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Channel coordination and transaction cost: A game-theoretic analysis

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Abstract

Traditional research identified equilibrium marketing channel coordination by using a classical demand function, and classical economic theory often ignored transaction costs. This paper develops a transaction cost linear demand function to investigate channel decision marking when transaction costs exist. Game theory is used to compare a non-cooperative equilibrium of a differential game played under Stackelberg strategies. By focusing on the effect of the distributor's transaction costs with respect to the marketing decision variables, especially the transaction cost and profit distribution, a fuller understanding of the entire decision structure is obtained. Some results are surprising, which set up the benchmark comparisons for future work in this area.

Keywords: Transaction cost; Channel coordination; Distributor; Game theory

1. Introduction

Over the past decade marketing scientists have developed a significant and multifarious literature concerning the structure and coordination in distribution, and its related issues have also generated considerable researches in both the marketing and economic literature (Choi, 1991; Coughlan, 1985; Douglas, 1975; Ingene & Parry, 1995; Jeuland & Shugan, 1983; McGuire & Staelin, 1983). Many of these studies have only limited to manufacturers and their channel intermediaries, and the analysis of competition and cooperation were confined to members in the general demand function. For example, the linear demand function is $q = A - bp$ (where q = demand or sold volume, A = constant denoting demand or sold volume when price is zero, b = constant denoting the slope of the demand curve, p = the pricing (monetary cost). Thus at price p, $A - bp$ units will be demand or sold volume. The slope of the demand curve is negative, indicating that customers will buy less of the product as its price increases). In reality, when the general demand function was being used, most of the past research papers have neglected the extra cost in price which are needed to be paid by customers. The extra cost is a nonmonetary expenditure, for example; the searching cost of information (Salop & Stiglitz, 1997). Such as total customer cost, addressed by Kotler (2003, p.60) is the bundle of costs customers expect to incur in evaluating, obtaining, using, and disposing of given market offering.

As Adam Smith had addressed over two centuries ago, "The real price of anything is the toil and trouble of acquiring it." In other words, this total customer cost includes the buyer's time, energy, psychic and other costs. The buyer evaluates these elements together with the monetary cost to form a total customer cost (Kotler, 2003). These abstractions are useful in order to understand the customer's transaction cost. Therefore, the linear demand function can be written such as $q = A - bp$, in accordance with the concept of real price (p) from Adam

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Smith, that the $p = p_m + \alpha$, α is the extra cost for buyers to pay, which is identical with transaction cost. On the other hand, sellers also need to provide some extra cost in proportion, such as time, energy, and psychic costs that associated with buyers. The following example will support the point: more customers would be drawn and attracted to the sellers who offer free services such as information, delivery, training and maintenance (e.g., in order to improve the service to these dealer, Whirlpool developed a B2B trading partner portal to reduce the dealer's nonmonetary costs). Above example has clearly pointed out that a customer would estimate which offer delivers the most value. Customers are value-maximizes, within the bounds of time costs and energy cost (Kotler, 2003). Whether or not the offer lives up to the value expectation affects both satisfaction and repurchase probability.

Many factors may affect a customer's decision to purchase from certain channel stores. One particular aspect that is being examined closely is the costs which associated with the transaction process. In other words, if all other factors are equal; a customer would go with a channel that offers lower transaction costs. When customers purchase a product from a seller, they would go through a process which is called transaction cost analysis to evaluate the complete cost of acquiring the product from a specific source.

If products are identical, then transaction cost is the major concern when a customer is choosing among several distributors. The transaction cost has been applied to analyze many issues such as strategic impact of information systems, resource allocation, and outsourcing decisions; however, little attention has been paid to marketing channel structure. Transaction cost is a viable theory to explain the acquisition decision in marketing channel.

By focusing on a case of a single manufacturer selling an identical product to two competing distributors and adopting the two most popular powerful structures in pervious studies; (1) Manufacturer–Stackelberg; in this scenario the manufacturer uses the distributors' response function to decide its promotion allowances. The distributors determine the transaction cost so as to maximize total profit from the manufacturer given the respective promotion allowance. (2) Retailer–Stackelberg; the distributors use the manufacturer's response function to decide their transaction cost. The manufacturer determines the promotion allowance so as to maximize total profit from the distributors given the respective transaction cost (e.g., Choi, 1996). In game theoretic terms the first steps is to assume the manufacturer acts as a Stackelberg leader, second step is to assume the distributor acts as a Stackelberg leader; and then develop a transaction cost linear demand function model to investigate the following questions:

1. When the manufacturer or the distributor is a leader, will the leader be the more powerful player and receive higher profit?
2. When a manufacturer or a distributor is a leader, how do transaction cost, margin, sold quantities and the manufacturer's promotion allowance profit compare with the case of the Maunfacturer–Stackelberg and the Retailer–Stackelberg games?
3. How does the transaction cost sensitivities and the transaction cost efficiency index affect the channel's decision variables?

The following Sections will review the literature on the use of marketing channel coordination and transaction cost. Section 3 develops a transaction cost linear demand function model derived from analytical equilibrium solutions for various quantities such transaction cost, sales volume and profit which lead back to the questions that are raised in this paper. Section 4 compares and analyzes the decision variables affected by the transaction cost sensitivity and the efficiency index of transaction cost. The final Section presents managerial implications and suggestions for future researches.

2. Literature review

2.1. Channel coordination

McGuire and Staelin (1983) studied the impact of product substitutability on Nash equilibrium distribution structures in a duopoly where each manufacturer distributes its goods through an exclusive distributor. Jeuland and Shugan (1983) focused on channel coordination in the context of a single producer and a single distributor channel. They found that coordination between a producer and a distributor via a quantity discount schedule could lead to higher profit for channel members. Jeuland and Shugan (1988) analyzed the possibility of channel coordination without formal arrangement such as vertical integration or contracts. They argued that channel members, being aware of interdependencies between themselves, might form conjectures concerning other members' reactions to their own actions. Iyer (1988) studied channel coordination under both price and non-price (e.g., customer service) competition.

In another expansion, Choi (1991) addressed channel profits when the channel structure consists of two manufacturers and a single common distributor. The model consisted of three non-cooperative games: the Manufacturer–Stackelberg game, the Retailer–Stackelberg game and Vertical–Nash equilibrium. Choi proposed product differentiation and cost reduction as methods to encourage channel coordination. Sudhir (2001) extended Choi's channel structure by studying vertical manufacturer and distributor interaction as well as horizontal interactions between the manufacturers. Sudhir (2001) modeled manufacturer–retailer interactions by using the Manufacturer–Stackelberg and Vertical–Nash equilibrium games.

Rather than two manufacturers using a common distributor, Ingene and Parry (1995) took the opposite approach and studied channel coordination by focusing on a single manufacturer using two competing distributors. They also used a non-cooperative Stackelberg game, where the manufacturer could apply either two-part tariffs or a schedule for quantity discounts. They found that while quantity discount schedule had facilitated channel coordination, the two-part tariff did not. Gerstner and Hess (1991) looked at a monopolist manufacturer distributed goods through a single, independent distributor with two types of customers: those who were willing to pay a high price and the others were only willing to pay a low price. They found that when the manufacturer used price promotion, it would motivate distributor's participation. In previous research, Gerstner, Hess, and Holthausen (1994) extended their model by having a single manufacturer with several competitive distributors. The manufacturer employed a pull discount strategy by offering consumers a low price, and then set wholesale prices after observing the markup percentage used by distributors. Lee and Staelin (1997) attempted to provide a generalized model allowing two manufacturers to interact with two distributors.

Manufacturers may coordinate with distributors through several different methods. In particular, the rise in distributor power has created significant problems and conflicts for manufacturers (Bandyopadhyay & Divakar, 1999). The growing power of large distributors (e.g., key accounts) has increased significantly in the past decade. Many of these large distributors depend on promotional allowances from manufacturers and no manufacturers can unilaterally stop offering trade allowance without losing distributor support (Kotler, 2003). Segal-Horn and McGee (1989) suggested several methods for manufacturers to diminish these concerns including vertical integration, franchising and alternative channels such as a mail order, electronic commerce or telemarketing thereby reducing the importance of intermediaries (Keh & Shieh, 2001).

2.2. Transaction cost

A transaction is a process by which a good or service is transferred across a technologically separable interface (Williamson, 1975, 1985). In the classical economic theory it is not only argued that the price mechanism to be able to coordinate the behavior of transaction, but also assumed that consumer information is symmetric in the market. Since both buyers and sellers have the same amount of information; the transaction can be executed without cost. In reality markets are often inefficient (e.g., information asymmetry) and uncertain (e.g., product and process uncertainty). In order to process a transaction, customers must conduct activities such as searching for information, negotiating terms, and monitoring the on-going process to ensure a favorable deal (Coase, 1937). The cost involved with such transaction-related activities cost represent transaction cost. McEachern (2000) argued that the transaction costs are the costs of time and information required to carry out market exchange.

Transaction cost theoretically explains why a buyer or a seller chooses a particular form of transaction instead of the other. The principle of transaction cost is that people like to conduct transactions in a way that minimize their transaction cost because transaction cost provides no value to either the buyer or seller. Williamson (1979) observed that human nature and the environment of exchange can cause market failure due to unacceptably high transaction costs in transaction processes; differences in the character of exchange level such as uncertainty, frequency and asset specificity can influence the transaction cost.

The transaction cost can also be affected by product uncertainty and process uncertainty. Product uncertainty refers to possible unexpected outcomes of product use or the inability of the product to meet customer expectations. Process uncertainty refers to the customer not having a complete confidence in the transaction process and a higher level of uncertainty generally implies a higher transaction cost (Liang & Huang, 1998).

2.3. Model development

The basic vertical distribution model is a channel consisting one manufacturer who sells through two independent distributors, and offers a promotional allowance as a trade incentive. The following are the key assumptions used in this analysis:

1. A two-level vertical channel;
2. Manufacturer offers an identical promotion allowance, a, to distributors;
3. Profit maximizing behavior by all channel members;
4. A downward sloping demand function;
5. Transaction cost t_i decisions depend only on the change of the promotion allowance;
6. To decrease the complexity of expression, assumes $\lambda_1=\lambda_2=\lambda>1$, where λ_1 and λ_2 denote the customer's efficiency index by a distributor 1 and distributor 2 under the transaction cost.

In game-theoretic terms, the manufacturer first acts as a Stackelberg leader; this is followed by the distributor acting as a Stackelberg leader. These rules are illustrated in Fig. 1a and b. Notice that the arrow indicates that each channel member conditions its decision variable on the other's variable at the tail of the arrow. Namely, that the reaction functions $t_1(a)$ and $t_2(a)$ in Maunfacturer–Stackelberg Model and the reaction function $a(t_1,t_2)$ in Retailer–Stackelberg Model.

During the promotional period, the manufacturer will first determine the size of promotion allowance a, that is, the allowance that differs from the regular wholesale price to be

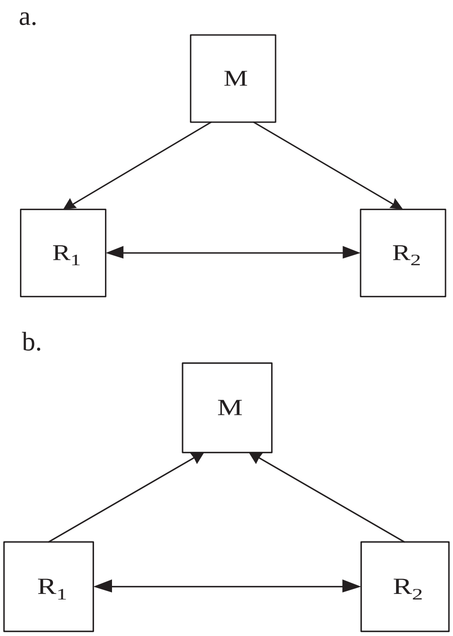

Fig. 1. (a) The Maunfacturer–Stackelberg Model. In the first, manufacturer M determines value a after distributors R_1 determines value $t_1(a)$ and R_2 determines value $t_2(a)$. (b) The Retailer–Stackelberg Model. In the first, distributors R_1 determine value t_1 and R_2 determines value t_2 after manufacturer M determines value $a(t_1,t_2)$.

offered to the distributors. When given this allowance the distributor i can then calculate the unit transaction cost t_i. In recent years, many distributors have asked for unreasonably low prices or high promotional allowances for them to accept manufacturer goods. These requests may be requested for either part of the formal contract or as an informal understanding between the parties. The growing power of large distributors (e.g., key accounts) has increased as having their dependence on promotion money from manufacturers. Manufacturers cannot unilaterally stop offing trade allowance without losing distributor support (Kotler, 2003).

Consistent with pervious research, the distributors are symmetric that they have the same response to marketing variables. Symmetric is a common assumption made in game-theoretic models that study price competition in the context of manufacturer–distributor channel structure (e.g., Choi, 1996; McGuire & Staelin, 1983). For instance, as competitors are symmetrical in two-level vertical channel structure; one manufacturer with two distributors which confront the same demand function, they have the same costs and same response to marketing variables. In this instance both the regular monetary retail price P_i, $i \in \{1,2\}$ and the wholesale price w_i remain fixed while deciding on promotion allowance decisions. These assumptions also appear reasonable since regular price and promotion budgets are often made prior making price cut decisions. The sales volume resulting from regular prices is denoted as q_i, $i \in \{1,2\}$. Assuming symmetrical across distributors: $p_1=p_2=p_r$ (say); $w_1=w_2=w_r$ and $q_1=q_2=q_r$, the distributor's gross retail margin is $g_r=p_r=w_r$, and the manufacturer's margin is $m_r=w_r-c$, where c is variable cost to a manufacturer (Sethuraman & Tellis, 2002) and $p_r>w_r>c$.

A demand function that contains a term with its own price (transaction cost) and another term that captures the difference effect between the own price (transaction cost) and the competitor price (transaction cost) which is consistent with individual utility maximization behavior (Raju, Sethuraman, & Dhar, 1995; Shubik & Levitan, 1980). Sethuraman and Tellis (2002) extended the demand function styles to the case of the manufacturer's advertising to suppress or stimulate retail price promotion. In this paper, the demand model is extended to discuss the case of transaction cost. Assuming that the demand q_{t_i} for the distributor i is linear with regard to its own transaction cost t_i and competitive transaction cost t_j is based on the regular monetary retail price, the demand function is formed as:[3]

$$q_{t_i} = q_r + \lambda_i t_i + \theta\left(\lambda_i t_i - \lambda_j t_j\right). \tag{1}$$

Eq. (1) denotes the demand function modified by transaction cost, where λ_i denotes the customer's efficiency index when the transaction cost expenditure is responsible by distributor i, such as the searching cost of information and negotiating terms of the transaction, and $\lambda_i t_i$ represents the decrease in the customer's payment as the transaction cost t_i increases (here $\lambda_i t_i$ can also represents the changes in demand by the customer's payment decrease). The function (1) is assuming to satisfy the following requirements: $q_r>0$, $0 \le \theta < 1$, $t_i \ge 0$, $0 \le \lambda_i < 1$, and $i, j \in \{1,2\}$, $i \ne j$.

The parameter θ explains the impact of transaction cost sensitivity on customer demand. When the $\theta \to 1$, the impact of transaction cost sensitivity of distributors is almost homogeneous (i.e., high substitutability), on the other hand, when $\theta \to 1$ the distributors (or price competition) are almost independent (i.e., less substitution). Therefore, the smaller the difference is the greater easier it is to be substituted which in turn draws more potential transaction cost competition. Note that θ can be interpreted as a measure of the degree of substitutability between the two distributors (e.g., between channel competition). In the paper, the manufacturer's decision variable is the promotion allowance to the distributors and the distributors' decision variables are the transaction cost expenditure to the customer.

[3] The demand function used by Raju et al. (1995) can be written as $q_i=1-p_i+\theta(p_j-p_i)$ Similarly, using the concept from Adam Smith, this research assumes $p=p_r-\lambda t$, where p_r is regular prices; t is the transaction cost changed by sellers and λ is the efficiency index of transaction cost, λt is cost to cut down by customers to pay, $0 \le \lambda t \le p_r$. Referring the practice of Sethuraman and Tellis (2002) by substituting $p_i=p_r-\lambda_i t_i$, $p_j=p_r-\lambda_j t_j$ and noting that p_r and θ are constant, the demand function can be rewritten as $q_{t_i}=q_r+\lambda_i t_i+\theta(\lambda_i t_i-\lambda_j t_j)$, where $q_r=1-p_r$.

2.4. Manufacturer–Stackelberg game

Under the assumption of Manufacturer–Stackelberg game, the manufacturer is the leader, the distributor's reaction function is determined in the first stage. The manufacturer will take the distributor's reaction function into consideration for its promotion allowance decisions. Therefore, the distributor's reaction functions can be derived from maximizing their profit functions when the promotion allowance, a is given by the manufacturer. The profit functions for distributor i are given as:

$$\underset{t_i}{\text{Max}}\, \Pi_{R_i}^{M} = (g_r - t_i + a)\left[q_r + \lambda_i t_i + \theta\left(\lambda_i t_i - \lambda_j t_j\right)\right],$$
$$i,j \in \{1,2\}, \qquad i \neq j. \tag{2}$$

In the first stage, from (2), as θ, λ_1, λ_2 are fixed and the distributor's reaction function say, $\hat{t}_1$ and $\hat{t}_2$ can be derived from the first-order conditions of Eq. (2), respectively (see Appendix A1-A4). The reaction functions provide some insights on direction of the variables of the follower when the leader changes its decision variables. The second column in Table 1 shows the reaction functions of the distributor (transaction costs and sales volume; all are functions of promotion allowance to distributors), based on the first-order conditions if the manufacturer is the channel leader. As the manufacturer increases its promotion allowance to the distributors, the distributors' transaction costs and sales volume increase. In addition, substituting the transaction costs reaction functions $\hat{t}_1$ and $\hat{t}_2$ into Eq. (1), respectively, the sales volume reaction functions say, $q_{\hat{t}_1}$ and $q_{\hat{t}_2}$ have derived.

In the second stage, the manufacturer's target involve selecting promotion allowance, a so as to maximizes its own profit function, when given sales volume reaction functions, $q_{\hat{t}1}$ and $q_{\hat{t}2}$. The manufacturer's profit function is given as:

$$\underset{a}{\text{Max}}\, \Pi_{M}^{M} = (m_r - a)\left(q_{\hat{t}_1} + q_{\hat{t}_2}\right), \tag{3}$$

where $q_{\hat{t}_1} = q_r + \lambda_1 \hat{t}_1 + \theta(\lambda_1 \hat{t}_1 - \lambda_2 \hat{t}_2)$ and $q_{\hat{t}2} = q_r + \lambda_2 \hat{t}_2 + \theta(\lambda_2 \hat{t}_2 - \lambda_1 \hat{t}_1)$.

The first-order condition of Eq. (3) produces an optimal promotion allowance say, $\hat{a}^M$. Recalling the reaction function in Table 1 and substituting $\hat{a}^M$ into the equations of equation, $\hat{t}_1$ and $\hat{t}_2$, the equilibrium transaction cost say, $\hat{t}_1^M$ and $\hat{t}_2^M$ are received. The results of the major decision variables and profits of the channel at equilibrium under the Maunfacturer–Stackelberg game are presented in the second column in Table 2 and the derivation process can be seeing in Appendix A.

2.5. Retailer–Stackelberg game

If under the Retailer–Stackelberg game, the distributors are the leaders, the manufacturer's reaction function is determined in the first stage. The manufacturer's reaction function can be derived from maximizing its profit functions when the transaction costs, t_1 and t_2 be given by the distributors. The profit function for the manufacturer is given as:

$$\underset{a}{\text{Max}}\, \Pi_{M}^{R} = (m_r - a)(q_{t_1} + q_{t_2})$$
$$= (m_r - a)(2q_r + \lambda_1 t_1 + \lambda_2 t_2), \tag{4}$$

where $q_{t_1} = q_r + \lambda_1 t_1 = \theta(\lambda_1 t_1 - \lambda_2 t_{21})$, $q_{t_2} = q_r + \lambda_2 t_2 + \theta(\lambda_2 t_2 - \lambda_1 t_1)$ and $t_1 = t_1(a)$, $t_2 = t_2(a)$.

In the first stage, keeping θ, λ_1, λ_2 fixed and transaction cost decisions depend only on the promotion allowance changes, the manufacturer's reaction function say, $\hat{a}$ can be derived from the first-order conditions of Eq. (4). The third

Table 1
Reaction function

	Manufacturer as leader (the distributor's reaction function)	Distributor as leader (the manufacturer's reaction function)
Allowance deal by mfr.		$\hat{a} = \dfrac{(m_r - t_1)\lambda_1 + (m_r - t_2)\lambda_2 - 2q_r}{\lambda_1 + \lambda_2}$
Distributor 1 transaction cost	$\hat{t}_1 = \dfrac{(a+g_r)(1+\theta)[\lambda_2\theta + 2\lambda_1(1+\theta)] - q_r(2+3\theta)}{\lambda_1\left(4+8\theta+3\theta^2\right)}$	
Distributor 2 transaction cost	$\hat{t}_2 = \dfrac{(a+g_r)(1+\theta)[\lambda_1\theta + 2\lambda_2(1+\theta)] - q_r(2+3\theta)}{\lambda_2\left(4+8\theta+3\theta^2\right)}$	
Sales volume by distributor 1	$q_{\hat{t}_1} = \dfrac{(1+\theta)\left\{q_r(2+3\theta) + (a+g_r)\left[\lambda_1\left(2+4\theta+\theta^2\right) - \lambda_2\theta(1+\theta)\right]\right\}}{4+8\theta+3\theta^2}$	
Sales volume by distributor 2	$q_{\hat{t}_2} = \dfrac{(1+\theta)\left\{q_r(2+3\theta) + (a+g_r)\left[\lambda_2\left(2+4\theta+\theta^2\right) - \lambda_1\theta(1+\theta)\right]\right\}}{4+8\theta+3\theta^2}$	

Table 2
The channel solutions of Stackelberg game after transaction cost ($\lambda_1 = \lambda_2 = \lambda$)

	Manufacturer as leader	Distributor as leader
Retail transaction cost	$\hat{t}^M = \hat{t}_1^M = \hat{t}_2^M = \dfrac{\lambda(g_r + m_r)(1+\theta) - q_r(3+\theta)}{2\lambda(2+\theta)}$	$\hat{t}^R = \hat{t}_1^R = \hat{t}_2^R = \dfrac{2\lambda(g_r + m_r)(1+\theta) - q_r(5+2\theta)}{\lambda(7+4\theta)}$
Manufacturer allowance	$\hat{a}^M = \dfrac{\lambda(m_r - g_r) - q_r}{2\lambda}$	$\hat{a}^R = \dfrac{\lambda m_r(5+2\theta) - 2\lambda g_r(1+\theta) - 2q_r(1+\theta)}{\lambda(7+4\theta)}$
Sales volume	$\hat{q}^M = q_{\hat{t}_1}^M = q_{\hat{t}_2}^M = \dfrac{\lambda(g_r + m_r)(1+\theta) + q_r(1+\theta)}{2(2+\theta)}$	$\hat{q}^R = q_{\hat{t}_1}^R = q_{\hat{t}_2}^R = \dfrac{\lambda m_r(5+2\theta) - 2\lambda g_r(1+\theta) - q_r(5+2\theta)}{(7+4\theta)}$
Retail margin	$\hat{g}^M = g_{\hat{t}_1}^M = g_{\hat{t}_2}^M = \dfrac{q_r + \lambda(g_r + m_r)}{2\lambda(2+\theta)}$	$\hat{g}^R = g_{\hat{t}_1}^R = g_{\hat{t}_2}^R = \dfrac{3q_r + 3\lambda(g_r + m_r)}{\lambda(7+4\theta)}$
Mfr margin	$\hat{m}_t^M = \dfrac{\lambda(g_r + m_r) + q_r}{2\lambda}$	$\hat{m}_t^R = \dfrac{2\lambda(g_r + m_r)(1+\theta) + 2q_r(1+\theta)}{\lambda(7+4\theta)}$
Retail profits	$\Pi_R^M = \Pi_{R_1}^M = \Pi_{R_2}^M = \hat{g}^M \cdot \hat{q}^M$	$\Pi_R^R = \Pi_{R_1}^R = \Pi_{R_2}^R = \hat{g}^R \cdot \hat{q}^R$
Mfr profits	$\Pi_M^M = 2\hat{m}_t^M \cdot \hat{q}^M$	$\Pi_M^R = 2\hat{m}_t^R \cdot \hat{q}^R$

column in Table 1 shows the promotion allowance reaction function of the manufacturer (promotion allowance; it is the functions of distributors' transaction cost) based on the first-order conditions if the distributors are the channel leaders. As the distributor increases its transaction costs that the manufacturer promotion allowance decreases.

In the second stage, the distributors' targets involve selecting transaction costs t_1 and t_2 so as to maximize their profit function, when given promotion allowance reaction function, $\hat{a}$ from the manufacturer. The distributors' profit functions are given as:

$$\operatorname*{Max}_{t_i} \Pi_{R_i}^M = (g_r - t_i + \hat{a})\left[q_r + \lambda_i t_i + \theta\left(\lambda_i t_i - \lambda_j t_j\right)\right],$$
$$i,j \in \{1,2\}, \qquad i \neq j. \tag{5}$$

The first-order condition of Eq. (5) produce optimal transaction costs say, $\hat{t}_1^R$ and $\hat{t}_2^R$, respectively (see Appendix B.3-B.4. Recalling the reaction function in Table 1 and substituting $\hat{t}_1^R$ and $\hat{t}_2^R$ into the equation $\hat{a}$, the equilibrium promotion allowance say, $\hat{a}^R$ is obtained. The results of the major decision variables and profits of the channel at equilibrium under the Retailer–Stackelberg game are presented in the third column in Table 2 and the derivation process can be seen in Appendix B.

Note that, all the variables listed in Table 2 are greater than zero. In Table 2 assuming that the transaction cost efficiency index is the same ($\lambda_1 = \lambda_2 = \lambda$). The major advantage of this model is to decrease the complexity of expression which may incorporate the Maunfacturer–Stackelberg and Retailer–Stackelberg games within one framework.

2.6. Transaction cost, promotion allowance, and sales volume

According to the example model, the transaction costs decision depends only on the promotion allowance changed by the manufacturer. Comparing the distributor transaction costs under the Maunfacturer–Stackelberg and Retailer–Stackelberg games (i.e., $\hat{t}^M < \hat{t}^R$ in Table 3), the transaction cost under the Retailer–Stackelberg game is higher than under the Maunfacturer–Stackelberg game for the distributors. These results indicate that an increase in promotion allowance utilization from the manufacturer in the distributors is the leader rather than the manufacturer.

A comparison of the analytical result between the Maunfacturer–Stackelberg and the Retailer–Stackelberg games, which shows that the promotion allowance of the manufacturer under the Maunfacturer–Stackelberg is less than under the Retailer–Stackelberg game (i.e., $\hat{a}^M < \hat{a}^R$ in Table 3). The result indicates a channel's power, when the distributor is the leader, it will produce more power (e.g., the negotiation of trade deal) than the manufacturer. The growing power of distributors (e.g., franchise distributor) has increased and they depend on heavily promotion money (e.g., promotion allowance) from the manufacturers (Kotler, 2003).

As for as the above example shown, the results for sales volume in Table 5; are identical with the results in the

Table 3
Comparison of manufacturer as leader with distributor as leader

	Expression
Retail transaction cost	$\hat{t}^M < \hat{t}^R$
Manufacturer allowance	$\hat{a}^M < \hat{a}^R$
Sales volume after transaction cost	$\hat{q}^M < \hat{q}^R$
Retail margin after transaction cost	$\hat{g}^M < \hat{g}^R$
Manufacturer margin after transaction cost	$\hat{m}_t^M < \hat{m}_t^R$
Retail profits after transaction cost	$\Pi_R^M < \Pi_R^R$
Manufacturer profits after transaction cost	$\Pi_M^M > \Pi_M^R$

If $\hat{q}^M = \hat{q}^R$, we get $\Pi_M^M > \Pi_M^R$, otherwise it needs that the function or the value of the parameter be given, then the relation is determined.

Table 2, as the transaction cost efficiency index, λ increases, the market share of direct sales to customers increases. Namely, the sales volume by the distributor is always bigger than the sales volume to customers by the manufacturer.

2.7. Profits and margins

In this Section, Table 3 is comparing the manufacturer and distributor profits under the Maunfacturer–Stackelberg and Retailer–Stackelberg games. It is expected that within the same channel structure, the more powerful player will have higher profit (higher margin given the same sales volume). When the distributor is the leader, under the transaction cost structure will produce more profit than the manufacturer as the follower. An interesting question is that when the manufacturer is the leader, and if $\hat{q}^M=\hat{q}^R$, here is the result, $\Pi_M^M>\Pi_M^R$ otherwise when the function or the value of parameter is given, then the relationship is determined. A comparison between the results of the Maunfacturer–Stackelberg and Retailer–Stackelberg leads to the following relationships, as $\hat{q}^M=\hat{q}^R$.

$$\Pi_R^M > \Pi_R^R \quad \text{and} \quad \Pi_M^M > \Pi_M^R.$$

Whether the distributor or manufacturer is more powerful than the other, when it is the leader, it has higher control than the follower in channel. Initially, it is expected that the leader of a channel would produce higher margin. When the channel member is a leader, under the transaction cost structure, it will produce more margins than when the channel member is a follower (i.e., $\hat{g}^M<\hat{g}^R$ and $\hat{m}_t^M>\hat{m}_t^R$ in Table 3). Table 3 summarized the comparison of a manufacturer as a leader with a distributor as a leader regarding the transaction cost, promotion allowance, sales volume, profits and margins; also the derivation process can be seen in Appendix C.

3. Transaction cost sensitivity and efficiency index

3.1. Effect of transaction cost sensitivity (θ)

Williamson (1979) introduced that the transaction cost can be affected by several factors including uncertainty. Under the same motivation, this subsection will investigate the effect of parameter θ, on equilibrium solution for the transaction cost and the other major decision variables. The partial derivatives of the transaction costs will be provided in Table 4.

Under the circumstance when the manufacturer is a leader, the θ increases, leading to the distributor's transaction costs and sales volume increase, but the distributors' margins decline. This interprets that the degree of cross transaction cost of distributors are almost homogeneous (i.e., less differentiation decrease the profitable). In addition, there is an interesting finding which is when the distributor is a leader, the results are the same. However, when the distributor is a leader, as θ increases the manufacturer's allowance and margin increase, on the other hand, the manufacturer's allowance and margin will have no effect when it is a leader. The major cause may be that the manufacturer applies indirect sales, which does not relate to the customers directly.

3.2. Effects of transaction cost efficiency index (λ)

How does the change in transaction cost efficiency index affect other decision marking variables? Here, instead of using the efficiency index represents the lower paying price by customers as the transaction cost increases; Table 5 also provided the partial derivatives of transaction cost efficiency index λ.

As the transaction cost efficiency index to the customer increases, the distributor's transaction cost also increases under the time when the manufacturer is a leader or the

Table 4
Effects of transaction cost sensitivity (θ) under Stackelberg-game

	Manufacturer as leader	Distributor as leader
Retail transaction cost	$\frac{\partial \hat{t}^M}{\partial \theta} = \frac{q_r+\lambda(g_r+m_r)}{2\lambda(2+\theta)^2} > 0$	$\frac{\partial \hat{t}^R}{\partial \theta} = \frac{6(q_r+\lambda(g_r+m_r))}{\lambda(7+4\theta)^2} > 0$
Manufacturer allowance deal	$\frac{\partial \hat{a}^M}{\partial \theta} = 0$	$\frac{\partial \hat{a}^R}{\partial \theta} = \frac{6(q_r+\lambda(g_r+m_r))}{\lambda(7+\theta)^2} > 0$
Sales volume	$\frac{\partial \hat{q}^M}{\partial \theta} = \frac{q_r+\lambda(g_r+m_r)}{2(2+\theta)^2} > 0$	$\frac{\partial \hat{q}^R}{\partial \theta} = \frac{6(q_r+\lambda(g_r+m_r))}{(7+4\theta)^2} > 0$
Retail margin	$\frac{\partial \hat{g}^M}{\partial \theta} = \frac{q_r+\lambda(g_r+m_r)}{2\lambda(2+\theta)^2} < 0$	$\frac{\partial \hat{g}^R}{\partial \theta} = \frac{12(q_r+\lambda(g_r+m_r))}{\lambda(7+4\theta)^2} < 0$
Manufacturer margin	$\frac{\partial \hat{m}_t^M}{\partial \theta} = 0$	$\frac{\partial \hat{m}_t^R}{\partial \theta} = \frac{6(q_r+\lambda(g_r+m_r))}{\lambda(7+4\theta)^2} < 0$

Table 5
Effects of transaction cost efficiency index (λ) under Stackelberg-game

	Manufacturer as leader	Distributor as leader
Retail transaction cost	$\frac{\partial \hat{t}^M}{\partial \lambda} = \frac{q_r(3+\theta)}{2\lambda^2(2+\theta)} > 0$	$\frac{\partial \hat{t}^R}{\partial \lambda} = \frac{q_r(5+2\theta)}{\lambda^2(7+4\theta)} > 0$
Manufacturer allowance deal	$\frac{\partial \hat{t}^M}{\partial \lambda} = \frac{q_r}{2\lambda^2} > 0$	$\frac{\partial \hat{a}^R}{\partial \lambda} = \frac{2q_r(1+\theta)}{\lambda^2(7+\theta)} < 0$
Sales volume	$\frac{\partial \hat{q}^M}{\partial \lambda} = \frac{(g_r+m_r)(1+\theta)}{2(2+\theta)} > 0$	$\frac{\partial \hat{q}^R}{\partial \lambda} = \frac{2q_r(1+\theta) - m_r(5+2\theta)}{(7+4\theta)} > 0$
Retail margin	$\frac{\partial \hat{g}^M}{\partial \lambda} = -\frac{q_r}{2\lambda^2(2+\theta)} < 0$	$\frac{\partial \hat{g}^R}{\partial \lambda} = -\frac{3q_r}{\lambda^2(7+4\theta)} < 0$
Manufacturer margin	$\frac{\partial \hat{m}_t^M}{\partial \lambda} = -\frac{q_r}{2\lambda^2} < 0$	$\frac{\partial \hat{m}_t^R}{\partial \lambda} = -\frac{2q_r(1+\theta)}{\lambda^2(7+4\theta)} < 0$

distributor is a leader, it leads to the decline in retail margin and the manufacturer margins. As the customers request lower transaction costs, the channel members obviously need to be responsible for higher transaction cost. The λ increases which represents that the customers become more transaction cost sensitive. In addition, as λ increases, the manufacturer's allowance also rises under the manufacturer as a leader, but also declines under the distributor as a leader. Few other interesting findings also derived from Table 5 is that as the efficiency index to the customer increases, the sales volume rises under manufacturer as the leader, also under the time when distributor is the leader.

4. Conclusions and implications

The major contribution of this paper is that it combined and extended previous studies that only focused on a single structure to develop a transaction costs demand function model. By using the transaction cost model, the finding obtained is rather transparent and intuitive. At the beginning, the paper has indicated the previous channel-literature that they were using the classical demand function, which argued that the transaction cost can be ignored; therefore, a transaction cost demand function offers the approach to analyze channel coordination problems. The most important question is how the transaction cost impacts the channel member's decision variable under different power games. The answer depends on the transaction cost structure (e.g., how much payment for seller and how much impact for buyer) and base on the market size, as well as on the model specification (e.g., channel structure). Derived from earlier analysis, a comparison of distributor transaction cost in the manufacturer, as a leader, and the distributor, as a leader, shows that the manufacturer promotion allowance, the distributor's sales volume, margin and profits under the distributor as a leader exceeds under the manufacturer as the leader. Therefore, a leader can gain more controlling power in selling and obtain higher profit from a follower in marketing channel. These conclusions are also in accordance with the observed practice.

When the distributor sets up a transaction cost for customers, the distributor will find that as a transaction cost sensitivity increases, the transaction cost put in by distributors also raise which leads to higher sales volume, as the substitutability of customers' transaction cost increases. Therefore, the high transaction cost sensitivity indicates less differentiation that the seller needs to put in higher differentiation cost (e.g., place and equipment costs) to reduce the effect of transaction cost, and at the same time it will lead to lower seller margin as both the manufacturer and the distributor are leaders.

In addition, the more transaction cost efficiency index increases, the more transaction cost will need to be input by sellers, this indicates that the customers will become more transaction cost sensitive, and the sellers will lose more margins by changing to a higher transaction cost. Another important finding is that, under some conditions, sales volume increases under the time when the manufacturer is a leader and declines when the distributor is a leader. In addition, as transaction cost efficiency index increases, the manufacturer's margin increases while the distributor is a leader and decreases when the manufacturer is a leader.

These findings are interpretable in terms of the relative transaction of customers and channel structures. The explicit consideration of transaction cost has yielded a number of meaningful managerial insights as follows:

1. A powerful channel member needs the desire to control over its marketing channel so as to assure the delivery of service outputs and/or to expropriate profits.
2. By virtue of "owning" a marketing activity, a distributor increases the probability of gaining absolute control over how activity is performed across several levels of

distribution. Controlling power permits a channel member to assure that the service outputs demanded by its customers will be appropriately delivered, and increases the differentiation of transaction cost by seller to pay.

3. The channel member has to attract customers through better service or merchandising, strong customer's loyalties and increases the transaction cost paid by customers (e.g., the switch cost inside customers), so that they can pursue higher margin and higher sales.
4. The channel member who gets the major advantages of the transaction cost is the customers who can reduce expenses, as the channel members may provide an expenditure that lowers the searching and time cost by helping customers to locate the products.
5. The channel member would pay attention to the transaction cost efficiency index of customers which will affect the behavior of a customer's purchase decision.

While the intention was to use a model as simple as possible to highlight the important issue, this work is obviously limited by some particular assumptions. In this paper, it is only assuming that the transaction cost efficiency index to customers is the same (e.g., $\lambda_1=\lambda_2=\lambda$). In reality, they affect each other tremendously since locations are different, customers are different and there are different preferences for each type of distribution channel. It is important for future researches to consider the uniqueness of each distributor (e.g., services), preferences of different customers (e.g., perceived transaction costs), and an empirical analysis in the model. In addition, Ozer (2004) studied that the Internet leads to more successful new products, since it helps firms to identify large and growing markets, to reach otherwise hard to reach market, and to create demands for new products. Thus, the web and e-mail are becoming more fully integrated into the business communication mix (Lichtenthal & Eliaz, 2003). More recently, some firms have chosen to rely exclusively on direct channels, bypassing all forms of Internet distributors (Park & Keh, 2003). However, the Internet will affect the transaction activities and transaction costs, which can be worthy research topics in the future. Hoping this research will set up the benchmark comparison for future researches.

Appendix A

The equilibrium solutions are obtained by the Maunfacturer–Stackelberg game analysis under transaction cost. The distributors have profit functions given by Eq. (2):

$$\Pi_{R_i}^M=(g_r-t_i+a)[(q_r+\lambda_i t_i+\theta(\lambda_i t_i-\lambda_j t_j)],$$
$$i,j\in\{1,2\},\qquad i\neq j.$$

Let $\frac{\partial\Pi_{R_1}^M}{\partial t_1}=0$ and $\frac{\partial\Pi_{R_2}^M}{\partial t_2}=0$, obtains

$$-2\lambda_1(1+\theta)t_1+\lambda_2\theta t_2+a\lambda_1(1+\theta)+g_r\lambda_1(1+\theta)-q_r=0, \tag{A.1}$$

$$\lambda_1\theta t_1-2\lambda_2(1+\theta)t_2+a\lambda_2(1+\theta)+g_r\lambda_2(1+\theta)-q_r=0. \tag{A.2}$$

Solving the simultaneous Eqs. (A.1) and (A.2), and substitute t_1 by $\hat{t}_1$ and t_2 by $\hat{t}_2$, obtains the reaction functions of the distributors (transaction costs);

$$\hat{t}_1=\hat{t}_1(a)=\frac{(a+g_r)(1+\theta)[\lambda_2\theta+2\lambda_1(1+\theta)]-q_r(2+3\theta)}{\lambda_1(4+8\theta+3\theta^2)} \tag{A.3}$$

and

$$\hat{t}_2=\hat{t}_2(a)=\frac{(a+g_r)(1+\theta)[\lambda_1\theta+2\lambda_2(1+\theta)]-q_r(2+3\theta)}{\lambda_2(4+8\theta+3\theta^2)}. \tag{A.4}$$

Substituting from Eqs. (A.3) and (A.4) into Eq. (1), respectively, yields

$$q_{\hat{t}_1}=\frac{(1+\theta)\{q_r(2+3\theta)-(a+g_r)[\lambda_2\theta(1+\theta)-\lambda_1(2+4\theta+\theta^2)]\}}{4+8\theta+3\theta^2} \tag{A.5}$$

and

$$q_{\hat{t}_2}=\frac{(1+\theta)\{q_r(2+3\theta)-(a+g_r)[\lambda_1\theta(1+\theta)-\lambda_2(2+4\theta+\theta^2)]\}}{4+8\theta+3\theta^2}. \tag{A.6}$$

Substituting from Eqs. (A.5) and (A.6) into Eq. (3), and let $\frac{\partial\Pi_M^M}{\partial a}=0$, gets

$$-\left(\frac{1+\theta}{2+\theta}\right)[2q_r+(2a+g_r-m_r)(\lambda_1+\lambda_2)]=0. \tag{A.7}$$

Solving Eq. (A.7) and substituting a by $\hat{a}^M$, gets the manufacturer's optimal allowance,

$$a=\hat{a}^M=\frac{(\lambda_1+\lambda_2)(m_r-g_r)-2q_r}{2(\lambda_1+\lambda_2)}. \tag{A.8}$$

If $\lambda_1=\lambda_2=\lambda$, the Eq. (A.8) can be rewritten as;

$$a=\hat{a}^M=\frac{\lambda(m_r-g_r)-q_r}{2\lambda}. \tag{A.9}$$

Subsequent discussion, assumes that $\lambda_1=\lambda_2=\lambda$.

A.1. Retails transactions cost ($\hat{t}^M$)

Substituting Eq. (A.9) into Eqs. (A.3) and (A.4), and substitute $\hat{t}_1$ by $\hat{t}_1^M$and $\hat{t}_2$ by $\hat{t}_2^M$, yields

$$\hat{t}_1^M = \frac{\lambda(g_r + m_r)(1+\theta) - q_r(3+\theta)}{2\lambda(2+\theta)}, \tag{A.10}$$

and

$$\hat{t}_2^M = \frac{\lambda(g_r + m_r)(1+\theta) - q_r(3+\theta)}{2\lambda(2+\theta)} \tag{A.11}$$

where $\hat{t}_1^M = \hat{t}_2^M$, hence we can get

$$\hat{t}^M = \hat{t}_1^M = \hat{t}_2^M = \frac{\lambda(g_r + m_r)(1+\theta) - q_r(3+\theta)}{2\lambda(2+\theta)}. \tag{A.12}$$

A.2. Sales volume ($\hat{q}^M$)

Substituting Eq. (A.9) into Eqs. (A.5) and (A.6), respectively, and substitute $q_{\hat{t}_1}$ by $q_{\hat{t}_1}^M$ and $q_{\hat{t}_2}$ by $q_{\hat{t}_2}^M$, yields

$$q_{\hat{t}_1} = q_{\hat{t}_1}^M = \frac{\lambda(g_r + m_r)(1+\theta) + q_r(1+\theta)}{2(2+\theta)}, \tag{A.13}$$

and

$$q_{\hat{t}_2} = q_{\hat{t}_2}^M = \frac{\lambda(g_r + m_r)(1+\theta) + q_r(1+\theta)}{2(2+\theta)}, \tag{A.14}$$

where $q_{\hat{t}_1}^M = q_{\hat{t}_2}^M$, we get

$$\hat{q}^M = q_{\hat{t}_1}^M = q_{\hat{t}_2}^M = \frac{\lambda(g_r + m_r)(1+\theta) + q_r(1+\theta)}{2(2+\theta)}. \tag{A.15}$$

A.3. Retail margin ($\hat{g}^M$)

The margin of distributor 1 is $g_{\hat{t}_1}^M = g_r - \hat{t}_1^M + \hat{a}^M$, and the margin of distributor 2 is $g_{\hat{t}_2}^M = g_r - \hat{t}_2^M + \hat{a}^M$, using Eqs. (A.12) and (A.9), obtains

$$\hat{g}^M = g_{\hat{t}_1}^M = g_{\hat{t}_2}^M = g_r - \frac{\lambda(g_r + m_r)(1+\theta) - q_r(3+\theta)}{2\lambda(2+\theta)} + \frac{\lambda(m_r - g_r) - q_r}{2\lambda} = \frac{q_r + \lambda(g_r + m_r)}{2\lambda(2+\theta)}. \tag{A.16}$$

A.4. Manufacturer margin ($\hat{m}_t^M$)

Using Eq. (A.9), obtains

$$\hat{m}_t^M = m_r - \hat{a}^M = m_r - \frac{\lambda(m_r - g_r) - q_r}{2\lambda} = \frac{\lambda(g_r + m_r) + q_r}{2\lambda}. \tag{A.17}$$

Appendix B

The equilibrium solutions are obtained by the Retailer–Stackelberg game analysis under transaction cost. The manufacturer has profit function given by Eq. (4):

$$\begin{aligned}\Pi_M^R &= (m_r - a)(q_{t_1} + q_{t_2}) = (m_r - a)[2q_r + t_1\lambda_1 + \theta(t_1\lambda_1 - t_2\lambda_2) + t_2\lambda_2 + \theta(t_2\lambda_2 - t_1\lambda_1)] \\ &= (m_r - a)(2q_r + t_1\lambda_1 + t_2\lambda_2)\end{aligned}$$

Initially, assuming that the transaction cost decisions depend only on the promotion allowance, a, changed by the manufacturer and not on the price or fixed cost. Therefore, the manufacturer's reaction function can be derived from the first-order conditions of Eq. (4). Let $\frac{\partial \Pi_M^R}{\partial a} = 0$, getting

$$(m_r - t_1 - a)\lambda_1 + (m_r - t_2 - a)\lambda_2 - 2q_r = 0 \tag{B.1}$$

Solving the Eq. (B.1), and substituting a by $\hat{a}$, obtains the reaction function of the manufacturer (allowance);

$$a = \hat{a} = \frac{(m_r - t_1)\lambda_1 + (m_r - t_2)\lambda_2 - 2q_r}{\lambda_1 + \lambda_2} \tag{B.2}$$

where $t_i(a)$ and $i, j \in \{1,2\}$, $i \neq j$.

Substituting Eq. (B.2) into Eq. (5), let $\frac{\partial \Pi_{R_1}^R}{\partial t_1} = 0$ and $\frac{\partial \Pi_{R_2}^R}{\partial t_2} = 0$, we get

$$\frac{1}{2}[2\lambda_1(1+\theta)(g_r + m_r - 3t_1) - \lambda_1 t_2(1-2\theta) - q_r(5+2\theta)] = 0, \tag{B.3}$$

and

$$\frac{1}{2}[2\lambda_1(1+\theta)(g_r+m_r-3t_2)-\lambda_2 t_1(1-2\theta)-q_r(5+2\theta)]=0. \tag{B.4}$$

Solving the simultaneous Eq. (B.3) to Eq. (B.4), and substituting $\hat{t}_1$ by $\hat{t}_1^R$ and $\hat{t}_2$ by $\hat{t}_2^R$, gets the distributors' optimal transaction costs;

$$\hat{t}_1=\hat{t}_1^R=\frac{2\lambda_1\lambda_2(g_r+m_r)(1+\theta)(5+8\theta)-3q_r(5+2\theta)[6\lambda_2(1+\theta)-\lambda_1(1-2\theta)]}{\lambda_1\lambda_2(7+4\theta)(5+8\theta)} \tag{B.5}$$

and

$$\hat{t}_2=\hat{t}_2^R=\frac{2\lambda_1\lambda_2(g_r+m_r)(1+\theta)(5+8\theta)-3q_r(5+2\theta)[6\lambda_1(1+\theta)-\lambda_2(1-2\theta)]}{\lambda_1\lambda_2(7+4\theta)(5+8\theta)}. \tag{B.6}$$

Subsequent discussion will also assume $\lambda_1=\lambda_2=\lambda$, thus, the Eqs. (B.5) and (B.6) can be rewritten and can be simplified as

$$\hat{t}_1^R=\frac{2\lambda(g_r+m_r)(1+\theta)-q_r(5+2\theta)}{\lambda(7+4\theta)} \tag{B.7}$$

and

$$\hat{t}_2^R=\frac{2\lambda(g_r+m_r)(1+\theta)-q_r(5+2\theta)}{\lambda(7+4\theta)} \tag{B.8}$$

where $\hat{t}_1^R=\hat{t}_2^R$, hence getting

$$\hat{t}^R=\hat{t}_1^R=\hat{t}_2^R=\frac{2\lambda(g_r+m_r)(1+\theta)-q_r(5+2\theta)}{\lambda(7+4\theta)} \tag{B.9}$$

B.1. Manufacturer allowance ($\hat{a}^R$)

Substituting Eq. (B.9) into Eq. (B.2), and substituting $\hat{t}_1$ by $\hat{t}_1^R$and $\hat{t}_2$ by $\hat{t}_2^R$, yields

$$\hat{a}^R=\frac{\lambda m_r(5+2\theta)-2\lambda g_r(1+\theta)-2q_r(1+\theta)}{\lambda(7+4\theta)} \tag{B.10}$$

B.2. Sales volume ($\hat{q}^R$)

Substituting Eqs. (B.7) and (B.8) into Eq. (1), respectively, and substituting $q_{\hat{t}_1}$ by $q_{\hat{t}_1}^R$ and $q_{\hat{t}_2}$ by $q_{\hat{t}_2}^R$, yields

$$q_{\hat{t}_1}=q_{\hat{t}_1}^R=\frac{\lambda m_r(5+2\theta)-2\lambda g_r(1+\theta)+q_r(5+2\theta)}{7+4\theta}, \tag{B.11}$$

and

$$q_{\hat{t}_2}=q_{\hat{t}_2}^R=\frac{\lambda m_r(5+2\theta)-2\lambda g_r(1+\theta)+q_r(5+2\theta)}{7+4\theta}, \tag{B.12}$$

where $q_{\hat{t}_1}^R=q_{\hat{t}_2}^R$, hence getting

$$\hat{q}^R=q_{\hat{t}_1}^R=q_{\hat{t}_2}^R=\frac{\lambda m_r(5+2\theta)-2\lambda g_r(1+\theta)+q_r(5+2\theta)}{7+4\theta} \tag{B.13}$$

B.3. Retail margin ($\hat{g}^R$)

The margin of distributor 1 is $g_{\hat{t}_1}^R=g_r-\hat{t}_1^R+\hat{a}^R$, and the margin of distributor 2 is $g_{\hat{t}_2}^R=g_r-\hat{t}_2^R+\hat{a}^R$, using Eqs. (B.9) and (B.10), obtains

$$\hat{g}^R=\hat{g}_{t_1}^R=\hat{g}_{t_2}^R=g_r-\frac{2\lambda(g_r+m_r)(1+\theta)-q_r(5+2\theta)}{\lambda(7+4\theta)}+\frac{\lambda m_r(5+2\theta)-2\lambda g_r(1+\theta)-2q_r(1+\theta)}{\lambda(7+4\theta)}=\frac{3q_r+3\lambda(g_r+m_r)}{\lambda(7+4\theta)}. \tag{B.14}$$

B.4. Manufacturer margin ($\hat{m}_t^R$)

Using Eq. (B.2), obtains

$$\hat{m}_t^R = m_r - \hat{a}^R = m_r - \frac{\lambda m_r(5+2\theta) - 2\lambda g_r(1+\theta) - 2q_r(1+\theta)}{\lambda(7+4\theta)} = \frac{2\lambda(g_r+m_r)(1+\theta) - 2q_r(1+\theta)}{\lambda(7+4\theta)}. \tag{B.15}$$

Appendix C

The following mathematics derivation provides a property of the decision variables in Table 3.

C.1. Retail transaction cost

$$\begin{aligned}\hat{t}^M - \hat{t}^R &= \frac{\lambda(g_r+m_r)(1+\theta) - q_r(3+\theta)}{2\lambda(2+\theta)} \\ &\quad - \frac{2\lambda(g_r+m_r)(1+\theta) - q_r(5+2\theta)}{\lambda(7+4\theta)} \\ &= -\frac{(1+\theta)(q_r+\lambda(g_r+m_r))}{2\lambda\left(14+15\theta+4\theta^2\right)} < 0.\end{aligned} \tag{C.1}$$

C.2. Manufacturer allowance

$$\begin{aligned}\hat{a}^M - \hat{a}^R &= \frac{\lambda(m_r-g_r) - q_r}{2\lambda} \\ &\quad - \frac{\lambda m_r(5+2\theta) - 2\lambda g_r(1+\theta) - 2q_r(1+\theta)}{\lambda(7+4\theta)} \\ &= -\frac{3(q_r+(g_r+m_r(1+\theta)))}{2\lambda(7+\theta)} < 0.\end{aligned} \tag{C.2}$$

C.3. Demand after transaction cost

$$\begin{aligned}\hat{q}^M - \hat{q}^R &= \frac{\lambda(g_r+m_r)(1+\theta) + q_r(1+\theta)}{2(2+\theta)} \\ &\quad - \frac{\lambda m_r(5+2\theta) - 2\lambda g_r(1+\theta) + q_r(5+2\theta)}{7+4\theta} \\ &= \frac{\lambda g_r(1+\theta)(15+8\theta) - (q_r+\lambda m_r)(13+7\theta)}{2(2+\theta)(7+4\theta)} < 0.\end{aligned} \tag{C.3}$$

As q_r is large, the fraction of numerator is a negative number.

C.4. Retail margin after transaction cost

$$\begin{aligned}\hat{g}^M - \hat{g}^R &= \frac{q_r+\lambda(g_r+m_r)}{2\lambda(2+\theta)} - \frac{3q_r+3\lambda(g_r+m_r)}{\lambda(7+4\theta)} \\ &= -\frac{(5+2\theta)(q_r+\lambda(g_r+m_r))_r}{2\lambda(2+\theta)(7+4\theta)} < 0.\end{aligned} \tag{C.4}$$

C.5. Manufacturer margin after transaction cost

$$\begin{aligned}\hat{m}_t^M - \hat{m}_t^R &= \frac{\lambda(g_r+m_r) + q_r}{2\lambda} \\ &\quad - \frac{2\lambda(g_r+m_r)(1+\theta) + 2q_r(1+\theta)}{\lambda(7+4\theta)} \\ &= \frac{3(q_r+\lambda(g_r+m_r))}{2\lambda(7+4\theta)} > 0.\end{aligned} \tag{C.5}$$

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