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When a channel is vertically separated, there can be inefficiencies, double marginalization. Channel coordination to amend this inefficiency has been an important issue in marketing and economics. Channel coordination deals with maximization of joint profit and achieving proper profit sharing among participants. In this paper, a manufacturer and heterogeneous multiple retailers with exclusive territory are assumed, and channel coordination with two-part tariff is considered. When multiple heterogeneous retailers are assumed, profit sharing can be an issue even though the tariffs based on marginal cost can maximize joint profit. In case of multiple heterogeneous retailers, the manufacturer earns the same profit (fixed fee) from each retailer. This means that a large retailer occupies all the gaps of channel profit between small and large markets. Then, the manufacturer, which generally plays the role of Stackelberg leader, will consider increasing fixed price or marginal price to earn more profit from large retailer. Those reactions can sacrifice maximization of joint profit by making small retailer withdraw or by changing the sales quantities.

In this paper, to maximize joint profit and achieve proper profit sharing, two kinds of optional tariffs are considered. The first is an optional two-part tariff based on marginal cost and the second is an optional modified two-part tariff in which marginal prices are higher than the manufacturer's marginal cost. In both types of optional tariffs, maximization of joint profit in each market can be achieved. Moreover, optional tariffs alleviate the problem of profit sharing. Optional tariffs can provide a manufacturer more profit from a large retailer when profit from a small retailer is given.

However, the analysis shows that the maximum share of manufacturer from a large retailer is restricted by the condition for self-selection. In case of optional two-part tariffs based on marginal cost, if the gap between demands is large, the maximum share of the manufacturer is sufficient to achieve proper profit sharing. If the gap between demands is not sufficiently large, the manufacturer cannot earn sufficient share from increased profit. An optional modified two-part tariff where marginal price is more than marginal cost of manufacturer is considered because of this scenario. The marginal price above the marginal cost may additionally control the distribution of the increased profit. However, the analysis shows that a manufacturer's maximum profit from a large retailer with given profit from a small retailer is the same as or lower than the maximum profit when optional two-part tariffs based on marginal cost are applied. Therefore, it can be concluded that the optional modified tariffs do not

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have additional contribution to profit sharing relative to the tariffs based on marginal cost. Although this paper does not cover all kinds of optional tariffs that are different from tariffs based on marginal cost, it shows the advantage of optional tariffs based on marginal cost and has important theoretical implications. The result of this paper also gives guide for channel coordination. Optional two-part tariff based on marginal cost can increase efficiency in channel coordination.

Key words: channel coordination, optional tariffs, profit sharing, two-part tariff

Ⅰ. Introduction

When a channel is vertically separated, there can be inefficiencies. An example of this problem is double marginalization. Channel coordination to amend this inefficiency has been an important issue in marketing and economics. Notable studies in this area include those conducted by Jeuland and Shugan (1983) and Moorthy (1987). Jeuland and Shugan (1983) showed that a wholesale price which adopts quantity discount can maximize the joint profit of manufacturer and retailer. In this price scheme, the quantity discount creates a marginal cost for the retailer at the optimal quantity equal to the marginal cost of integrated channel. Moreover, the discount can secure the manufacturer's profit margin. Considering this, Jeuland and Shugan explained that the quantity discount can be interpreted as a tool for profit sharing, which cannot be achieved through general marginal cost pricing. On the other hand, Moorthy (1987) showed that the quantity discount proposed by Jeuland and Shugan is only one of the price schemes which maximizes joint profit and makes profit sharing available, suggesting that a two-part tariff can be a simple alternative. In the two-part tariff, marginal price is the same as the manufacturer's marginal cost, which maximizes the joint profit. Furthermore, the fixed price makes profit sharing available. The important aspect of these two tariffs is that the marginal price at the optimal quantity is the same as the marginal cost of the manufacturer (tariffs based on marginal cost, hereafter). Many other studies after those discussed above are also based on marginal cost (Weng 1995a; Weng 1995b Chen et al. 2001; Viswanathan and Wang 2003; and Qin et al. 2007).

In this paper, channel coordination, in which joint profit maximization and profit sharing are main issues, is dealt with assumption of heterogeneous multiple retailers with exclusive territory. Many can think the manufacturer does not have to consider joint profit maximization. A firm just wants to maximize its own profit. However, if manufacturer can collect large portion of joint profit, maximizing joint profit can also be helpful to maximize its own profit.

Hence, above mentioned studies like Jeuland and Shugan (1983) and Moorthy (1987) considered joint profit maximization. In their price scheme, manufacturer can determine its share from joint profit. However, those studies, except Chen et al. (2001), dealt with either a single retailer or homogeneous retailers. When multiple heterogeneous retailers are assumed, profit sharing can be an issue even though the tariffs based on marginal cost can maximize joint profit. In case of multiple heterogeneous retailers, the manufacturer earns the same profit (fixed fee) from each retailer. This means that a large retailer occupies all the gaps of channel profit between small and large markets. Then, the manufacturer, which generally plays the role of Stackelberg leader, will consider increasing fixed price or marginal price to earn more profit from large retailer.[1] Those reactions can sacrifice maximization of joint profit by making small retailer withdraw or by changing the sales quantities. Therefore, manufacturer should have tool to earn sufficient profits from each heterogeneous retailer to achieve channel coordination. In this paper, proper profit sharing is defined to mean that manufacturer's profit is sufficient to give incentive to maintain the tariff which maximizes joint profit.

To handle this problem, one can consider optional tariffs in which different tariffs are applied to different markets with the constraint of self-selection. Chen et al. (2001) considered different tariffs for different markets, but those tariffs were not optional. When a manufacturer deals with a number of retailers, each retailer has incentive to distort its demand information to derive favorable tariff. This opportunistic behavior can diminish joint profit and incur additional bargaining cost. If the tariffs are optional and freely chosen tariffs guarantee optimal quantity, opportunistic behavior or bargaining costs can be avoided.

In this paper, two kinds of optional tariffs are considered. First is the optional two-part tariff based on marginal cost, in which only fixed fees control the level of profit sharing. In this case, larger retailers should pay a higher fixed fee. Since retailers prefer a lower fixed fee, there are quantity restrictions such that only retailers selling lower quantities can choose a tariff with lower fixed fee. With this restriction, tariffs may not be deemed optional. However, firms have the option to set their quantities freely and the tariff is determined according to these quantities. This paper will show that if the gap between demands in each market is large, these optional tariffs can achieve proper profit sharing as well as maximize joint profit. However, if the gap between demands is low and the manufacturer's profit from a small

1) Stealin (2008, p. 113) stated, "Generally, manufacturers are logical leaders in most channel structure. However, with the advent of big box stores, private labels, and the Internet, it is less clear who is leader."

retailer is given, the manufacturer is unlikely to earn sufficiently for profit sharing with a large retailer.

The second optional tariff is the modified two-part tariff, in which marginal prices are above the manufacturer's marginal cost. Optional modified tariffs can also be planned to guarantee the maximization of joint profit, and are considered because not only fixed fees, but also marginal prices can contribute to profit sharing. However, the analysis shows that optional two-part tariffs based on marginal cost rather than modified tariffs can provide more profit to the manufacturer and are, therefore, better with respect to profit sharing.

These results provide firms with practical guides for channel coordination with heterogeneous multiple retailers. Moreover, although this paper does not cover all kinds of optional tariffs that are different from tariffs based on marginal cost, it does show the advantage of optional tariffs based on marginal cost.

In the next section, a review of related literature is presented to specify the purpose of this present paper. Section 3 contains the assumptions and notations for modeling. Sections4 and 5 analyze the characteristics of optional two-part tariffs. The final section presents the concluding remarks.

Ⅱ. Related research

Manufacturers manage an exclusive retailer (independent retailer or franchise) locally in many industries. Franchisors like pizza houses or family restaurants generally disperse their franchisees into other provinces to maximize their market coverage and to minimize cannibalization. Then, competition among franchisees becomes minimized and can be abstracted as monopolistic situation in each region. Thus, most previous studies assumed a case where a manufacturer has only a single retailer in each of the markets has significant implication, even though some studies considered channel coordination to assume multiple retailers or multiple manufacturers in a single market (Choi 1991; Sudhir 2001; Bhardwaj and Balasubramanian 2005 Moorthy 2005; Cattani et al. 2006). In this single retailer (or multiple homogeneous retailers) situation, wholesale tariff based on marginal cost is considered mainly to achieve channel coordination.[2)]

The works of Jeuland and Shugan (1983) and Moorthy (1987) mentioned above are considered model studies. Since then, Weng (1995b) additionally considered purchasing cost, inventory holding cost, and ordering cost, and proposed a tariff to maximize joint profit, which includes volume discount (based on yearly quantity)

2) Lantz (2009) and Cheng (2002) proposed the dynamic negotiation of wholesale price between manufacturer and retailer as a tool for channel coordination.

and quantity discount (based on quantity per an order).[3] In this tariff, quantity discount is used to achieve Economic Order Quantity (EOQ) minimizing total purchasing cost, inventory holding cost, and ordering cost. When the average per-unit price of an ordered quantity is considered as a marginal price, the tariff proposed by Weng is the same as the two-part tariff proposed by Moorthy. Therefore, Weng (1995b) can be considered to have combined Moorthy (1984) and the models which considered EOQ with fixed demand (Lal and Staelin 1984 Monahan 1984; Weng and Wong 1993 Weng 1995a). The tariff can also be included in the tariffs based on marginal cost, even though the marginal price is set to further optimize the order quantity. Viswanathan and Wang (2003), and Qin et al. (2007) among others dealt with similar topics with Weng (1995b), and the tariffs they proposed have similar features. All of them considered a single retailer or homogeneous multiple retailers having exclusive territory.

On the other hand, Chen et al. (2001) considered heterogeneous multiple retailers with exclusive territory, which is the main concern of this paper. The tariff proposed contains three components. Average marginal price does the role of optimizing yearly quantity, and discount based on order quantity and reorder interval minimizes inventory cost and ordering cost. Fixed fees (franchise fees) control the level of shared profit. Therefore, this tariff is also similar with those of Weng (1995b) and Moorthy (1984). However, the tariff for each retailer is not optional and this problem will be considered below. Other studies considering heterogeneous multiple retailers include Lal and Staelin (1984), Kim and Hwang (1988), Drezner and Wesolowsky (1989), and Wang and Wu, (2000). However, these studies considered fixed demand, with a focus on minimizing inventory holding cost and ordering cost.

In summary, first, regardless of inventory holding cost and ordering cost, studies on channel coordination to maximize joint profit through optimal yearly quantity are based on marginal cost. Second, studies considering heterogeneous multiple retailers generally assume a fixed demand and cannot consider the channel coordination for optimal choice of yearly quantities. One exception is Chen et al. (2001).

This paper considers heterogeneous multiple retailers with price-sensitive demand. To achieve channel coordination, optional tariffs are planned. In this situation, optional tariffs mean that a tariff designed for a type of retailer should be chosen according to the type of retailer and other retailers should choose other tariffs designed for them as well. Hence, the tariffs consider a constraint for self-selection. To determine why optional tariffs should be planned for heterogeneous multiple retailers, the defi-

3) Whether it is an all-unit discount or incremental discount, quantity discount has the same features as fixed fee. See Weng (1995b, pp. 1516 - 1519).

ciencies of applying just one tariff and the deficiencies of applying non-optional tariffs should be reviewed.

First, applying only one tariff restricts achieving proper profit sharing, resulting in the unsuccessful maximization of joint profit. Reviewing the result of Ingene and Parry (1995) is helpful for understanding this situation. Ingene and Parry (1995) analyzed the profit maximization of manufacturers, without consideration of channel coordination, using a (non-optional) two-part tariff with heterogeneous multiple retailers. The manufacturer acts as a Stackelberg leader and offers the two-part tariff on a take-it-or-leave-it basis. The analysis shows that small retailers do not participate even though their potential joint profit is positive. Profit-maximizing marginal price is also found to be generally different from the marginal cost of manufacturer. Those results occur because manufacturer sacrifices maximization of joint profit to earn more from large retailers. With a single two-part tariff, proper profit sharing cannot be achieved.

Second, consider the case where different tariffs are applied, which is not optional as proposed by Chen et al. (2001). When a manufacturer deals with a number of retailers, each retailer has incentive to distort its demand information to derive favorable tariff. An example of this scenario is the case where a manufacturer adopts two-part tariffs in which larger fixed fees are applicable to large retailers. A large retailer can then choose a quantity lower than the optimum quantity to pay a lower fixed fee. This opportunistic behavior can diminish joint profit and incur additional bargaining cost. If the tariffs are optional and freely chosen tariffs guarantee optimal quantity, opportunistic behavior or bargaining costs can be avoided.[3)]

In this paper, dealing with channel coordination with heterogeneous multiple retailers with exclusive territory and the two types of optional tariffs are considered: First, a two-part tariff based on marginal cost, which represents tariffs from previous studies and second, a modified two-part tariff in which marginal cost is larger than the marginal cost of the manufacturer.

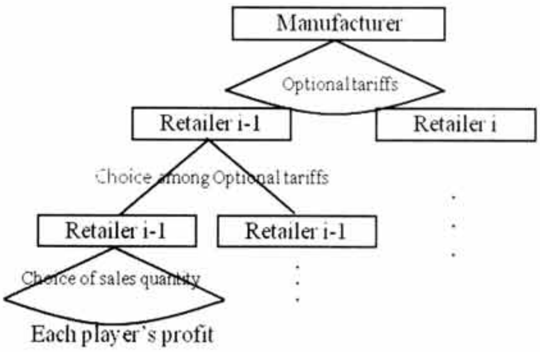
Ⅲ. Notations and assumptions

This paper focuses on the case of a single manufacturer distributing its product through multiple independent retailers, each of which has an exclusive territory. Each territory (market, hereafter) is characterized by its demand function. In the model, the manufacturer acts as a Stackelberg leader and the retailers act as followers. The structure of game can be explained with 〈Figure 1〉. First, manufacture offers optional tariffs to retailers. Then, each

3) Kim and Hong (2008), Kim et al. (2000), and Lee et al. (2002)dealt with the issue of controlling opportunistic behavior.

retailer chooses one of optional tariffs and their quantity sold. The chosen quantity in each market determines retail price and resulting profit for each player.

⟨Figure 1⟩ Decision procedure of players



With the decision process of players in ⟨Figure 1⟩, equilibria will be derived from backward reduction. In the model, constant marginal costs are assumed, but fixed costs are not considered. Some basic notations and assumptions are as follows:

$q_i = D_i(p)$: consumers' yearly demand in type i market as a function of retail price p. $dD_i(p)/dp < 0$ and $D_i(p) > D_j(p)$ when $D_j(p) > 0$, if $i > j$

$MR_i(q)$: marginal revenue from $q_i = D_i(p)$ at q. $dMR_i(q)/dq < 0$

$p_i = P_i(q)$: inverse function of $q_i = D_i(p)$

R_i : a retailer with demand $D_i(p)$

C, c : constant marginal costs of manufacturer and retailer which are the same in all markets

G_i : margin of manufacturer per unit

F_i : fixed fee charged by manufacturer

S_i : profit-sharing control factor

Π_i : maximized joint profit of manufacturer and R_i in a market with $D_i(p)$

q_i^*, p_i^* : quantity and price which maximizes Π_i

$s_i(G,F)$: maximized profit of R_i given G, F

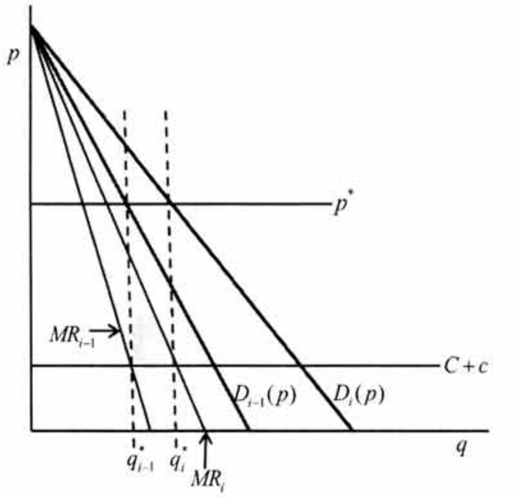
Subscript i means the notation is related to market with $D_i(p)$. When superscript * is added, the notations

are related to optimal value in the perspective of joint profit. A two-part tariff based on marginal cost is represented as $(0, F^M)$, and a modified two-part tariff is represented as (G, F). Superscript M is used to distinguish the two kinds of two-part tariffs.

Ⅳ. Two-part tariffs based on marginal cost

Two-part tariffs based on marginal cost always maximize joint profit, and the main concern is profit sharing. In this section, first, a manufacturer dealing with two types of markets [$D_{i-1}(p)$, $D_i(p)$] and optional two-part tariffs based on marginal cost [(0, F_{i-1}^M), (0, F_i^M), $q_{C,i-1}$] are considered, where $F_{i-1}^M < F_i^M$ and q_C refers to the quantity criterion for tariff choice. If a retailer sells products lower than $q_{C,i-1}$, then the retailer can choose (0, F_{i-1}^M) otherwise, the retailer will not have the option to do so. Because retailers always prefer lower fixed fees, the optional tariffs should include the criterion. The main consideration with these optional tariffs is that $F_i^M - F_{i-1}^M$ can be sufficiently high for proper profit sharing to be achieved.

〈Figure 2〉 Increase of profit with linear demand



To understand the maximum size of $F_i^M - F_{i-1}^M$ and the role of the criterion $q_{C,i-1}$, consider 〈Figure 2〉. In the figure, demand curves with $D_{i-1}(p) = a - bp$ and $D_i(p) = m(a - bp)(a > 0,\ b > 0,\ m > 1)$, and their marginal revenue curves are depicted. If R_i chooses q_i^* instead of $q_{C,i-1}$, the joint profit from R_i increases as much as the shaded area, which can be presented as follows:

$$\Delta F_{i,q_{C,i-1}}^{Max} = \int_{q_{C,i-1}}^{q_i^*} MR_i(q) - (C+c)dq. \quad (1)$$

Next, consider the optional tariffs $[(0,\ F_{i-1}^M),\ (0,\ F_i^M),\ q_{C,i-1}]$. Only if $F_i^M - F_{i-1}^M < \Delta F_{i,q_{C,i-1}}^{Max}$, R_i will choose $(0,\ F_i^M)$ and sell q_i^*. If the condition is not satisfied, R_i will earn more profit by selling $q_{C,i-1}$ and paying F_{i-1}^M. R_{i-1} will choose $(0,\ F_{i-1}^M)$ and sell q_{i-1}^* only if $0 < F_i^M - F_{i-1}^M$ and $q_{C,i-1} \geq q_{i-1}^*$. Considering all these, the maximum value of $F_i^M - F_{i-1}^M$ is $\Delta F_{i,q_{C,i-1}}^{Max}$ and it increases as $q_{C,i-1}$ decreases. Therefore, considering the channel coordination with R_{i-1}, the maximum value of $\Delta F_{i,q_{C,i-1}}^{Max}$ is achieved when $q_{C,i-1} = q_{i-1}^*$. Hereafter, the maximized $\Delta F_{i,q_{C,i-1}}^{Max}$ will be notated as ΔF_i^{Max}.

Although 〈Figure 2〉 assumed linear demand functions, the characteristics explained are correct with general demand functions assumed in 3. The characteristics of optional tariffs $[(0,\ F_{i-1}^M),\ (0,\ F_i^M),\ q_{C,i-1} = q_{i-1}^*]$ are described below.

Proposition 1. Optional tariffs $[(0,\ F_{i-1}^M),\ (0,\ F_i^M),\ q_{C,i-1} = q_{i-1}^*]$ for two markets maximize the joint profit of each market.

i) Condition for self-selection is $0 < F_i^M - F_{i-1}^M < \Delta F_i^{Max} = \int_{q_{i-1}^*}^{q_i^*} MR_i(q) - (C+c)dq.$

ii) R_{i-1}'s profit is $\Pi_{i-1} - F_{i-1}^M$ and R_i's profit is $\Pi_i - F_i^M$. The manufacturer earns F_{i-1}^M from R_{i-1} and F_i^M from R_i. The maximum value of F_i^M is $F_{i-1}^M + \Delta F_i^{Max}$.

iii) These characteristics can be extended to more than two markets with optional tariffs $[(0,\ F_1^M),\ (0,\ F_2^M), \ldots,\ (0,\ F_n^M),\ q_{C,1} = q_1^*,\ q_{C,2} = q_2^*, \ldots,\ q_{C,n-1} = q_{n-1}^*]$, which satisfies

$0 < F_i^M - F_{i-1}^M < \Delta F_i^{Max}$ for all $i = 2, ..., n$.

Proof. See Appendix 1.

Proposition 1-i implies that $F_i^M - F_{i-1}^M$, which means manufacturer's share from increased joint profit has an upper limit of ΔF_i^{Max}. ΔF_i^{Max} is the increased joint profit obtained by choosing q_i^* instead of q_{i-1}^*. This is because R_i should earn more than the profit earned by deviating from F_i^M. Maximum profit from deviation refers to the profit from choosing q_{i-1}^* and paying F_{i-1}^M. To guarantee more profit to R_i than the profit from choosing q_{i-1}^*, the manufacturer's share from increased joint profit is limited to ΔF_i^{Max}. Proposition 1-ii describes the profit of participants. Proposition 1-iii shows that the tariff can be extended to more than two markets.

The ratio of manufacturer's share to increased joint profit $[\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1})]$ is the key issue in this paper. If F_{i-1}^M is set to earn proper profit sharing with R_{i-1}, the manufacturer's profit from R_i is restricted to $F_{i-1}^M + \Delta F_i^{Max}$. Only when the ratio $\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1})$ is sufficiently large, manufacturer can earn proper profit sharing also with R_i. The ratio of the manufacturer's share to increased joint profit is affected by the gap between $D_{i-1}(p)$ and $D_i(p)$.

Proposition 2. When optional two-part tariffs based on marginal cost are applied, the ratio of manufacturer's share from increased joint profit, $\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1})$, is affected by the gap between $D_{i-1}(p)$ and $D_i(p)$.

i) With $D_i(p) = mD_{i-1}(p)$, if m becomes close to 1, $\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1})$ becomes close to 0. As m increases from 1, the ratio increases, and with a sufficiently large m, it become close to 1.

ii) With $D_i(p) = D_{i-1}(p/m)$, if m becomes close to 1, the ratio become close to 0.

Proof. See Appendix 2.

Consider the situation where manufacturer assumes that $\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1})$ should be larger than r $(0 < r < 1)$ to earn proper profit sharing. $D_i(p) = mD_{i-1}(p)$, which is dealt with in Proposition 2-i, means that $D_i(p)$ and $D_{i-1}(p)$ have the same distribution of willingness-to-pay of consumers, but the number of consumers in $D_i(p)$ is m times larger than $D_{i-1}(p)$. In this case, for a manufacturer to earn the ratio r, m should be more than some value. With the linear demand function $D_{i-1}(p) = a - bp$, a manufacturer can earn more than half of the increased joint profit $(\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1}) > 1/2)$ if and only if $m > 2$.

The other kind of increase in demand refers to the willingness-to-pay of consumers in $D_i(p)$, which is m times larger than $D_{i-1}(p)$ with the same number of consumers. This case is dealt with in Proposition 2-ii. If the increase in willingness-to-pay is very small $(m \to 1 + \epsilon)$, a manufacturer cannot earn from an increased joint profit. The impact of the increase of m on the ratio is not derived using a general demand function. However, in analyzing linear demand functions $D_{i-1}(p) = a - bp$ and $D_i(p) = a - (b/m)p$, the ratio $\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1})$ is seen to increase as m becomes larger, but the maximum value of the ratio is $(c/(a/b))^2$. The value a/b is the maximum price satisfying $D_{i-1}(p) > 0$. Considering this, the maximum value of the ratio is very small in general. Therefore, the increase in willingness-to-pay is not so helpful relative to increase in the number of consumers with respect to profit sharing, at least with linear demand function.

Considering this, an optional two-part tariff based on marginal cost has limitations with respect to profit sharing. Specifically, when the gap between $D_i(p)$ and $D_{i-1}(p)$ is small, the manufacturer can only earn little from the increased joint profit and proper profit sharing is not achieved. In this case, the manufacturer does not possess the incentive to maintain this optional tariff and may consider the following:

Proposition 3. With optional tariffs $[(0,\ F_{i-1}^M),\ (0,\ F_i^M),\ q_{C,i-1} = q_{i-1}^*]$ for two markets, the manufacturer's maximum profit increases, if $q_{C,i-1}$ decreases from q_{i-1}^* and F_i^M increases. However, when $q_{C,i-1} < q_{i-1}^*$, R_{i-1} chooses $q_{C,i-1}$ and maximization of joint profit with R_{i-1} cannot be achieved.

Proof. $\partial \Delta F_i^{Max}/\partial q_{C,i-1} > MR_{i-1}(q_{C,i-1}) - (C+c) = 0$. This means that the manufacturer's increased maximum profit from R_i is bigger than the decreased joint profit from R_{i-1}. The choice of R_{i-1} and the joint profit are self-evident.

Proposition 3 means that the manufacturer can increase its share by sacrificing channel coordination. Hence, sufficient profit sharing in large market should be guaranteed, which needs sufficient gap between markets.

V. Modified two-part tariffs

5.1 Single market

The main issue in this paper is profit sharing with a number of heterogeneous multiple retailers. Two-part tariff based on marginal cost has limitations when the gap between demands is not so large. One can assume that this is because the fixed fee alone controls profit sharing. Considering this, in this section, an optional modified two-part tariff where marginal price is more than the marginal cost of manufacturer is designed. To begin with, a single market is considered in understanding the structure of a modified two-part tariff. Each notation does not have a subscript because only one market is considered. In the tariff presented in Proposition 4, constant unit price $(G+C)$ is charged. In addition, if the sold quantity is less than q^*, a fixed fee (F') is charged and if the sold quantity is more than q^*, a discounted fixed fee (F) is charged.

Proposition 4. When a manufacturer charges $q(G+C)+F'$ in case of $q < q^*$ and charges

$q(G+C)+F$ in case of $q \geq q^*$ to the retailer, and when G, F', and F satisfies the conditions below

$$\begin{cases} i) \quad G > 0 \\ ii) \quad F' > s(G,0) \\ iii) \; F = s(G,0)|_{q=q^*} - S \end{cases},$$

then the retailer chooses q^* and earns profit S. The manufacturer thus earns $\Pi^* - S$.

Proof. See Appendix 3.

In the modified two-part tariff, the discount of fixed fee $(F' - F)$ inhibits the retailer from choosing the quantity less than the optimal quantity (q^*), which maximizes the market profit. The unit price $(G+C)$ also inhibits the retailer from choosing the quantity more than the optimal quantity. As a result, the retailer should choose optimal quantity. Manufacturer and retailer can control the distribution of maximized market profit by S.

Moorthy (1987) mentioned that discount schedules including two-part tariffs should have two characteristics for retailers to choose optimal quantity. First, the retailer's marginal revenue at optimal quantity should be equal to the marginal cost of channel. This condition can be interpreted as the unit wholesale price at optimal quantity being the same as the marginal cost of the manufacturer. Second, effective marginal cost curve should be below the effective marginal revenue curve for quantities less than optimal quantity. However, the modified two-part tariff proposed here does not satisfy both conditions because $G > 0$. Therefore, the modified two-part tariff is different from that of previous studies.

In the modified two-part tariff, F' is not applied to the retailer if the tariff works well. Furthermore, the condition of the amount of F' is sufficiently large in value to prevent the retailer from choosing a quantity less than the optimal. Considering this, a specifically modified two-part tariff is written as (G, F).

5.2 Optional tariff with multiple markets

Optional tariffs which consist of modified two-part tariffs satisfying Proposition 1 is considered in this section. The manufacturer has (G_{i-1}, F_{i-1}) in mind for R_{i-1}, and (G_i, F_i) for R_i. However, retailers can freely choose one of the two tariffs.

Proposition 5. An optional modified two-part tariff $[(G_{i-1}, F_{i-1}), (G_i, F_i)]$ for two markets can maximize the joint profit if (G_{i-1}, F_{i-1}) and (G_i, F_i) satisfy Proposition 4. Moreover,

i) The tariffs satisfy the condition of self-selection if $s_{i-1}(G_i,0)|_{q=q_i^*} - S_{i-1} < F_i < s_i(G_i,0)|_{q=q_i^*} - s_i(G_{i-1},F_{i-1})|_{q \geq q_{i-1}^*}$.

ii) With $S_{i-1} = \Pi_{i-1} - F_{i-1}^M$, when $s_i(G_{i-1},F_{i-1})|_{q \geq q_{i-1}^*}$ is maximized at q_{i-1}^*, the manufacturer's maximum profit from R_i occurs and the values become $F_{i-1}^M + \Delta F_i^{Max}$ (profit of $R_i = \Pi_i - F_{i-1}^M - \Delta F_i^{Max}$, likewise when $[(0, F_{i-1}^M), (0, F_i^M), q_{C:i-1} = q_{i-1}^*]$ are applied. If there is no G_{i-1} with which $s_i(G_{i-1},F_{i-1})|_{q \geq q^*_{i-1}}$ is maximized at q^*_{i-1}, the maximum profit of the manufacturer from R_i is lower than $F^M_{i-1} + \Delta F^{Max}_i$.

Proof. See Appendix 4.

The condition $s_{i-1}(G_i,0)|_{q=q^*_i} - S_{i-1} < F_i < s_i(G_i,0)|_{q=q^*_i} - s_i(G_{i-1},F_{i-1})|_{q \geq q^*_{i-1}}$ in Proposition 5 is the condition for self-selection. If both the condition for self-selection and conditions in Proposition 4 are satisfied, then R_{i-1} and R_i should sell q^*_{i-1} and q^*_i, respectively, to maximize their profit. Therefore, the optional modified two-part tariffs can maximize joint profit.

On the other hand, if $s_{i-1}(G_i,0)|_{q=q^*_i} - S_{i-1} < s_i(G_i,0)|_{q=q^*_i} - s_i(G_{i-1},F_{i-1})|_{q \geq q^*_{i-1}}$ is not satisfied, the optional tariffs with self-selection cannot exist because F_i cannot be defined. Since $s_{i-1}(G_i,0)|_{q=q^*_i} = [P_{i-1}(q^*_i) - - G_i - C - c]q^*_i$ and $s_i(G_i,0)|_{q=q^*_i} = [p^*_i - G_i - C - c]q^*_i$, the inequality can be translated to $s_i(G_{i-1},F_{i-1})|_{q \geq q^*_{i-1}} - S_{i-1} = [p^*_i - P_{i-1}(q^*_i)]q^*_i$. Considering $s_i(G_{i-1},F_{i-1})|_{q \geq q^*_{i-1}} - S_{i-1} < [p^*_i - C - c]q^*_i$, if q^*_i is sufficiently large for $P_{i-1}(q^*_i)$ to become close to $C+c$, the inequality is satisfied. That is, optional tariffs with self-selection exist if q^*_i is sufficiently large relative to $D_{i-1}(p)$. However, this is not so restrictive. With demands of $D_{i-1}(p) = a - bp$ and $D_i(p) = m(a-bp)$, if $G_i = G_{i-1} = (a - C - c)/2$, then $m > 1.054$ is needed for optional modified tariffs to exist. If $G_i = G_{i-1} = (a - C - c)/4$, $m > 1.113$.

Proposition 4-ii means that the maximum profit of manufacturer from R_i is lower than when optional two-part tariffs based on marginal cost are applied. When G_{i-1} and F_{i-1} (or the profit of R_{i-1}) is given, (G_i, F_i) should be set to avoid R_i from deviating. This is the same as the case of optional two-part tariffs based on marginal cost. However, when R_i deviates, it chooses $q \geq q^*_{i-1}$ rather than $q \leq q^*_{i-1}$ because the optional tariffs contain quantity restrictions of the type $q \geq q^*_{i-1}$. It is a basic difference from optional two-part tariffs based on marginal cost, which contains restriction of the type $q \leq q^*_{i-1}$. Therefore, the profit of R_i from deviation can be higher than the case of optional two-part tariffs based on marginal cost. As a result, the maximum share of manufacturer from R_i is either the same or lower. This means that optional modified two-part tariffs do not have benefits relative to optional two-part tariffs based on marginal cost with respect to profit sharing.

Ⅵ. Concluding remarks

Channel coordination with heterogeneous multiple retailers having exclusive territories is considered in this paper. Optional two-part tariffs based on marginal cost and optional modified two-part tariffs are dealt with. Since those tariffs include quantity restrictions, the tariff may be compulsory. However, firms have the option to select their own quantities, and the tariff is determined according to these quantities. Quantity restriction contributes to self-selection. Although one can consider restriction based on retail price, the retail price is more difficult to observe because of temporary promotion or price discrimination. Furthermore, Economides (1999) showed that the quality of service can be decreased and the intended market performance cannot be achieved if retail prices are restricted.

In both types of optional tariffs, maximization of joint profit in each market can be achieved. Moreover, optional tariffs alleviate the problem of profit sharing. If a tariff is applied to all heterogeneous retailers, a manufacturer's profit from a large retailer is the same as the profit from a small retailer. This means that increased profit from larger demand is appropriated only by the retailer. Optional tariffs can provide a manufacturer more profit from a large retailer when profit from a small retailer is given.

However, the maximum share of manufacturer from a large retailer is restricted by the condition for self-selection. In case of optional two-part tariffs based on marginal cost, if the gap between demands is large, the maximum share of the manufacturer is sufficient to achieve proper profit sharing. The impact of the gap between demands on the maximum share of manufacturer is somewhat different according to the type of gap. When the number of consumers increases sufficiently, the maximum share reaches 1. However, an increase in willingness-to-pay without increasing the number seems unqualified in enlarging the share sufficiently, which is shown with linear demand function. If the gap between demands is not sufficiently large, the manufacturer cannot earn sufficient share from increased profit, which means proper profit sharing cannot be achieved. The manufacturer then loses the incentive to maintain both tariff and optimal quantity, which maximizes the joint profit.

An optional modified two-part tariff where marginal price is more than marginal cost of manufacturer is considered because of this scenario. The marginal price above the marginal cost may additionally control the distribution of the increased profit. However, the analysis above shows that a manufacturer's maximum profit from a large retailer with given profit from a small retailer is the same as or lower than the maximum profit when optional two-part tariffs based on marginal cost are applied. Therefore, it can be concluded that the optional modified tariffs do not have additional contribution to profit sharing relative to the tariffs based on marginal cost. Although this paper does not cover all kinds of optional tariffs that are different from tariffs based on marginal cost, it shows the advantage of optional tariffs based on marginal cost and has important theoretical implications.

These results provide firms with practical insight for channel coordination with heterogeneous multiple retailers. Manufacturers or franchisors should maximize their own profits on condition that providing proper profit to retailers or franchisees. When manufacturers try to increase their profit by increasing per-unit price, the joint profit will decrease and manufacturers' profit becomes more restricted. Hence, maintaining their per-unit wholesale price at the marginal cost and earning profit from fixed fee can generate more profit to manufacturers. One other issue is that manufacturers should be able to collect more fixed fee from larger retailers. If manufacturers make their manager for each retailer determine the level of fixed fee, it will create opportunistic behavior and agency problem. Retailers can try to lower their fixed fee and report lower demand than actual demand. The manager for each retailer can be captured. Those can increase managerial cost and lower revenue. Considering this, this paper recommends optional tariff. Optional tariff makes retailers choose suitable tariff for their actual demand spontaneously. This can be the win-win strategy for both.

However, optional tariff can make manufacturer collect large portion of gap between profits from different demands, only when the difference between demand is sufficiently large. Therefore, firms should have tools to handle small difference between demand. Generally, manufactures or franchisors collect other kind of charge from retailers or franchisees like interior fee or management fee which are not directly related to sales quantity. Those can be tools for handle small difference between demands. In this paper, combining those tools are not dealt with and can be future research topic.

This paper focuses on the perspective of channel coordination (or optimization of joint profit). Therefore, the profit maximization of a manufacturer, which plays the role of Stackelberg leader, is not analyzed in detail. A manufacturer can earn more profit by sacrificing channel coordination. A simple method for obtaining more profit is by controlling the quantity criteria for lower fixed fee as explained in Proposition 3. Analyzing the profit maximization of a manufacturer with more detailed assumptions can be meaningful. Additionally, many previous studies focused on channel coordination with respect to inventory cost and ordering cost, assuming homogeneous retailers or heterogeneous retailers with demands non-sensitive to price. This paper does not consider this issue, but rather focuses on optimal yearly quantity. Combining these issues presents a good challenge.

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⟨Appendix 1⟩ Proof of Proposition 1

I) is explained above.

ii) is self evident.

iii) With F_i^Ms which satisfies $0 < F_i^M - F_{i-1}^M < \Delta F_i^{Max}$, when R_i chooses q_{i-j}^* to pay F_{i-j}^M ($j \geq 1$), its profit is $\Pi_i - F_{i-j}^M - \int_{q_{i-j}^*}^{q_i^*} MR_i(q) - (C+c)dq$ and is lower than $\Pi_i - F_i^M$ because $F_i^M - F_{i-j}^M \leq \sum_{k=i-j+1}^{i} \Delta F_k^{Max} \leq \int_{q_{i-j}^*}^{q_i^*} MR_i(q) - (C+c)dq$. Then, R_i prefers F_i^M to F_{i-j}^M. Furthermore, R_i prefers F_i^M to F_{i+j}^M because $F_i^M < F_{i+j}^M$. Therefore, self-selection is achieved. Arguments about profit are self-evident.

⟨Appendix 2⟩ Proof of Proposition 2

$$\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1}) = \frac{\int_{q_{i-1}^*}^{q_i^*} MR_i(q) - (C+c)dq}{(p_i^* - C - c)(q_i^* - q_{i-1}^*) + (p_i^* - p_{i-1}^*)q_{i-1}^*}$$
$$= \frac{(p_i^* - C - c)(q_i^* - q_{i-1}^*) - (P_i(q_{i-1}^*) - p_i^*)q_{i-1}^*}{(p_i^* - C - c)(q_i^* - q_{i-1}^*) + (p_i^* - p_{i-1}^*)q_{i-1}^*}. \quad \text{(A1)}$$

i) With $D_i(p) = mD_{i-1}(p)$, $p_i^* = p_{i-1}^*$ and $q_i^* = mq_{i-1}^*$. Therefore,

$$\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1}) = \frac{\int_{q_{i-1}^*}^{mq_{i-1}^*} MR_i(q) - (C+c)dq}{(p_i^* - C - c)(m-1)q_{i-1}^*} < \frac{MR_i(q_{i-1}^*) - (C+c)}{(p_i^* - C - c)}. \quad \text{(A2)}$$

If $m = 1 + \epsilon\,(\epsilon \to +0)$, in the last term in the inequality, the numerator becomes zero, whereas the denominator is strictly positive. Therefore, $\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1})$ becomes zero.

The ratio $\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1})$ can be rewritten as follows:

$$\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1}) = \frac{(p_i^* - C - c)(m-1) - (P_i(q_{i-1}^*) - p_i^*)}{(p_i^* - C - c)(m-1)} = 1 - \frac{(P_i(q_{i-1}^*) - p_i^*)}{(p_i^* - C - c)(m-1)}. \quad \text{(A3)}$$

With some modification, $P_i(q_i^*) = P_{i-1}(q_i^*/m)$ and $\partial P_i(q_i^*)/\partial m = -q_i^* P_{i-1}^{/}(q_i^*/m)/m^2$ can be derived. $\partial p_i^*/\partial m = 0$ because p_i^* does not change according to m. Then,

$$\partial\left[\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1})\right]/\partial m = -\frac{(m-1)\partial(P_i(q_{i-1}^*) - p_i^*)/\partial m - (P_i(q_{i-1}^*) - p_i^*)}{(p_i^* - C - c)(m-1)^2}$$

$$= \frac{\dfrac{(1-m)q_{i-1}^*}{m^2} P_{i-1}^{/}(q_{i-1}^*/m) + P_{i-1}(q_{i-1}^*/m) - P_{i-1}(q_{i-1}^*))}{(p_i^* - C - c)(m-1)^2}. \quad \text{(A4)}$$

Considering $P_{i-1}^{/}(q) < 0$ and $m > 1$, $\partial\left[\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1})\right]/\partial m$ is positive. Furthermore, from Equation (A3), if $m = \infty$, $\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1}) = 1$ because $P_i(q_{i-1}^*)$ is a limited value.

ii) $D_i(p) = D_{i-1}(p/m)$ and $D_i^{/}(p) = D_{i-1}^{/}(p/m)/m$. With these, $\partial \Pi_i/\partial p|_{p=p_i^*}$ can be expressed as follows:

$$D_i(p_i^*) + D_i^{/}(p_i^*)(p_i^* - C - c) = D_{i-1}(p_i^*/m) + D_{i-1}^{/}(p_i^*/m)(p_i^* - C - c)/m$$
$$= D_{i-1}(p_i^*/m) + D_i^{/}(p_i^*/m)(p_i^*/m - C - c) + [(m-1)/m]\left[(C+c)D_{i-1}^{/}(p_i^*/m)\right] = 0 \quad \text{(A5)}$$

In the second line of Equation (A5), $[(m-1)/m]\left[(C+c)D_{i-1}^{/}(p_i^*/m)\right] < 0$. Therefore, $D_{i-1}(p_i^*/m) + D_i^{/}(p_i^*/m)(p_i^*/m - C - c) = \partial \Pi_{i-1}/\partial p|_{p=p_i^*/m} > 0$. This means that $p_i^*/m > p_{i-1}^*$ and $p_i^* > p_{i-1}^*$.

From (A1), the following can be derived:

$$\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1}) < \frac{MR_i(q_{i-1}^*) - (C+c)}{(p_i^* - C - c) + (p_i^* - p_{i-1}^*)q_{i-1}^*/(q_i^* - q_{i-1}^*)} \quad \text{(A6)}$$

If $m = 1 + \epsilon\,(\epsilon \to +0)$, $q_i^* = q_{i-1}^* + \epsilon^{/}$ $(\epsilon^{/} \to +0)$. Then, the numerator in the inequality (A6) becomes zero and the denominator is strictly positive ($\because q_i^* > q_{i-1}^*$, $p_i^* > p_{i-1}^*$). Therefore, $\Delta F_i^{Max}/(\Pi_i - \Pi_{i-1})$ becomes zero.

〈Appendix 3〉 Proof of Proposition 4

Retailer's profit is $(p-G-C-c)D(p)-F$.

i) $p>p^*$ and $q<q^*$: The profit before a fixed fee is lower than $s(G,0)$ and retailer should pay $F^{/}$ $(>s(G,0))$. Therefore, the retailer's profit will be negative.

ii) $p=p^*$ and $q=q^*$: Retailer's profit is $s(G,0)|_{q=q^*}-F$ and $F=s(G,0)|_{q=q^*}-S$. Therefore, retailer' profit is S.

iii) $p<p^*$ and $q>q^*$: Marginal revenue of retailer decreases as q increases, and marginal revenue of retailer at $q=q^*$ is $C+c$. Therefore, the marginal revenue of retailer at quantity $q>q^*$ is lower than marginal cost of retailer $(G+C+c)$, and the profit of retailer at quantity $q>q^*$ is lower than the profit at $q=q^*$.

Summarizing these, the retailer should choose $q=q^*$ and market profit is Π^*. The retailer's profit is S and the manufacturer earns the rest (Π^*-S).

〈Appendix 4〉 Proof of Proposition 5

I) If R_{i-1} and R_i choose (G_{i-1}, F_{i-1}) and (G_i, F_i), respectively, and those tariffs satisfy the conditions in Proposition 4, R_{i-1} and R_i should sell q^*_{i-1} and q^*_i, respectively, to maximize their profit.

If (G_i, F_i) is given to R_{i-1}, R_{i-1} will choose q^*_i, because $F^{/}_i$ is sufficiently large and marginal revenue at $q>q^*_i$ is less than its marginal cost G_i+C+c. Therefore, given (G_i, F_i), $s_{i-1}(G_i,F_i)|_{q=q^*_i}$ is the maximized profit of R_{i-1}. Then, $s_{i-1}(G_i,F_i)|_{q=q^*_i}<S_{i-1}$ is the condition for R_{i-1} to choose (G_{i-1}, F_{i-1}). This inequality can be translated to $s_{i-1}(G_i,0)|_{q=q^*_i}-S_{i-1}<F_i$. $s_i(G_{i-1},F_{i-1})|_{q\geq q^*_{i-1}}$ is the maximized profit of R_i given (G_{i-1}, F_{i-1}), and $s_i(G_i,F_i)|_{q=q^*_i}$ is the maximized profit of R_i given (G_i, F_i). Therefore, $s_i(G_{i-1},F_{i-1})|_{q\geq q^*_{i-1}}<s_i(G_i,F_i)|_{q=q^*_i}$ is the condition for R_i to choose (G_i, F_i). This inequality can be translated to $F_i<s_i(G_i,0)|_{q=q^*_i}-s_i(G_{i-1},F_{i-1})|_{q\geq q^*_{i-1}}$. In summary,

$s_{i-1}(G_i,0)|_{q=q_i^*} - S_{i-1} < F_i < s_i(G_i,0)|_{q=q_i^*} - s_i(G_{i-1},F_{i-1})|_{q \geq q_{i-1}^*}$ is the condition for self-selection.

ii) The minimum profit of R_i is $s_i(G_i,F_i)|_{q=q_i^*} = s_i(G_{i-1},F_{i-1})|_{q \geq q_{i-1}^*}$ because $F_i < s_i(G_i,0)|_{q=q_i^*} - s_i(G_{i-1},F_{i-1})|_{q \geq q_{i-1}^*}$. Furthermore, if $S_{i-1} = \Pi_{i-1} - F_{i-1}^M = s_{i-1}(0,F_{i-1}^M)$, $F_{i-1}^M = q_{i-1}^* G_{i-1} + F_{i-1}$. $\Pi_i = \Pi_i|_{q=q_{i-1}^*} + \int_{q_{i-1}^*}^{q_i^*} MR_i(q) - (C+c)dq = \Pi_i|_{q=q_{i-1}^*} + \Delta F_i^{Max}$. If $s_i(G_{i-1}, F_{i-1})|_{q \geq q_{i-1}^*}$ is maximized at q_{i-1}^*, $s_i(G_i,F_i)|_{q=q_i^*} = s_i(G_{i-1},F_{i-1})|_{q=q_{i-1}^*}$. Considering $F_{i-1}^M = q_{i-1}^* G_{i-1} + F_{i-1}$, $s_i(G_{i-1},F_{i-1})|_{q=q_{i-1}^*} = s_i(0,F_{i-1}^M)|_{q=q_{i-1}^*}$, and $s_i(0,F_{i-1}^M)|_{q=q_{i-1}^*} = \Pi_i|_{q=q_{i-1}^*} - F_{i-1}^M = \Pi_i - F_{i-1}^M - \Delta F_i^{Max}$.

If there is no G_{i-1} with which $s_i(G_{i-1},F_{i-1})|_{q \geq q_{i-1}^*}$ is maximized at q_{i-1}^*, $s_2(G_1,F_1)|_{q \geq q_1^*}$ is maximized at $q \geq q_1^*$. Then, $s_i(G_i,F_i)|_{q=q_i^*} = s_i(G_{i-1},F_{i-1})|_{q > q_{i-1}^*}$. $s_i(G_{i-1},F_{i-1})|_{q > q_{i-1}^*} = s_i(G_{i-1},F_{i-1})|_{q=q_{i-1}^*} + \int_{q_{i-1}^*}^{q_i^*} MR_i(q) - (G_{i-1}+c)dq > s_i(0,F_{i-1}^M)|_{q=q_{i-1}^*} = \Pi_i - F_{i-1}^M - \Delta F_i^{Max}$.

Therefore, The minimum profit of R_i is the same as or larger than $\Pi_i - F_{i-1}^M - \Delta F_i^{Max}$. This means that the maximum profit of manufacturer from R_i is the same as or lower than $F_{i-1}^M + \Delta F_i^{Max}$.