unit shelf space cost is \( h = 3 \).

In order to analyze the impact of slotting allowances rate on the supply chains with different power structures, the optimal decisions and profits are given by changing value of \( \phi \) while keeping the other parameters unchanged, where \( \phi \) is assumed to range from 0 to 0.5.

![Figure 1. Effect of \( \phi \) on optimal decisions of wholesale price, retail price, shelf space and product sales.](image1)

![Figure 2. Effect of \( \phi \) on optimal profits of the supplier, the retailer and the total supply chain.](image2)

From Figure 1 and 2, it can be found that as the slotting allowance rate increases, in the supplier Stackelberg supply chain, the shelf space allocated is not affected, while in the retailer Stackelberg supply chain the shelf space allocated increases. As the slotting allowance rate increases, in the
supplier Stackelberg supply chain, the wholesale price charged by the supplier increases, but the retail price remains unchanged. In the retailer Stackelberg supply chain, when the slotting allowance rate is low, the wholesale price decreases as the slotting allowance rate increases; otherwise the wholesale price increases as the slotting allowance rate increases. In the supplier Stackelberg supply chain, the product sales are not affected by the changing of slotting allowance rate; while in the retailer Stackelberg supply chain, the slotting allowances have a positive effect on the product sales. The profits of the supplier, the retailer and the total supply chain are not affected by the slotting allowances in the supplier Stackelberg supply chain. The profits of the retailer and the total supply chain increase with the slotting allowance rate in the retailer Stackelberg supply chain. The profit of the supplier increases with the slotting allowance rate when the slotting allowance rate is low, but the profit of the supplier decreases with the slotting allowance rate when the slotting allowance rate is over a certain threshold.

Summary

A two-echelon supply chain composed of a supplier and a retailer is considered, in which the demand is both price and shelf-space sensitive and the supplier needs to pay slotting allowances to the retailer. The results show that slotting allowances have different effects on the supply chain with different power structures. In the supplier Stackelberg supply chain, the retail price and shelf space allocated are not affected by the slotting allowances, hence the product sales are also not affected. On the contrary, in the retailer Stackelberg supply chain, the retailer will reduce the retail price and allocate more shelf space as the slotting allowance rate increases. The numerical simulation results show that the profits of the retailer and the total supply chain increase with the slotting allowance rate in the retailer Stackelberg supply chain. However, the profit of the supplier increases only when the slotting allowance rate is below a certain threshold. Therefore it does good to the retailer Stackelberg supply chain when proper slotting allowances are paid to the retailer.

Acknowledgement

This research was financially supported by the National Nature Science Foundation of China (Grant No. 71402084).

References