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TWO ESSAYS ON SLOTTING ALLOWANCES UNDER

DEMAND UNCERTAINTY

DISSERTATION

Presented in Partial Fulfillment of the Requirements for

the Degree Doctor of Philosophy in the Graduate School of

The Ohio State University

By

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*****

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"Find rest, O my soul, in God alone; my hope comes from him. He alone is my rock and my salvation; he is my fortress, I will not be shaken."

(Psalms 62:5-6)

TO MY WIFE AND PARENTS,

who have always been behind me.
I praise God and my Lord Jesus Christ, who have been leading and protecting my entire life. God’s glory is the only objective of my life.

I wish to pay special tribute to my adviser, Professor Howard P. Marvel, for his invaluable guidance and encouragement during the entire course of my studies and dissertation research. He has taught me how to interpret real world situations and to find out the true nature of economic phenomena.

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I am deeply indebted to my parents for their love and support without margin. Without their sacrifices, I could not accomplish this achievements. Finally, I wish to express the deepest thanks to my wife Piloh and my children Shinku and Hyunku for their love and patience.
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Chapter I

Introduction

Vertical relationships between upstream firms and downstream firms have attracted considerable attention in both economic and legal literatures. Much of this work has been concerned with vertical restraints, restrictions on the behavior of firms by bilateral contracts. Vertical restraints range from simple nonlinear prices (for example, franchise fees) to instruments that restrict intra-brand competition (such as exclusive territories or resale price maintenance (RPM)) and inter-brand competition (such as exclusive dealing). Two key questions about those restraints are first, whether they are procompetitive or anticompetitive and second, whether they enhance or reduce welfare. There exist two mainstream arguments which oppose each other in the economic literature: efficiency explanations for the restraints and explanations for the restraints as anticompetitive devices.

Efficiency explanations for vertical restraints dated from Lester Telser's (1960) seminal study of RPM. He argued that manufacturers wish to impose RPM on retailers because it results in the provision by retailers of valuable pre-sale information. Such information is important for consumers as well as increasing manufacturers' sales. Thus, he concluded that RPM can enhance welfare. Following Telser, there have been similar
and improved arguments for not only RPM (Marvel and McCafferty, 1984; Mathewson and Winter, 1983, 1984, 1986; Deneckere, Marvel and Peck, 1993, 1994; Marvel, 1994) but also for other vertical restraints such as exclusive territories (Warren, 1975; Mathewson and Winter 1986) and exclusive dealing (Marvel, 1982).

In contrast, some authors have insisted that vertical restraints are tools for facilitating dealer coercion (Salop, 1986; Shaffer, 1991) or manufacturer cartels (Telser, 1960; Posner, 1977) through price fixing or closed territory distribution. They thus argued that vertical restraints are anticompetitive and thereby reduce welfare. Others have interpreted vertical restraints as anticompetitive, welfare-deteriorating devices under information asymmetry (Rey and Tirole, 1986) or supramarginal profit extraction mechanisms for retailers even if they suggested that regional RPM is efficient (Klein and Murphy, 1988).

One rapidly developing form of vertical restraint has not attracted as much attraction as RPM or territorial restrictions. In the grocery industry, slotting allowances have appeared as the main vertical restraint in the 1980s. This practice is prevalent today and dominates one third or a half of total trade promotion in the grocery distribution channel. The debate on slotting allowances also seems to follow the above two streams of arguments about other vertical restraints.

Slotting allowances have been regarded as a retailer price fixing method (Shaffer, 1991), as a manufacturer market foreclosing or retailer profit extraction tool (Cannon and Bloom, 1991), a retailer screening and profit extraction means (Chu, 1992; Desiraju,
1994). These arguments have suggested that slotting allowances are anticompetitive and tend to reduce welfare.

On the other hand, other studies (Kelly, 1991; Lariviere, 1994) including Sullivan’s (1993) valuable empirical analysis have suggested that slotting allowances give a means for channel coordination by providing signaling and screening mechanisms to manufacturers and retailers under information asymmetry. They also argued that slotting allowances can be a tool to share the retail cost. They thus claimed that slotting allowances are procompetitive and welfare-enhancing.

Our analysis of slotting allowances begins with the question of why slotting allowances have become the dominant form of vertical restraint in the grocery distribution channel since the late 1980s. Franchise fees or other vertical restraints including RPM were used in the past. In contrast, both manufacturers and retailers prefer slotting allowances to other promotional practices today. Why did this kind of change occur?

The anticompetitive arguments on slotting allowances have tried to explain it by the retailer bargaining power hypothesis. However, this hypothesis is not valid theoretically and empirically. Therefore, we at first rebut the hypothesis and suggest a new view on slotting allowances in this study. Findings in this analysis are the following. First, slotting allowances are an inventory promotion method for manufacturers' new products under demand uncertainty. Second, slotting allowances enhance consumer
surplus as well as social efficiency by the channel coordination because they promote
enough inventories to cover the high demand state and provide relatively low price, and
an opportunity of fire sale pricing in case of the low demand state in the last period.

We proceed as follows. Chapter II addresses why slotting allowances are
prevalent in the grocery distribution channel through a simple rectangular demand model
with two periods. Through comparing the subgame perfect Nash equilibria of an
inventory promotion wholesale pricing game and a slotting allowance game, this chapter
shows that slotting allowances are preferred because they are a better method of
inventory promotion for manufacturers under demand uncertainty while they remove the
negative profit possibility of retailers. Chapter III extends the outcome of Chapter II
with a linear demand model and discusses the welfare effect of slotting allowances. It
also suggests some policy implications for the application of antitrust laws about slotting
allowances.
Chapter II

Slotting Allowances as a Manufacturer’s Inventory Promotion Method under Demand Uncertainty

1. Introduction

The decade of the 1980’s brought rapid change to grocery marketing in the United States. Grocery stores expanded in size and in the variety of assortments offered for sale. The number of products sold in the typical supermarket increased sharply from about 10,000 to 20,000 through the 1980s.¹ Competing for shelf space in these expanded assortments, 10,000 new products were introduced in both 1987 and 1988, a marked increase from the 2,600 introduced in 1978². The failure rate of the newly introduced product has also been 90 to 94 percent in recent years.³ The size of the average chain stores increased from about 26,000 square feet in 1982 to about 34,000 square feet in 1991, a 31 percent increase.⁴ From 1982 to 1991, the average number of

¹ Chicago Tribune (1988), Section 7, p.1.
SKU (Stock Keeping Units)’s stocked per supermarket chain is from approximately 11,200 to over 20,000, an increase of 7.8 percent per year.⁵

One result of these changes has been the emergence of slotting allowances. A slotting allowance is a fee paid by a manufacturer to a retailer when he introduces a new product to the retailer’s shelf. Slotting allowances account for about one third to one half of total trade promotion in recent years.⁶ However, although the slotting allowance has emerged as a leading trade promotion practice, and substantial anti-trust concerns against this practice have been raised, only a few formal analyses have considered the role of slotting allowances in manufacturer-retailer relations.

Most formal analyses have depended on the assumption that slotting allowances have resulted from the shift of the bargaining power from manufacturers to retailers in the grocery industry in the 1980s. They have interpreted slotting allowances as a retailer facilitating practice for the price fixing (Shaffer, 1991), a retailer screening mechanism under information asymmetry (Chu, 1992) and a retailer profit extraction method under two sided information asymmetry (Desiraju, 1994). Since each assumes rather than deduces that retailers possess a disproportional share of bargaining power in manufacturer-retailer relation, the above analyses have not paid attention to the role of slotting allowances as a manufacturers' inventory promotion method to maximize their profits.

This chapter suggests a different explanation about why slotting allowances are prevalent today. Manufacturers may promote their new products for stocking high inventories on retail shelves under demand uncertainty because retailers’ high inventory holdings may imply higher demand for the manufacturer’s product and thus higher profits under demand uncertainty. If manufacturers do not adequately support retailers’ inventory holdings under demand uncertainty, retailers will not hold high inventories which can give rise to negative profits in the event of slack demand. Manufacturers in that case can only sell the quantity consistent with relatively unfavorable realization of demand uncertainty. They therefore may forgo valuable sales and product exposure should realized demand be high. In order to avoid this lack of enough inventory holdings on retail shelves, manufacturers can use several promotion methods including slotting allowances. The subsequent question is when and why manufacturers prefer slotting allowances to other promotion practices. This study will focus only on slotting allowances and the inventory promotion by low wholesale prices (hereafter, “inventory promotion wholesale pricing”) because the latter is a general and convenient promotion method while the former is prevalent as the actual promotion method. Manufacturers must prefer slotting allowances to inventory promotion wholesale pricing only if they can earn higher profits from the former practice.

---

7 According to a grocery business journal, *Grocery Marketing*, the net effect of trade promotions was to increase inventory holdings in the distribution system. For a more complete explanation, refer to *Grocery Marketing* (1993), p.16.

8 For the formal explanation about why the manufacturers dislike the discounters and about the relationship between the higher profit and high inventory holdings under demand uncertainty, refer to Deneckere, R., H. P. Marvel and J. Peck (1993).
We will set up a two-period model with a risk-neutral monopoly manufacturer and with identical, risk-neutral, competitive retailers to explain our argument that manufacturers select slotting allowances as the promotion method because they induce high inventories on retail shelves and they thus give higher profit to manufacturers. This model is a dynamic model which has two periods. We thus can distinguish slotting allowances from inventory promotion wholesale pricing and can analyze the intertemporal effect of slotting allowances fully.\(^9\)

This analysis will show that the outcomes of the inventory promotion wholesale pricing game and the slotting allowance game support my argument. That is, It will show that under the certain ranges of probability of high demand realization, both inventory promotion wholesale pricing and slotting allowances give manufacturers higher profit than that of no support for retailers' inventory holdings while both promotional practices guarantee retailers' nonnegative profits. Moreover, I will also show that slotting allowances always give the higher profit to manufacturers than that of inventory promotion wholesale pricing under the above probability conditions. Thus, manufacturers prefer slotting allowances to inventory promotion wholesale pricing.

We will proceed as follows. In section 2, we will survey the existing analyses and will suggest a different explanation for slotting allowances. In section 3, we will set up a model and will explain the game rules for inventory promotion wholesale pricing.

\[^{9}\] If we consider only one stage, slotting allowances are the same as the inventory promotion wholesale pricing. Therefore, we can only distinguish slotting allowances from the inventory promotion wholesale pricing in a multi-period model. For more explanation, see the next section in this chapter.
game and slotting allowance game. In section 4, we will report the outcomes and will compare the subgame-perfect Nash equilibria of two games. From that comparison, we will illustrate why slotting allowances could become the leading promotional practice in the 1980s. Finally, we will offer some concluding remarks in section 5.

2. Slotting Allowances as a Manufacturer’s Inventory Promotion Method

Most existing studies on slotting allowances focused on their nature as a profit extraction mechanism for retailers because they assumed that retailers have the bargaining power in the distribution channel. Other studies rebutted the assumption of the retailers’ bargaining power dominance or did empirical analysis about the above arguments. This section reviews existing studies and suggests a different view on the role of slotting allowances as a leading manufacturer’s promotion practice to place sufficient inventories on retail shelves.

The following analyses rely on the assumption of retailer bargaining power dominance in the distribution channel.

Shaffer (1991) argued that slotting allowances occurred because of the increased bargaining power of retailers in the 1980s and that they became the main trade promotion practice because they can guarantee higher profits to retailers through
reduced competition. As causes for the shift of the bargaining power from manufacturers to retailers, he illustrated increased competition among manufacturers owing to product proliferation, mergers in the retail industry and the appearance of super markets. He analyzed slotting allowances and resale price maintenance (RPM) as facilitating practices of retailers and arrived at the following conclusions: first, both slotting allowances and RPM serve to increase retailers' profits under manufacturers' shelf space rivalry because they restrict the competition between retailers through commitment to high marginal cost or high price; second, slotting allowances lead to higher retail price and thus higher profits than those of RPM because retailers keep their pricing flexibility as a punishment mechanism for their rivals' deviations in slotting allowances case, while they cannot punish other retailers' deviations through price competition in the RPM case. However, because he ignored that slotting allowances are paid only for new products and have multi-period effects, he could not explain why slotting allowances have been prevalent in recent years.

Chu (1992) examined advertisement and slotting allowances as a communication method between retailers and manufacturers under asymmetric information on the newly introduced product demand. He showed that if manufacturers have the bargaining power, they choose advertisement as the signaling method for the success possibilities of their newly introduced products because advertisement gives them higher profits. He also showed that if retailers have the bargaining power, they choose slotting allowances as the screening mechanism for the newly introduced product because they can
appropriate total channel profits. Finally, he concluded that slotting allowances can be a leading trade promotion practice because they yield higher total channel profits than those of advertisement if the advertisement effect is low and because they bring to retailers who have the bargaining power a method to appropriate total channel profits.

Desiraju (1994) argued that retailers who have bargaining power can extract the channel profit through brand-by-brand slotting allowances or uniform slotting allowances for all categories of goods under two sided information asymmetry\(^\text{10}\). He also showed that retailers prefer the brand-by-brand method when the proportion of low demand manufacturers is relatively large, while the uniform method gives retailers higher profits when the proportion of high demand manufacturers is sufficiently large.

In contrast, two other analyses focused on the characteristic of slotting allowances as the product of active competition among manufacturers under information asymmetry and demand uncertainty. Another analysis examined empirical evidences of several arguments about slotting allowances.

Kelly (1991) argued that slotting allowances emerged as a natural reaction to increased product innovation in the grocery industry in the 1980s. He also insisted that manufacturers prefer slotting allowances to other trade promotion practices because they can effectively inform retailers of the likely success of their newly introduced goods under asymmetric information and because that signaling gives their products a chance

\(^{10}\) Dejiraju (1994) defined two sided information asymmetry in the distribution channel as retailers having more information about the possibility of success of the brand in the local market while manufacturers have more information on the potential demand of their brands.
for gaining retailers' favor. He argued that retailers, in contrast, like slotting allowances because they give retailers a method to impute risks to manufacturers under demand uncertainty and they may also give retailers information to screen successful products from failed products in the face of the flooding of new products which are not really new. Thus, he concluded that slotting allowances are procompetitive because they are a product of manufacturers' reinforced competition in the grocery industry. However, there is no formal explanation for his argument by model and he did not explain why slotting allowances were the superior inventory promotion method to other promotional methods like inventory promotion wholesale pricing.

Lariviere (1994) tried to explain slotting allowances as a method of signaling the manufacturer's private information about demand to retailers under asymmetric information and as a sharing method of retailers' high opportunity costs for the introduction of new product, without assuming retailers' bargaining power. He concluded that slotting allowances took place because profit maximizing manufacturers tried to differentiate their products from low demand products and because they wanted to extract higher merchandising effort from skillful and competent retailers by compensating retailers for their opportunity costs.

Sullivan (1993) tested the following four hypotheses on slotting allowances empirically: shelf space rationing, retail cost compensation, signaling/screening and retailers' market power. From her study of secondary data, she concluded that slotting allowances function as a signaling and/or screening device under information asymmetry
and the retail cost compensation mechanism in the distribution channel. However, she found that the rationing and the retailers' market power hypotheses were not valid.

Existing analyses have two different views on slotting allowances. One view starts from the assumption of retailers' bargaining power (Shaffer, 1991; Chu, 1992; Desiraju, 1994). The other is that slotting allowances are an efficient cooperation method in the distribution channel (Kelly, 1991; Sullivan, 1993; Lariviere, 1994). However, the former view has the following weaknesses.

First, as Kelly (1991) indicated, if there were the shift of bargaining power from manufacturers to retailers in the 1980s, then retailers should have the market power which forces manufacturers to reduce their wholesale price and/or the consumers to pay higher price for the product in question. However, retailers impose up-front lump-sum payment on manufacturers of newly introduced products in the slotting allowance case. Why do retailers prefer slotting allowances for new products to the low wholesale price on all products to sell if they have the market power? Usually, the existing product with a strong brand name makes higher profit which exceeds all possible costs even including promotional fees and the cost of failed products. If a retailer or a cartel of retailers has the market power, then such a product should be targeted for the profit appropriation rather than the newly introduced product which has no strong demand and no consumer loyalty and thus no higher profit. If slotting allowances are devised by retailers to exploit the newly acquired bargaining power advantage, why do they make efforts at such clearly unpromising targets -- newly introduced products, while ignoring the attractive
alternatives --existing products with strong brand name? Especially, in case of Shaffer (1991), he could not analyze the real nature of slotting allowances because he did not consider that slotting allowances were paid only for new products.

Moreover, there exist several empirical findings which oppose to the retailers' bargaining power hypothesis. Through the study of the concentration ratio for large retail firms and the trend in the concentration of multi-unit retailers, Sullivan (1993) discovered that the concentration has been a long term trend in the retail industry caused by demographic factors since the 1940s. Messinger and Narsimahn (1992) also found out that the retailers' return on their investments was declined in the 1980's relative to past periods. In addition, Farris and Ailawadi (1992) found that retailers' profits did not increase during the 1980's, while the manufacturers' profits over the same period increased. These three results are inconsistent to the retailers' bargaining power hypothesis thus making the assumption unpersuasive.

Second, almost all models in the existing analyses are one-shot game models. In their models, the effects of slotting allowances cannot be discussed fully because slotting allowances have multi-period effects in manufacturer-retailer relations. In a one-shot game, slotting allowances are like the inventory promotion by the low wholesale price. Thus, although manufacturers set the wholesale price relatively high in the slotting allowance promotion, retailers may not regard the wholesale price as their marginal cost for the product in an one-shot model. Furthermore, since they can interact with their rivals strategically when they set the retail price in the slotting allowance case, they can
seldom attain any collusive outcome. Thus, Shaffer (1991)'s argument that slotting allowances are a facilitating practice for retailers cannot be dealt with in the one-shot model.

Third, Chu (1992) argued that if manufacturers have the bargaining power, then they only signify the product demand information through advertisement and high wholesale prices under information asymmetry. However, manufacturers as well as retailers may use slotting allowances as a substitute for advertisement when there exists information asymmetry in manufacturer-retailer relations. That is, manufacturers can offer retailers slotting allowances in place of advertising. However, because he depended on the retailers' bargaining power hypothesis, Chu concluded slotting allowances as a retailers' effective screening mechanism and he hence overlooked the other role of slotting allowances as a manufacturers' inventory promotion method.

As we have already argued in the above, the assumption that retailers have the bargaining power is not persuasive. We may thus think that manufacturers still have the bargaining power in the distribution channel and can use several vertical restraints as their promotional methods for their interests. We can then consider slotting allowances as an inventory promotion method for manufacturers when they introduce their new

---

11 Small manufacturers insist that large manufacturers try to foreclose their entry by bidding up the slotting allowance offers. On the other hand, small retailers complain that manufacturers offer different amounts of slotting allowances to retailers. We can infer from these arguments that manufacturers can use slotting allowances for the purpose of promoting their products. For more information, refer to Cannon and Bloom (1991).

12 The following story also shows that slotting allowances can be a manufacturer’s promotion method for their products. “Giants such as Frito-Lay, Bordens and the new Eagle snacks owned by Anheuser Busch are aggressively buying shelf space in the grocery stores, paying enormous sums of money.” Johnson (1992), P.2.
products. Manufacturers can promote high inventories under demand uncertainty through several trade promotion practices including slotting allowances and inventory promotion wholesale pricing. However, we can see slotting allowances have been the leading promotion practice in the distribution channel. The subsequent question is why manufacturers prefer slotting allowances over other promotion methods. For inventory support, a convenient and easy method may be inventory promotion wholesale pricing. Therefore, we wish to explain under what condition slotting allowances are preferred to inventory promotion wholesale pricing or no promotion.

3. A Model with Rectangular Demand

Let us set up a rectangular demand model to illustrate why a manufacturer prefers slotting allowances to inventory promotion wholesale pricing. This model is somewhat restrictive in describing consumer demand. However, it can provide gives manageable solutions from both promotion games.

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13 Kelly (1991) and Lariviere (1994) suggested the similar hypothesis. Sullivan (1993) also rejected the bargaining power hypothesis empirically. However, Lariviere thought that slotting allowances take place because of their role of inducing retailers' merchandising efforts by sharing retailers' opportunity costs and by distinguishing the manufacturer's product from other manufacturers' products.

14 Deneckere, Marvel and Peck (1993), Deneckere, Marvel and Peck (1994) and Marvel (1994) have already shown that RPM can be imposed for the high inventory holdings on retail shelves under demand uncertainty and that the high inventory holdings lead to an increase in manufacturers' sales and thus profit. Furthermore, Marvel (1994) has suggested that slotting allowances can be an alternative for RPM which is still per se illegal under the antitrust law.

Consider a risk-neutral monopoly manufacturer selling his product through identical, risk-neutral, competitive retailers. The market is open for two periods. The multi-period model permits us to consider the intertemporal effect of slotting allowances.

Each period demand is described in Table 1.

**[Table 1] Characterization of Demand**

<table>
<thead>
<tr>
<th>State of Demand</th>
<th>Low Demand</th>
<th>High Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Consumers</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Consumer Reservation Price Per Unit</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Probability of State</td>
<td>( \mu )</td>
<td>1-( \mu )</td>
</tr>
</tbody>
</table>

That is, every consumer has the same reservation value at 1 which is the same in every demand state. The number of consumers that arrive is uncertain. The probabilities of demand states are in the range of \( 0 < \mu < 1 \). The demand is also identical in each period in its expectation under demand uncertainty. This means that there is no change in the probability of each state of demand over periods.

Retailers must acquire inventories prior to the demand realization of each period. They may order as much as they wish at the manufacturer’s wholesale price. They can reorder after the first period transaction. Period 1 inventories that remain unsold can be carried over costlessly to period 2. However, remnant inventories at the end of period 2 have no scrap value. For simplicity, production and retailing are assumed to be costless and all information is also assumed to be common knowledge.
In order to explain why manufacturers prefer slotting allowances, we need to compare two promotional practices -- inventory promotion wholesale pricing and slotting allowances. I thus focus on the subgame-perfect Nash equilibria of the following games.

**Inventory Promotion Wholesale Pricing Game**

First, the manufacturer offers his wholesale price $W_1$ in the first period. Second, retailers determine how much they order at $W_1$, before the market opens and they then determine the market supply curve given the first period retail price, $P_1$. Third, demand is realized in the market. $P_1$ and carryover inventories from the first period are then determined by the supply and demand. Fourth, the manufacturer offers retailers the second-period wholesale price, $W_2$. Fifth, retailers determine whether they replenish inventories on their shelves before the market opens in the second period. Finally, the second period demand is realized and $P_2$ is determined by supply and demand.

**Slotting Allowance Game**

First, in the beginning of the first period, the manufacturer offers retailers a contract $(S, W_1, W_2)$ which contains the following term: if retailers hold inventories sufficient to satisfy demand in case of the high demand realization under the manufacturer's wholesale prices $W_1$ and $W_2$ over two periods, the manufacturer agrees to pay a slotting allowance $S$. Second, retailers determine whether to accept or reject the contract. If they choose to accept, they order the product 3 units (the high demand level) at $W_1$ in the first period and receive the slotting allowances. Thereafter, they
determine the market supply curve given retail price $P_1$. Third, demand is realized in the market. $P_1$ and carryover inventories from the first period are determined according to demand and supply. Fourth, retailers replenish their inventories at the predetermined wholesale price of $W_2$ for the second period sales before the market opens. Finally, demand is realized in the market and $P_2$ is determined according to supply and demand.

4. Inventory Promotion Wholesale Pricing Vs. Slotting Allowances

Under demand uncertainty, a manufacturer who is confident about his new product's success will wish to induce retailers to hold inventories sufficient to satisfy high demand realizations. On the other hand, retailers must be compensated for expected losses of insufficient sales when they introduce the manufacturer's new product. The compensation can take the form of reduced wholesale prices to retailers or direct payments for stocking the manufacturer's product. In particular, slotting allowances have proven very popular and have become the leading promotion practice in the distribution channel in the late 1980s. This section explains why slotting allowances could be the leading promotional practice under demand uncertainty by solving the following two games: inventory promotion wholesale pricing game and slotting allowance game.
4.1. Inventory Promotion Wholesale Pricing Game

The manufacturer ought to set the wholesale price sufficiently low for the promotion of high inventories in this game. Otherwise, he must set the wholesale price without considering inventory promotion on retail shelves. Because we are interested in subgame-perfect Nash equilibria, let us solve this game by backward induction. Consider the second period first.

When the retail market opens, retailers dump all their inventories on the market because the scrap value of remnant inventories in the end of the second period is zero. The market supply curve is therefore horizontal at the retail price of zero until it arrives at the quantity stocked, $Q'_2$, while it is vertical at $Q'_2$ because it is impossible to increase the inventory any more at that point of time. Retailers may keep their inventories three (high inventory stocking) or two (low inventory stocking) according to the manufacturer's second period wholesale price, $W_2$. The second period retail price, $P_2$, is then determined by the demand and supply.

If the demand is greater than or equal to the supply (i.e., $Q'_2 \leq Q'_2$), then $P_2$ is determined at the consumer reservation price of one\(^\text{16}\). If the demand is smaller than

\(^{16}\text{Because the model assumes the rectangular demand, the second period retail price may appear to be technically indeterminate between zero and one if the quantity demanded is equal to the quantity stocked. In the retail market subgame, any price in [0, 1] may be an equilibrium price. However, the manufacturer does not have any incentive to support any other subgame equilibrium except one. That is, if the second period retail price is not equal to one, the manufacturer may set the second period wholesale price slightly higher and make the retailers' inventory slightly lower than the realized demand level. Thereby increasing profit, the manufacturer can choose the second period retail price to be one. If the second period retail price cannot be guaranteed at the consumer reservation price of one, retailers do not want to keep the high inventory level because they may lose money. Retailers' avoidance of enough\)
supply (i.e., \( Q'_2 > Q'_2 \)), then \( p_2 \) goes to zero because of fire sale pricing in the end of the second period. In summary, the subgame-perfect Nash equilibrium for the second period retail prices, \((p^h_2, p^l_2)\), are as follows:

\[
\begin{align*}
    p^h_2 &= p_2(Q'_2 \leq Q'_2) = 1 \\
    p^l_2 &= p_2(Q'_2 > Q'_2) = 0
\end{align*}
\]  

where the superscripts indicate the level of demand that is realized.

Retailers decide their inventory level according to \( W_2 \). That is, \( Q'_2 \) depends on \( W_2 \). Retailers choose how much to stock in order to maximize their second period profit. If they order sufficiently to stock high inventory (i.e., 3) on their shelves and sell at a positive price in the high demand state only, the retailers’ second period profit is

\[
\pi'_2(Q'_2 = 3) = ((1 - \mu) P^h_2 + \mu P^l_2 - W_2) Q'_2 = (1 - \mu - W_2) Q'_2.  
\]  

If they stock low inventory, they will sell at a positive price in both demand states with the profit given by,

\[
\pi'_2(Q'_2 = 2) = ((1 - \mu) P^h_2 + \mu P^l_2 - W_2) Q'_2 = (1 - W_2) Q'_2.  
\]  

Retailers maximize their profit by choosing \( Q'_2 \) given \( W_2 \). When retailers solve their profit maximization problem with respect to \( Q'_2 \), they know that the high inventory, 3, is the most profitable when \( W_2 \) is 1-\( \mu \), while low inventory, 2, is the most profitable inventory holding results in the relatively lower profit to the manufacturer. Therefore, the second period retail price is decided at one in the subgame-perfect Nash equilibrium in this game.
when $W_2$ is one from the first order conditions. That is, the subgame-perfect Nash equilibria of the second period inventory levels are as follows:

$$Q_2^* = Q_2^*(W_2 = 1 - \mu) = 3$$  \hspace{1cm} (5)

$$Q_2' = Q_2'(W_2 = 1) = 2.$$  \hspace{1cm} (6)

The manufacturer will choose $W_2$ according to the level of carryover inventories to maximize his second period profit and to induce retailers' participation. Therefore, $W_2$ depends on the carryover inventory from the first period, $A$, and the probability of low demand realization, $\mu$. $A$ must be either zero or one for no retailer would be willing to stock more than 3 units in the first period.

If $A = 1$, the manufacturer's second period profit is $\pi_2^m = W_2 (Q_2^* - 1)$. When he sets $W_2$, the manufacturer has to consider the retailers' participation constraint (i.e., $\pi_2^r \geq 0$). According to the retailers' participation constraint, they stock the inventory high, 3, if $W_2$ is in $0 < W_2 \leq 1 - \mu$, while they hold the inventory low, 2, if $1 - \mu < W_2 \leq 1$.

Therefore, if he promotes the retail inventory stock by low wholesale price, the manufacturer will set $W_2$ at $1 - \mu$ which is the highest price he can set. It is consistent with the price of retailers' profit maximization. In that case, $\pi_2^m(W_2 = 1 - \mu; A = 1) = 2(1 - \mu)$. If he does not promote the retail inventory, he will set $W_2$ at one for the same reason as above. Then $\pi_2^m(W_2 = 1; A = 1) = 1$. Comparing the
second period profits from both cases, we know that given $\Delta = 1$, the manufacturer sets $\bar{w}_2$ at $1-\mu$ when $\mu$ is less than $1/2$, while he sets $\bar{w}_2$ at 1 when $\mu$ is greater than $1/2$.

If $\Delta = 0$, the manufacturer's second period profit is $\pi_2^w = w_2 q_2^r$. The manufacturer considers the same things as above. That is, if he promotes the retail inventory, he must set $\bar{w}_2$ at $1-\mu$, while he sets $\bar{w}_2$ at 1 if he does not promote it. The manufacturer's profits from those actions are then $\pi_2^w (\bar{w}_2 = 1-\mu; \Delta = 0) = 3(1-\mu)$ and $\pi_2^w (\bar{w}_2 = 1; \Delta = 0) = 2$ respectively. Given $\Delta = 0$, the manufacturer must set $\bar{w}_2$ at $1-\mu$ when $\mu$ is less than $1/3$ while he sets $\bar{w}_2$ at 1 when $\mu$ is greater than $1/3$. Therefore, the subgame-perfect Nash equilibrium second period wholesale prices are,

\[
W_2^g = W_2 \begin{cases}
((\Delta = 1 \text{ or } \Delta = 0) \text{ and } 0 \leq \mu < (1/3)); \\
\text{or } (\Delta = 1 \text{ and } (1/3) \leq \mu < (1/2)) = 1-\mu, \quad (7)
\end{cases}
\]

\[
W_2^p = W_2 \begin{cases}
(\Delta = 0 \text{ and } (1/3) \leq \mu < (1/2)); \\
\text{or } (\Delta = 1 \text{ or } \Delta = 0) \text{ and } (1/2) < \mu \leq 1 \} = 1. \quad (8)
\end{cases}
\]

The second period manufacturer's profits can then be calculated according to the size of $\mu$ and the first period order of retailers, $q_i^r$. First, when $0 \leq \mu < 1/3$, the second period manufacturer's profit $\pi_2^w = (1-\mu)w_2^g q_2^h + \mu w_2^p (q_2^h - 1) = (3-\mu)(1-\mu)$ if retailers order high in the first period (i.e., $q_i^r = 3$), while $\pi_2^w = (1-\mu)w_2^g q_2^h + \mu w_2^p q_2^h = 3(1-\mu)$ if they order low in the first period (i.e., $q_i^r = 2$). Second, when $1/3 \leq \mu < 1/2$, $\pi_2^w = (1-\mu)w_2^p q_2^h + \mu w_2^p (q_2^h - 1) = 2(1-\mu)(1+\mu)$ if retailers order $q_i^r = 3$, or
\[ \pi^* = (1 - \mu)W_2^p Q_2 + \mu W_2^p Q_1 \]

- if they order \( Q_1 = 2 \). Third, when \( 1/2 < \mu \leq 1 \),

\[ \pi^* = (1 - \mu)W_2^p Q_2 + \mu W_2^p (Q_1 - 1) = (2-\mu) \] if retailers order \( Q_1 = 3 \), or

\[ \pi^* = (1 - \mu)W_2^p Q_2 + \mu W_2^p Q_1 = 2 \] if they order \( Q_1 = 2 \). This is summarized in the Table 2.

<table>
<thead>
<tr>
<th>( \mu )</th>
<th>Retailers' 1st Period Order</th>
<th>( \pi^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 0 \leq \mu &lt; 1/3 )</td>
<td>High (3)</td>
<td>((3-\mu)(1-\mu))</td>
</tr>
<tr>
<td></td>
<td>Low (2)</td>
<td>(3(1-\mu))</td>
</tr>
<tr>
<td>( 1/3 \leq \mu &lt; 1/2 )</td>
<td>High</td>
<td>(2(1-\mu)(1+\mu))</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>2</td>
</tr>
<tr>
<td>( 1/2 &lt; \mu \leq 1 )</td>
<td>High</td>
<td>(2-\mu)</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>2</td>
</tr>
</tbody>
</table>

Knowledge of the possible payoffs in period two permits us to characterizes the first period retailer behavior. Because retailers can carry forward their inventories to the second period, fire sale pricing does not take place in the first period, even if excess supply exists.

In the retail market, retailers decide their supply schedule according to the marginal opportunity cost of their inventories which have been stocked. The opportunity cost of the carryover inventory from the first period is \( W_2 \) since that inventory replaces the second period order for the product. Therefore, the market supply schedule in the
first period is horizontal at $W_2$ until it arrives at the inventory stocked $Q_1'$ and it is vertical at $Q_1'$ because retailers can only reorder the product after the first period transaction. Retail prices are then determined by supply and demand. If $Q_1' \leq Q_1^d$, then the first period retail price, $P_1$, is determined at the consumer reservation price of one. On the other hand, if $Q_1' > Q_1^d$, $P_1$ is determined at $W_2$ which is the marginal cost of retail inventories. That is,

\[ P_1^h = P_1(Q_1' \leq Q_1^d) = 1 \]

\[ P_1^v = P_1(Q_1' > Q_1^d) = W_2. \]  

When they decide their orders in the first period, retailers want to maximize their first period profit. The retailers' order in the first period, $Q_1'$, depends on $W_1$. If they order high, 3, then their first period profit is

\[ \pi_1'(Q_1' = 3) = (1 - \mu) P_1^h + \mu P_1^v - W_1) Q_1' = (1 - \mu) + \mu W_2 - W_1) Q_1'. \]

If they order low, 2, and sell them out, then

\[ \pi_1'(Q_1' = 2) = (1 - \mu) P_1^h + \mu P_1^v - W_1) Q_1' = (1 - W_1) Q_1'. \]

Retailers maximize their first period profit by choosing $Q_1'$ given $W_1$. Retailers solve their profit maximization problem with respect to $Q_1'$ given retail prices and wholesale prices. According to the first order conditions for the retailers' profit maximization, retailers can determine how much they order given $W_1$. If $W_2 = W_2^* =
1-μ, then retailers order high, 3, when $W_1$ is $(1-μ)(1+μ)$. If $W_2 = W_2^{eq} = 1$, they also order high, 3, although the manufacturer does not set $W_1$ low (that is, although $W_1 = 1$). However, retailers cannot know $W_2$ when they order the product in the first period. Hence, if retailers order high in spite of $W_1 = 1$, retailers may then make losses because, thereby increasing his profit, the manufacturer may set $W_2$ at less than one. Retailers thus order high only when the manufacturer promotes retail inventories by the wholesale price of $(1-μ)(1+μ)$. The only exception is the case that the manufacturer cannot obtain higher profit from that kind of the second period promotional action. Retailers in this case know that the manufacturer will set $W_2 = 1$. They can therefore order high in the first period in spite of $W_1 = 1$. Then, the equilibrium quantity ordered in the first period is

$$Q_1^* = Q_1(W_1 = (1-μ)(1+μ), W_2 = 1 - μ; or W_1 = 1, W_2^{eq} = 1) = 3 \quad (13)$$

$$Q_1^* = Q_1(W_1 = 1, W_2 = 1 - μ) = 2 \quad (14)$$

Consider the manufacturer’s first period profit to find out the first period equilibrium wholesale prices. The first period wholesale prices are determined from the manufacturer’s profit maximization conditions. When the manufacturer would like to maximize his profit by the determination of $W_1$, he has to consider the retailers’ participation constraint (i.e., $π_i^* ≥ 0$). From the above constraint, the manufacturer knows the following conditions. On the one hand, when they are unsure that $W_2$ will be one, retailers order high if only $W_1 ≤ (1-μ)(1+μ)$ while they order low if
On the other hand, if retailers are sure that $W_2$ is certainly one, they can order high although $(1 - \mu)(1 + \mu) < W_1 \leq 1$.

The manufacturer's first period profit is $\pi^m_1 = W_1 Q_1'$. That is, $\pi^m_1$ is an increasing linear function of $W_1$. Hence, the manufacturer will set the highest price that he can set under the retailers' participation constraint. We have to consider the following two cases to find out the first period equilibrium wholesale prices. The first is the case that the manufacturer makes higher profit from retail inventory promotion during the second period when retailers order high at $W_1$ of one. Retailers cannot make nonnegative profit if they order high in this case. The manufacturer thus has to set $W_1$ at $(1 - \mu)(1 + \mu)$ if he wants to promote the retail inventory. However, if he does not want to promote, he sets $W_1$ at one. The second is the case that the manufacturer cannot make higher profit from the same action as above. Why does the manufacturer then set $W_1$ at less than one in this case?

For the determination of the range of $\mu$ in which retailers order high without worrying about $W_2$, let us calculate the manufacturer's total profit over two periods in the case that retailers order high although the manufacturer set $W_1$ at one. If retailers order high at $W_1$ of one, then the manufacturer's first period profit, $\pi^m_1 = W_1 Q_1' = 3$. Hence, the manufacturer's total profit over two periods, $\pi^m = \pi^m_1 + \pi^m_2$, is as follows. If the manufacturer sets $W_2$ at $W_2^p = 1 - \mu$, $\pi^m(W_1 = 1; W_2 = 1 - \mu) = 6 - 4\mu + \mu^2$. If he sets $W_2$ at $W_2^p = 1$, then $\pi^m(W_1 = 1; W_2 = 1) = 5 - \mu$. If he sets $W_2$ at $W_2^p = 1 - \mu$ in the case
that $\Delta = 1$ and he sets $W_2$ at $W_{2}^p = 1$ in the case that $\Delta = 0$, 
$\pi^m(W_1 = 1; W_2 = 1 - \mu, or W_2 = 1) = 5 - 2\mu^2$. From the comparison among the above 
three manufacturer's profits, we can infer that although $W_1 = 1$, retailers order high in 
the range of $1/2 < \mu < 1$. Otherwise, (i.e., $0 \leq \mu < 1/2$), retailers order high only if the 
manufacturer sets $W_1$ at $(1-\mu)(1+\mu)$. Therefore, the first period equilibrium wholesale 
prices are 

$$W_1^p = W_1(0 \leq \mu < 1/2) = (1 - \mu)(1 + \mu),$$
$$W_1^p = W_1(1/2 < \mu \leq 1) = 1,$$ 

(15) 

$$W_{1}^{mp} = W_1(0 \leq \mu < 1/2) = 1.$$ 

(16) 

Consider the manufacturer’s first period profit when $0 \leq \mu < 1/2$ to find out the 
equilibrium total profit of the manufacturer. If the manufacturer sets $W_1$ at $(1-\mu)(1+\mu)$, 
$\pi_1^m = W_1^p Q_1^h = 3(1 - \mu)(1 + \mu)$. If he sets $W_1$ at one, $\pi_1^m = W_1^{mp} Q_1^l = 2$. The 
manufacturer’s total profit over two periods of each combination of actions is 
summarized in the following table.

[Table 3] Manufacturer Total Profit over Two Periods When $0 \leq \mu < 1/2$

<table>
<thead>
<tr>
<th>$\mu$</th>
<th>$W_1$</th>
<th>$W_2$</th>
<th>$\pi^m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0 \leq \mu &lt; 1/3$</td>
<td>$(1-\mu)(1+\mu)$</td>
<td>$1-\mu$</td>
<td>$6 - 4\mu + 2\mu^2$</td>
</tr>
<tr>
<td></td>
<td>$1$</td>
<td>$1-\mu$</td>
<td>$5 - 3\mu$</td>
</tr>
<tr>
<td>$1/3 \leq \mu &lt; 1/2$</td>
<td>$(1-\mu)(1+\mu)$</td>
<td>$1$ if $\Delta = 0$</td>
<td>$5 - 5\mu^2$</td>
</tr>
<tr>
<td></td>
<td>$1-\mu$ if $\Delta = 1$</td>
<td>$1$</td>
<td>$4$</td>
</tr>
</tbody>
</table>
First, when $0 < \mu < 1/3$, $\pi'' = 6 - 4\mu - 2\mu^2$ if $W_1 = (1-\mu)(1+\mu)$ and $W_2 = 1-\mu$, while $\pi'' = 5 - 3\mu$ if $W_1 = 1$ and $W_2 = 1-\mu$. Comparing the above two profits, we can infer that if the manufacturer promotes retail inventories in the second period, then it is sure that he certainly promoted the inventory in the first period in this range of $\mu$. That is, when $0 \leq \mu < 1/3$, the inventory promotion wholesale pricing in both periods is dominant.

Second, when $1/3 \leq \mu < 1/2$, $\pi'' = 5 - 5\mu^2$ if $W_1 = (1-\mu)(1+\mu)$ and $W_2 = 1-\mu$ in the case that $\Delta = 1$ and $W_2 = 1$ in the case that $\Delta = 0$, while $\pi'' = 4$ if $W_1 = W_2 = 1$. From the comparison about those two profits, we can infer that when $1/3 \leq \mu < 1/\sqrt{5}$, the manufacturer always chooses the inventory promotion wholesale pricing in the first period and he determines whether he promotes the retail inventory in the second period according to the carryover inventory from the first period. In contrast, when $1/\sqrt{5} \leq \mu < 1/2$, no promotion pricing gives higher profit to the manufacturer.

Third, when $1/2 < \mu < 1$, the manufacturer always chooses no promotion in both periods. That is, he chooses no promotion strategy only when the probability of success is almost 50 percent or less. This is natural because the manufacturer as well as retailers does not want to take losses from the product's failure in the market if the probability of success is low.

In summary, inventory promotion wholesale pricing is beneficial only when the probability of high demand realization is relatively high. That is, inventory promotion
wholesale pricing is profitable to the manufacturer when $\mu$ is less than $1/\sqrt{5}$ in this model. Otherwise, no promotion is the best strategy for the manufacturer. Thus, we can infer that manufacturers who have really innovative products always promote retail inventories. Table 4 summarizes the above subgame-perfect Nash equilibria according to the size of $\mu$.

4.2. Slotting Allowance Game

We do not consider the effect of signaling. However, given our assumption of common knowledge the manufacturer has the option of buying shelf space through slotting allowances. We now analyze that case. The manufacturer may suggest a slotting allowance offer to retailers for promoting his products on retail shelves. If he chooses a slotting allowance promotion, then the manufacturer must announce both period wholesale prices ($W_1$ and $W_2$) before retailers order the first period inventories. He must also pay slotting allowances which cover the retailers' negative profit possibilities from high inventory holdings. On the other hand, if retailers accept the slotting allowance offer, they always have to stock inventories high on their shelves in each and every period. Both the manufacturer and retailers are interested only in the maximization of the total profit over two periods in this game because slotting allowances absorb the possibility of expected losses from the channel.

In the second period, retailers can only replenish their inventories at $W_2$ and supply whole inventories to the market. Thus, the market supply curve is horizontal at
[Table 4] Subgame-Perfect Nash Equilibria of the Inventory Promotion Wholesale Pricing Game

<table>
<thead>
<tr>
<th>$\mu$</th>
<th>$P_1^h$</th>
<th>$P_1^l$</th>
<th>$P_2^h$</th>
<th>$P_2^l$</th>
<th>$\pi'$</th>
<th>$W_1^p$</th>
<th>$W_1^l$</th>
<th>$W_2^p$</th>
<th>$W_2^l$</th>
<th>$\pi''$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0 &lt; \mu &lt; \frac{1}{3}$</td>
<td>1</td>
<td>$(1-\mu)$</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>$(1-\mu)(1+\mu)$</td>
<td>-</td>
<td>$(1-\mu)$</td>
<td>$6 - 4\mu - 2\mu^2$</td>
</tr>
<tr>
<td>$\mu = \frac{1}{3}$</td>
<td>1</td>
<td>$(1-\mu)$</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>$(1-\mu)(1+\mu)$</td>
<td>-</td>
<td>$(1-\mu)$</td>
<td>$6 - 4\mu - 2\mu^2$</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>$(1-\mu)$</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>$(1-\mu)(1+\mu)$</td>
<td>1 if $\Delta = 0$</td>
<td>$(1-\mu)$ if $\Delta = 1$</td>
<td>$5 - 5\mu^2$</td>
</tr>
<tr>
<td>$\frac{1}{3} &lt; \mu &lt; \frac{1}{\sqrt{5}}$</td>
<td>1</td>
<td>$(1-\mu)$</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>$(1-\mu)(1+\mu)$</td>
<td>1 if $\Delta = 0$</td>
<td>$(1-\mu)$ if $\Delta = 1$</td>
<td>$5 - 5\mu^2$</td>
</tr>
<tr>
<td>$\mu = \frac{1}{\sqrt{5}}$</td>
<td>1</td>
<td>$(1-\mu)$</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>$(1-\mu)(1+\mu)$</td>
<td>1 if $\Delta = 0$</td>
<td>$(1-\mu)$ if $\Delta = 1$</td>
<td>$5 - 5\mu^2$</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>0</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>$\frac{1}{\sqrt{5}} &lt; \mu &lt; \frac{1}{2}$</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>0</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>$\frac{1}{2} &lt; \mu \leq 1$</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>0</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>$5-\mu$</td>
</tr>
</tbody>
</table>
the retail price of zero until it reaches to the inventory stocked, \( Q'_2 \), and it is vertical at \( Q'_2 \) because the scrap value of the product is zero in the end of the second period and reorder is not possible. \( P_2 \) is then determined by the demand and supply.

If \( Q'_2 \leq Q'_2 \), then \( P_2 \) is determined at one. If \( Q'_2 > Q'_2 \), then \( P_2 \) goes to zero because of fire sale pricing in the end of the second period. Thus, the equilibrium retail prices are

\[
P'_2 = P_2(Q'_2 \leq Q'_2) = 1
\]  
(17)

\[
P'_2 = P_2(Q'_2 > Q'_2) = 0.
\]  
(18)

The retailers’ revenue is only from the sales in the high demand state. Thus, the second period retailers’ profit is \( \pi'_2 = (P'_2 + P'_2 - W_2)Q'_2 = 3(1 - \mu) - 3W_2 \). On the other hand, the manufacturer only supplies retailers' orders at the predetermined wholesale price \( W_2 \). If there is no carryover inventory from the first period, the manufacturer sells \( Q'_2 \) while he sells \( (Q'_2 - 1) \) if there is carryover inventory of one. Then, because \( Q'_2 = 3 \),

\[
\pi''_2 = (1 - \mu)W_2Q'_2 + \mu W_2(Q'_2 - 1) = (3 - \mu)W_2.
\]

In the first period, if they accept the manufacturer's slotting allowance offer, retailers have to order and supply high at the given wholesale price \( W'_1 \). In the retail market, retailers decide their supply schedule according to the marginal opportunity cost of their inventories which have already been stocked. The opportunity cost of the carryover inventory from the first period is \( W_2 \) since that inventory replaces the second
period order for the product. Therefore, the market supply schedule in the first period is horizontal at $W_2$ until it arrives at the inventory stocked $Q_1'$ and it is vertical at $Q_1'$ because retailers can only reorder the product after the first period transaction.

Retail prices are determined by supply and demand in the retail market. If $Q_1' \leq Q_1^d$, then the first period retail price, $P_1$, is determined at the consumer reservation price of one. On the other hand, if $Q_1' > Q_1^d$, $P_1$ is determined at $W_2$ which is the marginal cost of retail inventories. That is,

$$P_1^i = P_1(Q_1' \leq Q_1^d) = 1$$

$$P_1^i = P_1(Q_1' > Q_1^d) = W_2.$$  \hspace{1cm} (19) \hspace{1cm} (20)

The retailers' first period profit is $\pi_1 = \{(1 - \mu)P_1^h + \mu P_1^i - W_1\}Q_1' + S = 3(1-\mu) + 3\mu W_2 - 3 W_1 + S$ where $S$ is the slotting allowance payment. The manufacturer's first period profit is $\pi_1^m = W_1 Q_1' - S = 3 W_1 - S$.

Now let us consider the total profit of both periods for the manufacturer and retailers. The manufacturer's profit is $\pi^m = 3 W_1 + (3 - \mu) W_2 - S$ and the retailers' total profit is $\pi^r = 6(1 - \mu) - 3(1 - \mu) W_2 - 3 W_1 + S$. From the manufacturer's total profit function, we can infer that the manufacturer wants to set the highest possible $W_1$ and $W_2$ under the retailers' participation constraint (i.e., $\pi^r \geq 0$) and pay retailers the least amount of $S$ to maximize his profit. Therefore, $W_1 = W_2 = 1$ because one is the highest price that he can set in this game. Then, the retailers' total profit is $\pi^r = S - 3\mu$. For the
maximization of the manufacturer's profit, slotting allowance payments have to be minimized while they induce retailers to hold high inventories. Therefore, equilibrium slotting allowances are $S^* = S(Q_1' = Q_2' = 3) = 3\mu$. That is, the slotting allowance payments depend on the size of the high demand (3) and the probability of low demand realization ($\mu$). Here, we can deduce that slotting allowances only compensate retailers for losses from the slack demand state. The manufacturer's total profit over two periods is $\pi''(W_1 = W_2 = 1; S^* = 3\mu) = 6 - 4\mu$. The following table summarizes the subgame-perfect Nash equilibrium of the slotting allowance game.

<table>
<thead>
<tr>
<th>$P^h_1$</th>
<th>$P^l_1$</th>
<th>$P^h_2$</th>
<th>$P^l_2$</th>
<th>$S^*$</th>
<th>$\pi''$</th>
<th>$W_1$</th>
<th>$W_2$</th>
<th>$\pi''$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>$3\mu$</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>6 - 4$\mu$</td>
</tr>
</tbody>
</table>

4.3. Inventory Promotion Wholesale Pricing Vs. Slotting Allowances

Compare the outcomes of above two promotion methods. From Table 4 and Table 5, we can see that the slotting allowance promotion gives higher profits than that of the inventory promotion wholesale pricing to the manufacturer if $0 < \mu < 1/2$. That is, slotting allowances give the manufacturer higher profits than those of inventory promotion wholesale pricing if the probability of success is at least 50 percent or more\(^{17}\).

\(^{17}\) This is very robust result because we assume the difference between low demand and high demand is only 50%. However, when we expand the difference from 50% to 100% or more, the profit from slotting allowances is far greater than that of the inventory promotion wholesale pricing even under the very low probability of high demand realization.
Therefore, we may conclude that the manufacturer uses slotting allowances as a promotion method inducing high inventories on retail shelves to maximize his profit under demand uncertainty.

What is the intuition for this? As long as the market cycle permits reordering, a low wholesale price encourages excessive competition too early from the manufacturer’s point of view and thus bleeds away profits. If the manufacturer promotes his product’s inventories by low wholesale prices, retailers compete in both periods. Therefore, the realized retail price does not extract all available surplus from consumers. In contrast, slotting allowances can delay the competition to the terminal period and they thus induce higher inventories on the retail shelves. Because retailers can sell their inventories in the second period and they know the second period wholesale prices in the beginning of the first period, they do not compete in price in the first period. However, all inventories are dumped and fire sale pricing occurs in the slack demand case because there is no other sales opportunities for remnant inventories in the second period. That is, even slotting allowances cannot avoid the competition in the terminal period. To correct this problem, the manufacturer needs RPM in the final period. RPM keeps the product's retail price high through contract and hence can prevent retailers from excessive competition even in the last period of the game.

There exist arguments against slotting allowances in the grocery industry. Those arguments can be evaluated by this analysis now. Small manufacturers argued that their large rivals foreclose the market by slotting allowance payments to retailers.18 This

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analysis has shown that a manufacturer who has low \( p \) promotes his product's inventories through slotting allowances to maximize his profit. That is, it has suggested that slotting allowances are not a mechanism of market foreclosure but an effective inventory promotion mechanism for really innovative products. Another argument by small retailers is that manufacturers differentiate them by different amounts of slotting allowances\(^{19}\). This analysis has shown that slotting allowances depend on the probability of low demand, \( p \), and the level of high demand, \( 3 \). According to the size of retailers, quantity demanded in the high demand state must be different. Slotting allowance payments to each retailer are naturally different in that case. Thus, the unfairness argument against slotting allowances is not plausible.

5. Conclusion

Several previous analyses have argued that slotting allowances are the phenomena which are caused by a change of the bargaining power in the distribution channel. However, they did not explain why manufacturers and retailers prefer slotting allowances to inventory promotion wholesale pricing although the latter is easy and convenient to impose while it accomplishes the same objective. In this chapter, I have explained why slotting allowances are prevalent for inventory promotion of newly introduced products under demand uncertainty. The manufacturer's inventory promotion

wholesale pricing always gives higher profit than that of no promotion strategy when the probability of high demand realization is approximately 60 percent. Moreover, if the probability of high demand realization is 50 percent or more, the slotting allowance promotion always gives higher profit than that of inventory promotion wholesale pricing. Only when the probability of success is less than and equal to 50 percent, no promotion strategy is dominant.

What are the reasons for these results? First, slotting allowances induce high inventories on retail shelves under demand uncertainty and keep the product price high when the market opens. Thus, slotting allowances bring higher profits to manufacturers. Second, if the manufacturer chooses a low wholesale price as the inventory promotion method, retailers start their competition too early from the manufacturer's point of view. That competition is noxious to the manufacturer's profit maximization. Therefore, the manufacturer wishes to prevent the retailers' competition. RPM is a method for that prevention. However, that vertical restraint is per se illegal in the antitrust law. Hence, manufacturers might choose slotting allowances as their inventory promotion method to keep retailers from excessive competition while inducing high inventories on retail shelves.
Chapter III

The Welfare Effect of Slotting Allowances under Demand Uncertainty

1. Introduction

We have already shown that slotting allowances result in higher inventories of the manufacturer's newly introduced product on retail shelves and thus provide a higher profit to the manufacturer in Chapter II. This result is attained because slotting allowances eliminate the effect of demand uncertainty in the distribution channel by compensating retailers for possible losses from low demand realization under full stocking. In this chapter, we examine the welfare effect of slotting allowances under demand uncertainty with a more general specification of demand.

First, we will start with a two-period linear demand model which reflects the intrinsic nature of slotting allowances and will explain why manufacturers and retailers prefer slotting allowances under demand uncertainty. Because the model is extended with a linear demand assumption, it is a generalization of my hypothesis in the previous chapter --slotting allowances as the manufacturer's inventory promotion mechanism.
We will corroborate the result in the previous chapter through solving two different inventory inducing promotion games: an inventory promotion wholesale pricing game and a slotting allowance game.

Second, we will check the welfare effect of slotting allowances compared with that of inventory promotion wholesale pricing. We will employ normal welfare economics tools: consumer surplus (CS) and social efficiency (SW) which is generally defined as the sum of consumer surplus and total channel profits and will show that slotting allowances result in higher consumer surplus and higher channel profits if the product has a high probability of success or a large difference between low and high demand in size. This results are consistent with Sullivan (1993)'s empirical findings and other theoretical arguments (Kelly, 1991; Lariviere, 1994) about the welfare and competition effect of slotting allowances. However, it rebuts the arguments about slotting allowances as an welfare deteriorating, price fixing, and anticompetitive trade promotion practice (Shaffer, 1991), as a market foreclosure and unfair promotion method (Cannon and Bloom, 1991) and as a retailer profit extraction mechanism at the cost of manufacturers (Chu, 1992).

We will proceed as follows. Section 2 will define a two-period linear demand model and explain the model in detail. It will also describe the rules for both games. Section 3 will demonstrate the subgame-perfect Nash equilibria and their paths in detail and will thus explain why manufacturers prefer slotting allowances to inventory promotion wholesale pricing under demand uncertainty through comparing the outcomes.
of the slotting allowance game with that of the inventory promotion wholesale pricing game. Section 4 will compare the welfare effects of both games by consumer surplus and social efficiency measures and will give some policy implications for the application of the antitrust laws on slotting allowances. Finally, we will summarize the main results of this analysis in section 5.

2. Linear Demand Model

For the analysis of the welfare effect of slotting allowances, let us set up a two period linear demand model and describe the game rules for the inventory promotion wholesale pricing game and the slotting allowance game in this section.

Consider a risk-neutral, monopoly manufacturer and identical, risk-neutral, competitive retailers who in turn sell to consumers. The market is open two periods to reflect the effect of slotting allowances over periods.

Each period's demand is described as follows:

\[ Q = 1 - P \quad \text{with probability of } 1/3 \text{ in the low demand state;} \]

\[ Q = \theta(1 - P) \quad (\theta > 1) \quad \text{with probability of } 2/3 \text{ in the high demand state.} \]

Retailers ought to order their inventories before the retail market opens. They can order as much as they wish at the manufacturer's wholesale price. They can also reorder the product to replenish inventories for second period sales after the first period.
transaction. The remnant inventories from period 1 carry forward to the second period without cost. However, the scrap value of second period remnant inventories is zero at the end of the second period. Thus, unsold inventories in the second period are a sunk cost to retailers because the manufacturer does not permit returns of unsold products, while the first period remnant inventories have equal per unit value with the second period wholesale price when the market opens in the first period. For simplicity, production and distribution are assumed to be costless and all information is also assumed to be common knowledge.

Our interest is in comparing the welfare effect of the inventory promotion wholesale pricing with that of slotting allowances. Thus, we have to solve the same games as those of Chapter II with a linear demand model and calculate the CS’s and the SW’s of both games. The permissible contracts and timing of moves in each game are the same as those specified in Chapter II.

3. Inventory Promotion Wholesale Pricing
   Vs. Slotting Allowances

The manufacturer desires high orders from retailers so as to prepare for high demand realization. Retailers, on the other hand, would not like to bear the risk of the slack demand state when they order high. Hence, they need special business practices to settle this conflict of interests. Slotting allowances and inventory promotion wholesale
pricing can be methods for resolving the conflict among both parties. Slotting allowances have become the leading promotion practice since the late 1980s while inventory promotion wholesale pricing is general and easy method for the same purpose. This section addresses why slotting allowances are preferred to inventory promotion wholesale pricing with a linear demand model.

3.1. Inventory Promotion Wholesale Pricing Game

The manufacturer uses a low wholesale price for the high inventory stocking when he introduces a new product. If he does not promote high inventories on retail shelves, he must set the wholesale price without considering demand uncertainty. Now, let us solve the inventory promotion wholesale pricing game by backward induction.

In the second period, retailers supply their entire inventory to the market. Because the scrap value of remnant inventories at the end of the second period is zero, the marginal opportunity cost of the second period retail inventories is zero. Thus, the market supply curve is horizontal at the retail price of zero until it arrives at the inventory stocked, \( \bar{Q}_2 \), and it is vertical at \( \bar{Q}_2 \) because reordering is not possible. That is, the market supply curve is

\[
Q_2'(P_2) = \bar{Q}_2 \quad \text{if } P_2 \geq 0.
\]  

(21)
The second period retail price, $P_2$, is then determined by the market supply and demand. If the second period demand, $Q^d_2$, is high (i.e., $Q^d_2 = Q^h_2 = \theta(1 - P_2)$), the second period equilibrium retail price is

$$P_2(Q^h_2) = 1 - \frac{1}{\theta}Q^h_2 \quad \text{if } 0 \leq Q^h_2 < \theta$$

$$= 0 \quad \text{if } Q^h_2 \geq \theta. \quad (22)$$

On the other hand, if $Q^d_2 = Q^l_2 = 1 - P_2$,

$$P_2(Q^l_2) = 1 - Q^l_2 \quad \text{if } 0 \leq Q^l_2 < 1$$

$$= 0 \quad \text{if } Q^l_2 \geq 1. \quad (23)$$

Because retailers are competitive, they take the second period equilibrium retail prices as given. When they determine their second period inventory level, $Q^r_2$, retailers only depends on the second period wholesale price, $W_2$. According to $W_2$, retailers may hold inventories high and obtain revenue in the high demand state only (i.e., $Q^r_2 \geq 1$) or they may hold inventories low and sell their inventories at the positive price in both demand states (i.e., $Q^r_2 < 1$). The retailers' second period profit is

$$\pi^r_2(Q^r_2) = \frac{2}{3} P_2(Q^h_2) + \frac{1}{3} P_2(Q^l_2) - W_2 \cdot Q^r_2. \quad (24)$$

From the first order condition for the retailers' second period profit maximization, we can infer that retailers hold their inventory $Q^r_2 \geq 1$ if $W_2 = \frac{2}{3} - \frac{2}{3\theta} Q^r_2$, while they hold
\( Q_2' < 1 \) if \( W_2 = 1 - \frac{2 + \theta}{3\theta} Q_2' \). This means that the second period equilibrium quantity stocked is

\[
Q_2'(\geq 1) = \theta - \frac{3\theta}{2} W_2, \tag{25}
\]

\[
Q_2'(\leq 1) = \frac{3\theta}{2 + \theta} (1 - W_2). \tag{26}
\]

The manufacturer wishes to maximize his profit through choosing \( W_2 \). When he chooses \( W_2 \), he will consider the carryover inventory level from the first period, \( \Delta \), which replaces the new order in the second period. The manufacturer's second period profit is

\[
\pi_2^m(W_2) = W_2 (Q_2' - \Delta). \tag{27}
\]

When he chooses \( W_2 \), the manufacturer must consider the retailers' participation constraint (i.e., \( \pi_2^r(Q_2') \geq 0 \)). That is, \( W_2 \) has to be less than or equal to \( \frac{2}{3} P_2(Q_2^b) + \frac{1}{3} P_2(Q_2') \). Moreover, the manufacturer sets \( W_2 \) at \( \frac{2}{3} P_2(Q_2^b) + \frac{1}{3} P_2(Q_2') \) only if it gives the maximum profit to the manufacturer. Otherwise, he can deviate from that price although retailers would like to hold the above optimal quantity stocked at that price. That is, the manufacturer only sets \( W_2 \) at \( \frac{2}{3} P_2(Q_2^b) + \frac{1}{3} P_2(Q_2') \) if
\[
\pi^*_{2} (W_2 = \frac{2}{3} P_2(Q'_2) + \frac{1}{3} P_2(Q'_2)) \geq \pi^*_{2} (W_2 < \frac{2}{3} P_2(Q'_2) + \frac{1}{3} P_2(Q'_2)) \].  \tag{28}
\]

Because this constraint is always satisfied when the manufacturer sets \( W_2 \) at \( \frac{2}{3} P_2(Q'_2) + \frac{1}{3} P_2(Q'_2) \), the manufacturer's second period profit is

\[
\pi^*_{2} (Q'_2 \geq 1) = W_2 \{ \theta - \frac{3\theta}{2} W_2 - \Delta \} \tag{29}
\]

when he induces \( Q'_2 \geq 1 \), while

\[
\pi^*_{2} (Q'_2 < 1) = W_2 \{ \frac{3\theta}{2 + \theta} - \frac{3\theta}{2 + \theta} W_2 - \Delta \} \tag{30}
\]

when the manufacturer induces retailers' inventory at \( Q'_2 < 1 \). According to the first order conditions of maximizing (29) and (30), the manufacturer sets \( W_2 \) at

\[
W_2 = \frac{1}{3} - \frac{1}{3\theta} \Delta \quad \text{if he wishes to induce} \quad Q'_2 = \theta - \frac{3\theta}{2} W_2 \tag{31}
\]

\[
W_2 = \frac{1}{2} - \frac{2 + \theta}{6\theta} \Delta \quad \text{if he wants to induce} \quad Q'_2 = \frac{3\theta}{2 + \theta} \{1 - W_2\}. \tag{32}
\]

That is, \( W_2 \) depends on the carryover inventory from the first period, \( \Delta \). For the calculation of \( \Delta \), let us consider the first period of the game next.

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\(^{20}\) This incentive compatibility constraint can be satisfied when \( W_2 = \frac{2}{3} p_i(Q'_2) + \frac{1}{3} p_i(Q'_2) \). From the retailers' second period profit function, the manufacturer's second period profit \( \pi^*_{2} W_2 = \frac{2}{3} p_i(Q'_2) + \frac{1}{3} p_i(Q'_2) = W_2 Q'_2 = \left( \frac{2}{3} p_i(Q'_2) + \frac{1}{3} p_i(Q'_2) \right) Q'_2 > \pi^*_{2} (W_2 < \frac{2}{3} p_i(Q'_2) + \frac{1}{3} p_i(Q'_2)) \). Thus, \( W_2 = \frac{2}{3} p_i(Q'_2) + \frac{1}{3} p_i(Q'_2) \) always gives the highest profit to the manufacturer and satisfies the manufacturer's incentive compatibility constraint.
In the first period, retailers supply their inventory stocked, $Q'_1$, according to the marginal opportunity cost of $Q'_1$. The marginal cost of the already stocked inventory in the first period is $W_2$ because carryover inventories from the first period take the place of retailers' new orders of the product for the second period. Therefore, the market supply curve in the first period is horizontal at $W_2$ until it arrives at $Q'_1$ and it is vertical at $Q'_1$. That is, the first period market supply curve is

$$Q'_1(P_1) = \begin{cases} \dot{Q}'_1 & P_1 \geq W_2 \\ 0 & P_1 < W_2. \end{cases} 
$$

(33)

The first period retail prices and the carryover inventory level are determined by supply and demand. When the first period demand, $Q'^d_1$, is realized high (i.e., $Q'^d_1 = Q'^h_1 = \theta(1 - P_1)$), the first period equilibrium retail price is

$$P_1(Q'^h_1) = 1 - \frac{1}{\theta} Q'^h_1 \quad \text{if} \quad 0 \leq Q'^h_1 < \theta (1 - W_2)$$

$$= W_2 \quad \text{if} \quad Q'^h_1 \geq \theta (1 - W_2)$$

(34)

and when $Q'^d_1 = Q'_1 = 1 - P_1$, the equilibrium retail price is

$$P_1(Q'_1) = 1 - Q'_1 \quad \text{if} \quad 0 \leq Q'_1 < 1 - W_2$$

$$= W_2 \quad \text{if} \quad Q'_1 \geq 1 - W_2$$

(35)

The carryover inventory level to the second period, $\Delta = Q'_2 - Q'^d_1$, is also determined by supply and demand. In the high demand state, all inventories are sold out because the market always clears. However, there may exist carryover inventories in the
low demand state. If the retail price is equal to \( W_2 \), \( Q_1^d \) is \( 1-W_2 \) in the low demand state. Hence, if \( Q_1' \) is less than equal to \( 1-W_2 \), all inventories are sold out. On the other hand, if \( Q_1' \) is greater than \( 1-W_2 \), \( \Delta \) is positive. That is, the carryover inventory in equilibrium is

\[
\Delta = 0 \quad \text{if } Q_1' \leq Q_1^d. \tag{36}
\]

\[
\Delta = Q_1' - (1-W_2) \quad \text{if } Q_1' > Q_1^d. \tag{37}
\]

Before the retail market opens, retailers order and hold inventories for their business according to the first period wholesale price, \( W_1 \). When they order the manufacturer's product in the first period, their first period profit is

\[
\pi_1(Q_1') = \left( \frac{2}{3} P_1(Q_1') + \frac{1}{3} P_1(Q_1') - W_1 \right) Q_1'. \tag{38}
\]

From the first order condition of maximizing (38), retailers decide their amount of inventories. That is, they order \( Q_1' \) which exceeds the demand which is realized low (i.e., \( Q_1' > 1-W_2 \)) if \( W_1 = \frac{2}{3} \left( 1 - \frac{1}{\theta} Q_1^d \right) + \frac{1}{3} W_2 \), while they just order \( Q_1' \) which is exactly the same or less quantity as that of the low demand, (i.e., \( Q_1' \leq 1-W_2 \)) if \( W_1 = 1 - \frac{2+\theta}{3\theta} Q_1' \). Therefore, retailers' first period equilibrium inventory stocked is

\[
Q_1'(>1-W_2) = \frac{\theta}{2} W_2 - \frac{3\theta}{2} W_1. \tag{39}
\]
\[ Q'_1(\leq 1 - W_3) = \frac{3\theta}{2 + \theta} \{1 - W_1\} \] (40).

When the manufacturer sets \( W_1 \), he has to consider the retailers' first period participation constraint to induce retailers' high inventory and the manufacturer's own incentive compatibility constraint. Then, the manufacturer sets \( W_1 \) at \( \frac{2}{3} \{1 - \frac{1}{\theta} Q'_1\} + \frac{1}{3} W_2 \) in the case that he wishes to induce \( Q'_1 > 1 - W_2 \), while he sets \( W_1 \) at \( 1 - \frac{2 + \theta}{3\theta} Q'_1 \) for the inventory of \( Q'_1 \leq 1 - W_2 \). The manufacturer's first period profit is \( \pi_1^n = W_1 Q'_1 \).

Therefore, if he induces \( Q'_1 > 1 - W_2 \), the manufacturer's first period profit is

\[ \pi_1^n(\; Q'_1 > 1 - W_2) = W_1 \{\theta + \frac{\theta}{2} W_2 - \frac{3\theta}{2} W_1\} \] (41)

while if he induces \( Q'_1 \leq 1 - W_2 \),

\[ \pi_1^n(\; Q'_1 \leq 1 - W_2) = W_1 \frac{3\theta}{2 + \theta} \{1 - W_1\} \] (42)

From the first order conditions of maximizing (41) and (42), the manufacturer will set \( W_1 \) at

\[ W_1 = \frac{1}{3} + \frac{1}{6} W_2 \quad \text{if he wishes to induce} \quad Q'_1 = \theta + \frac{\theta}{2} W_2 - \frac{3\theta}{2} W_1 \] (43)

\[ W_1 = \frac{1}{2} \quad \text{if he wants to induce} \quad Q'_1 = \frac{3\theta}{2 + \theta} \{1 - W_1\}. \] (44)
For the calculation of the subgame-perfect Nash equilibrium profit of the manufacturer, we can substitute (43) and (44) into other related equations. If we solve those equations, we can obtain the equilibrium value of retail prices, wholesale prices, the carryover inventory and quantity stocked according to the manufacturer's strategy for inventory promotion.

First, let us consider the case when the manufacturer induces

\[ Q_1' = \theta + \frac{\theta}{2} w_2 - \frac{3\theta}{2} w_1 \]

by \( w_1 = \frac{1}{3} + \frac{1}{6} w_2 \). This means that in the first period, the manufacturer induces retail inventories which exceed the quantity demanded in the slack demand situation. Then, the manufacturer can determine two different carryover inventories. In the case that the carryover inventories are positive,

\[
W_2 = \frac{2(\theta + 2)}{13\theta + 4} \quad \text{if the manufacturer induces } Q_2' \geq 1, \quad (45)
\]

\[
W_2 = \frac{2(4 + 6\theta - \theta^2)}{\theta^2 + 30\theta + 8} \quad \text{if he induces } Q_2' < 1, \quad (46)
\]

from (31), (32), (37), (39), and (43). In that case, the retailers’ second period equilibrium inventory stocked, the second period equilibrium retail prices and carryover inventories from the first period are as follows:

\[
Q_2'(w_2) = \frac{2(\theta + 2)}{13\theta + 4} = \frac{2\theta(5\theta - 1)}{13\theta + 4} \quad \text{when } \theta \geq 1.731070844, \quad (47)
\]

\[
Q_2'(w_2) = \frac{3\theta(10\theta - 8)}{2(\theta^2 + 30\theta + 8)} = \frac{9\theta^2(\theta + 6)}{(2 + \theta)(\theta^2 + 30\theta + 8)} \quad \text{when } 1 < \theta < 2, \quad (48)
\]
\[ P_2(Q'_2) = \frac{3(\theta + 2)}{13\theta + 4} \quad \text{if} \quad Q'_2 = \frac{2\theta(5\theta - 1)}{13\theta + 4}, \quad (49) \]

\[ P_1(Q'_2) = 0 \quad \text{if} \quad Q'_2 = \frac{2\theta(5\theta - 1)}{13\theta + 4}, \quad (50) \]

\[ P_2(Q'_2) = \frac{\theta^3 + 23\theta^2 + 14\theta + 16}{(2 + \theta)(\theta^2 + 30\theta + 8)} \quad \text{if} \quad Q'_2 = \frac{9\theta^2(\theta + 6)}{(2 + \theta)(\theta^2 + 30\theta + 8)}, \quad (51) \]

\[ P_2(Q'_2) = \frac{2(8 + 34\theta - \theta^2 - 4\theta^3)}{(2 + \theta)(\theta^2 + 30\theta + 8)} \quad \text{if} \quad Q'_2 = \frac{9\theta^2(\theta + 6)}{(2 + \theta)(\theta^2 + 30\theta + 8)}, \quad (52) \]

\[ \Delta(W_2) = \frac{2(\theta + 2)}{13\theta + 4} = \frac{\theta(7\theta - 8)}{13\theta + 4}, \quad (53) \]

\[ \Delta(W_2) = \frac{2(4 + 6\theta - \theta^2)}{\theta^2 + 30\theta + 8} = \frac{3\theta(5\theta - 4)}{\theta^2 + 30\theta + 8}. \quad (54) \]

On the other hand, in the case that there does not exist carryover inventories from the first period,

\[ W_2 = \frac{1}{3} \quad \text{if the manufacturer wishes to sell} \; Q'_2 \geq 1, \quad (55) \]

\[ W_2 = \frac{1}{2} \quad \text{if the manufacturer sells} \; Q'_2 < 1. \quad (56) \]

In that case, retailers' equilibrium inventory stocked and carryover inventories from the first period are as follows:

\[ Q'_2(W_2 = \frac{1}{3}) = \frac{\theta}{2} \quad \text{when} \; \theta \geq 2, \quad (57) \]
Next, we calculate the manufacturer’s second period profits according to above four different situations and compare each other according to the level of the carryover inventories. If \( \Delta \) is positive, then the manufacturer’s second period profit is

\[
\pi_2^c(W_2) = \frac{2(\theta + 2)}{13\theta + 4} = \frac{4\theta(5\theta^2 + 9\theta - 2)}{(13\theta + 4)^2},
\]

(63)

\[
\pi_2^w(W_2) = \frac{2(4 + 6\theta - \theta^2)}{\theta^2 + 30\theta + 8} = \frac{18\theta^2(\theta + 6)(4 + 6\theta - \theta^2)}{(2 + \theta)(\theta^2 + 30\theta + 8)^2}.
\]

(64)

Let us compare (63) with (64) and consider the constraints about \( Q_2^c \) in (47) and (48). Then, we can obtain the second period subgame-perfect Nash equilibrium wholesale prices according to the range of \( \theta \) as follows. When \( 1 < \theta < 2 \), the manufacturer’s second period equilibrium wholesale price is
\[ W^{\pi}_{2}(\Delta > 0) = \frac{2(4 + 6\theta - \theta^2)}{\theta^2 + 30\theta + 8}, \]  \hspace{1cm} (65) 

while when \( \theta \geq 2 \), his second period equilibrium wholesale price is 

\[ W^{\pi}_{2}(\Delta > 0) = \frac{2(\theta + 2)}{13\theta + 4}. \]  \hspace{1cm} (66) 

On the other hand, when \( \Delta \) is zero, the manufacturer's second period profits are 

\[ \pi^{\pi}_{2}(W_2 = \frac{1}{3}) = \frac{\theta}{6}, \]  \hspace{1cm} (67) 

\[ \pi^{\pi}_{2}(W_2 = \frac{1}{2}) = \frac{3\theta}{4(2 + \theta)}. \]  \hspace{1cm} (68) 

Therefore, 

\[ W^{\pi}_{2}(\Delta = 0) = \frac{1}{3} \]  \hspace{1cm} when \( \theta > 2.5 \),  \hspace{1cm} (69) 

\[ W^{\pi}_{2}(\Delta = 0) = \frac{1}{2} \]  \hspace{1cm} when \( 1 < \theta \leq 2.5 \).  \hspace{1cm} (70) 

From (64) - (70), we calculate the manufacturer's second period profit according to the size of demand parameter \( \theta \). The manufacturer's second period equilibrium profit is 

\[ \pi^{\pi}_{2} = \frac{2}{3} W^{\pi}_{2}(\Delta = 0) Q^{\prime}_{2}(W^{\pi}_{2}(\Delta = 0)) + \frac{1}{3} W^{\pi}_{2}(\Delta > 0) Q^{\prime}_{2}(W^{\pi}_{2}(\Delta > 0)) 
\]  

\[ = \frac{\theta(187\theta^2 + 176\theta + 20)}{9(13\theta + 4)^2} \]  \hspace{1cm} when \( \theta > 2.5 \),  \hspace{1cm} (71)
\[ \pi_T^* = \frac{2}{3} \pi_T^p(\Delta = 0) \mathcal{Q}_2^r(\pi_T^p(\Delta = 0)) + \frac{1}{3} \pi_T^p(\Delta > 0) \mathcal{Q}_2^r(\pi_T^p(\Delta > 0)) \]
\[ = \frac{173 \theta^3 + 128 \theta^2 + 64 \theta + 32}{2(2 + \theta)(13 \theta + 4)^2} \quad \text{when } 2 < \theta \leq 2.5, \quad (72) \]

\[ \pi_T^* = \frac{2}{3} \pi_T^p(\Delta = 0) \mathcal{Q}_2^r(\pi_T^p(\Delta = 0)) + \frac{1}{3} \pi_T^p(\Delta > 0) \mathcal{Q}_2^r(\pi_T^p(\Delta > 0)) \]
\[ = \frac{\theta(\theta^3 + 68 \theta^2 + 300 \theta + 976 \theta + 416)}{2(2 + \theta)(\theta^2 + 30 \theta + 8)^2} \quad \text{when } 1 < \theta \leq 2. \quad (73) \]

For the calculation of the first period wholesale prices, we replace (65) and (66) with (43). Then, the manufacturer's first period wholesale prices are

\[ W_1^f = W_1(W_1^p = \frac{2(\theta + 2)}{13 \theta + 4}) = \frac{2(7 \theta + 3)}{3(13 \theta + 4)}, \quad (74) \]

\[ W_1^{rp} = W_1(W_1^{rp} = \frac{2(4 + 6 \theta - \theta^2)}{\theta^2 + 30 \theta + 8}) = \frac{4(3 \theta + 1)}{\theta^2 + 30 \theta + 8}. \quad (75) \]

If we replace these two possible first period wholesale prices to (34), (35), and (39) to calculate \( \mathcal{Q}_r^l, P_1(\mathcal{Q}_r^l), \) and \( P_1(\mathcal{Q}_r^l) \), then,

\[ \mathcal{Q}_r^l(W_1) = \frac{2(7 \theta + 3)}{3(13 \theta + 4)} = \frac{\theta(7 \theta + 3)}{13 \theta + 4} \quad \text{when } \theta \geq 1.142857143, \quad (76) \]

\[ \mathcal{Q}_r^l(W_1) = \frac{4(3 \theta + 1)}{\theta^2 + 30 \theta + 8} = \frac{6 \theta(3 \theta + 1)}{\theta^2 + 30 \theta + 8} \quad \text{when } \theta > 1, \quad (77) \]

\[ P_1(\mathcal{Q}_r^l) = \frac{6 \theta + 1}{13 \theta + 4}, \quad \text{if } \mathcal{Q}_r^l = \frac{\theta(7 \theta + 3)}{13 \theta + 4}, \quad (78) \]
\[ P_1(Q_t) = \frac{2(\theta + 2)}{13\theta + 4}, \quad \text{if } Q_t = \frac{\theta(7\theta + 3)}{13\theta + 4}, \quad (79) \]

\[ P_1(Q_t') = \frac{\theta^2 + 12\theta + 2}{\theta^2 + 30\theta + 8}, \quad \text{if } Q_t' = \frac{6\theta(3\theta + 1)}{\theta^2 + 30\theta + 8}, \quad (80) \]

\[ P_1(Q_t') = \frac{2(4 + 6\theta - \theta^2)}{\theta^2 + 30\theta + 8}, \quad \text{if } Q_t' = \frac{6\theta(3\theta + 1)}{\theta^2 + 30\theta + 8}. \quad (81) \]

Therefore, when he induces \( Q_t' \geq 1 - W_2 \), the manufacturer’s first period profit is

\[ \pi^* (W_t^1) = \frac{2(7\theta + 3)}{3(13\theta + 4)} = \frac{2\theta(7\theta + 3)^2}{3(13\theta + 4)^2}, \quad (82) \]

\[ \pi^* (W_t^{p1}) = \frac{4(3\theta + 1)}{\theta^2 + 30\theta + 8} = \frac{24\theta(3\theta + 1)^2}{(\theta^2 + 30\theta + 8)^2}. \quad (83) \]

Second, let us consider the case that the manufacturer sells \( Q_1' = \frac{3\theta}{2 + \theta} (1 - W_1) \)

with \( W_1 = \frac{1}{2} \). In this case, retailers always sell out their inventories in the first period.

Thus, the first period equilibrium wholesale price is not affected by \( W_2 \). However, the first period inventory stocked can be carried forward to the second period without selling if the first period retail price in the low demand state, \( P_1(Q_t') \), is lower than \( W_2 \). Because \( P_1(Q_t') \) has to be greater than or equal to \( W_2 \) and \( P_1(Q_t') = 1 - Q_t' \), \( Q_t' = \frac{3\theta}{2 + \theta} (1 - W_1) \) should be less than equal to \( 1 - W_2 \). When \( W_1 = \frac{1}{2} \), \( Q_t' = \frac{3\theta}{2(2 + \theta)} \).

When the retail market clears and all inventories are sold out, the second period
wholesale prices may be $W_{lp}^p(\Delta = 0) = \frac{1}{2}$ or $W_{lp}^p(\Delta = 0) = \frac{1}{3}$. When $W_{lp}^p(\Delta = 0) = \frac{1}{2}$, $Q_1' = \frac{3\theta}{2(2 + \theta)}$ does not satisfy $Q_1' \leq 1 - W_2$ because the constraint is only satisfied by $\theta < 1$. In the case that $W_{lp}^p(\Delta = 0) = \frac{1}{3}$, $Q_1' = \frac{3\theta}{2(2 + \theta)}$ satisfies the constraint when $1 < \theta < 1.6$. However, because $W_{lp}^p(\Delta = 0) = \frac{1}{3}$ only when $\theta > 2.5$, this $Q_1'$ cannot be the quantity stocked of the first period.

From the above discussion, we can derive the manufacturer's equilibrium total profit over two periods as follows.

$$
\pi^m = \pi_1^m(W_l^l) + \pi_2^m(W_{lp}^p(\Delta = 0), W_{lp}^p(\Delta > 0))
= \frac{\theta(481\theta^2 + 428\theta + 74)}{9(13\theta + 4)^2} \text{ when } \theta > 2.5,
$$

(84)

$$
\pi^m = \pi_1^m(W_l^l) + \pi_2^m(W_{lp}^p(\Delta = 0), W_{lp}^p(\Delta > 0))
= \frac{(196\theta^4 + 1079\theta^3 + 756\theta^2 + 264\theta + 96)}{6(2 + \theta)(13\theta + 4)^2} \text{ when } 2 \leq \theta \leq 2.5,
$$

(85)

$$
\pi^m = \pi_1^m(W_l^l) + \pi_2^m(W_{lp}^p(\Delta = 0), W_{lp}^p(\Delta > 0))
= \frac{\theta^5 + 500\theta^4 + 1452\theta^3 + 1600\theta^2 + 512\theta}{2(2 + \theta)(\theta^2 + 30\theta + 8)^2} \text{ when } 1 < \theta < 2.
$$

(86)

In this analysis, the demand difference parameter $\theta$ only varies while the probability of high and low demand realization is fixed at $2/3$ and $1/3$ respectively.
Table 6 summarizes the subgame-perfect Nash equilibria of inventory promotion wholesale pricing game. When $1 < \theta < 2$, (i.e., the high demand is less than double of the low demand), no retail inventory promotion (i.e., $Q_i^t < 1$) in both periods is the best strategy. When $2 < \theta < 2.5$, the promotion in the first period (i.e., $Q_i^t \geq 1$) is always the dominant strategy and the promotion for retail inventories is determined according to carryover inventories in the first period. When $\theta > 2.5$, the promotion by low wholesale prices over two periods gives the manufacturer higher profit. That is, the larger the difference between low demand and high demand is, the more profitable the manufacturer promotes his product inventory stocking on retail shelves. This means that the manufacturer can acquire higher profit from the promotion for retailers' inventories under demand uncertainty, if he really has an innovative product while retailers do not know about that possibility of success. In this case, the wholesale price without considering inventory promotion surely results in the loss of the manufacturer's potential profit.

3.2. Slotting Allowance Game

We consider the slotting allowance promotion of retail inventory stocking here. Both the manufacturer and retailers must be concerned only about the maximization of total profit because they can have a contract to guarantee their transaction over two periods in this game. When he suggests slotting allowances to retailers, the manufacturer wishes to minimize the amount of that payment. In the first period,
[Table 6] Subgame-Perfect Nash Equilibria in the Inventory Promotion Wholesale Pricing Game

<table>
<thead>
<tr>
<th>θ</th>
<th>1 &lt; θ &lt; 2</th>
<th>2 ≤ θ &lt; 2.5</th>
<th>2.5 &lt; θ</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p^1(Q^i)$</td>
<td>$\theta + 23 \theta^2 + 14 \theta + 16 \frac{2 \theta + 1}{2(\theta + 2)} \frac{2 \theta + 1}{2(\theta + 2)} \frac{2 \theta + 1}{2(\theta + 2)} \frac{2 \theta + 1}{2(\theta + 2)}$</td>
<td>$\frac{3 \theta + 2}{13 \theta + 4}$</td>
<td>$\frac{3 \theta + 2}{13 \theta + 4}$</td>
</tr>
<tr>
<td>$p^2(Q^i)$</td>
<td>$\frac{2(8 + 34 \theta - 4 \theta^2)}{(2 + \theta)(2 + \theta + 30 \theta + 8)} \frac{4 - \theta}{2(\theta + 2)} \frac{4 - \theta}{2(\theta + 2)} \frac{4 - \theta}{2(\theta + 2)} \frac{4 - \theta}{2(\theta + 2)}$</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$Q^i$</td>
<td>$\frac{9 \theta(\theta + 6)}{(2 + \theta)(2 + \theta + 30 \theta + 8)} \frac{3 \theta}{2(\theta + 2)} \frac{3 \theta}{2(\theta + 2)} \frac{3 \theta}{2(\theta + 2)} \frac{3 \theta}{2(\theta + 2)}$</td>
<td>$\frac{2 \theta(5 \theta - 1)}{13 \theta + 4}$</td>
<td>$\frac{2 \theta(5 \theta - 1)}{13 \theta + 4}$</td>
</tr>
<tr>
<td>$W^p_1$</td>
<td>$\frac{2(4 + 6 \theta + \theta^2)}{\theta^2 + 30 \theta + 8} \frac{1}{2} \frac{1}{2} \frac{1}{2} \frac{1}{2}$</td>
<td>$\frac{2(\theta + 2)}{13 \theta + 4}$</td>
<td>$\frac{2(\theta + 2)}{13 \theta + 4}$</td>
</tr>
<tr>
<td>$W^p_2$</td>
<td>$\frac{2(4 + 6 \theta + \theta^2)}{\theta^2 + 30 \theta + 8} \frac{1}{2} \frac{1}{2} \frac{1}{2} \frac{1}{2}$</td>
<td>$\frac{2(\theta + 2)}{13 \theta + 4}$</td>
<td>$\frac{2(\theta + 2)}{13 \theta + 4}$</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>$\frac{3 \theta(5 \theta - 4)}{\theta^2 + 30 \theta + 8}$</td>
<td>$\frac{\theta(7 \theta - 8)}{13 \theta + 4}$</td>
<td>$\frac{\theta(7 \theta - 8)}{13 \theta + 4}$</td>
</tr>
<tr>
<td>$P^1(Q^i)$</td>
<td>$\frac{\theta^2 + 12 \theta + 2}{\theta^2 + 30 \theta + 8}$</td>
<td>$\frac{6 \theta + 1}{13 \theta + 4}$</td>
<td>$\frac{6 \theta + 1}{13 \theta + 4}$</td>
</tr>
<tr>
<td>$P^2(Q^i)$</td>
<td>$\frac{2(4 + 6 \theta + \theta^2)}{\theta^2 + 30 \theta + 8}$</td>
<td>$\frac{2(\theta + 2)}{13 \theta + 4}$</td>
<td>$\frac{2(\theta + 2)}{13 \theta + 4}$</td>
</tr>
<tr>
<td>$Q^i$</td>
<td>$\frac{6 \theta(3 \theta + 1)}{(2 + \theta)(\theta^2 + 30 \theta + 8)} \frac{\theta(7 \theta + 3)}{13 \theta + 4}$</td>
<td>$\frac{\theta(7 \theta + 3)}{13 \theta + 4}$</td>
<td>$\frac{\theta(7 \theta + 3)}{13 \theta + 4}$</td>
</tr>
<tr>
<td>$W^p_1$</td>
<td>$\frac{2(\theta + 2)}{13 \theta + 4}$</td>
<td>$\frac{2(\theta + 2)}{13 \theta + 4}$</td>
<td>$\frac{2(\theta + 2)}{13 \theta + 4}$</td>
</tr>
<tr>
<td>$W^p_2$</td>
<td>$\frac{4(3 \theta + 1)}{\theta^2 + 30 \theta + 8}$</td>
<td>$\frac{2(\theta + 3)}{13 \theta + 4}$</td>
<td>$\frac{2(\theta + 3)}{13 \theta + 4}$</td>
</tr>
<tr>
<td>$\pi^*$</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$\pi^m$</td>
<td>$\frac{\theta^3 + 500 \theta^4 + 1453 \theta^5 + 1600 \theta^6 + 511 \theta + 91}{2(2 + \theta)(\theta^2 + 30 \theta + 8)} \frac{196 \theta^3 + 1079 \theta^4 + 756 \theta^5 + 264 \theta^6 + 96 \theta^7}{6(2 + \theta)(13 \theta + 4)^2} \frac{6(481 \theta^2 + 238 \theta + 74)}{9(13 \theta + 4)^2}$</td>
<td>(0)</td>
<td></td>
</tr>
</tbody>
</table>

* ( ) represents the equilibrium value of each variable when $\Delta = 0$.
retailers have no possibility of loss because they can carry over remnant inventories to
the second period and replace the new order for the second period sales if the retail price
in the low demand state is lower than \( W_2 \) which is predetermined and noticed to retailers
before the first period ordering. Thus, the manufacturer will only compensate for the
potential loss from the slack demand in the second period because the possibility of loss
exists only when the demand is realized low in the second period.

Suppose that the manufacturer gives slotting allowances, \( S \), which is equivalent
to the potential expected loss from the slack demand state in period 2 (i.e., \( S = \frac{1}{3} W_2 Q_2^* \))
and that he also announces both period wholesale prices \( W_1 \) and \( W_2 \) at the beginning of
the first period. If retailers accept this offer, they have to stock the inventory which is
greater than or at least equal to one in this model.

In the second period, retailers face the marginal opportunity cost of zero when
the market opens because the scrap value of unsold inventories is zero at the end of this
period. Thus, the market supply curve is horizontal at the price of zero until it arrives at
\( Q_2^* \) and it is vertical at \( Q_2^* \) because no additional supply is possible in this period. That
is, the second period supply curve is

\[
Q_2'(P_2) = \bar{Q}_2^* \quad P_2 \geq 0.
\]
The second period retail price is then determined by the market supply and demand. If \( Q_2^d \) is high (i.e., \( Q_2^d = Q_2^h = \theta(1 - P_2) \)), the second period equilibrium retail price is

\[
P_2(Q_2^h) = 1 - \frac{1}{\theta} Q_2^h
\]  

(88)

while if \( Q_2^d = Q_2^l = 1 - P_2 \),

\[
P_2(Q_2^l) = 0.
\]  

(89)

because \( Q_2^l \geq 1 \).

Because retailers are competitive, they take the second period equilibrium retail prices as given. In addition, since retailers stock the inventory high and sell it at the high demand state only, the quantity of inventory is greater than 1, i.e., \( Q_2^l \geq 1 \). Therefore, retailers receive revenue from high demand state only and their second period profit is

\[
\pi_2^r = \left\{ \frac{2}{3} P_2(Q_2^h) - W_2 \right\} Q_2^l
\]  

(90)

On the other hand, the manufacturer's profit in the second period is affected by the carryover inventory from the first period. Therefore, the manufacturer's second period profit is

\[
\pi_2^m = \frac{2}{3} W_2 Q_2^l + \frac{1}{3} W_2 \{ Q_2^l - \Delta \},
\]  

(91)
In the first period, retailers order high when they accept the slotting allowance offer. Retailers know the wholesale prices of two periods and receive slotting allowances prior to ordering. Therefore, the opportunity cost of the inventory ordered in this period is \( W_2 \) because retailers can carry over the inventory to the second period without cost. The market supply curve in the first period is also a horizontal at \( W_2 \) until it arrives at \( Q_1' \) and it is vertical at \( Q_1' \) because no additional order for the first period sales is possible until the retail market transaction ends. That is, the first period market supply curve is

\[
Q_1'(P_1) = \begin{cases} 
Q_1' & P_1 \geq W_2 \\
0 & P_1 < W_2
\end{cases} \quad (92)
\]

Then, the first period retail prices and the carryover inventory level are determined by the demand and supply. When \( Q_1' \) is realized high (i.e., \( Q_1' = Q_1' = \theta(1 - P_1) \)), the first period equilibrium retail price is

\[
P_1(Q_1') = 1 - \frac{1}{\theta} Q_1' \quad (93)
\]

while if \( Q_1' = Q_1' = 1 - P_1 \),

\[
P_1(Q_1') = W_2 \quad (94)
\]

because \( Q_1' \geq 1 \).
On the other hand, the carryover inventory level to the second period, \( \Delta = Q'_1 - Q'_2 \), is also determined by market supply and demand. In the low demand state, \( Q'_1 \) is \( 1 - W_2 \) if the retail price is \( W_2 \). Hence, the equilibrium carryover inventory level in the low demand state is

\[
\Delta = Q'_1 - \{1 - W_2\}. \tag{95}
\]

In that case, retailers' profit in the first period is

\[
\pi^r = \left\{ \frac{2}{3} P_1(Q'_1) + \frac{1}{3} W_2 - W_1 \right\} Q'_1 + S
\]

\[
= \left\{ \frac{2}{3} P_1(Q'_1) + \frac{1}{3} W_2 - W_1 \right\} Q'_1 + \frac{1}{3} W_2 Q'_2. \tag{96}
\]

On the other hand, the manufacturer's profit in the first period is

\[
\pi^m = W_1 Q'_1 - S = W_1 Q'_1 - \frac{1}{3} W_2 Q'_2. \tag{97}
\]

Both the manufacturer and retailers are interested in the total profit over two periods. Therefore, the retailers' total profit over two periods is

\[
\pi^r = \left\{ \frac{2}{3} P_1(Q'_1) + \frac{1}{3} W_2 - W_1 \right\} Q'_1 + \frac{2}{3} \{ P_2(Q'_2) - W_2 \} Q'_2 \tag{98}
\]

from (90) and (96) and the manufacturer's total profit over two periods is

\[
\pi^m = W_1 Q'_1 + \frac{1}{3} W_2 Q'_2 + \frac{1}{3} W_2 \{ Q'_2 - (1 - W_2) \} \tag{99}
\]

from (91) and (97).
Retailers pursue their profit maximization by the choice of $Q'_1$ and $Q'_2$. From the first order conditions of (99), retailers stock the inventory in each and every period as follows:

$$Q'_2 = \theta(1-W_2) \quad (100)$$

$$Q'_1 = \theta + \frac{\theta}{2}W_2 - \frac{3\theta}{2}W_1 \quad (101)$$

(100) and (101) guarantee the maximum profit of zero to retailers in the case that retailers receive slotting allowances. In addition, these quantities satisfy the retailers' participation constraint. The manufacturer also maximizes his profit by setting wholesale prices at prices which induce the inventory stocked of (100) and (101).

Let us replace $Q'_1$ and $Q'_2$ of (99) by (100) and (101). Then the manufacturer's total profit is

$$\pi^m = W_1\left\{\theta + \frac{\theta}{2}W_2 - \frac{3\theta}{2}W_1\right\} + \frac{1}{3}\theta W_2(1-W_2)$$

$$+ \frac{1}{3}W_2\left\{1 - \frac{3\theta + 2}{2}W_2 + \frac{3\theta}{2}W_1\right\} \quad (102)$$

The manufacturer wishes to maximize his profit by choosing optimal wholesale prices. From the first order condition of (102), the manufacturer can obtain the following equilibrium wholesale prices which maximize his profit when he promotes the retail inventory by slotting allowance payments.
\[ W_1 = W_2 = \frac{1}{2} \]  

(103)

Then we can calculate \( Q_1', Q_2', P_1(Q_1'), P_1(Q_2'), P_2(Q_1'), P_2(Q_2') \), \( S \) and \( \Delta \) by substituting (103) for \( W_1 \) and \( W_2 \) of corresponding equations.

\[ Q_1' = Q_2' = \frac{\theta}{2}, \quad \text{when} \quad \theta \geq 2 \]  

(104)

\[ P_1(Q_1') = P_1(Q_2') = P_2(Q_1') = P_2(Q_2') = \frac{1}{2}, \]  

(105)

\[ P_2(Q_2') = 0, \]  

(106)

\[ S = \frac{\theta}{12}, \]  

(107)

\[ \Delta = \frac{\theta - 1}{2}. \]  

(108)

The manufacturer's equilibrium profit over two periods is therefore,

\[ \pi^w = \frac{4\theta + 1}{12}. \]  

(109)

The manufacturer in this game sets wholesale prices at the monopoly profit maximization level and sell the monopoly sales level in each and every period because slotting allowances cover the retailers' risk under the low demand state. That is, slotting allowances play an important role in sharing the retail opportunity cost of high inventory stocking because they create channel cooperation between the manufacturer and retailers.
under demand uncertainty. Table 7 summarizes the subgame-perfect Nash equilibrium of the slotting allowance game.

**Table 7** The Subgame-Perfect Nash Equilibria of the Slotting Allowance Game

<table>
<thead>
<tr>
<th>$P_1(\mathcal{Q}_2^1)$</th>
<th>$P_2(\mathcal{Q}_2^1)$</th>
<th>$\mathcal{Q}_2^1$</th>
<th>$P_1(\mathcal{Q}_2^0)$</th>
<th>$P_1(\mathcal{Q}_1^0)$</th>
<th>$\Delta$</th>
<th>$\pi^*$</th>
<th>$S$</th>
<th>$W_1$</th>
<th>$W_2$</th>
<th>$\pi^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{1}{2}$</td>
<td>$0$</td>
<td>$\frac{\theta}{2}$</td>
<td>$\frac{1}{2}$</td>
<td>$\frac{1}{2}$</td>
<td>$\theta$</td>
<td>$\frac{\theta-1}{2}$</td>
<td>$0$</td>
<td>$\frac{\theta}{12}$</td>
<td>$\frac{1}{2}$</td>
<td>$\frac{1}{2}$</td>
</tr>
</tbody>
</table>

**3.3 Inventory Promotion Wholesale Pricing Vs. Slotting Allowances**

Now let us compare the subgame perfect Nash equilibria from both inventory promotion wholesale pricing game and slotting allowance game. If we compare the manufacturer’s total profits from Table 6 and Table 7, the profit from the slotting allowance promotion is strictly greater than that of inventory promotion wholesale pricing in the range of $\theta \geq 2$ in this model while the slotting allowance promotion cannot be used in the case that $1 < \theta < 2$. This means that the larger the difference between high and low demand, the more effective slotting allowances are. In Chapter II, I have shown that the higher the probability of high demand realization is, the more effective slotting allowances are. Thus, these two results shows that slotting allowances result in higher profit to the manufacturer who has a successfully innovative product by removing the risk from the demand uncertainty. However, when $1 < \theta < 2$, no promotion of product inventories under demand uncertainty is the best for the manufacturer. This
means that a manufacturer who has a really good new product can receive the benefit from the inventory promotion by slotting allowances. Besides, slotting allowances provide a compensation retailers who face the flood of new products for their expected losses from high inventory stocking. Thus, both manufacturers and retailers may prefer slotting allowances to other promotion mechanisms.

4. The Welfare Effect of Slotting Allowances

In section 3, we have addressed why slotting allowances are preferred to other promotion practices. Because slotting allowances give higher total profit over two periods to the manufacturer through alleviating the retailers’ expected losses from high inventory stocking, slotting allowances are prevalent in the grocery industry today. What then is the welfare effect of slotting allowances? This section answers this question. In addition, we will examine the application of anti-trust laws to this practice from the standpoint of the welfare analysis on slotting allowances. For the welfare analysis of slotting allowances, we will employ standard welfare economics tools: consumer surplus (CS) and social efficiency (SW). SW is defined as the sum of CS and total distribution channel profit in this analysis.

Consider the CS and the SW of both promotion practices. The CS and the SW of each and every equilibrium of both games can be summarized in Table 8.

---

21 In this analysis, we do not consider the inter-brand competition of a product. Therefore, the welfare effect from slotting allowances may be overestimated in this analysis. That is, if we consider the competition among brands, the CS of slotting allowances may be smaller than that of this analysis.
[Table 8] The CS and SW of Both Game Equilibria

<table>
<thead>
<tr>
<th>Game</th>
<th>( \theta )</th>
<th>Consumer Surplus (CS)</th>
<th>Social Efficiency (SW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory Promotion</td>
<td>1 &lt; ( \theta ) &lt; 2</td>
<td>( \frac{39 \theta^2 + 653 \theta + 3444 \theta^4 + 6120 \theta^2 + 2688 \theta^4 + 576 \theta}{4(\theta + 2)(13\theta + 4)^2} )</td>
<td>( \frac{41 \theta^2 + 1657 \theta^2 + 8438 \theta^2 + 15128 \theta^2 + 10112 \theta^2 + 2624 \theta}{4(\theta + 2)(13\theta + 4)^2} )</td>
</tr>
<tr>
<td></td>
<td>2 \leq ( \theta ) &lt; 25</td>
<td>( \frac{\theta(294 \theta^2 + 1203 \theta^2 + 1284 \theta + 184)}{18(\theta + 2)(13\theta + 4)^2} )</td>
<td>( \frac{882 \theta^2 + 4440 \theta^2 + 3552 \theta^2 + 976 \theta + 288}{18(\theta + 2)(13\theta + 4)^2} )</td>
</tr>
<tr>
<td></td>
<td>25 \leq ( \theta )</td>
<td>( \frac{369 \theta^2 + 531 \theta^2 + 336 \theta + 48}{18(13\theta + 4)^2} )</td>
<td>( \frac{1625 \theta^2 + 2002 \theta^2 + 536 \theta + 48}{18(13\theta + 4)^2} )</td>
</tr>
<tr>
<td>Slotting Allowances</td>
<td>( \theta &lt; 2 )</td>
<td>( \frac{4 \theta + 5}{24} )</td>
<td>( \frac{12 \theta + 7}{24} )</td>
</tr>
</tbody>
</table>
First, when the inventory stocking on retail shelves increases, consumer surplus increases according to the size of the demand difference. This is natural because consumers can buy their favorite product without limit at the market price if retailers keep the inventory stock high. However, in case of the insufficient stocking of the product, the price is high and the quantity supplied is less. Therefore, the consumer surplus is smaller than otherwise. Now, we can say that the inventory promotion by the low wholesale pricing is beneficial to consumers when high demand is considerably higher than low demand.

Second, the consumer surplus of slotting allowances is always higher than that of low wholesale price promotion in the relevant range of $\theta$. In the slotting allowance promotion case, retailers order high without considering each period profit and stock the product enough for the high demand situation. Thus, there is no possibility of shortage and the retail price is less than or equal to that of the low wholesale pricing in case of the high demand state. Moreover, at the end of the second period, fire sale pricing gives consumers an opportunity to gain surplus in the slotting allowance promotion case.

Third, because the consumer surplus and the total channel profit from the slotting allowances promotion are higher than that of the inventory promotion wholesale pricing, the social efficiency is higher in the slotting allowances. However, this result occurs only when high demand is at least two times higher than low demand in the distribution channel.
From the welfare effect analysis, we know that slotting allowances are beneficial to consumers as well as the manufacturer and retailers if slotting allowances are paid for a high demand product. Thus, slotting allowances are an excellent settlement method for the conflict of interests in the distribution channel. This effective settlement of the conflict results in stable distribution cooperation and it thus gives benefits to all interested parties -- the manufacturer, retailers and consumers. That is, the manufacturer can increase his profit from his product sales and retailers can get the compensation for losses from the high inventory stocking in case of slack demand. Consumers, in addition, can enjoy the product without shortage and get the chance of a fire sale. Therefore, we can conclude that slotting allowances are welfare enhancing business practice.

Cannon and Bloom (1991) were concerned about the anticompetitiveness and unfairness resulting from slotting allowances. Facing the flood of new products and the extremely high failure rate of new products in the grocery industry, both manufacturers and retailers can stabilize the channel through slotting allowances because slotting allowances compensate retailers for possible losses from high inventory stocking of the product under demand uncertainty. This stability results in enough inventory stocking of valuable new products and can cause a relatively lower price of the product when the demand is realized high. Thus, slotting allowances are an welfare-enhancing and procompetitive practice.

If any manufacturer gives slotting allowances to retailers without confidence about his product’s success possibility, he will be punished with a loss. Thus, the Federal
Trade Commission (FTC) or Justice Department need not intervene this efficient trade practice in the distribution channel. If any intervention about slotting allowances payment takes place, it will cause the social efficiency loss. Moreover, both manufacturers and retailers must seek a new channel coordination mechanism if the government bans the use of slotting allowances. The search and implementation of the new practice must be costly to society.

5. Summary and Conclusion

This chapter has examined why slotting allowances became prevalent in the grocery industry and has assessed the welfare effects of the slotting allowances under demand uncertainty. We have used a two-period linear demand model to analyze the nature and the welfare effect of slotting allowances. By comparing slotting allowance promotion with inventory promotion wholesale pricing, we have arrived at the conclusion that the manufacturer prefers slotting allowances to inventory promotion wholesale pricing because the former results in high inventory stocking on retail shelves under demand uncertainty and it thus generates higher manufacturer profit.

In our analysis of the welfare effects of both inventory promotion wholesale pricing and slotting, slotting allowances give higher consumer surplus as well as higher social efficiency in the case that the difference between the low and high demand state is large. This result derives from the fact that slotting allowances stabilize the unstable channel relationship under demand uncertainty through the contract between
manufacturers and retailers. Consumers can benefit from this stable channel relationship because they can purchase their favorable goods without shortages and at relatively lower market prices and because they can enjoy fire sale opportunities.

Slotting allowances are a socially welfare-enhancing business practice and they are the product of active competition among manufacturers facing the flood of new products since the late 1980s. Therefore, the ban of slotting allowances in the distribution channel would give rise to social efficiency loss.
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