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THREE ESSAYS ON DISTRIBUTION CHANNELS AND PRICING
STRATEGY

BY

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DISSERTATION

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ABSTRACT

This dissertation involves three essays, studying firms' decision-making on marketing mix variables. Specifically, the first essay (Chapter 2) studies the effects of distribution channels on firms' advertising content decision. In many markets, consumers may not have full information of product features and prices when they shop. While consumers can search to acquire such information, manufacturers and retailers often advertise price, product, or both types of information to help resolve consumers' uncertainty. This chapter studies manufacturers' and retailers' advertising content decisions in either a centralized channel or a decentralized channel, in a market where advertising affects consumers' search behaviors and purchase decisions. I show that in a decentralized channel, advertising may include more information than in a centralized channel. Specifically, when a retailer in a decentralized channel makes its advertising decision before the manufacturer and the retailer decide on prices, it prefers more price-product advertising than in a centralized channel; otherwise, it prefers more price-only advertising and more price-product advertising than in a centralized channel. I also show that in a decentralized channel where the manufacturer decides on product advertising and the retailer decides on price advertising, there will be more price-only advertising than in a centralized channel. Finally, I examine the consequent effects of advertising strategies in different distribution channels on channel members' profitability, consumer welfare and social welfare.

The second essay (Chapter 3) studies the effects of channel structure and types of consumer heterogeneity on a manufacturer's product quality decision. I show that a manufacturer's product quality decision depends on both its channel structure and the type of consumer heterogeneity. When consumers are heterogeneous either vertically on their willingness-to-pay for product quality or horizontally on their transaction costs, a manufacturer will provide the same or lower product quality in a decentralized channel

than in a centralized channel. However, when consumers are heterogeneous on both their willingness-to-pay for product quality and transaction costs, a manufacturer may even offer higher product quality in a decentralized channel than in a centralized channel under certain conditions, and consumers, as well as the distribution channel, can benefit from an increase of consumer transaction cost.

The third essay (Chapter 4) studies how firms with high service quality (i.e. the high-type) can use tipping policy to signal their service quality and distinguish from firms with low service quality (i.e. the low-type) when consumers are comprised of informed and uninformed consumers. I characterize the conditions under which tipping policy together with complete information price can be effective signal device. In addition, I show that when the ratio of the informed consumers to uninformed consumers is low, if the high-type's optimal decision is to choose to have a tipping policy under complete information, it will signal with a tipping policy together with a distorted price. Furthermore, I show that even when the high-type's optimal decision is non-tipping policy under complete information, it might strategically adopt a tipping policy to signal its service quality.

To Robert and Matteo, for their love and support.

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CHAPTER 1

INTRODUCTION

Consumers' reservation prices (willingness-to-pay) are directly related to the product/service firms provide although consumers may be different from each other in terms of how much they value the product/service. Hence, in their marketing activities, firms influence consumers' reservation prices taking into account consumers' heterogeneity. For instance, in the first essay (Chapter 2), firms affect consumers' reservation prices with their decisions on advertising strategy. In the second essay (Chapter 3), a manufacturer sets its product quality to influence consumers' willingness-to-pay. And in the third essay (Chapter 4), firms' service offering directly affects how much a consumer is willing to pay for the service. Particularly, when incorporating richer consumer characteristics in the market, firms' decision might be different from what the literature has suggested. For instance, the second essay (Chapter 3) "the effects of consumer heterogeneity on product quality in distribution channels" investigates the issue of a manufacturer's product quality decision when consumers' heterogeneity is either two-dimensional or one-dimensional.

Moreover, consumers may not have full information of product/service in the market, and firms can choose to resolve consumers' uncertainty or not. This dissertation involves two strategies which firms can adopt to resolve consumers' uncertainty. The first one is advertising as studied in the first essay "advertising content with consumer search in distribution channels". Firms can choose different advertising strategies, i.e., product-only advertising, price-only advertising, or product-price advertising to partially or fully resolve consumers' uncertainty. The second strategy is signaling as in the third essay "tipping policy and signaling service quality". A firm with high service quality can use a tipping policy to "authorize" consumers to decide part of the final price. By doing so, the firm sends a signal to uninformed consumers such that they can infer its service quality.

Furthermore, a firm’s decision-making on marketing mix needs to consider the existence of other firms, either its direct partner in the distribution channel, or its competitors. The interaction between firms may lead to surprising difference as compared to the situations without such an interaction. In the first two essays (Chapter 2 and Chapter 3) of this dissertation, I study how a firm’s interaction with its direct distribution partner will influence its decision on marketing mix variables. Specifically, the first essay “advertising content with consumer search in distribution channels” examines how change of distribution channel (with or without an independent distributor) will affect firms’ advertising strategy. The second essay “the effects of consumer heterogeneity on product quality in distribution channels” studies how the interaction between channel members influences a manufacturers decision-making on product quality. In the third essay (Chapter 4) “tipping policy and signaling service quality”, I study how a firm with high service quality can send signal to uninformed consumers in the market to distinguish itself from those with low service quality.

In general, Figure 1.1 describes the connections among three essays.

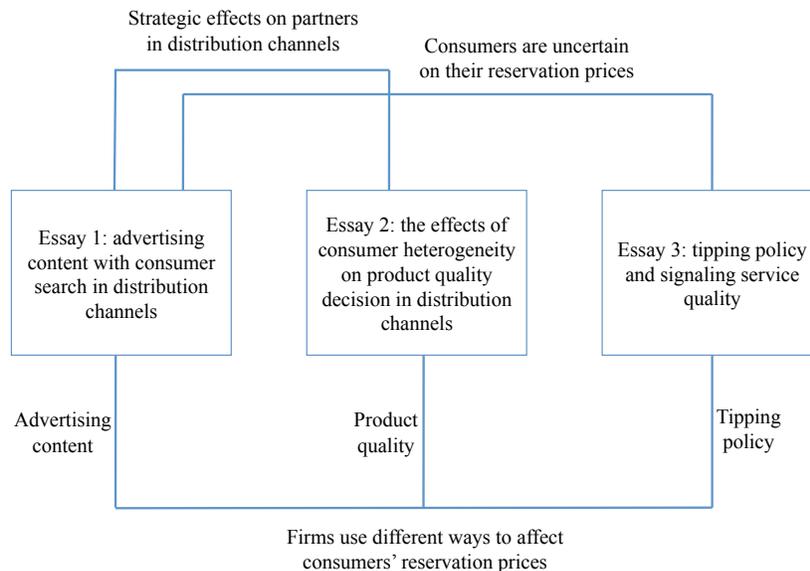


Figure 1.1: Connections among three essays

CHAPTER 2

ADVERTISING CONTENT WITH CONSUMER SEARCH IN DISTRIBUTION CHANNELS

2.1 INTRODUCTION

In many markets, although consumers know of the existence of a product, they may not have full information of its features (Kuksov, 2004; Villas-Boas 2009; Guo 2009; Sun 2010) or even prices (Zhang 2009; Desai et al. 2010). On the one hand, consumers can actively acquire information on their own.¹ For instance, a consumer may physically travel to a store to find out the price or product features by incurring a search cost (Kuksov 2004). As indicated in this example, once a consumer searches, she has to incur a sunk cost of searching despite the subsequent purchase decision.² Hence, the uncertainty of how well the product will match her taste preference as well as the price may restrain her from searching. This search restraint, in turn, can prohibit the consumer's purchasing intention.

On the other hand, manufacturers and retailers often use advertising as a tool to resolve consumers' uncertainty by informing them about the product features, prices, or both. For instance, Wal-Mart Pharmacy advertises many manufacturers' medicines such as Prevacid and Advil online with detailed item descriptions, nutrition facts, applicable symptoms and even possible side effects. Target and Gamestop often advertise product information of video games supplied by manufacturers. In the music industry, major retail outlets are typically the sole advertisers and they advertise music samples of recent releases. U.S. Cellular offers details of its plans through television advertisements, including specific descriptions about minutes, messaging, and

¹While information on product features can be acquired prior to consumers' purchase decision, this research mainly refers to the context of search products. In contrast, information on non-search products can only be known after consumers' consumption experience.

²This search cost can contain both direct dollar expenditures and indirect costs when consumers spend time and effort searching (Klein 1998). When the expected benefit of searching is lower than the search cost, consumers will not search (Stigler 1961).

data.

In addition to using advertising to help resolve consumers' uncertainty on product match, many retailers also advertise their retail prices. Specifically, retail chains such as Wal-Mart routinely advertise their prices on television and radio. Also, retailers often distribute weekly flyers with retail prices for their upstream manufacturers' products (Desai et al. 2010) or advertise retail prices on their websites (Zhang 2009).³ Furthermore, it is also common for firms to convey both product and price information in their advertisements. For example, Macy's reveals specific information such as textile, style, color about Ralph Lauren's products as well as the prices.

Firms' involvement in decisions on advertising/information revelation has been studied in channel literature (e.g. Huang et al. 2002; He et al. 2009; Guo 2009) which in general concludes that channel decentralization leads to less advertising/information revelation. In a centralized channel where a manufacturer owns the retailer, the advertising decisions are made integratedly. In a decentralized channel, an independent retailer often plays a significant role in providing information to consumers via television, newspaper, direct mail and internet as indicated in the above examples (e.g. Kotler 2003). Specifically, in some markets, retailers may need to make strategic plans for their investment in advertising, or upstream manufacturers may require their downstream partners to commit to such an advertising plan even before they reach their deals on wholesale prices. In other markets, the retailer may make its advertising decision after its upstream manufacturer offers the wholesale price. Additionally, the practice of advertising can also be executed by different channel members, with each member in charge of one type of advertising content. For instance, while only the retailers can advertise the final retail prices, manufacturers can also advertise their product details.

In this chapter, I intend to investigate three important issues regarding firms' decision-making on advertising content, namely, whether to advertise and what to advertise, in a market where consumers are able to search for information about product features and price. The first issue is the effect of different distribution channel structures on firms' decisions on advertising

³Note that although in these advertisements, information such as product names is unavoidable, I call them price advertising because the main focus is on price information rather than product details.

strategy. Would more or less information be advertised in a decentralized channel than in a centralized channel? The second issue regards the effect of the timing of the advertising decisions on channel members' profitability. The third issue relates to the effect of advertising strategies on consumer welfare and social welfare. While advertising can partially or fully, depending on the level of the advertising content, resolve consumers' uncertainty, it also influences the channel members' pricing decisions. Would consumers, at an aggregate level, always benefit more from one type of advertising than the others? How would the change in consumers' search costs affect consumer welfare and social welfare? The answers to these questions can help shed light on the advertising and pricing decisions for marketing managers.

To address these questions, I develop a game-theoretic model. First, the model studies a firm's decision on its advertising content in a centralized channel as a benchmark case. Then, the model examines various cases in a decentralized channel. In the decentralized channel, I first consider the case where only the retailer can advertise, then I study the case where both the manufacturer and the retailer can advertise.

2.1.1 SUMMARY OF MAIN RESULTS

The main result of this chapter is that consumers' uncertainty on product and price can be an incentive for firms to advertise more or include more information in their advertisements in a decentralized channel than in a centralized channel. This finding complements the literature in marketing showing that there will be less advertising in a decentralized channel than in a centralized channel (Michael 1999; Huang et al. 2002; He et al. 2009; Guo 2009). The intuition of this finding is as follows. As commonly known, consumers may be charged a higher retail price in a decentralized channel than in a centralized channel because of the double-marginalization issue. With uncertainty on product match and price, consumers are less willing to incur a search cost to acquire such information and consequently are less likely to buy the product in a decentralized channel. To mitigate this negative effect on consumers' purchasing intention, a retailer in a decentralized channel may be more likely to use advertising as a tool to resolve consumers' uncertainty on product match and retail price.

Furthermore, I show that a manufacturer may not always benefit from requesting a retailer to pre-commit on its advertising strategy before wholesale transactions. This is because this pre-commitment will restrict the manufacturer's strategic influence over the retailer's decision-making via the manufacturer's decision on the wholesale price. Instead, if the retailer makes the advertising decision after the wholesale price decision, both the retailer and the manufacturer can be better off. In this case, the manufacturer benefits from having a strategic influence over the retailer's decision on both advertising and retail price. In the meanwhile, the retailer benefits from not having to purposely avoid certain advertising strategies to prevent being taken advantage by the manufacturer.

Additionally, I show that consumer welfare can be higher in a decentralized channel than in a centralized channel. This happens when price-product advertising is practiced in the decentralized channel and price-only advertising is practiced in the centralized channel. Although consumers get charged a higher retail price in the decentralized channel, their uncertainty on both product match and price is resolved by price-product advertising. Hence only consumers whose tastes match the product well enough will visit the store and purchase the product. While in the centralized channel, even consumers get charged a lower retail price, their uncertainty on product match still remains. This uncertainty requires all consumers to visit the store to acquire the product information, including consumers whose tastes do not match the product well enough and eventually do not purchase the product. Therefore, consumers at an aggregate level may benefit from channel decentralization.

2.1.2 RELATED LITERATURE

The research in this chapter is mainly related to two streams of literature. One is about firms' advertising of product (e.g. Grossman and Shapiro 1984; Meurer and Stahl 1994; Anderson and Renault 2009), price (e.g. Zhang 2009; Desai 2010), or both (Anderson and Renault 2006, 2007). For instance, Grossman and Shapiro (1984) consider a competitive market where advertising plays the role of matching products to consumers, and where all consumers observe prices. Meurer and Stahl (1994) discuss two competing firms' advertising with horizontally differentiated products assuming

again that all consumers observe prices. Zhang (2009) studies two competitive retailers' decisions on multichannel and price advertising. Desai et al. (2010) discuss the price advertising strategies of two competitive retailers with different service levels. This literature mostly focuses on one type of advertising, either product or price. Anderson and Renault (2006, 2007) are the two exceptions, which examine a monopolist's decision-making on advertising content. Two main aspects distinguish the research in this chapter from this stream of literature. The first is that I examine firms' advertising decision-making in different distribution channel. And the second is that I allow different types of advertising to be conducted by different channel members, where advertising affects consumers' search behavior and purchase decision.

The other stream of related literature concerns advertising in different distribution structures. Traditional advertising literature involving distribution channels focuses on cooperative advertising (e.g. Berger 1972; Bergen and John 1997; Huang et al. 2002; He et al. 2009), persuasive advertising in distribution channels (e.g. Shaffer and Zettelmeyer 2004), and information revealing in distribution channels (e.g. Guo 2009). There are both empirical and theoretical research in this area. For instance, using data in the restaurant and the hotel industry, Michael (1999) empirically tests the theory that franchised chains (decentralized channel) advertise less than corporate chains (centralized channel) because of spillover effects across the franchisees. Theoretically, Huang et al. (2002) demonstrate that both national and local advertising are higher in a partnership model than in the traditional leader-follower relationship of a manufacturer and a retailer. He et al. (2009) extend Huang et al. (2002) to a dynamic model and show that, as compared to the vertically integrated channel, the advertising level is lower with a cooperative advertising mode where the manufacturer announces a co-op advertising policy. In this series of literature, firms have considered advertising as a tool to inform consumers the existence of the product, and consumers know the price as they are aware of the product. Another closely related article is by Guo (2009), who studies a manufacturer's decisions on the format of product quality disclosure in both centralized and decentralized channels. He shows that in a decentralized channel, no matter whether a manufacturer or a retailer discloses product quality information, there will be less information disclosure in the decentralized channel than in the centralized channel. While

this stream of literature usually focuses on one type of advertising in distribution channels without considering consumers' search behavior, I study firms' decisions on different types of advertising in different distribution channels where advertising affects consumers search behavior and purchase decision. In this chapter, I show that there may be more advertising in a decentralized channel than in a centralized channel.

The rest of this chapter is organized as follows. In Section 2.2, I set up the model, study firms' decisions on advertising content in both a centralized channel and a decentralized channel, and analyze the effect of the distribution channel structure on advertising strategy and the consequent effects on channel members' profitability, consumer welfare and social welfare. In Section 2.3, I discuss how the relaxation of some of the main assumptions may affect the findings. I conclude this chapter with Section 2.4.

2.2 THE MODEL

I. Consumers. The market consists of one unit mass of consumers with their reservation prices v uniformly distributed along a Hotelling line between 0 and 1, which is common knowledge to both firms and consumers. A consumer's reservation price is directly determined by the extent of product match. The more the product matches a consumer i 's taste preference, the higher her reservation price (v_i). Consumers face uncertainty about the product match (v) and price (r) if the firms do not advertise the information. To resolve the uncertainty, consumers incur a search cost c to acquire information and discover their exact reservation prices. For instance, a consumer must travel to a retailer to inspect the product and find the price. The consumer incurs the search cost even when she decides not to buy the product after inspecting it and obtaining the price information. This search cost is also unavoidable for those consumers who choose to purchase the product even when the product and price information are publicly advertised since they need to travel to the store to purchase (Anderson and Renault 2006, 2007). A consumer's decision to initiate the search process or not depends on whether her expected benefit of searching exceeds the search cost c , which is common to all consumers. Once a consumer completes her search process, she buys the product if her reservation price (v) is not lower than the re-

tail price (r), that is, $v \geq r$. Each consumer purchases at most one unit of the product. To avoid the trivial case where no consumer will purchase the product, I assume $c < 1$.

II. Firms. I consider a distribution channel where an upstream manufacturer produces a product and sells through a downstream retailer to end consumers. In a centralized channel, the manufacturer owns the retailer and decides the retail price (r) and the advertising content, which will be defined shortly. In a decentralized channel, the two firms are independent, where the manufacturer decides the wholesale price (w) and the retailer decides the retail price (r). I first study the cases where only the retailer advertises in the decentralized channel. Then, I examine the case where the manufacturer decides on product advertising and the retailer decides on price advertising. The marginal cost for producing the product is normalized to zero and the wholesale price is the only cost for the retailer in the decentralized channel. In addition, the cost to advertise either product or price or both types of information is normalized to zero, and a positive cost does not qualitatively change the main results, which will be discussed further in Section 1.3.

III. Advertising content. In this chapter, I study two types of advertising content. One is product advertising, which helps consumers to figure out the extent of product match. In other words, if the retailer advertises the product information, each consumer will be informed about her exact v . This product information can be advertised either by a retailer or by a manufacturer in a decentralized channel. The other type is price advertising, which is always conducted by the retailer. If the retailer advertises the retail price (r), consumers will completely resolve their uncertainty on price; otherwise, they will rationally form their expectations. Different combinations of these two types of advertising content affect consumer behavior differently. First, when there is no advertising, consumers are homogeneous on their search decisions and they all decide to search when the expected benefit of searching is not lower than the search cost. Once they finish their search processes, consumers resolve their uncertainty on product match and retail price, and consumers with a reservation price v higher than the retail price r will purchase the product. Second, when there is only product advertising, because of the hold-up problem, consumers will not visit the store although they are certain on the exact v (Anderson and Renault 2006). Third, when there is price-only advertising, consumers are still homogeneous on their uncertainty

on product match, and they all will decide to search when the expected benefit of searching is not lower than the search cost. Again, only those consumers with reservation prices higher than the retail price will purchase the product. Fourth, when there is price-product advertising, consumers completely resolve their uncertainty on both product match and retail price, and they are heterogeneous such that only those consumers with a non-negative surplus will visit the store and purchase the product. In this research, advertising is credible and truthful (Jovanovic 1982). The tie-breaking rule is if a firm is indifferent between advertising and not advertising, it will choose not to advertise; and if a firm is indifferent between advertising only one type (either product or price) and advertising both price and product, it will choose to advertise only one type.

2.2.1 A CENTRALIZED CHANNEL

I first consider a benchmark case of a centralized channel where the manufacturer owns the retailer. The retailer decides the retail price and the combination of advertising content.

I. NO-ADVERTISING

When the retailer does not advertise either the price or the product information, consumers rationally anticipate the retail price and decide to search if the expected benefit of searching exceeds the search cost. While consumers' preferences are unknown to the firm, it cannot infer consumers' reservation prices even when they show up in the store. Once consumers are in the store, after they inspect the product and retail price (r), only those consumers with their reservation prices higher than or equal to the retail price ($v \geq r$) will purchase the product. Then the expected number of consumers who will purchase the product is $Prob(v \geq r) = 1 - r$. The retailer maximizes its expected profit $E(\pi^n) = r(1 - r)$ and obtains $r^{n*} = \frac{1}{2}$, where the superscript n refers to no-advertising.

Prior to search, all consumers are homogeneous and each of them has the expected benefit of searching $E(max\{v - r^{n*}, 0\}) = \int_{r^{n*}}^1 (v - r^{n*})dv = \frac{1}{8}$.

Therefore, the condition under which all consumers will search is

$$c \leq E(\max\{v - r^{n*}, 0\}) = \frac{1}{8} \quad (2.1)$$

When the retailer does not advertise either the product or the price, if $c \leq \frac{1}{8}$, consumers rationally form the expectation of the monopoly price $r^{n*} = \frac{1}{2}$ and choose to search. The retailer's expected profit is $E(\pi^{n*}) = \frac{1}{4}$. If $c > \frac{1}{8}$, consumers will not initiate the search process and there will be no market for the product. Hence, the retailer's profit will be zero.

II. PRICE-ONLY ADVERTISING

When the retailer advertises only its retail price, it optimally charges a price r^p , where the superscript p refers to price-only advertising, such that the expected benefit of searching for all the consumers equals to their search cost. That is $\int_{r^p}^1 (v - r^p) dv = c$, and we have $r^{p*} = 1 - \sqrt{2c}$. With this advertised retail price r^p , all consumers visit the store to find out the product match information and only those consumers with realized reservation prices higher than or equal to the retail price ($v \geq r^{p*}$) will purchase the product. Hence, the retailer's expected profit is $E(\pi^{p*}) = r^{p*}(1 - r^{p*}) = \sqrt{2c} - 2c$.

III. PRICE-PRODUCT ADVERTISING

When the retailer advertises both its price and product information, a consumer decides to visit the store only when her reservation price v , which now is certain, is greater than or equal to the retail price r^{pp} and the search cost c , that is, $v \geq r^{pp} + c$. Those consumers with $v < r^{pp} + c$ will not visit the store. Hence, given r^{pp} , the number of consumers who will visit the store and purchase the product is $1 - r^{pp} - c$. The retailer maximizes its profit $\pi^{pp} = r^{pp}(1 - r^{pp} - c)$ and obtains $r^{pp*} = \frac{1-c}{2}$. The retailer's profit thus is $\pi^{pp*} = \frac{(1-c)^2}{4}$.

When the retailer advertises only its product information, all consumers will be certain on their reservation price (v). However, since the retail price is not advertised, consumers need to infer the retail price they will get charged once they visit the store to purchase the product. While consumers know that

they need to incur a search cost c , in case they initiate the visit, the search cost becomes a sunk cost. And once consumers show up in the store, they will get charged a retail price higher than that they expect before they search. With this inference, consumers will not visit the store, which eventually leads to no demand for the product and zero profit for the firm.

Table 2.1: Decisions and profits in a centralized channel

c	Ad. strategy	retail price	profit
$c \leq \frac{1}{8}$	no-ad	$1/2$	$1/4$
$\frac{1}{8} < c < 0.4075$	price-only	$1 - \sqrt{2c}$	$\sqrt{2c} - 2c$
$0.4075 < c < 1$	price-product ad	$(1 - c)/2$	$(1 - c)^2/4$

By comparing the firm's profit across different combinations of advertising content, I summarize the optimal strategy and the firm's profits in a centralized channel in Table 2.1. Since advertising serves as a tool for the firm to resolve consumers' uncertainty, the firm chooses to advertise more information when it is more costly for consumers to acquire the information on their own.

2.2.2 A DECENTRALIZED CHANNEL

I now consider a decentralized channel where the manufacturer and the retailer are independent. As observed in the market, many retailers such as Wal-Mart and Macy's are in charge of the advertising activities, so I first study the cases where the retailer determines advertising strategy. Later, I will examine the case where the manufacturer can decide on product advertising and the retailer decides on price advertising.

I. RETAILER DETERMINES ADVERTISING STRATEGY

In a decentralized channel, when the downstream retailer is the only firm in charge of the advertising strategy, I first consider the following timing of the game sequence. In stage 1, the retailer decides whether to advertise and what to advertise. In stage 2, the manufacturer sets the wholesale price (w). In stage 3, the retailer sets the retail price (r). This sequence (R-M-R) as

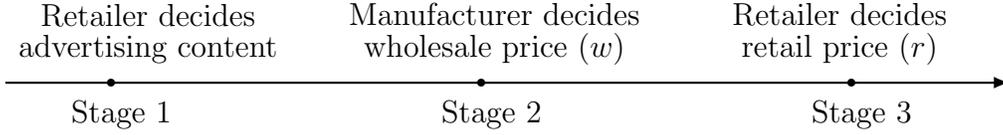


Figure 2.1: Timing of the game with R-M-R sequence

shown in Figure 2.1 may apply to two scenarios. First, the retailer needs to invest in advertising capabilities or plan advertising expenditures which are not flexible and difficult to change, while the manufacturer and retailer's prices are more flexible. Second, the manufacturer requests its downstream partner to pre-commit on the advertising content.⁴ I will study alternative sequences later.

Based on the retailer's decision in stage 1, I have four sub-games, namely, no-advertising, price-only advertising, product-only advertising, and price-product advertising. For each sub-game, I first solve the retailer's maximization problem, which is then followed by the manufacturer's maximization problem. For instance, when the retailer decides not to advertise at all, then the channel members profit functions are $\pi_{dcM}^n = w_{dc}^n(1 - r_{dc}^n)$ and $\pi_{dcR}^n = (r_{dc}^n - w_{dc}^n)(1 - r_{dc}^n)$. Solving the retailer's profit maximization gives $r_{dc}^{n*} = \frac{1+w_{dc}^n}{2}$. Then the manufacturer maximizes its profit and obtains $w_{dc}^{n*} = \frac{1}{2}$. These two pricing decisions are subject to the condition that consumers will visit the store: $c \leq E(\max\{v - r_{dc}^{n*}, 0\}) = \frac{1}{32}$. Similarly, I solve the other three sub-games. I save the detailed derivations in the Appendix and summarize the optimal decisions and channel members' profits in Table 2.2.

Table 2.2: Decisions and profits with R-M-R game sequence

c	Ad. strategy	w	r	M's profit	R's profit
$c \leq \frac{1}{32}$	no-ad	$1/2$	$3/4$	$1/8$	$1/16$
$\frac{1}{32} < c < 1$	price-product ad	$\frac{1-c}{2}$	$\frac{3(1-c)}{4}$	$(1-c)^2/8$	$(1-c)^2/16$

I compare the retailer's advertising strategy to the benchmark case and

⁴This pre-commitment on advertising content refers to the mode of advertising, i.e., no-advertising, product advertising, price advertising, or product and price advertising, which does not mean that the retailer has to pre-commit on the retail price for the price advertising option.

have the following finding:

Proposition 1. *When $\frac{1}{32} < c < 0.4075$, a retailer does price-product advertising in a decentralized channel where the retailer makes the advertising decision prior to its upstream manufacturer's wholesale price decision, but it conducts no-advertising or price-only advertising in a centralized channel.*

Interestingly, Proposition 1 shows that more information may be revealed in a decentralized channel than in a centralized channel when consumers have uncertainty on product match and price, and the retailer can choose the advertising content. This finding complements the extant literature on advertising or information revelation in channels (e.g. Michael 1999; Huang et al. 2002; He et al. 2009; Guo 2009), which either empirically or theoretically demonstrates that channel decentralization leads to less advertising. The intuition behind our finding is as follows. When consumers have uncertainty on product match and price, and they need to incur search costs to acquire such information, they are less willing to initiate the search process in a decentralized channel than in a centralized channel. This happens because of the higher retail price resulting from the double-marginalization problem in a decentralized channel. Consequently, if the search cost is high, consumers may not even initiate the search process to visit the store and consequently do not purchase the product, which directly hurts the retailer. Thus, to reduce the negative effect of double-marginalization and to attract consumers, when the retailer has control over advertising content in a decentralized channel, it is more likely to advertise its product and price information to resolve consumers' uncertainty than in a centralized channel. This resolving of uncertainty can in turn facilitate consumers to purchase the product.

The R-M-R game sequence captures the case where the retailer's advertising decision is less flexible as compared to pricing decisions or the retailer has to pre-commit its advertising to its upstream manufacturer.

Next, I study the game with M-R sequence, where the manufacturer first decides its wholesale price (w), then the retailer decides the retail price (r) and advertising content.

I solve the game again by backward induction. Given any wholesale price (w_d), the retailer decides its retail price (r_d) and the advertising content, where the subscript d refers to a decentralized channel where the retailer is

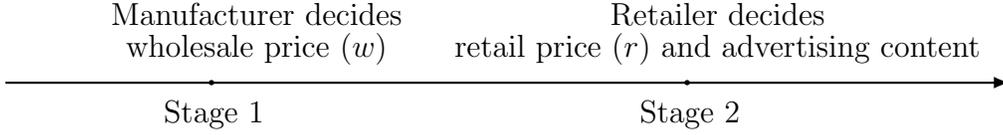


Figure 2.2: Timing of the game with M-R sequence

in charge of the advertising decision with the M-R game sequence as shown in Figure 2.2. It can choose either no-advertising, price-only advertising, product-only advertising, or price-product advertising. We leave the derivation details to the Appendix and summarize the optimal decisions and channel members' profits in Table 2.3.

Table 2.3: Decisions and profits with M-R game sequence

c	Ad. strategy	w	r	M's profit	R's profit
$c \leq 0.0139$	no-ad	$1/2$	$3/4$	$1/8$	$1/16$
$0.0139 < c \leq 0.3447$	price-only	w_1	p_1	π_{dM1}	π_{dR1}
$0.3447 < c < 1$	price-product	$\frac{1-c}{2}$	$\frac{3(1-c)}{4}$	$(1-c)^2/8$	$(1-c)^2/16$

$$w_1 = 1 - 2\sqrt{2c} + 2^{5/4}c^{3/4} - c, \quad p_1 = 1 - \sqrt{2c}, \quad \pi_{dM1} = (1 - 2\sqrt{2c} + 2^{5/4}c^{3/4} - c)\sqrt{2c},$$

$$\pi_{dR1} = (\sqrt{2c} - 2^{5/4}c^{3/4} + c)\sqrt{2c}.$$

Now, I compare the retailer's advertising strategies in a decentralized channel with the M-R game sequence to its advertising strategies in a centralized channel, and summarize the main findings in the following proposition:

Proposition 2. *When $0.0139 < c < \frac{1}{8}$ ($0.3447 < c < 0.4075$), the retailer does price-only advertising (price-product advertising) in a decentralized channel where it makes its advertising decision after its upstream manufacturer's wholesale price decision, but it conducts no-advertising (price-only advertising) in a centralized channel.*

Proposition 2 confirms Proposition 1 and shows that the retailer may advertise more information in a decentralized channel than in a centralized channel.⁵ Again, the retailer uses advertising as a tool to mitigate the negative effect of double marginalization in a decentralized channel on consumer

⁵This implies that the retailer's pre-commitment on advertising content is not the driving force behind the finding of more advertising in a decentralized channel than in a centralized channel.

search and purchase decisions. When players follow the sequence of M-R, as a follower of the decision-making in the decentralized channel, the retailer decides its advertising strategy based on the given wholesale price. As a leader of decision-making in the decentralized channel, the manufacturer optimally sets the wholesale price considering the trade-off between its profit margin and consumer demand. The manufacturer's pricing decision induces the retailer to practice the price-only advertising strategy when the consumer search cost is $c > 0.0139$. Therefore, compared to a centralized channel where the retailer does not advertise when $c \leq \frac{1}{8}$, it is more likely to operate price-only advertising in a decentralized channel when $0.0139 < c \leq \frac{1}{8}$.

When the retailer decides its advertising content after the wholesale price decision, if the consumer search cost is high such that $c > 0.3447$, to attract consumers to initiate the search process and lead to purchasing behavior, the retailer has to inform consumers of both price and product information before they begin their search. Otherwise, because of the high sunk cost, consumers will not risk searching, knowing that if the product does not match their tastes well enough, they will not purchase the product even after they search. Still, due to the higher retail price in the decentralized channel than in the centralized channel, the retailer starts to advertise both the product and price information at a lower threshold value of c than in the centralized channel. Therefore, even without the retailer's pre-commitment on advertising content, in a decentralized channel, the retailer is more likely to practice price and product advertising than in a centralized channel.

To summarize, Propositions 1 and 2 demonstrate the possibility that channel decentralization may lead to more information revelation in the market where consumers have uncertainty on product and price and where the retailer decides on advertising strategy. So far, the retailer is in charge of the decisions of both price and product advertising in the decentralized channel. In the following section, I allow the manufacturer to decide whether to advertise the product information and leave the decision on price advertising with the retailer.



Figure 2.3: Timing of the game with separated advertising decisions

II. BOTH MANUFACTURER AND RETAILER DECIDE ADVERTISING STRATEGY

The timing of the game sequence is that in Stage 1, the manufacturer decides whether to advertise the product information and sets the wholesale price. Then the retailer sets the retail price and decides whether to advertise it in Stage 2. This game sequence as shown in Figure 2.3, corresponds to the scenarios where an upstream manufacturer runs national advertisements on the product it produces and a downstream retailer conducts local advertisements on the final retail price.

The manufacturer has two options, advertising the product information and not advertising the product information. Then I solve the retailer's decisions on retail price and advertising given any wholesale price under each of the manufacturer's advertising options. I leave the derivation details to the Appendix and report the final optimal advertising decisions in Table 2.4.

Table 2.4: Decisions and profits with separate decisions

c	Ad. strategy	w	r	π_{dsM}	π_{dsR}
$c \leq 0.011$	no-ad	$1/2$	$3/4$	$1/8$	$1/16$
$0.011 < c \leq 0.463$	price-only	$1 - \sqrt{2c}$	$1 - \sqrt{2c}$	$\sqrt{2c} - 2c$	0
$0.463 < c < 1$	price-product	$\frac{1-c}{2}$	$\frac{3(1-c)}{4}$	$\frac{(1-c)^2}{8}$	$\frac{(1-c)^2}{16}$

I compare the channel members' advertising decisions to the benchmark case and summarize the finding in the following proposition.

Proposition 3. *When $0.011 < c < \frac{1}{8}$, the retailer does price-only advertising in a decentralized channel where an upstream manufacturer decides on product advertising and a downstream retailer decides on price advertising as modeled, but it conducts no advertising in a centralized channel.*

Proposition 3 further confirms that channel decentralization may result in more information revelation. In the current scenario, the manufacturer is a leader in a series of decision-making and has control over product advertising. As a follower, the retailer's advertising strategy depends on the manufacturer's decisions on its wholesale price as well as product advertising. When the manufacturer chooses not to advertise the product information, the retailer does not advertise if the wholesale price is low and advertises the price information if the wholesale price is high. Anticipating the retailer's response, the manufacturer optimally charges a high wholesale price to induce the retailer to advertise and set a retail price such that consumers' expected benefit of searching equals their search cost. In this case, the manufacturer obtains the full amount of the channel's profit.

To further extend the discussion, when the manufacturer decides on the product advertising, I allow the retailer to decide on both product and price advertising.⁶ The analysis falls into two sub-games: the manufacturer does product advertising, and the manufacturer does no-advertising. While the first sub-game has the solution of price-product advertising with the manufacturer and the retailer's profits $\frac{(1-c)^2}{8}$ and $\frac{(1-c)^2}{16}$, the second sub-game converges to the analysis of the game with M-R sequence. By comparing the manufacturer's profits across two sub-games, the manufacturer's no-advertising sub-game is dominant. So, the main findings are verified when the manufacturer decides on the product advertising first, then the retailer decides on both product and price advertising.

2.2.3 EFFECTS OF CHANNEL STRUCTURES ON CHANNEL MEMBERS' PROFITABILITY, CONSUMER WELFARE AND SOCIAL WELFARE

I compare the channel members' profits in different decentralized channels and report the most interesting finding below.

Proposition 4. (*Channel members' profits*) *In a decentralized channel, the retailer's pre-commitment on the advertising content benefits the retailer and*

⁶Since there is no extra benefit to do repetitive advertising, when the manufacturer decides to do product advertising, the retailer will not advertise the product information again.

hurts the manufacturer when $0.0139 < c \leq 0.0886$ and hurts both channel members when $0.0886 < c < 0.3447$.

Interestingly, Proposition 4 shows that the retailer's pre-commitment on advertising content may hurt the manufacturer, which implies that in practice, it is not always to the manufacturer's benefit to require its downstream partner to pre-commit on advertising content. The retailer's pre-commitment on advertising content may not benefit the retailer either. When $0.0139 < c \leq \frac{1}{32}$, the retailer will not advertise at all if it makes its decision on advertising strategy before the wholesale price decision, since consumers in any case will automatically initiate the search process to find out the product information with the expectation of the retail price r_{dc}^{n*} in the decentralized channel. However, if the retailer decides the advertising content after the wholesale price decision, it will not be able to replicate the strategy of no-advertising as when it decides the advertising strategy earlier, since its advertising strategy is conditioned on the manufacturer's wholesale price decision. Without the presence of the retailer's commitment to its advertising strategy prior to the wholesale price decision, the manufacturer increases its wholesale price to take advantage of higher profit margins and induce the retailer to advertise its retail price. Therefore, compared to the situation of being taken advantage of when the retailer makes the later advertising decision, the retailer's commitment to its advertising strategy protects and benefits itself. When $\frac{1}{32} < c < 0.0886$, if the retailer decides its advertising content earlier, it will advertise both product and price information. However, when the retailer makes the later advertising decision, it will advertise only the price. This ironically will not benefit the retailer, since the manufacturer charges a high wholesale price and obtains a high proportion of the channel's profit by taking advantage of its leadership in decision-making on pricing. In general, because of the separation of the decisions of advertising content and retail price, the retailer has more opportunities to benefit itself.

While the retailer's earlier decision on its advertising content can sometimes benefit itself, interestingly, under certain conditions, it can hurt itself while hurting the manufacturer. This happens when $0.0886 < c < 0.3447$. This is because when the retailer makes the earlier decision on its advertising content, its caution against the manufacturer's subsequent pricing decision restricts its own decision on advertising content. When the retailer makes the

later decision on its advertising strategy, it advertises only the retail price, although the manufacturer sets a high wholesale price which lowers the retailer's margin. With the increase of consumer search cost, the channel members also face an increasing expected demand, $1 - r_d^{p*} = 1 - (1 - \sqrt{2c}) = \sqrt{2c}$, which would not be possible for the case when the retailer advertises both the product and price information. While this positive effect of increasing expected demand outperforms the negative effect of a thin profit margin, the retailer is better off when it makes the later decision on its advertising strategy. Therefore, the retailer's earlier decision on its advertising content can ironically hurt itself.

Next, I examine how different advertising strategies in different decentralized channels influence consumer welfare and social welfare. Below, I summarize the most interesting effects on consumer welfare and social welfare.

Proposition 5. *(Consumer and social welfare) When $\frac{1}{8} < c < 0.4075$ ($0.3447 < c < 0.4075$), channel decentralization leads to higher consumer welfare if the retailer makes the advertising decision before (after) the manufacturer's wholesale price decision. When $0.0139 < c < 0.3447$, the retailer's pre-commitment on advertising content improves consumer welfare; When $0.0139 < c \leq 0.0394$, the retailer's earlier decision on advertising content improves social welfare and when $0.0394 < c < 0.3447$, the retailer's earlier decision on advertising content deteriorates social welfare.*

The most interesting result in Proposition 5 is that consumer welfare can be higher in a decentralized channel than in a centralized channel where the retailer makes the advertising decisions. This happens when price-product advertising is conducted in the decentralized channel and price-only advertising is conducted in the centralized channel. With price-product advertising in the decentralized channel, consumers receive information on both the product and price, which ensures that only consumers with non-negative utility will visit the store and purchase the product. However, with price-only advertising in the centralized channel, consumers only receive information on the price, which means that consumers still remain uncertain on the product match. To acquire this information, all consumers need to visit the store and some of them eventually will not purchase the product after incurring the search cost as a sunk cost. Therefore, consumers at an aggregate level may

benefit from channel decentralization.

Furthermore, this proposition presents that the retailer's decision on advertising content in advance can benefit consumers under certain conditions. The intuition is as follows. As discussed earlier, when the retailer pre-commits on its advertising content, if $c \leq \frac{1}{32}$, it will not advertise and all consumers will be uncertain about both product match and price. They form expectations of the retail price $r_{dc}^{n*} = \frac{3}{4}$ and visit the store because their expected benefit of searching is higher than their search cost. However, when the retailer does not pre-commit on its advertising content, if $0.0139 < c \leq \frac{1}{32}$, it will advertise its retail price $r_d^{p*} = 1 - \sqrt{2c}$, which is higher than $r_{dc}^{n*} = \frac{3}{4}$ such that all consumers will search for the product match information. The common point across these two cases is that all consumers will search, resulting in the same total search cost at an aggregate level. The different point, however, is that consumers will be charged a higher retail price when the retailer makes the later decision on its advertising strategy than the earlier decision, because the manufacturer charges a higher wholesale price to induce the retailer to advertise. Hence, the retailer's pre-commitment benefits consumers when $0.0139 < c \leq \frac{1}{32}$. If $c > \frac{1}{32}$, when the retailer makes the later decision on its advertising content, it will advertise both the product and price. This price and product advertising completely resolves consumers' uncertainty before they search; as such, only consumers with a non-negative surplus will visit the store and purchase the product. However, when the retailer does not pre-commit on its advertising content, if $\frac{1}{32} < c \leq 0.3447$, the retailer will advertise only its price without resolving consumers' uncertainty on product match. All consumers will visit the store and only some consumers with their reservation prices higher than the retail price will purchase the product. Therefore, the retailer's commitment to its advertising content can benefit consumers when $\frac{1}{32} < c < 0.3447$. To summarize, the retailer's commitment to its advertising content can improve consumer welfare when $0.0139 < c < 0.3447$.

Additionally, Proposition 5 shows that the retailer's earlier decision on its advertising strategy benefits social welfare only when $0.0139 < c \leq 0.0394$ since the benefits to consumer welfare and the retailer's profit offset the manufacturer's loss. Hence, from the social welfare perspective, the decentralized channel with the retailer's later decision on its advertising strategy will lead to under-advertising comparing to that with the retailer's pre-commitment.

When $0.0394 < c < 0.3447$, the loss on the channel's profit with the retailer's earlier decision on its advertising strategy cannot be offset by the benefit to consumer welfare. Hence, social welfare is lower with the retailer's commitment to its advertising content. Therefore, from the social welfare perspective, there will be over-advertising in the decentralized channel with the retailer's earlier decision on its advertising strategy, compared to the retailer's later decision on its advertising strategy.

2.3 DISCUSSION

In the basic model, I assume that firms can advertise at no cost and firms' advertising does not reduce consumers' search cost. It would be interesting to investigate the robustness of our findings with the presence of advertising cost, and more importantly, with the consideration of reduced consumer search cost due to advertising. To this end, in this section I discuss two extensions in which advertising cost is included, first without affecting consumer search cost, then with the reduction of consumer search cost.

I. Cost of advertising. Suppose a firm needs to incur a fixed cost of f to do advertising. I then check the firms' advertising decision in a centralized channel as well as a decentralized channel where the retailer makes the advertising decision. In a centralized channel, the firm's profit of no-advertising is the same as in the benchmark case $\pi_{cf}^{n*} = \frac{1}{4}$ when $c < \frac{1}{8}$. The firm's profits of price-only advertising, product-only advertising and price-product advertising are the profits in the benchmark case minus the advertising cost: $\pi_{cf}^{p*} = \sqrt{2c} - 2c - f$, $\pi_{cf}^{pr*} = -f$, and $\pi_{cf}^{pp*} = \frac{(1-c)^2}{4} - f$. Hence, the optimal advertising strategy is the same as in the main model if f is not too high. Stated differently, if $f < \sqrt{2c} - 2c$ when $\frac{1}{8} < c < 0.4075$ and $f < \frac{(1-c)^2}{4}$ when $0.4075 < c < 1$.

Similarly, in a decentralized channel where the retailer makes the advertising decision prior to its upstream manufacturer's wholesale price decision, if the advertising cost is such that $f < \frac{(1-c)^2}{16}$ when $\frac{1}{32} < c < 1$, the optimal advertising strategy is the same as listed in Table 2. In a decentralized channel where the retailer makes the advertising decision later than its upstream manufacturer's wholesale price decision, if the advertising cost is such that $f < (\sqrt{2c} - 2^{5/4}c^{3/4} + c)\sqrt{2c}$ when $0.0139 < c < 0.3447$ and $f < \frac{(1-c)^2}{16}$ when

$0.3447 < c < 1$, the optimal advertising strategy is the same as in the main model.

II. Reduced search cost due to advertising. In the main model, I assume that consumers search cost is unaffected by firms' advertising strategies. Now suppose when consumers receive information from firms' advertising, their search cost is reduced. More specifically, consumers search cost will be reduced to $c/2$ when they receive either product information, price information or both.⁷ In a centralized channel, the firm's price decision and profit are the same under the no-advertising option. When the firm does price-only advertising, the retail price is set such that consumers' expected benefit equals to the cost which leads to $r = 1 - \sqrt{c}$ and the firm's expected profit $E(\pi_f^{p*}) = \sqrt{c} - c - f$. When the firm does product-only advertising, there is no demand for the product because of the hold-up problem. When the firm does price-product advertising, the firm maximizes its profit $\pi_f^{pp*} = r^{pp}(1 - r^{pp} - \frac{c}{2}) - f$ and gets $r_f^{pp*} = \frac{2-c}{4}$ and $\pi_f^{pp*} = \frac{(2-c)^2}{16} - f$. Hence the retailer's optimal advertising strategy is: when $c \leq \frac{1}{8}$, no-advertising; when $\frac{1}{8} < c \leq 0.815$, price-only advertising; and when $0.815 < c < 1$, price-product advertising.

In a decentralized channel where the retailer makes the advertising decision before its upstream manufacturer makes the wholesale price decision, the problem-solving follows the similar procedure as in the main model except the consideration of advertising cost f and the reduced consumer search cost $c/2$ when there is advertising. So, the optimal advertising strategy is: when $c < \frac{1}{32}$, no-advertising; and when $\frac{1}{32} < c < 1$, price-product advertising. Therefore, by comparing the optimal advertising strategy in the decentralized channel to that in the centralized channel with a reduced search cost because of advertising, when $\frac{1}{32} < c \leq 0.815$, more information will be revealed in the decentralized channel. This means that the range becomes even broader as compared to the main model.

⁷Since firms incur a fixed cost of f of advertising, and we do not distinguish between different fixed costs for different types of advertising, it is reasonable to assume that every type of advertising will reduce the consumer search cost by the same amount. I can show that if consumer search cost is lower than $\frac{c}{2}$ when firms do price-product advertising, the results will not change qualitatively.

2.4 CONCLUSION

In many industries, consumers need to incur search costs to acquire information prior to making their purchase decision, and firms can advertise price, product or both types of information to facilitate consumers' purchases by resolving their uncertainty. The research in this chapter examines firms' decision-making on advertising content in a centralized channel as well as a decentralized channel and the consequent effects on channel members, consumer welfare, and social welfare. There are several interesting results which complement the extant literature, and have important managerial implications for marketing practices.

First, a retailer may be more likely to advertise or include more information in its advertisement in a decentralized channel than in a centralized channel, which is different from extant literature showing that channel decentralization usually leads to less advertising (e.g. Michael 1999; Huang et al. 2002; He et al. 2009; Guo 2009). A retailer can use advertising as a tool to reduce consumers' uncertainty about product match and price, and mitigate the negative effect of double-marginalization along with a decentralized channel.

Second, in a decentralized channel where the retailer makes the advertising decision before its upstream manufacturer makes the wholesale price decision, there may be less price-only advertising and more price-product advertising than in a centralized channel. While in a decentralized channel where the retailer makes the advertising decision after its upstream manufacturer makes the wholesale price decision, there may be more price-only advertising and more price-product advertising than in a centralized channel. This finding implies that a retailer's advertising strategy should be conditioned on the interaction between itself and its upstream partner as well as consumer search cost.

Third, when a retailer makes the advertising decision prior to the wholesale price decision, the commitment to the advertising content may even hurt itself as well as the manufacturer. One important implication of this finding is that a manufacturer's manager should be cautious on requiring its downstream partner to commit to the advertising content. Instead, the manufacturer can achieve greater influence on the retailer's advertising decision if the retailer does not pre-commit to the advertising content. The implication

for a retailer's manager is that the decision on when to decide the advertising strategy should depend on the value of consumer search cost, and the earlier advertising decision may not always benefit the retailer.

Finally, channel decentralization may increase consumer welfare. In a decentralized channel, the retailer's earlier decision on its advertising strategy can benefit consumers as compared to the case of the retailer's later decision on its advertising strategy. From the social welfare perspective, the retailer with the earlier advertising decision can practice over-advertising under certain conditions. In addition, if the retailer makes the advertising decision after the wholesale price decision, an under-advertising could follow under certain conditions. This finding implies that from a social planner's perspective, whether a retailer's commitment to its advertising content is better depends on the nature of consumer search cost.

The relation between advertising strategy and different distribution channel structures is a very important issue. It has significant implications for marketing managers and warrants continuous research. In this chapter, I assume that if the retailer advertises the product information, then consumers can completely resolve their uncertainty about product match. In future research, it may be worthwhile to investigate the case where there exists residual uncertainty after the firm's advertisement. In addition, I focus on firms' advertising decisions in a bilateral-monopoly channel. Future research can extend to study the effects of competition at either the manufacturer level, the retailer level or both, on the decision of advertising content.

CHAPTER 3

THE EFFECTS OF CONSUMER HETEROGENEITY ON PRODUCT QUALITY IN DISTRIBUTION CHANNELS

3.1 INTRODUCTION

The product quality decision is one of the most important decisions for marketing managers. When a manufacturer makes quality decisions about its products, these decisions need to be conditioned on the structure of the distribution channel through which the products are delivered to customers (Jeuland and Shugan 1983; Gupta and Loulou 1998; Villas-Boas 1998; Economides 1999; Choi 2003). For example, Jeuland and Shugan (1983) present that a manufacturer will lower its product quality when it sells through a retailer as opposed to when it sells directly to end consumers. Similarly, Villas-Boas (1998) demonstrates that a firm should offer a product with lower quality in a decentralized channel for low-end consumers than in a centralized channel as in Mussa and Rosen (1978). While this stream of literature shows that channel decentralization leads to lower product quality, others often cite the fact that firms offer products with higher quality when they sell via retailers than when they sell directly. For instance, Parker et al. (2003), Lombart (2004), and Shergill and Chen (2008) quote that factory outlet stores operated by manufacturers often carry lower quality products than traditional department stores operated by independent retailers. Specifically, *Consumer Reports* (1998) states that firms like Levi Strauss produce different product lines for their factory outlet stores whose products may use "... less expensive or lighter weight fabrics and plastic rather than leather buttons"; and "... reductions in material quality and construction were found in cotton oxford cloth shirts, leather belts, tee-shirts and pantyhose", which can lead to lower product quality in the outlet shops than in the retail stores.¹ In this chapter,

¹More examples can be observed in marketing practice. For example, a survey of nearly 1200 information technology managers and professionals by Computerworld and InterUnity Group Inc. in 2004 shows that HP, which primarily sells through retailers, earned

I study a manufacturer's optimal quality decisions when it sells its products in a centralized channel and a decentralized channel, and examine whether a manufacturer may actually provide higher product quality in a decentralized channel than in a centralized channel.

While different distribution structures may affect firms' product quality decisions, different consumers may view product quality differently such that consumers can be heterogeneous on their willingness-to-pay for product quality. Additionally, when consumers purchase products, one important consideration to them is the transaction costs they have to incur in the purchasing process. On one hand, these transaction costs are necessary as consumers have to travel to a shop, wait in line for checking out, haggle over the price, return unwanted products, etc. On the other hand, these consumer transaction costs might matter differently to different consumers; in other words, consumers may be heterogeneous on their transaction costs. For instance, consumers may drive different distances to a shop; a slow internet may cause different transaction costs for consumers with different time valuations; and a computer software may require different learning costs for consumers with different software knowledge. Consumer transaction costs are heavily affected by market-level factors including political, economic, and technological factors. Economic factors like gas price hikes can increase consumers' transportation costs of shopping (Johnson 2006). Technological advances affecting personal computer operating systems can reduce consumer transaction costs (Tyagi 2004).²

In this chapter, I design a game-theoretic model to study the optimal quality decisions for a manufacturer when it sells its product in either a centralized or a decentralized channel. I first consider a market where consumers are heterogeneous on one dimension, i.e., either vertically on their willingness-to-pay for product quality or horizontally on their transaction costs. I then allow consumers to be heterogeneous on two dimensions, i.e.,

higher quality ratings than Dell, which was famous for direct selling (Enterprise IT Vendors: Cost, Expectation, and Satisfaction, InterUnity Group and Computerworld Survey, May 2004. <http://www.computerworld.com/newsletter/0,4902,93340,00.html?nlid=AM>). Additionally, Lawton (2007) points out that "... there is a movement afoot by PC makers such as Hewlett-Packard Co., Dell Inc. and Toshiba Corp. to build exclusive PCs for certain retailers... Choosing an exclusively designed PC can end up costing consumers more money, but the products are generally of higher quality."

²See Tyagi (2004) for an excellent review of consumer transaction costs affected by technological advances.

both their willingness-to-pay for product quality and their transaction costs when making the purchase. I further investigate the effects of the manufacturer's quality decisions on channel members' profits, consumer welfare and social welfare.

3.1.1 SUMMARY OF MAIN RESULTS

I have obtained a few interesting results. First, when consumers are heterogeneous either vertically on their willingness-to-pay for product quality or horizontally on their transaction costs, the manufacturer in a decentralized channel offers the same or lower product quality than in a centralized channel. Consequently, channel decentralization can lead to the same or lower channel profits, and the same or lower consumer and social welfare. However, I show that, surprisingly, a manufacturer may provide higher quality in a decentralized channel than in a centralized channel when consumers are heterogeneous on both their willingness-to-pay for product quality and transaction costs. Thus, channel decentralization may have a quality-enhancing effect. Intuitively, channel decentralization leads to demand recession due to the double-marginalization issue. In addition, the manufacturer gets hurt from demand recession especially when consumers with a high willingness-to-pay for quality and high transaction costs are left out of the market because those consumers are willing to pay more for the products than those with low willingness-to-pay for quality, *ceteris paribus*. Therefore, a manufacturer may optimally increase the product quality to make its product more attractive to those consumers who highly value the product quality, but with high transaction costs.

Secondly, I find that, interestingly, the increase of consumer transaction cost can benefit a retailer and the channel as a whole. This happens in a decentralized channel when consumers are heterogeneous on both willingness-to-pay for product quality and transaction costs. The manufacturer in the decentralized channel has a strong incentive to keep consumers with high willingness-to-pay for quality, especially those with large transaction costs to stay in the market by providing higher quality without increasing the wholesale price much, mitigating the double-marginalization problem in the decentralized channel. These efforts by the manufacturer result in a higher

demand as well as a higher profit margin for the retailer. When the transaction cost increases, the manufacturer's efforts become stronger. Hence, the retailer benefits from the increase of consumer transaction cost. The manufacturer is worse off when consumer transaction cost increases with a lower profit margin because of the higher cost to produce higher quality product. Interestingly, the distribution channel as a whole can benefit from the increase of consumer transaction cost, as double-marginalization is mitigated and the benefit to the retailer is more than the loss to the manufacturer.

Thirdly, I show that consumer welfare may even increase in consumer transaction cost when consumers are heterogeneous on two dimensions and the manufacturer sells in a decentralized channel. The quality-enhancing effect and the mitigation of the double-marginalization in a decentralized channel allows consumers at the aggregate level to offset the the increase of their transaction costs. Social welfare, which combines the channel profit and consumer welfare, may also increase along with consumer transaction cost. In contrast, in a centralized channel, the double-marginalization problem is absent, and the manufacturer does not have the same incentive as in a decentralized channel to increase its product quality. Consequently, consumer and social welfare always decrease with the increase of consumer transaction cost in the centralized channel.

3.1.2 RELATED LITERATURE

The research in this chapter is related to two streams of literature. The first stream is the effects of channel structure and channel coordination on distribution channel relationships (Zusman and Etgar 1981; McGurie and Staelin 1983; Moorthy 1987, 1988b; Jeuland and Shugan 1983, 1988; Villas-Boas 1998; Economides 1999; Desai et al. 2004; Raju and Zhang 2005; Xu 2009). Among this stream of literature, the following articles are particularly related to this paper. Jeuland and Shugan (1983) discuss that channel decentralization makes the manufacturer lower product quality below the joint maximum level. Similarly, Villas-Boas (1998) shows that channel decentralization leads to lower product quality for low valuation consumers in product line design when consumers are only heterogeneous on their preference for quality. Economides (1999) argues that independent vertically-related monopolists

provide products of lower quality level than a sole integrated monopolist when consumers have different willingness-to-pay for quality. Xu (2009) examines a manufacturer's product and price decisions in both centralized and decentralized channels. Xu concludes that the concavity of the marginal revenue function determines whether the manufacturer chooses a lower, same or higher product quality when selling through a retailer than when selling directly to consumers. These papers do not consider the effects of different types of consumer heterogeneity on firms' optimal decisions on product quality and the consequent effects on channel members' profits, consumer and social welfare, which is the focus of the research in this chapter.

The second related stream of literature is the research on product quality in the context of different consumer heterogeneities, namely, vertical (e.g. Villas-Boas 1998; Economides 1999) or horizontal consumer heterogeneity, or both vertical and horizontal consumer heterogeneity (Neven and Thisse 1990; Desai 2001; Tyagi 2004; Ellison 2005; Hotz and Xiao 2006). Tyagi (2004) studies the effect of two-dimensional consumer heterogeneity on a monopolist's decision-making. Desai (2001) studies a monopolist's product quality and price decisions in a market where consumers, with either high or low quality valuations, are continuously heterogeneous on their taste preferences, and shows that consumer taste preferences do not affect the firm's product quality decision. Neven and Thisse (1990) demonstrate the effect of consumer heterogeneity on two horizontal firms' quality and price competition. Ellison (2005) and Hotz and Xiao (2006) focus on duopoly competition in a market where consumers are two-dimensionally heterogeneous. These papers do not study the important effects of distribution channel structure on firms' optimal quality decisions. In this chapter, I study the effects of different types of consumer heterogeneity on product quality in different channel structures.

The rest of this chapter is organized as follows. In section 3.2, I study a manufacturer's product quality decision and its consequent effects on channel members' profits, consumer and social welfare in a market when consumers are heterogeneous either vertically on their willingness-to-pay for product quality or horizontally on their transaction costs. In section 3.3, I examine a manufacturer's product quality decision in a market when consumers are heterogeneous on both their willingness-to-pay for product quality and transaction costs. I conclude this chapter with section 3.4.

3.2 ONE-DIMENSIONAL CONSUMER HETEROGENEITY

3.2.1 VERTICAL HETEROGENEITY

I first consider a market where consumers are vertically heterogeneous with respect to their willingness-to-pay for product quality. The mass of consumers in the market is normalized to one. Consumers are uniformly distributed over $\theta \in [a, 1]$ where $0 \leq a < 1$. Given product quality q and retail price p , the utility of a consumer of type θ is given by $u(\theta, q, p) = \theta q - p$. Each consumer purchases one unit of product if her utility is non-negative. The manufacturer's unit production cost is a quadratic function of product quality $c = q^2$ (Moorthy 1988a; Desai 2001; Tyagi 2004).³

I. A CENTRALIZED CHANNEL

When the manufacturer sells its products directly to end consumers, for any given product quality q_{vc} and price p_{vc} , where v and c respectively refer to vertically heterogeneous consumers and centralized channel, consumers who are located at $\theta \in [\max\{a, \frac{p_{vc}}{q_{vc}}\}, 1]$ will purchase the product. The manufacturer's profit is given by $\pi_{vc} = (p_{vc} - q_{vc}^2)D_{vc}$ where $D_{vc} = \min\{\frac{1}{1-a}(1 - \frac{p_{vc}}{q_{vc}}), 1\}$.

I maximize the manufacturer's profit π_{vc} with respect to its retail price p_{vc} and product quality q_{vc} , and obtain the following optimal decisions q_{vc}^* , p_{vc}^* and the consequent profit π_{vc}^*

$$q_{vc}^* = \begin{cases} \frac{1}{3}, & \text{if } a \leq \frac{2}{3}; \\ \frac{a}{2}, & \text{if } \frac{2}{3} < a < 1; \end{cases} \quad p_{vc}^* = \begin{cases} \frac{2}{9}, & \text{if } a \leq \frac{2}{3}; \\ \frac{a^2}{2}, & \text{if } \frac{2}{3} < a < 1. \end{cases} \quad (3.1)$$

$$\pi_{vc}^* = \begin{cases} \frac{1}{27(1-a)}, & \text{if } a \leq \frac{2}{3}; \\ \frac{a^2}{4}, & \text{if } \frac{2}{3} < a < 1. \end{cases} \quad (3.2)$$

When consumers are more heterogeneous ($a \leq \frac{2}{3}$), the market is not fully covered since the consumers with low willingness-to-pay $\theta \in [a, \frac{2}{3})$ are rel-

³The results will not change qualitatively if the production cost is more general as $c = s \times q^2$, where $s > 0$ (Desai 2001). Here, s can be understood as the level of production technology. The more advanced the production technology, the lower the production cost and the smaller the value of s .

actively not profitable to the manufacturer and the manufacturer's optimal product quality q_{vc}^* is independent of a . However, when consumers are less heterogeneous ($a > \frac{2}{3}$), the market is fully covered and the manufacturer's optimal product quality q_{vc}^* increases with a .

Given the manufacturer's optimal decisions q_{vc}^* and p_{vc}^* , each individual consumer's utility is given by $u(\theta, q_{vc}^*, p_{vc}^*) = \theta q_{vc}^* - p_{vc}^*$. By summing up each individual consumer's utility, I get the total consumer surplus CS_{vc}^* . And by summing up the total consumer surplus and the channel profit, I obtain the social welfare SW_{vc}^* .

$$CS_{vc}^* = \begin{cases} \frac{1}{54(1-a)}, & \text{if } a \leq \frac{2}{3}; \\ \frac{a(1-a)}{4}, & \text{if } \frac{2}{3} < a < 1; \end{cases} \quad SW_{vc}^* = \begin{cases} \frac{1}{18(1-a)}, & \text{if } a \leq \frac{2}{3}; \\ \frac{a}{4}, & \text{if } \frac{2}{3} < a < 1. \end{cases} \quad (3.3)$$

II. A DECENTRALIZED CHANNEL

When the manufacturer sells its products through an independent retailer to end consumers, the manufacturer first sets the product quality q_{vd} and wholesale price w_{vd} , then the retailer sets the retail price p_{vd} . The channel members' profit functions are given by $\pi_{vm} = (w_{vd} - q_{vd}^2)D_{vd}$ and $\pi_{vr} = (p_{vd} - w_{vd})D_{vd}$ where $D_{vd} = \min\{\frac{1}{1-a}(1 - \frac{p_{vd}}{q_{vd}}), 1\}$.

Following backward induction, I first maximize the retailer's profit π_{vr} with respect to its retail price p_{vd} to get its best response, then maximize the manufacturer's profit π_{vm} with respect to its wholesale price w_{vd} and product quality q_{vd} with the anticipation of the retailer's best response. I have the following optimal decisions q_{vd}^* , w_{vd}^* and p_{vd}^*

$$q_{vd}^* = \begin{cases} \frac{1}{3}, & \text{if } a \leq \frac{5}{6}; \\ \frac{2a-1}{2}, & \text{if } \frac{5}{6} < a < 1; \end{cases} \quad w_{vd}^* = \begin{cases} \frac{2}{9}, & \text{if } a \leq \frac{5}{6}; \\ \frac{(2a-1)^2}{2}, & \text{if } \frac{5}{6} < a < 1. \end{cases} \quad (3.4)$$

$$p_{vd}^* = \begin{cases} \frac{5}{18}, & \text{if } a \leq \frac{5}{6}; \\ \frac{a(2a-1)}{2}, & \text{if } \frac{5}{6} < a < 1. \end{cases} \quad (3.5)$$

The profits for the manufacturer and the retailer, π_{vm}^* and π_{vr}^* are

$$\pi_{vm}^* = \begin{cases} \frac{1}{54(1-a)}, & \text{if } a \leq \frac{5}{6}; \\ \frac{(2a-1)^2}{4}, & \text{if } \frac{5}{6} < a < 1; \end{cases} \quad \pi_{vr}^* = \begin{cases} \frac{1}{108(1-a)}, & \text{if } a \leq \frac{5}{6}; \\ \frac{(2a-1)(1-a)}{2}, & \text{if } \frac{5}{6} < a < 1. \end{cases} \quad (3.6)$$

In the decentralized channel, the market is not fully covered when $a \leq$

$\frac{5}{6}$ and fully covered when $a > \frac{5}{6}$. Calculating in the same way as in the centralized channel, in a decentralized channel, total consumer surplus CS_{vd}^* and social welfare SW_{vd}^* are given by

$$CS_{vd}^* = \begin{cases} \frac{1}{216(1-a)}, & \text{if } a \leq \frac{5}{6}; \\ \frac{(2a-1)(1-a)}{4}, & \text{if } \frac{5}{6} < a < 1; \end{cases} \quad (3.7)$$

$$SW_{vd}^* = \begin{cases} \frac{7}{216(1-a)}, & \text{if } a \leq \frac{5}{6}; \\ \frac{(2a-1)(2-a)}{4}, & \text{if } \frac{5}{6} < a < 1. \end{cases} \quad (3.8)$$

3.2.2 HORIZONTAL HETEROGENEITY

I now consider a market where consumers are horizontally heterogeneous on their transaction costs when they make the purchase. In this model, consumers are uniformly located on a Hotelling line $x \in [0, 1]$ (Hotelling 1929) and the store is located at $x = 0$, the left end of the Hotelling line.⁴ Given product quality q and retail price p , the utility of a consumer located at x is given by $u(q, p, t, x) = q - p - tx$, where $t > 0$ is the unit transaction cost.

I. A CENTRALIZED CHANNEL

In a centralized channel, given product quality q_{hc} and retail price p_{hc} , where h and c respectively refer to horizontally heterogeneous consumers and centralized channel, consumers located at $x \in [0, \min\{\frac{q_{hc}-p_{hc}}{t}, 1\}]$ will purchase the product. The manufacturer's profit is given by $\pi_{hc} = (p_{hc} - q_{hc}^2) \times D$, where $D = \min\{\frac{q_{hc}-p_{hc}}{t}, 1\}$.

I maximize the manufacturer's profit π_{hc} with respect to its retail price p_{hc} and product quality q_{hc} and obtain the optimal decisions

$$q_{hc}^* = \frac{1}{2}; p_{hc}^* = \begin{cases} \frac{3}{8}, & \text{if } t > \frac{1}{8}; \\ \frac{1}{2} - t, & t \leq \frac{1}{8}. \end{cases} \quad (3.9)$$

When the unit transaction cost is high ($t > \frac{1}{8}$), the market is not fully covered since those consumers located far from the store incur high transaction

⁴The store can locate anywhere on the Hotelling line. Different locations do not change the main results qualitatively.

costs and they are relatively not profitable to the manufacturer. When the unit transaction cost is low ($t \leq \frac{1}{8}$), the market is fully covered.

The manufacturer's profit π_{hc}^* is

$$\pi_{hc}^* = \begin{cases} \frac{1}{64t}, & \text{if } t > \frac{1}{8}; \\ \frac{1}{4} - t, & t \leq \frac{1}{8}. \end{cases} \quad (3.10)$$

Total consumer surplus CS_{hc}^* and social welfare SW_{hc}^* are given by

$$CS_{hc}^* = \begin{cases} \frac{1}{128t}, & \text{if } t > \frac{1}{8}; \\ \frac{t}{2}, & t \leq \frac{1}{8}; \end{cases} \quad SW_{hc}^* = \begin{cases} \frac{3}{128t}, & \text{if } t > \frac{1}{8}; \\ \frac{1}{4} - \frac{t}{2}, & t \leq \frac{1}{8}. \end{cases} \quad (3.11)$$

II. A DECENTRALIZED CHANNEL

In a decentralized channel, the manufacturer first decides the product quality q_{hd} and its wholesale price w_{hd} , the retailer then sets its retail price p_{hd} . The channel members' profit functions are $\pi_{hm} = (w_{hd} - q_{hd}^2)D_{hd}$ and $\pi_{hr} = (p_{hd} - w_{hd})D_{hd}$ where $D_{hd} = \min\{\frac{q_{hd} - p_{hd}}{t}, 1\}$. I solve the game based on backward induction and obtain the following optimal decisions.

$$q_{hd}^* = \frac{1}{2}; w_{hd}^* = \begin{cases} \frac{3}{8}, & \text{if } t > \frac{1}{16}; \\ \frac{1}{2} - 2t, & t \leq \frac{1}{16}; \end{cases} \quad p_{hd}^* = \begin{cases} \frac{7}{16}, & \text{if } t > \frac{1}{16}; \\ \frac{1}{2} - t, & t \leq \frac{1}{16}. \end{cases} \quad (3.12)$$

Similar to the case of a centralized channel, when the manufacturer sells its products through an independent retailer, it optimally covers all the market when the unit transaction cost is low ($t \leq \frac{1}{16}$). When the unit transaction cost is high ($t > \frac{1}{16}$), the market is not fully covered.

The channel members' profits are

$$\pi_{hm}^* = \begin{cases} \frac{1}{128t}, & \text{if } t > \frac{1}{16}; \\ \frac{1}{4} - 2t, & t \leq \frac{1}{16}; \end{cases} \quad \pi_{hr}^* = \begin{cases} \frac{1}{256t}, & \text{if } t > \frac{1}{16}; \\ t, & t \leq \frac{1}{16}. \end{cases} \quad (3.13)$$

Total consumer surplus CS_{hd}^* and social welfare SW_{hd}^* are given by

$$CS_{hd}^* = \begin{cases} \frac{1}{512t}, & \text{if } t > \frac{1}{16}; \\ \frac{t}{2}, & t \leq \frac{1}{16}; \end{cases} \quad SW_{hd}^* = \begin{cases} \frac{7}{512t}, & \text{if } t > \frac{1}{16}; \\ \frac{1}{4} - \frac{t}{2}, & t \leq \frac{1}{16}. \end{cases} \quad (3.14)$$

I summarize the effects of the channel structure and the type of consumer

heterogeneity on the manufacturer's product quality decision and the consequent effects on firms' profits, consumer and social welfare in the following proposition.

Proposition 1. *When consumers are vertically heterogeneous with respect to their willingness-to-pay for product quality, the manufacturer's optimal product quality decision is independent of channel structure if $a \leq \frac{2}{3}$ and the manufacturer offers a lower product quality in a decentralized channel than in a centralized channel if $a > \frac{2}{3}$. When consumers are horizontally heterogeneous on their transaction costs, the manufacturer's optimal product quality decision does not depend on the channel structure. The effects of consumer heterogeneity on the retailer and consumer welfare are:*

- i. (Retailer's profit) $\frac{d\pi_{vr}^*}{da} < 0$ when $a > \frac{5}{6}$; $\frac{d\pi_{hr}^*}{dt} > 0$ when $t < \frac{1}{16}$.*
- ii. (Consumer welfare) $\frac{dCS_{vc}^*}{da} < 0$ when $a > \frac{2}{3}$, $\frac{dCS_{vd}^*}{da} < 0$ when $a > \frac{5}{6}$; $\frac{dCS_{hc}^*}{dt} > 0$ when $t < \frac{1}{8}$, $\frac{dCS_{hd}^*}{dt} > 0$ when $t < \frac{1}{16}$.*

Proposition 1 shows that different types of consumer heterogeneity affect the channel decentralization effects in different ways. When consumers are vertically heterogeneous, in the decentralized channel, the manufacturer may offer the same or lower product quality than that in the centralized channel. Although this result is not surprising as it is consistent with literature (e.g. Villas-Boas 1998; Desai 2001), it offers a benchmark case for subsequent analysis when consumers are heterogeneous on both their willingness-to-pay for product quality and transaction costs. When consumers are more heterogeneous ($a \leq \frac{2}{3}$), the manufacturer's optimal decision results in a non-fully covered market in both the centralized and decentralized channel. Channel decentralization does not change the manufacturer's product quality decision because the demand functions in both channels have the same price elasticity. When consumers become less heterogeneous ($a > \frac{2}{3}$), the manufacturer is either more likely to cover the full market in a centralized channel than in a decentralized channel or the manufacturer has to lower its wholesale price to keep the same full market coverage. In either case, the manufacturer's benefit of providing high product quality will be lower in a decentralized channel than in a centralized channel. Consequently, the manufacturer will provide a lower product quality in a decentralized channel than in a centralized channel. Different from the model where consumers are vertically heterogeneous, when consumers are horizontally heterogeneous on their transaction costs,

the manufacturer provides the same product quality in both distribution channels. This is because all consumers have the same willingness-to-pay for product quality.

In addition, I find that in the decentralized channel, when consumers are less heterogeneous ($a > \frac{5}{6}$ for the market with vertical heterogeneity and $t < \frac{1}{16}$ for the market with horizontal heterogeneity), the retailer's profit increases with the increase of consumer heterogeneity, $\frac{d\pi_{vr}^*}{da} < 0$ and $\frac{d\pi_{hr}^*}{dt} > 0$. In those cases, the retailer enjoys the leverage of more heterogeneous consumers for lower wholesale prices. We also find that when consumers are less heterogeneous, consumer welfare may even increase with the magnitude of consumer heterogeneity, $\frac{dCS_{vc}^*}{da} < 0$, $\frac{dCS_{vd}^*}{da} < 0$; and $\frac{dCS_{hc}^*}{dt} > 0$, $\frac{dCS_{hd}^*}{dt} > 0$. This happens when the market is fully covered, and the manufacturer has the incentive to lower prices with the increase of consumer heterogeneity to keep all consumers to stay in the market.

3.3 TWO-DIMENSIONAL CONSUMER HETEROGENEITY

In this section, I consider a market where consumers are heterogeneous both vertically on their willingness-to-pay for product quality and horizontally on their transaction costs, and their heterogeneity is captured by a rectangle model as well established in literature (e.g., Neven and Thisse 1990; Tyagi 2004).⁵ In this rectangle model, the vertical dimension captures consumers' vertical locations ($\theta \in [a, 1]$) and heterogeneity on their willingness-to-pay for product quality.⁶ The horizontal dimension denotes consumers' horizontal locations ($x \in [0, 1]$) and captures consumers' heterogeneity on their transaction costs when they make a purchase. A unit mass of consumers are uniformly distributed over the rectangle $[a, 1] \times [0, 1]$, and the retailer is located on the left end of the horizontal dimension; that is $x = 0$.

Following the related literature in the context of two-dimensional consumer

⁵With this model, I implicitly assume that consumers' vertical heterogeneity and horizontal heterogeneity are independent. If these two dimensions are positively correlated, the findings in current model setup might still hold. If these two dimensions are negatively correlated, the findings in current model setup may not hold.

⁶In this chapter, I focus on the case of $a < \frac{3}{5}$ which generates the most interesting result.

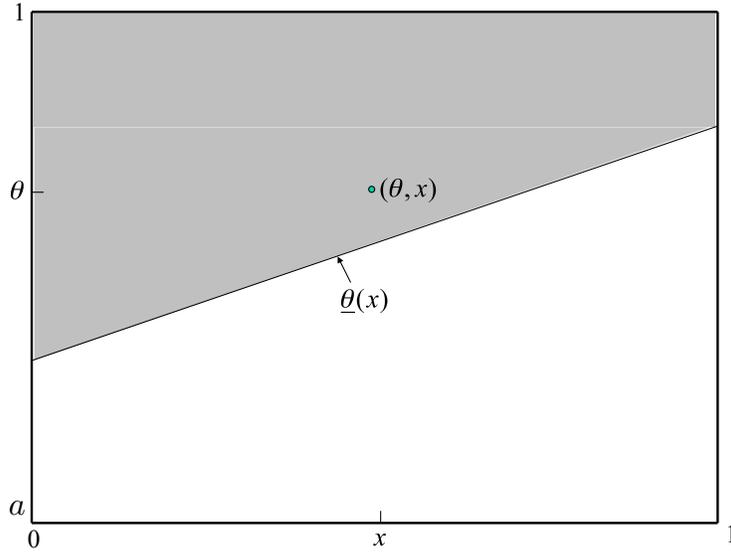


Figure 3.1: A rectangle model

heterogeneity (Desai 2001; Tyagi 2004; Ellison 2005; Hotz and Xiao 2006), I define consumers' utility function as follows. Given product quality q and retail price p , for a consumer located at (θ, x) as shown in Figure 3.1, her surplus from buying the product is given by

$$u(\theta, x, q, t, p) = \theta q - tx - p. \quad (3.15)$$

As shown in Figure 3.1, consumers located on line $\underline{\theta}(x)$ are marginal consumers who are indifferent between purchasing the product and not purchasing. All consumers above this line, as depicted by the shaded area in Figure 3.1, will purchase the product.

3.3.1 A Centralized Channel

I again start with the case when the manufacturer sells in a centralized channel. Depending on the product quality q and the retail price p , the

manufacturer's demand is characterized as⁷

$$D = \begin{cases} \frac{1}{1-a}(1 - \frac{p}{q} - \frac{t}{2q}), & \text{if } q - p \geq t; \\ \frac{(q-p)^2}{2qt(1-a)}, & \text{if } q - p < t. \end{cases} \quad (3.16)$$

It is noteworthy that the above two demand functions reflect two different shapes of market coverage. When $q - p > t$, the right end of the marginal consumer line $\underline{\theta}(x)$ is below $(\theta, x) = (1, 1)$, and the shape of market coverage is a trapezoid. When $q - p \leq t$, the right end of the marginal consumer line $\underline{\theta}(x)$ is left to $(\theta, x) = (1, 1)$, and the shape of market coverage is a triangle.

The manufacturer's profit is given by

$$\pi = (p - q^2) \times D = \begin{cases} (p - q^2)[\frac{1}{1-a}(1 - \frac{p}{q} - \frac{t}{2q})], & \text{if } q - p \geq t; \\ (p - q^2)\frac{(q-p)^2}{(1-a)2qt}, & \text{if } q - p < t. \end{cases} \quad (3.17)$$

Maximizing the manufacturer's profit with respect to the product quality and retail price, we have the optimal quality (q_C^*) and retail price (p_C^*) as

$$q_C^* = \begin{cases} \frac{1+\sqrt{1+6t}}{6}, & \text{if } 0 < t \leq \frac{4}{25}; \\ \frac{2}{5}, & \text{if } t > \frac{4}{25}; \end{cases} \quad p_C^* = \begin{cases} \frac{2-3t+2\sqrt{1+6t}}{18}, & \text{if } 0 < t \leq \frac{4}{25}; \\ \frac{6}{25}, & \text{if } t > \frac{4}{25}. \end{cases} \quad (3.18)$$

Consequently, the centralized channel's profit π_C^* is given by

$$\pi_C^* = \begin{cases} \frac{(1-6t+\sqrt{1+6t})^2}{54(1+\sqrt{1+6t})(1-a)}, & \text{if } 0 < t \leq \frac{4}{25}; \\ \frac{8}{3125t(1-a)}, & \text{if } t > \frac{4}{25}. \end{cases} \quad (3.19)$$

When the unit transaction cost is low ($t \leq \frac{4}{25}$), the manufacturer's optimal product quality increases in t (Tyagi 2004) and the market coverage has a trapezoid shape. While consumer transaction costs increase with t , the manufacturer has more incentive to increase its product quality to offset the negative effect of consumer transaction cost, especially on those consumers with high θ and x . When the unit transaction cost is high ($t > \frac{4}{25}$), to the manufacturer, covering the far-located consumers is no longer profitable

⁷When the consumer with the highest willingness-to-pay for product quality and the largest transaction cost $(\theta, x) = (1, 1)$ always buys a product, $u(\theta, x, q, t, p) = q \times 1 - p - t \times 1 \geq 0$, which means $q - p \geq t$, and $D = \frac{1}{1-a}(1 - \frac{p}{q} - \frac{t}{2q})$. When the consumer with the highest willingness-to-pay for product quality and the largest transaction cost $(\theta, x) = (1, 1)$ does not buy a product, $u(\theta, x, q, t, p) = q \times 1 - p - t \times 1 < 0$, which means $q - p < t$, and $D = \frac{(q-p)^2}{2qt(1-a)}$.

because of the large transaction costs, even for the consumers who value product quality the most ($\theta = 1$). Therefore, a further increase of the unit transaction cost t will no longer incentivize the manufacturer to increase product quality and the market coverage has a triangle shape.

3.3.2 A Decentralized Channel

In a decentralized channel, the manufacturer decides the wholesale price (w) and product quality (q), then the retailer decides the retail price (p). Depending on the product quality q and retail price p , the demand is the same as in the centralized channel case

$$D = \begin{cases} \frac{1}{1-a} \left[1 - \frac{p}{q} - \frac{t}{2q} \right], & \text{if } q - p \geq t; \\ \frac{(q-p)^2}{2qt(1-a)}, & \text{if } q - p < t. \end{cases} \quad (3.20)$$

The channel members' profits are

$$\pi(M) = (w - q^2) \times D = \begin{cases} (w - q^2) \frac{1}{1-a} \left[1 - \frac{p}{q} - \frac{t}{2q} \right], & \text{if } q - p \geq t; \\ (w - q^2) \frac{(q-p)^2}{2qt(1-a)}, & \text{if } q - p < t; \end{cases} \quad (3.21)$$

$$\pi(R) = (p - w) \times D = \begin{cases} (p - w) \frac{1}{1-a} \left[1 - \frac{p}{q} - \frac{t}{2q} \right], & \text{if } q - p \geq t; \\ (p - w) \frac{(q-p)^2}{2qt(1-a)}, & \text{if } q - p < t. \end{cases} \quad (3.22)$$

I first obtain the retailer's optimal retail price given the product quality and wholesale price, then solve the optimal product quality and the wholesale price for the manufacturer. The derivation details have been saved for the Appendix, and I report the optimal product quality q_D^* and prices w_D^*, p_D^* as the following:

$$q_D^* = \begin{cases} \frac{1+\sqrt{1+6t}}{6}, & \text{if } 0 < t \leq \frac{3}{32}; \\ \sqrt{\frac{3t}{2}}, & \text{if } \frac{3}{32} < t < \frac{8}{75}; \\ \frac{2}{5}, & \text{if } t \geq \frac{8}{75}; \end{cases} \quad w_D^* = \begin{cases} \frac{2-3t+2\sqrt{1+6t}}{18}, & \text{if } 0 < t \leq \frac{3}{32}; \\ \sqrt{\frac{3t}{2}} - \frac{3t}{2}, & \text{if } \frac{3}{32} < t < \frac{8}{75}; \\ \frac{6}{25}, & \text{if } t \geq \frac{8}{75}; \end{cases} \quad (3.23)$$

$$p_D^* = \begin{cases} \frac{5-12t+5\sqrt{1+6t}}{36}, & \text{if } 0 < t \leq \frac{3}{32}; \\ \sqrt{\frac{3t}{2}} - t, & \text{if } \frac{3}{32} < t < \frac{8}{75}; \\ \frac{22}{75}, & \text{if } t \geq \frac{8}{75}. \end{cases} \quad (3.24)$$

The profits for the manufacturer $\pi(M)^*$ and the retailer $\pi(R)^*$ are

$$\pi(M)^* = \begin{cases} \frac{(1-6t+\sqrt{1+6t})^2}{108(1+\sqrt{1+6t})(1-a)}, & \text{if } 0 < t \leq \frac{3}{32}; \\ \frac{t}{1-a} \left(\frac{1}{2} - \sqrt{\frac{3t}{2}} \right), & \text{if } \frac{3}{32} < t < \frac{8}{75}; \\ \frac{32}{28125t(1-a)}, & \text{if } t \geq \frac{8}{75}; \end{cases} \quad (3.25)$$

$$\pi(R)^* = \begin{cases} \frac{(1-6t+\sqrt{1+6t})^2}{216(1+\sqrt{1+6t})(1-a)}, & \text{if } 0 < t \leq \frac{3}{32}; \\ \frac{t}{1-a} \sqrt{\frac{t}{24}}, & \text{if } \frac{3}{32} < t < \frac{8}{75}; \\ \frac{64}{84375t(1-a)}, & \text{if } t \geq \frac{8}{75}. \end{cases} \quad (3.26)$$

When the unit transaction cost is low ($t < \frac{8}{75}$), the manufacturer's product quality increases in t . This is again due to the manufacturer's incentive to cover those consumers with a high willingness-to-pay for quality as in the centralized channel. The market coverage has a trapezoid shape. However, when the unit transaction cost is high ($t \geq \frac{8}{75}$), it is no longer profitable for the retailer to cover far-located consumers, even for those who value the product quality the most ($\theta = 1$). The market coverage has a triangle shape.

3.3.3 EFFECTS OF THE CHANNEL STRUCTURE AND TYPE OF CONSUMER HETEROGENEITY

Based on the results in the centralized and decentralized channels above, I analyze the effects of channel structure on product quality, channel members' profits, consumer and social welfare.

First, I compare the product quality levels in the centralized channel and in the decentralized channel when consumers are two-dimensionally heterogeneous, and summarize the most interesting result in the following proposition.

Proposition 2. (*Product quality*) *When consumers are two-dimensionally heterogeneous, $q_D^* > q_C^*$ when $\frac{3}{32} < t < \frac{4}{25}$.*

Interestingly, Proposition 2 shows that, a manufacturer may produce higher product quality in a decentralized channel than in a centralized channel,

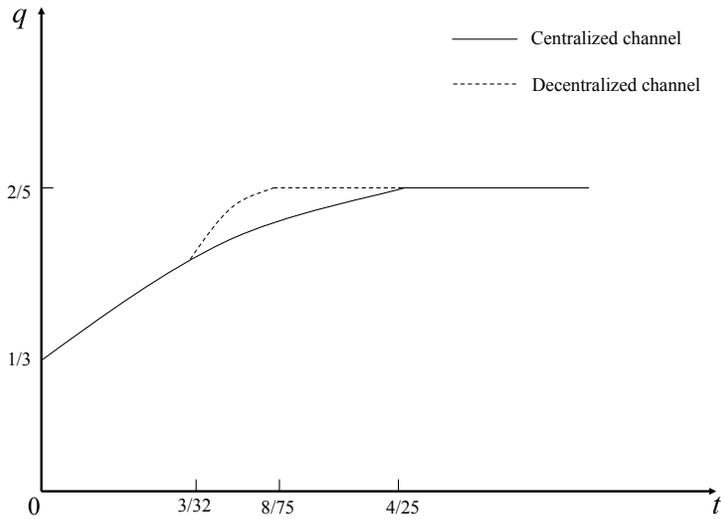


Figure 3.2: The effect of channel decentralization on product quality

which implicates a quality-enhancing effect by channel decentralization. This happens when the unit transaction cost is intermediate ($\frac{3}{32} < t < \frac{4}{25}$) as shown in Figure 3.2. This finding complements the extant literature (Jeuland and Shugan 1983; Villas-Boas 1998; Economides 1999) that channel decentralization always leads to the decrease of product quality such that “without joint ownership, the manufacturer has the incentive to lower the product quality below the joint maximum level ...” (Jeuland and Shugan 1983). The intuition behind Proposition 2 is as follows. When the unit transaction cost is intermediate ($\frac{3}{32} < t < \frac{4}{25}$), the manufacturer in the centralized channel can optimally decide its quality and price such that not only all consumers with the highest willingness-to-pay for quality ($\theta = 1$) always stay in the market, but also some consumers with the largest transaction cost ($x = 1$) purchase the product, as long as their willingness to pay for quality is sufficiently high. In other words, the manufacturer’s market coverage has a trapezoid shape. However, in a decentralized channel, the double-marginalization problem leads to a higher retail price, and it is more difficult to keep the same consumers as in the centralized channel in the market. Thus, the manufacturer faces a triangle demand function in the de-

centralized channel instead of a trapezoid demand function in the centralized channel. That is to say, many consumers with a high willingness-to-pay for quality and large transaction costs are left out of the market. Since those consumers with a high willingness-to-pay for quality are very profitable to the manufacturer, the manufacturer has the incentive to retain those consumers in the decentralized channel. To do so, the manufacturer has two approaches. The first is to decrease its wholesale price, and the second is to increase its product quality. The first approach with lowering wholesale price will benefit all consumers the same way, even for consumers who will buy the product anyway, and reduce the surplus the manufacturer can extract from each consumer it retains. In contrast, the second approach with increasing product quality is more efficient to target the consumers with a high willingness-to-pay for quality since they value quality increases more than do consumers with a low willingness-to-pay for quality. Therefore, the manufacturer optimally chooses to increase its product quality rather than lower its price to keep those consumers with a high willingness-to-pay for quality to stay in the market. Thus, Proposition 2 establishes a role for a manufacturer to increase its product quality to mitigate the double-marginalization problem in a decentralized channel. The implication of Proposition 2 is that we should not always expect lower product quality in a decentralized channel, and channel decentralization may actually lead to higher product quality.

It is important to compare the quality-enhancing effect of channel decentralization in this model to the results in the models where there is only one-dimensional consumer heterogeneity and where product quality in a decentralized channel is the same or lower than that in a centralized channel. In the two-dimensional model, consumer utility depends on both product quality and transaction costs. Therefore, far-located consumers with higher transaction costs who purchase the same product on average value quality more than close-located consumers with lower transaction costs. Therefore, channel decentralization hurts more far-located consumers than close-located consumers who have high willingness-to-pay for quality. As a response, the manufacturer has the incentive to increase its product quality to deal with the negative effect of channel decentralization on far-located consumers. In contrast, the one-dimensional models do not capture this effect of channel decentralization on hurting far-located consumers with high willingness-to-pay for quality; thus, the manufacturer does not have the incentive to overcome

that effect with a higher product quality.

It is noteworthy that when $\frac{3}{32} < t < \frac{8}{75}$, the product quality difference between the decentralized channel and the centralized channel increases in t . The reason is as follows. While the unit transaction cost is not yet so high as $t > \frac{8}{75}$, it is still profitable for the manufacturer to retain all the consumers with the highest willingness-to-pay for quality ($\theta = 1$), even the one with the largest transaction cost ($(\theta, x) = (1, 1)$). Consumers incur increasing transaction costs in t , and this effect is stronger for far-located consumers than close-located consumers. To attract those far-located consumers with significantly high willingness-to-pay for quality, with the increase of t , the manufacturer has to increase its product quality more. Stated differently, the quality-enhancing effect of channel decentralization becomes stronger when t increases. By offering this higher product quality, the manufacturer can effectively mitigate the negative effects of double-marginalization since consumers who highly value product quality will be back in the market even when their transaction costs are high (x is close to 1). When the unit transaction cost is relatively high ($\frac{8}{75} < t < \frac{4}{25}$), the further increase of unit transaction cost increases consumer transaction costs more excessively, especially to the far-located consumers. It is no longer profitable for the manufacturer to attract the consumers with large transaction costs, even when they have the highest willingness-to-pay for quality ($\theta = 1$). The quality difference between the decentralized channel and the centralized channel gets smaller and the manufacturer gradually gives up those far-located consumers with the increase of t .

In this research, the quality-enhancing effect of channel decentralization happens only when the unit transaction cost is intermediate ($\frac{3}{32} < t < \frac{4}{25}$). When the unit transaction cost is low ($t \leq \frac{3}{32}$), both the decentralized channel and the centralized channel face a trapezoid demand function. If the manufacturer increases its product quality, the retailer will mark up more than when the demand is a triangle shape. Therefore, the manufacturer lacks the incentive to increase product quality to mitigate the double-marginalization effect. Similarly, when the unit transaction cost is high ($t \geq \frac{4}{25}$), even the manufacturer in the centralized channel starts to give up some consumers with the highest willingness-to-pay because of their large transaction costs. That is to say, channel members have a triangle demand function in both channel structures. For the manufacturer, the cost of increasing product

quality to attract extra consumers is too high since consumer transaction costs are very high because of a high t . Therefore, the manufacturer does not have the incentive to increase the product quality in the decentralized channel to overcome the double-marginalization effect.

It is necessary to compare the research in this chapter to Xu (2009). Xu (2009) derives the possibility of higher product quality in a decentralized channel than in a centralized channel due to the high skewness of consumer distribution, which, as stated in the paper, may not happen in real markets. In contrast, the research in this chapter provides the conditions under which the manufacturer offers higher product quality in a decentralized channel than in a centralized channel with only uniform distribution on two dimensions, without the necessity of requiring high skewness of consumer distribution.

Next, I analyze the effects of consumer transaction costs on channel members' profits in different distribution channels. I report the main results in the following proposition.

Proposition 3. *(Channel members' profits) When consumers are both vertically and horizontally heterogeneous, in a decentralized channel, $\frac{d\pi(R)^*}{dt} > 0$ and $\frac{d(\pi(M)^* + \pi(R)^*)}{dt} > 0$ when $\frac{3}{32} < t < \frac{8}{75}$; and $\frac{d\pi(M)^*}{dt} < 0$ for any t . But in a centralized channel, $\frac{d\pi_C^*}{dt} < 0$ for any t .*

Surprisingly, a decentralized channel as a whole can benefit from an increase of the unit transaction cost, which happens when the unit transaction cost is intermediate ($\frac{3}{32} < t < \frac{8}{75}$). The intuition is as follows. Recall that from Proposition 2, when $\frac{3}{32} < t < \frac{8}{75}$, the manufacturer has a strong incentive to provide higher product quality in the decentralized channel than in the centralized channel. When t increases, the manufacturer has the incentive to provide higher quality without increasing the wholesale price much. This leads to a lower margin for the manufacturer, which alleviates the problem of double-marginalization in the decentralized channel, leading to a better coordination of the distribution channel. When offering the higher quality product, the manufacturer incurs higher production cost and has a lower profit margin. Consequently, the manufacturer is worse off from the unit transaction cost increase. In contrast, the retailer benefits from the increasing unit transaction cost due to the lower margin for the manufacturer. Altogether, when the unit transaction cost increases, the benefit for the retailer

is more than the loss for the manufacturer. Hence, the distribution channel as a whole benefits from the increase of unit transaction cost. This finding is counterintuitive since the conventional wisdom regards transaction cost in any form as a drain or waste when the channel is considered as a closed system, while this research shows that higher transaction cost can even benefit the closed decentralized channel system.

It is noteworthy to mention that Proposition 1 shows that the effects of consumer heterogeneity on the retailer's profit are similar to the finding $\frac{d\pi(R)^*}{dt} > 0$ in Proposition 3. The main difference is that when consumers are heterogeneous only either vertically on their willingness-to-pay for product quality or horizontally on their transaction costs, since there is no quality increase effect with channel decentralization, the positive effect (i.e., with the increase of t or decrease of a , the increase of the retailer's profit) is not strong enough to offset the negative effects on the manufacturer's profit. Hence, the total channel profit in the decentralized channel does not increase with the increase of t or decrease of a .

Interestingly, the effects of the unit transaction cost increase are different in the decentralized channel and in the centralized channel. As shown by Tyagi (2004), an increase of the unit transaction cost always hurts a monopolist. Proposition 3 shows that the unit transaction cost increase can actually benefit a retailer and the distribution channel when the channel is decentralized. Thus, channel structure becomes an important moderator for the effect of consumer transaction cost on a distribution channel. To compare with the decentralized channel, we look at the case when $\frac{3}{32} < t < \frac{8}{75}$ in the centralized channel. Without an independent retailer, there is no separation of the product quality decision and the retail price decision, and there is no double-marginalization effect, so the manufacturer does not have an incentive to offer product quality as high as in the decentralized channel. With the increase of t , this leads to a decreasing demand as well as a decreasing profit margin for the channel. Therefore, altogether, the centralized channel gets worse off from the increase of t .

Again, it is important to note that the beneficial effect of the unit transaction cost increase on the retailer and the distribution channel happens only when the unit transaction cost is intermediate ($\frac{3}{32} < t < \frac{8}{75}$). When the unit transaction cost is either low or high ($t \leq \frac{3}{32}$ or $t \geq \frac{8}{75}$), as explained earlier for Proposition 2, the quality-enhancing effect of channel decentralization is

no longer effective, and the profits for the manufacturer, the retailer, and consequently the channel will decrease when t increases.

Next, I study how the quality-enhancing effect affects consumer and social welfare in the decentralized channel, and report the most interesting result in the following proposition.

Proposition 4. *(Consumer and Social Welfare) When consumers are two-dimensionally heterogeneous, in a decentralized channel, $\frac{dCS_D^*}{dt} > 0$ and $\frac{dSW_D^*}{dt} > 0$ when $\frac{3}{32} < t < \frac{8}{75}$.*

Proposition 4 shows that an increase of t may benefit consumers as a whole because of the quality-enhancing effect in a decentralized channel. When $\frac{3}{32} < t < \frac{8}{75}$, Proposition 2 presents that when t increases, the manufacturer in the decentralized channel has a strong incentive to offer higher product quality than in the centralized channel to retain those consumers with a high willingness-to-pay for quality in the market. In the meantime, the manufacturer keeps its margin low. The quality-enhancing effect gets even stronger with the increase of t . Consequently, the increase of t actually benefits the consumers at an aggregate level despite the higher consumer transaction costs. Recall from Proposition 3, the decentralized channel's profits increase in t when $\frac{3}{32} < t < \frac{8}{75}$. Therefore, social welfare combining the channel profit and consumer welfare increases with t when $\frac{3}{32} < t < \frac{8}{75}$.

It is important to note that the beneficial effect of quality increase on consumer and social welfare only happens when the unit transaction cost t is in the range of $t \in (\frac{3}{32}, \frac{8}{75})$. When $\frac{8}{75} \leq t < \frac{4}{25}$, with the increase of t , each consumer who purchases the product receives less surplus because the quality-enhancing effect becomes weaker. Therefore, consumer welfare decreases with t . Again, recall from Proposition 3, the decentralized channel's profits decrease in t when $\frac{8}{75} \leq t < \frac{4}{25}$. Therefore, social welfare decreases with the increase when $\frac{3}{32} < t < \frac{8}{75}$.

3.4 CONCLUSION

Should a manufacturer always lower its product quality when selling in a decentralized channel than in a centralized channel as suggested by literature (Jeuland and Shugan 1983; Villas-Boas 1998; Economides 1999)? Or can

the quality of a product sold by a decentralized channel be even higher than that of a product sold by a centralized channel as shown by anecdotal evidence? By comparing the models in which consumers are heterogeneous on only one dimension, vertically on their willingness-to-pay for product quality or horizontally on their transaction costs, or on both dimensions, I study the manufacturer's product quality decisions in different channel structures with different types of consumer heterogeneity. There are several interesting results which are complements to extant literature and have important managerial implications for marketing practice.

First, when consumers are heterogeneous either vertically on willingness-to-pay for product quality or horizontally on transaction costs, channel decentralization leads to same or lower product quality, same or lower channel profits, and same or lower consumer and social welfare. However, when consumers are heterogeneous on both their willingness-to-pay for product quality and transaction costs, a manufacturer may want to optimally offer higher product quality when selling through an independent retailer than when selling directly by itself.

Secondly, when consumers are heterogeneous on both their willingness-to-pay for product quality and transaction costs, the decrease of consumer transaction cost does not necessarily increase a firm's profit. In a decentralized channel, we show that a retailer can benefit and a manufacturer gets hurt from the increase of consumer transaction cost. Interestingly, the retailer can benefit more from the unit transaction cost increase than that the manufacturer loses. Thus, the distribution channel as a whole can benefit from the consumer transaction cost increase. An interesting implication of this result is that if the retailer and the manufacturer can work out a transfer payment agreement, both the manufacturer and the retailer can benefit from higher consumer transaction costs. In addition, it is not necessarily a good idea for a retailer to reduce consumer transaction costs since such a reduction can hurt the retailer and the distribution channel.

Finally, when consumers are heterogeneous on both willingness-to-pay for product quality and transaction costs, the decrease of consumer transaction costs does not necessarily benefit consumers. With the separation of quality decision and retail price decision in the decentralized channel, total consumer surplus and social welfare may even decrease with the decrease of consumer transaction costs. This result has important implications for public policy

makers. Government interventions for reducing consumer transaction costs may actually hurt consumers and the society as a whole.

I acknowledge some limitations of the research in this chapter. In this chapter, consumers are uniformly distributed on both quality valuation and transaction cost dimensions. In the future, it will be worthwhile to examine the cases with different consumer distributions on either one of these two dimensions or both dimensions. In addition, in this chapter, there is only one manufacturer and one retailer. Future research can study competition at either the upstream level, the downstream level, or both levels, when consumers differ both horizontally and vertically. I am currently working on some of these topics, and hope this research can inspire more interest in this area.

CHAPTER 4

TIPPING POLICY AND SIGNALING SERVICE QUALITY

4.1 INTRODUCTION

A tip, also called gratuity, is a payment consumers voluntarily make in addition to the advertised transaction price. This definition depicts the tipping practice as a unique phenomenon in markets in two ways. One is that the tip amount is determined by consumers instead of firms, and the other is that tips are the payments made in addition to prices set by firms. Some typical tipping examples are, a passenger pays an extra amount after a taxi ride on top of the trip price, a diner pays a tip after a meal besides the meal price, and a traveler pays tips in addition to the hotel fee. The tipping practice has become prevalent in numerous service industries such as restaurants, bars, cruises, taxis, and resorts. For instance, Lynn et al. (1993) report that 33 service professions involve tipping. In the United States, consumers pay approximately \$40 billion of tips a year in the food industry (Azar 2008).

In many service industries, executives and managers have been actively managing the tipping behavior by choosing to adopt a tipping policy or non-tipping policy (Lynn and Withiam 2008). Evans and Dave (1999) depict the practice of different policies such as tipping policy at prominent U.S. resorts. An interesting example of these differing policies can be found when, in November 2006, Jay Porter, the owner of a restaurant in San Diego eliminated the tipping policy in his restaurant. Two years later, his restaurant was purchased and transformed into a high service oriented seafood restaurant, which then reverted to the tipping policy (Wachter 2008). This example reveals the commonly known phenomenon that firms with little or low-level of service, such as fast-food restaurants and shuttle buses, usually do not make active efforts to solicit tips. Moreover, firms with some or high-level service, such as bars, upscale restaurants, and taxis, often notify consumers

upfront that tips are appreciated.

Tipping policy serves two purposes, one is to motivate service providers to offer high service, the other is to signal service quality. In this chapter, I study how the tipping policy can signal service quality in service industries where some consumers cannot directly assess the service quality before making purchasing decisions. I call these consumers “uninformed consumers” and call those who can ascertain the service quality “informed consumers”. Specifically, I try to tackle two main issues. The first issue is while a firm with high service quality optimally chooses to have a tipping policy when all consumers can ascertain its service quality, whether it can use this policy to distinguish itself from those with low service quality where some consumers cannot ascertain its service quality.¹ Throughout this chapter, I denote the firm with high service quality as the high-type and the firm with low service quality as the low-type. The second issue is the question of whether a high-type firm still prefers to distinguish its type with a tipping policy when optimally it should choose not to have a tipping policy if all consumers can ascertain its service quality.

The tipping practice has been generally influenced by social norms, in the sense that it guides consumers with the appropriate amount of tips to pay at an average level although different consumers have varying levels of individual generosity. In this chapter, I denote this average level with “consumers’ generosity”. Consumers’ generosity may be different across different industries. More importantly, the evolvement of social norms has resulted in changes in the tipping amount over time. For instance, in early 1900s, the average tip in restaurants in the United States was 10% of the food price, while the average NYC tip in restaurants is 20% as of the year of 2009 (Bruni 2009). Furthermore, the tip amount a consumer gives usually is directly related to service quality, which is defined broadly in this paper. Service quality can have many dimensions, such as appropriate/inappropriate lighting, adjustable/nonadjustable temperature, various timelines of chefs, and attentiveness of the waiting staff. It is even possible that a consumer may pay tips higher than his/her valuation of the consumption experience (i.e., service quality). Azar (2004) discusses two possible situations where this phenomenon can occur. The first is that “the value of the service to

¹To distinguish itself means to send signals to those uninformed consumers about its true service quality.

different patrons can vary significantly, ... for some of them, this value can be below the tip dictated by the social norms”, and the second is that “if the worker can initiate the service and the buyer finds it too costly to refuse a service, the buyer may have to leave a tip that is larger than his valuation of the service.” Overtime, the increase of consumers’ generosity is so substantial that it can even influence consumers’ purchasing behavior. Consumers may even choose not to purchase the goods or services because they expect to pay high tips.² In this chapter, I study how social norms influence firms’ signaling strategy with tipping policy.

4.1.1 SUMMARY OF MAIN RESULTS

I first show that under certain conditions the high-type firm can effectively signal its service quality to uninformed consumers with a tipping policy and the retail price as its optimal decisions under complete information (i.e., when all consumers can ascertain the service quality). When consumers’ generosity guided by social norms is low, it is profitable for a high-type firm to choose to have a tipping policy under complete information. This is because the low consumers’ generosity does not require the high-type firm to lower its retail price substantially to accommodate consumers’ decisions on tips when it chooses to have a tipping policy. While under incomplete information (i.e. not all consumers can ascertain the service quality), if the ratio of informed consumers to uninformed consumers is relatively high, the high-type firm can follow the same strategy as under complete information, without being mimicked by the low-type firm. The low-type firm does not benefit from pretending to be the high-type by mimicking its strategy since the loss from the high proportion of informed consumers outweighs the gain from the low proportion of uninformed consumers. Therefore, the high-type firm can distinguish itself from the low-type firm with its optimal decisions under complete information. Moreover, when consumers’ generosity is intermediate, it is still profitable for the high-type firm to choose to have a tipping policy under complete information, with a heavily lowered retail price to accomo-

²For example, on the website <http://dinersjournal.blogs.nytimes.com/2009/02/18/tipping-and-the-recession/>, consumers give comments such as “I have always tipped 20% as the bottom line ... and haven’t changed my tipping behavior. I just eat out less.” “I will tip 15% for decent service, and if I cant afford to do so, I won’t go out to dinner.” “I believe that one should not go out to eat unless one can afford to tip fairly.”

date consumers' tip payment. This low retail price makes it less attractive for the low-type to mimic the high-type with less gains from the uninformed consumers and the same loss from the informed consumers. Different from the literature that pricing alone can signal product quality (e.g. Bagwell and Riordan 1991; Srinivasan 1991; Chu 1992; Balanchander and Srinivasan 1994; Desai and Srinivasan 1995), I show in this chapter that, under certain conditions, pricing alone can not signal the service quality when the tipping policy is banned. Pricing can signal the service quality with the assistance of the tipping policy.

I also show that under certain conditions the high-type firm prefers to distort its price (i.e., away from the optimal one under complete information) and have a tipping policy, rather than to have a non-tipping policy and charge the complete information price, to signal its service quality. As mentioned earlier, when consumers' generosity is low, the high-type firm optimally chooses to have a tipping policy under complete information. Under incomplete information, however, if the ratio of informed consumers to uninformed consumers is low, the high-type can no longer separate itself from the low-type with a tipping policy on top of the complete information price. This is because the low-type firm can charge the high-type's complete information price and adopt a tipping policy, profitably pretending to be its counterpart. The low-type's successful mimicry results from less loss of the informed consumers because of the low proportion of informed consumers. To prevent the low-type's imitation, the high-type firm has to change either its optimal price or its optimal policy, which both will negatively affect its profit. Since changing the optimal price while keeping the tipping policy does not lead to as strong effect as changing the optimal policy (to a non-tipping policy), the high-type distorts its retail price with a tipping policy to effectively signal itself.

In addition, I show that under certain conditions the high-type firm may even strategically choose to have a tipping policy to signal its service quality to uninformed consumers, although it is better off with a non-tipping policy under complete information. When consumers' generosity is high, the high-type firm optimally chooses to have a non-tipping policy under complete information, since it otherwise would have to lower its retail price substantially to accommodate consumers' tip payment. However, This non-tipping policy makes it easier for the low-type firm to mimic the high-type. This is because

when observing the non-tipping policy, uninformed consumers will pay their appreciation for service quality through normal retail price. When observing the tipping policy, uninformed consumers will pay part of their appreciation for service quality via tipping. If a low-type firm pretends to be the high-type, it will not receive the tip after consumers' consumption verification. Therefore, it is more attractive for the low-type to mimic the high-type with non-tipping policy, especially when the proportion of informed consumers is low so there will not be much loss the informed consumers by charging a high retail price. On the other hand, it is relatively more difficult for the low-type firm to pretend to be its counterpart when the high-type adopts the tipping policy. In other words, there is a tradeoff for the high-type firm between a policy which is less effective but more difficult to be imitated, i.e., tipping policy, and a policy which is more effective but less difficult to be imitated, i.e., non-tipping policy. When the ratio of informed consumers to uninformed consumers is low, it is even more attractive for the low-type firm to pretend to be high-type when it adopts a non-tipping policy. Hence, to separate itself from the low-type, the high-type firm adopts the less effective policy, i.e., tipping policy.

4.1.2 RELATED LITERATURE

The research in this chapter is related to three streams of literature. One stream is research on tipping phenomenon in Marketing and Economics. This stream of literature has mainly focused on empirical and experimental studies (e.g. Lynn et al. 1993; Lynn 2003; Azar 2007).³ There are very few analytical studies on tipping behavior in Marketing and Economics (e.g. Ben-Zion and Karni 1977; Jacob and Page 1980; Schwartz 1997; Flath 2009). Ben-Zion and Karni (1977) propose a leading explanation for the economic benefit of the social norm of tipping, which was later further developed by Jacob and Page (1980). Schwartz (1997) concludes that tipping may increase the firm's profits when two consumer segments coexist and differ in their demand functions and their propensity to tip. Flath (2009) develops a model to explain the tipping behavior in taxi industry and concludes that tipping amounts to Lindahl pricing of the services of vacant cabs. The research in this chapter differs

³Lynn (2003) and Azar (2007) have offered excellent reviews on empirical studies about tipping.

from the extant literature on tipping phenomenon with a new perspective. I focus on how a high-type firm can use tipping policy as a signal device to separate itself from a low-type firm in a market where consumers' tipping behavior is guided by social norms.

The second stream is signaling literature. There is an enormous amount of literature on signaling with various signal devices, for instance, price (Wolinsky 1983; Tirole 1988; Bagwell and Riordan 1991; Srinivasan 1991; Chu 1992; Balachander and Srinivasan 1994; Judd and Riordan 1994; Desai and Srinivasan 1995), advertising (Nelson 1974; Schmalensee 1978; Milgrom and Roberts 1986; Bagwell and Ramey 1988; Zhao 2000; Linnemer 2002; Erdem et al. 2008), warranties (Spence 1977; Grossman 1981; Lutz 1989), money-back guarantee (Moorthy and Srinivasan 1995), scarcity (Stock and Balachander 2005), product safety (Daughety and Reinganum 1995), and internet auction features (Li et al. 2009). My model contributes to the signaling literature by demonstrating that tipping policy can be (or strategically be used as) an effective signal of service quality, especially under certain conditions where pricing alone is not enough to separate the firm with high service quality from the firm with low service quality.

The third stream of related literature is research on service quality in Marketing. The majority of this stream of research is on measurement scales of service quality (e.g. Parasuraman et al. 1988; Cronin, Jr. and Taylor 1992) and conceptual or empirical models (e.g. Gronroos 1984; Parasuraman et al. 1985; Bolton and Drew 1991). One exception is the analytical paper by Bhargava and Sun (2008). Bhargava and Sun (2008) explore the performance-contingent pricing schemes with long-term statistical performance guarantees in IT services with the presence of uncertainty in service quality. Differing from literature, the research in this chapter examines the situation where some consumers can not assess service quality and how firms can use tipping policy to signal their service quality by transferring part of the final price decision to consumers.

The rest of the chapter is organized as follows. In section 4.2, I describe the model, analyze the complete information case, followed by the analysis of incomplete information case and discussions of equilibrium results. In section 4.3, I discuss some model extension where some assumptions in the main model are relaxed or changed. This chapter concludes with section 4.4. Detailed derivations and proofs are included in Appendix.

4.2 THE MODEL

In this research, I mainly follow the model setup in Bagwell and Riordan (1991) where a firm has private information about its service quality. I consider two possible levels of service quality $s \in \{s_H, s_L\}$, where $s_H > s_L$. In the main model, service quality is assumed to be exogenously determined. In the model extension, I allow firms to endogenously decide the service quality. The marginal cost for the firm with high service quality s_H (i.e. the high-type firm) is $c_H = c > 0$ and the marginal cost for the firm with low service quality s_L (i.e. the low-type firm) is normalized to be $c_L = 0$ without loss of generality. Besides the service quality, both types of firms have a common product quality V . The firms make two decisions. One is to choose to have a tipping policy or non-tipping policy. When it chooses to have a tipping policy, the firm transfers part of the final price decision to consumers. When it chooses to have a non-tipping policy, the firm decides the price by itself. The other decision is to set the corresponding retail price (p) under each policy. When there is a tie between a tipping policy and a non-tipping policy, we assume that the firm will choose to have a non-tipping policy.

In the market, there are two segments of consumers with a total mass of one. One segment consists of informed consumers with a size of α , who can ascertain both the product quality (V) and service quality (s). The other segment consists of uninformed consumers with a size of $1 - \alpha$, who can only be certain about the product quality (V), and have the prior beliefs (γ) about the distribution of the service quality (s). Mathematically, this means that the uninformed consumers believe the service quality is high with probability $Prob(s = s_H) = \gamma$ and the service quality is low with probability $Prob(s = s_L) = 1 - \gamma$. The uninformed consumers update their prior beliefs about the uncertain service quality based on the specific policy, tipping or non-tipping, and the retail price. Let b denote the uninformed consumers' updated beliefs,⁴ and s^u denote the perception of the uncertain service quality based on the updated beliefs.

Consumers' willingness-to-pay consists of two parts, one for the product quality V and the other for the service quality s . Let $\theta(s - s_L)$ denote consumers' valuation on service quality, where $s \in \{s_H, s_L\}$ for the informed consumers and $s = s^u$ for the uninformed consumers. The index θ captures

⁴ $Prob(s = s_H) = b, Prob(s = s_L) = 1 - b$

consumer heterogeneity in valuation on the service quality, which is assumed to be uniformly distributed over $[0, 1]$. This heterogeneity exists in both segments, the informed segment and the uninformed segment. The higher θ a consumer has, the more he/she appreciates the high service quality s_H . To focus on the analysis of service quality, I assume that all consumers, including both the informed and uninformed consumers, have the same willingness-to-pay (V) for the product quality.

When a firm chooses to have a non-tipping policy, consumers do not pay tips for either type of service quality. When it chooses to have a tipping policy, consumers' tips depend on both their valuations on the service quality and social norms. Consumers' heterogeneity in tipping behavior is also captured by θ . The higher θ a consumer has, the more he/she will pay as tips under tipping policy. While consumers are individually different with respect to the tip amount, their behavior in general is guided by social norms, which I call consumers' generosity and denote with β . Consumers' generosity may be different across various service industries.⁵ Furthermore, I assume that consumers' tips are proportional to the perceived service quality. The higher the perceived service quality, the more tips a consumer pays. Hence, consumers' tip amount under tipping policy is $\theta(s - s_L)\beta$ where $s \in \{s_H, s_L\}$ for the informed consumers and $s = s^u$ for the uninformed consumers. By $\theta(s - s_L)\beta$, I implicitly assume that when the uncertain service quality (s) is known to be low, that is, $s = s_L$, all consumers will not pay tips even when the firm has a tipping policy.

If a firm chooses to have the tipping policy, the informed consumers utility function is defined as

$$u_f = V + \theta(s - s_L) - p - \theta(s - s_L)\beta \quad (4.1)$$

where the first two parts represent consumer θ 's valuation on product and service quality, and the last two parts represent consumer θ 's payments of retail price and tips.

For the uninformed consumer θ , his/her expected utility function is

$$Eu_v = V + \theta(s^u - s_L) - p - \theta(s^u - s_L)\beta \quad (4.2)$$

⁵<http://www.tipping.com/> has guides for tipping in different professions.

where V , θ , p and s_L have the same meanings as explained for the informed consumers, and s^u is the updated level of the uncertain service quality based on the updated beliefs b . Specifically, $\theta(s^u - s_L)$ is the consumer θ 's expected valuation on service quality, and $\theta(s^u - s_L)\beta$ is his/her expected payment of tips.⁶

If a firm chooses to have the non-tipping policy, the informed consumer θ 's utility function is

$$u_f = V + \theta(s - s_L) - p \quad (4.3)$$

and the uninformed consumers expected utility function as

$$Eu_v = V + \theta(s^u - s_L) - p. \quad (4.4)$$

An informed consumer will purchase one unit of the product if his/her utility is non-negative. And an uninformed consumer will purchase one unit of the product if his/her expected utility is non-negative, given the updated beliefs (b) about the uncertain service quality. I assume that consumers are notified about the tipping or non-tipping policy and retail price before they make their purchasing decision.⁷ The timing of the game is defined as follows: (1) The firm decides to have a tipping policy or a non-tipping policy, and sets the retail price;⁸ (2) The informed consumers make their purchasing decision based on their utility functions given the specific policy, tipping or non-tipping, and the retail price. The uninformed consumers make their purchasing decision based on the expected utility functions given the tipping or non-tipping policy, the retail price and their updated beliefs. (3) All the consumers who purchased the product, consume and experience the true service quality and make payments accordingly.⁹

I first look at the benchmark case where all consumers are informed about the firm type. Then I examine the firm's signaling strategy when some

⁶This expected payment of tips is considered before consumers make purchasing decision, while the actual payment of tips depends on the verification of the true service quality.

⁷For example, before a consumer takes a ride, either by taxi or by shuttle, he/she will notice whether tips are expected. Another example is that before placing orders in a restaurant, consumers will be able to observe the tipping policy if there is one.

⁸In the case there is service charge on top of the retail price, we consider the sum of retail price and service charge as the real retail price.

⁹Under tipping policy, a consumer pays the retail price p and tips $\theta\beta(s_H - s_L)$ for the high-type and pays only the retail price p for the low-type. Under non-tipping policy, a consumer pays only the retail price p for both the high-type and low-type.

consumers are uncertain about the firm type.

4.2.1 COMPLETE INFORMATION CASE ($\alpha = 1$)

When all consumers are informed about the firm type, i.e. $\alpha = 1$, consumers make their purchasing decision based on their utility functions as defined earlier in Equations (1) and (3) given the tipping/non-tipping policy and retail price. Under complete information, the low-type firm is indifferent between tipping and non-tipping policy with the maximum profit $\pi^L = V$ and adopts a non-tipping policy according to the tie-breaking rule as specified before.¹⁰

If the high-type firm chooses to have a non-tipping policy, based on the utility function in Equation (3), consumers with θ such that $V + \theta(s_H - s_L) - p \geq 0$ will purchase the product, so its demand function is $D^{Hn} = 1 - \frac{p-V}{s_H-s_L}$ and its profit function is

$$\pi^{Hn} = (p - c)\left(1 - \frac{p - V}{s_H - s_L}\right) \quad (4.5)$$

The optimal retail price (p^{Hn*}) and profits (π^{Hn*}) are

$$p^{Hn*} = \begin{cases} \frac{c+V+s_H-s_L}{2}, & \text{if } s_H - s_L \geq V - c; \\ V, & \text{if } s_H - s_L < V - c. \end{cases} \quad (4.6)$$

$$\pi^{Hn*} = \begin{cases} \frac{(V-c+s_H-s_L)^2}{4(s_H-s_L)}, & \text{if } s_H - s_L \geq V - c; \\ V - c, & \text{if } s_H - s_L < V - c. \end{cases} \quad (4.7)$$

When the high-type firm chooses to have the non-tipping policy, its optimal retail price p^{Hn*} increases with the increase of the service quality difference $s_H - s_L$, if it is relatively high (i.e. $s_H - s_L \geq V - c$). The market is not fully covered, leaving the low-end consumers (i.e. consumers with low θ) uncovered. If the service quality difference is relatively low (i.e. $s_H - s_L < V - c$), the market is fully covered.

Next, I examine the high-type firm's pricing decision if it chooses to have a tipping policy. Based on the utility function as defined in Equation (1),

¹⁰The low-type's profit function under tipping policy as well as non-tipping policy is $\pi^{Lt} = \pi^{Ln} = p \times 1$ if $p \leq V$ and $\pi^{Lt} = \pi^{Ln} = 0$ if $p > V$. So the optimal decision is $p^L = V$ with non-tipping policy according to the tie-breaking rule defined before.

the firm's demand function is

$$D^{Ht} = \begin{cases} 1 - \frac{p-V}{(s_H-s_L)(1-\beta)}, & \text{if } \beta < 1; \\ \frac{V-p}{(s_H-s_L)(\beta-1)}, & \text{if } \beta > 1. \end{cases} \quad (4.8)$$

It is noteworthy to mention that the demand functions are different depending on the value of consumers' generosity β . This is because with different values of β , the profitable consumers for the firm are different. Specifically, when $\beta < 1$, the high-end consumers (i.e., with high θ) are relatively more profitable for the firm than the low-end consumers since the tip amount a consumer pays is less than the value he/she gets from the service quality.¹¹ When $\beta > 1$, the low-end consumers (i.e., with low θ) are more easily attracted by the firm than the high-end consumers since the tip amount a consumer pays is more than the value he/she gets from the service quality.¹²

Consequently, the high-type firm's profit function is written as

$$\pi^{Ht} = \begin{cases} (p-c) \times \left(1 - \frac{p-V}{(s_H-s_L)(1-\beta)}\right) + \int_0^1 \frac{p-V}{(s_H-s_L)(1-\beta)} (s_H-s_L) \beta \theta d\theta, & \text{if } \beta < 1; \\ (p-c) \frac{V-p}{(s_H-s_L)(\beta-1)} + \int_0^{\frac{V-p}{(s_H-s_L)(\beta-1)}} \frac{V-p}{(s_H-s_L)(\beta-1)} (s_H-s_L) \beta \theta d\theta, & \text{if } \beta > 1. \end{cases} \quad (4.9)$$

where the first part refers to the firm's revenue due to consumers' payment of retail price, and the second part is the firm's revenue due to consumers' payment of tips. I assume that the firm gets the full tip payment in the main model and the case that servers and firms share tips will be discussed later in the model extension.

Maximizing its profit with respect to the retail price, the high-type firm's

¹¹When $\beta = 1$, demand function is $D^{Ht} = 1$ if $p \leq V$ and $D^{Ht} = 0$ if $p > V$.

¹²One can understand β as a parameter describing a consumer's tip as percentage of his/her appreciation of the service quality. Then when β is low (high), for instance $\beta < 1$ ($\beta > 1$), it means that consumers in general pay a relatively low (high) tip comparing to the value they get from the service quality. A specific example for the low β is dining in an upscale restaurant where diners highly value the environment and service. An example for the high β is taxi rides within city where passengers do not need much extra service from the drivers.

optimal retail price (p^{Ht*}) and profits (π^{Ht*}) under tipping policy are

$$p^{Ht*} = \begin{cases} \frac{(1-\beta)c+V+(1-\beta)^2(s_H-s_L)}{2-\beta}, & \text{if } \beta < 1, (1-\beta)(s_H-s_L) \geq V-c; \\ V, & \text{if } \beta < 1, (1-\beta)(s_H-s_L) < V-c; \\ V-(\beta-1)(s_H-s_L), & \text{if } 1 \leq \beta \leq 2; \\ \frac{(1-\beta)c+V}{2-\beta}, & \text{if } \beta > 2, (\beta-2)(s_H-s_L) \geq V-c; \\ V-(\beta-1)(s_H-s_L), & \text{if } \beta > 2, (\beta-2)(s_H-s_L) < V-c. \end{cases} \quad (4.10)$$

$$\pi^{Ht*} = \begin{cases} \frac{(V-c+s_H-s_L)^2}{2(2-\beta)(s_H-s_L)}, & \text{if } \beta < 1, (1-\beta)(s_H-s_L) \geq V-c; \\ V-c + \frac{\beta}{2}(s_H-s_L), & \text{if } \beta < 1, (1-\beta)(s_H-s_L) < V-c; \\ V-c + (1-\frac{\beta}{2})(s_H-s_L), & \text{if } 1 \leq \beta \leq 2; \\ \frac{(V-c)^2}{2(\beta-2)(s_H-s_L)}, & \text{if } \beta > 2, (\beta-2)(s_H-s_L) \geq V-c; \\ V-c + (1-\frac{\beta}{2})(s_H-s_L), & \text{if } \beta > 2, (\beta-2)(s_H-s_L) < V-c. \end{cases} \quad (4.11)$$

Unlike the case of non-tipping policy, when the high-type firm adopts a tipping policy, its optimal retail price p^{Ht*} does not necessarily increase with the increase of the service quality difference $s_H - s_L$. It may even decrease with the increase of $s_H - s_L$, depending on the value of consumers' generosity β . For instance, when β is high, i.e., $\beta > 1$, since consumers in general pay tips higher than their valuation on the service quality, the high-type firm needs to lower its retail price substantially to attract consumers. The higher $s_H - s_L$, the more consumers pay as tips, and the more the firm needs to decrease its retail price to accommodate consumers' tips. Hence, the retail price p^{Ht*} may decrease with the increase of $s_H - s_L$.

By comparing the high-type firm's profits when it chooses to have a tipping policy and when it chooses to have a non-tipping policy, I summarize the high-type firm's optimal policy decision under complete information in the following Lemma.

Lemma 1. *Under complete information, the high-type firm should choose a tipping policy when consumers' generosity is low, i.e., $0 < \beta < \frac{3}{2} + \frac{V-c}{s_H-s_L} - \frac{(V-c)^2}{2(s_H-s_L)^2}$ if $s_H - s_L \geq V - c$ and $0 < \beta < 2$ if $s_H - s_L < V - c$. It should choose a non-tipping policy when consumers' generosity is high, i.e., $\beta > \frac{3}{2} + \frac{V-c}{s_H-s_L} - \frac{(V-c)^2}{2(s_H-s_L)^2}$ if $s_H - s_L \geq V - c$ and $\beta > 2$ if $s_H - s_L < V - c$.*

Lemma 1 shows that a high-type firm's decision to adopt a tipping policy

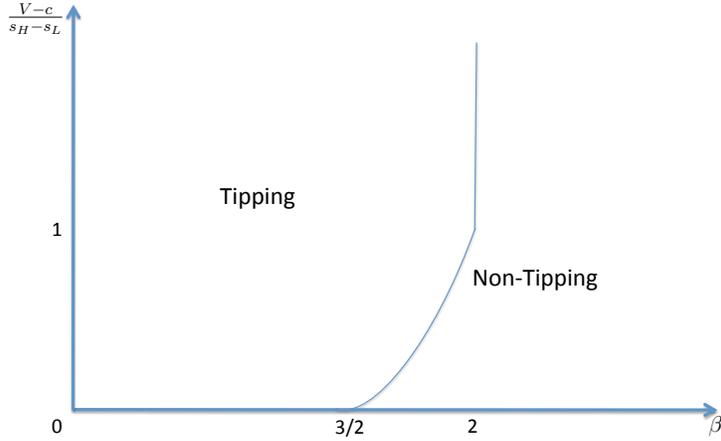


Figure 4.1: The effect of β and $\frac{V-c}{s_H-s_L}$ on the high-type firm's tipping/non-tipping decision

or non-tipping policy depends on consumers' generosity level (β) and the service quality difference ($s_H - s_L$). Surprisingly, the firm will only benefit from adopting a tipping policy if in general consumers are not so generous, i.e. β is low as shown in Figure 4.1. The driving force is as follows. When the high-type firm chooses to adopt a tipping policy, comparing to the non-tipping policy case, it has to lower its retail price to accommodate consumers' tipping behavior since consumers know that they will pay tips in addition to the retail price. The extent of lowering the retail price increases with the increase of consumers' generosity β . When consumers' generosity (β) is low, the high-type firm lowers its retail price slightly under the tipping policy than under the non-tipping policy. So the loss due to the lowered retail price is easily compensated by the gain from consumers' tips and the high-type firm benefits from the consumers' involvement in pricing decision. However, when consumers' generosity (β) is high, the high-type firm needs to lower its retail price substantially under the tipping policy than under the non-tipping policy, since consumers expect to pay much higher tips.¹³ Hence the loss due to the substantially lowered retail price can no longer be compensated by

¹³ $\theta(s_H - s_L)\beta - \theta(s_H - s_L) \geq \frac{1}{2}(s_H - s_L)$

the gain from consumers' tips. Therefore, the high-type firm is better off by choosing to have a non-tipping policy when consumers' generosity (β) is high.

4.2.2 INCOMPLETE INFORMATION CASE ($\alpha < 1$)

One can understand the complete information refers to the case where the ratio of informed to uninformed consumers is infinity, that is, there is no uninformed consumers in the market. When uninformed consumers appear in the market, the ratio decreases. In the following, I first discuss how to derive separating equilibria, then I derive the separating equilibrium results under different market conditions; finally I discuss the conditions under which no separating equilibrium exists.

I. *The characterization of separating equilibrium*

The high-type firm can effectively separate itself from the low-type firm when it maximizes its profits with respect to a specific policy, tipping or non-tipping, and retail price subject to two constraints: (1) the low-type firm does not have the incentive to mimic the high-type's policy and retail price; and (2) the high-type does not benefit from deviating to other strategies. All consumers observe the firm's policy, tipping or non-tipping policy and retail price, before they make their purchasing decision. While the informed consumers know the true service quality s , the uninformed consumers update their beliefs γ to b using Bayes' rule. To characterize the separating equilibrium, I define two sets of strategies, M and N , to represent the two constraints discussed above respectively.

The strategies in M represent those satisfying constraint (1). They give the low-type firm a lower profit ($\pi\{s_L, 1, p, X\}$) under the most favorable beliefs, i.e., the uninformed consumers believe it is high-type $b = 1$, than the maximum profit ($\pi\{s_L, 0, p, x\}$) obtainable under the worst beliefs, i.e., revealing its true type $b = 0$.

$$M = \{(X, p) | \pi\{s_L, 1, p, X\} \leq (\max \pi\{s_L, 0, p, x\} = V)\} \quad (4.12)$$

where $X \in \{tipping, non - tipping\}$.

If $X = \textit{tipping}$, based on the utility functions in Equations (1) and (2), the low-type firm's demand function ($D\{s_L, 1, p, t\}$) under the most favorable beliefs ($b = 1$) is

$$D\{s_L, 1, p, t\} = \begin{cases} 1, & \text{if } p \leq V, \beta < 1; \\ \alpha + (1 - \alpha) \frac{V-p}{(s_H-s_L)(\beta-1)}, & \text{if } p \leq V, \beta > 1; \\ (1 - \alpha) \left(1 - \frac{p-V}{(s_H-s_L)(1-\beta)}\right), & \text{if } V < p < V_1, \beta < 1; \\ 0, & \text{if } p > V_1, \beta < 1; \\ 0, & \text{if } p > V, \beta > 1; \end{cases} \quad (4.13)$$

where $V_1 = V + (s_H - s_L)(1 - \beta)$.

Consequently, the low-type firm's profit function under the most favorable beliefs ($b = 1$) is

$$\pi\{s_L, 1, p, t\} = \begin{cases} p, & \text{if } p \leq V, \beta < 1; \\ p \left[\alpha + (1 - \alpha) \frac{V-p}{(s_H-s_L)(\beta-1)} \right], & \text{if } p \leq V, \beta > 1; \\ p(1 - \alpha) \left(1 - \frac{p-V}{(s_H-s_L)(1-\beta)}\right), & \text{if } V < p < V_1, \beta < 1; \\ 0, & \text{if } p > V_1, \beta < 1; \\ 0, & \text{if } p > V, \beta > 1. \end{cases} \quad (4.14)$$

If $X = \textit{non-tipping}$, based on the utility functions in Equations (3) and (4), the low-type firm's demand function ($D\{s_L, 1, p, n\}$) under the most favorable beliefs ($b = 1$) is

$$D\{s_L, 1, p, n\} = \begin{cases} 1, & \text{if } p \leq V; \\ (1 - \alpha) \left(1 - \frac{p-V}{s_H-s_L}\right), & \text{if } V < p < V + (s_H - s_L); \\ 0, & \text{if } p > V + (s_H - s_L). \end{cases} \quad (4.15)$$

Consequently, the low-type firm's profit function under the most favorable beliefs ($b = 1$) is

$$\pi\{s_L, 1, p, n\} = \begin{cases} p, & \text{if } p \leq V; \\ p(1 - \alpha) \left(1 - \frac{p-V}{s_H-s_L}\right), & \text{if } V < p < V + (s_H - s_L); \\ 0, & \text{if } p > V + (s_H - s_L). \end{cases} \quad (4.16)$$

A necessary condition for a separating equilibrium to exist is that a low-type firm prefers to reveal its type rather than pretend to be of the high-

type by imitating the high-type's strategy. As discussed earlier, the highest profit the low-type firm can obtain when revealing its true type is $\pi^L = V$. The low-type is interested in mimicking the high-type when it can persuade the uninformed consumers with the high willingness-to-pay for service and tip under tipping policy, i.e., high θ to purchase. However, when doing so, the low-type needs to consider the possible loss of the other segment of consumers, that is, the informed consumers, since these consumers will not purchase when the low-type pretends to be the high-type with a high retail price and tipping policy, unless the retail price is low enough. So, the low-type will mimic the high-type's strategy when $\pi\{s_L, 1, p, t\} = p(1 - \alpha)(1 - \frac{p-V}{(s_H-s_L)(1-\beta)}) > \pi^L = V$ under tipping policy and $\pi\{s_L, 1, p, n\} = p(1 - \alpha)(1 - \frac{p-V}{s_H-s_L}) > \pi^L = V$ under non-tipping policy.

The strategies in N represent those satisfying constraint (2). They give the high-type firm a higher profit under the most favorable beliefs, i.e., the uninformed consumers believe it is high-type, than the maximum profit obtainable under the worst beliefs, i.e., the uninformed consumers believe it is low-type. It means that the high-type should not find it profitable to deviate from its equilibrium strategy. When an off-equilibrium strategy is observed, we specify that the uninformed consumers believe that the firm is low-type.

$$N = \{(X, p) | \pi\{s_H, 1, p, X\} \geq \max \pi\{s_H, 0, p, x\}\} \quad (4.17)$$

The high-type firm's profit function under the most favorable beliefs is the same as in the complete information case in previous section. If $X = \textit{tipping}$, according to the utility functions in Equations (1) and (2), the high-type firm's demand function under the worst beliefs is

$$D\{s_H, 0, p, t\} = \begin{cases} 1, & \text{if } \beta < 1, p \leq V; \\ \alpha(1 - \frac{p-V}{(s_H-s_L)(1-\beta)}), & \text{if } \beta < 1, p > V; \\ \alpha \frac{V-p}{(s_H-s_L)(\beta-1)} + (1 - \alpha), & \text{if } \beta > 1, p \leq V; \\ 0, & \text{if } \beta > 1, p > V. \end{cases} \quad (4.18)$$

The high-type's profit function under the worst beliefs $\pi\{s_H, 0, p, t\}$ is

$$\pi\{s_H, 0, p, t\} = \begin{cases} (p - c) \times 1 + \int_0^1 (s_H - s_L) \beta \theta d\theta, & \text{if } \beta < 1, p \leq V; \\ R_1 + T_1, & \text{if } \beta < 1, p > V; \\ R_1 + T_2 + T'_2, & \text{if } \beta > 1, p \leq V; \\ 0, & \text{if } \beta > 1, p > V; \end{cases} \quad (4.19)$$

where R refers to the profit from charging retail price and T refers to revenue from tips.¹⁴

If $X = \text{non-tipping}$, according to utility functions in Equations (3) and (4), the high-type firm's demand function under the worst beliefs is

$$D\{s_H, 0, p, n\} = \begin{cases} 1, & \text{if } p \leq V; \\ \alpha(1 - \frac{p-V}{s_H-s_L}), & \text{if } V < p < V + (s_H - s_L); \\ 0, & \text{if } p > V + (s_H - s_L). \end{cases} \quad (4.20)$$

The high-type's profit function under the worst beliefs $\pi\{s_H, 0, p, n\}$ is

$$\pi\{s_H, 0, p, n\} = \begin{cases} p - c, & \text{if } p \leq V; \\ (p - c)\alpha(1 - \frac{p-V}{s_H-s_L}), & \text{if } V < p < V + (s_H - s_L); \\ 0, & \text{if } p > V + (s_H - s_L). \end{cases} \quad (4.21)$$

A separating equilibrium satisfying intuitive criterion requires that (i) (X_H, p_H) maximizes the high-type's profit, (ii) $(X_H, p_H) \in M \cap N$, and (iii) $(X_H, p_H) \neq (X_L, p_L)$. I first discuss the case when $X_H \neq X_L$. A strategy pair $\{(tipping, p_H), (non-tipping, p_L)\}$ is a separating equilibrium when (1) each strategy is optimal given the uninformed consumers' updated beliefs; and (2) the uninformed consumers' updated beliefs are consistent with Bayes' rule. The uninformed consumers' updated beliefs are $b(tipping, p_H) = 1$ and $b(non-tipping, p_L) = 0$.

¹⁴ $R_1 = (p - c) \times [\alpha(1 - \frac{p-V}{(s_H-s_L)(1-\beta)})]$, $T_1 = \alpha \int_0^1 \frac{p-V}{(s_H-s_L)(1-\beta)} (s_H - s_L) \beta \theta d\theta$, $R_2 = (p - c) \times [\alpha \frac{V-p}{(s_H-s_L)(\beta-1)}$, $T_2 = (1 - \alpha)] + \alpha \int_0^{\frac{V-p}{(s_H-s_L)(\beta-1)}} (s_H - s_L) \beta \theta d\theta$, and $T'_2 = (1 - \alpha) \int_0^1 (s_H - s_L) \beta \theta d\theta$.

II. The separating equilibrium

According to Lemma 1, the high-type firm's optimal decision is to adopt a tipping policy under complete information when consumers' generosity (β) is low. In the following proposition, I summarize the conditions under which the strategy pair $\{(tipping, p^{Ht*}), (non - tipping, V)\}$ is a separating equilibrium satisfying intuitive criterion with the uninformed consumers' updated beliefs $b(tipping, p^{Ht*}) = 1$ and $b(non - tipping, V) = 0$. Please refer to the Appendix for the detailed proofs.

Proposition 1. *A strategy pair $\{(tipping, p^{Ht*}), (non - tipping, V)\}$ is a separating equilibrium satisfying intuitive criterion with the uninformed consumers' updated beliefs $b^*(tipping, p^{Ht*}) = 1$ and $b^*(non - tipping, V) = 0$, if one of the following conditions holds:*

- (i) $0 < \beta < 1$, $(1 - \beta)(s_H - s_L) > V - c$ and $\alpha > \max\{0, \bar{\alpha}\}$, where
$$\bar{\alpha} = 1 - \frac{(2-\beta)^2(s_H-s_L)V}{[V+(1-\beta)c+(1-\beta)^2(s_H-s_L)](s_H-s_L+V-c)}$$
- (ii) $0 < \beta < 1$ and $(1 - \beta)(s_H - s_L) < V - c$
- (iii) $1 < \beta < \frac{3}{2} + \frac{V-c}{s_H-s_L} - \frac{(V-c)^2}{2(s_H-s_L)^2}$ and $s_H - s_L > V - c$
- (iv) $1 < \beta < 2$ and $s_H - s_L < V - c$.

Proposition 1 shows that under certain conditions, the high-type firm can distinguish itself with its optimal decisions, tipping policy and retail price p^{Ht*} , under complete information. Specifically, condition (i) refers to the case when the high-type firm adopts a tipping policy with its retail price p^{Ht*} higher than V , the value of the product, and the proportion of the informed consumers is high. Due to the low consumers' generosity ($\beta < 1$) and relatively high after-tip valuation of the service quality, i.e., $(1 - \beta)(s_H - s_L) > V - c$, it is profitable for the high-type firm to focus on the high-end consumers (i.e., with high θ) rather than covering the whole market. Therefore, the high-type firm does not need to lower its retail price much to accommodate consumers' tips, which leads to the optimal retail price p^{Ht*} higher than V . This high retail price is attractive for the low-type firm to pretend to be its counterpart since it can earn high profit margin from those uninformed consumers who would purchase the product even with the consideration for paying tips. However, the high proportion of the informed consumers, $\alpha > \bar{\alpha}$, makes mimicry unattractive to the low-type firm because of the loss of the informed consumers and not enough uninformed consumers

to be mistakenly attracted. When the unattractiveness of high proportion of informed consumers offsets the attractiveness of high retail price, the low-type does not find it more profitable to imitate the high-type's strategy than revealing its true type. While the after-tip valuation of service quality is relatively low, $(1 - \beta)(s_H - s_L) < V - c$, as in condition (ii), it is profitable for the high-type firm to cover the full market under complete information with a retail price equal to V . However, it is still not attractive for the low-type firm to pretend to be high-type because doing so will not bring it a higher profit.

Conditions (iii) and (iv) refer to the case when the high-type firm chooses to adopt a tipping policy with its retail price lower than V . Due to the high level of consumers' generosity ($\beta > 1$), to adopt a tipping policy, the high-type firm needs to allow big payment space for consumers' tips and has to lower its retail price substantially to attract consumers. This low retail price, $p^{Ht*} < V$, prevents the low-type firm from imitating. This is because all consumers, including informed and uninformed consumers, would purchase the product. However, after the consumption experience of verifying the true service quality, no consumer would pay any amount of tip.

Proposition 1 also demonstrates that the tipping policy and pricing together signal the service quality s_H for the high-type firm. Considering the large amount of signaling literature where pricing alone can signal the product quality, one would naturally ask the question whether pricing alone can signal the service quality in this chapter. That is, if tipping policy is banned, whether the high-type firm can still signal its service quality with its pricing decision. Recall the analysis where the high-type firm chooses to have the non-tipping policy, its pricing decision and optimal profits under complete information are shown in Equations (6) and (7). Straightforwardly, if $s_H - s_L < V - c$, there does not exist a separating equilibrium satisfying intuitive criterion where pricing alone is the signaling device. However, when tipping policy is allowed, the high-type firm can signal its service quality whenever consumers' generosity is not too high, that is, $\beta < 2$. Part of condition (ii) and condition (iii) demonstrate the parameter areas where on the one hand, if tipping policy is banned, pricing alone will not be able to signal the high-type firm's service quality; on the other hand, if tipping policy is allowed, the high-type firm can signal its service quality by tipping policy and pricing decision.

Next, I look at the cases where tipping policy is the optimal choice under complete information for the high-type firm but it can not use the full information price decision p^{Ht*} to separate itself from the low-type firm. As noted in condition (i) in Proposition 1, if $0 < \beta < 1$ and $(1 - \beta)(s_H - s_L) > V - c$, only when the proportion of informed consumers is high, that is $\alpha > \bar{\alpha}$, the high-type firm can distinguish itself with tipping policy and full information price p^{Ht*} . When the proportion of informed consumers is low, that is, $\alpha < \bar{\alpha}$, the strategy (*tipping*, p^{Ht*}) is too lucrative for the low-type firm to imitate. This is because there are enough uninformed consumers in the market to be persuaded, that is, $1 - \alpha > 1 - \bar{\alpha}$. The high-type firm needs to take a further step to protect itself, either by changing its retail price and keeping the tipping policy or by changing to non-tipping policy. When keeping the tipping policy, the high-type firm can optimally distort its price upwards to \bar{p} or downwards to \underline{p} where $\bar{p} = \frac{V + (s_H - s_L)(1 - \beta) + \sqrt{[V + (s_H - s_L)(1 - \beta)]^2 - \frac{4V(s_H - s_L)(1 - \beta)}{1 - \alpha}}}{2}$ and $\underline{p} = \frac{V + (s_H - s_L)(1 - \beta) - \sqrt{[V + (s_H - s_L)(1 - \beta)]^2 - \frac{4V(s_H - s_L)(1 - \beta)}{1 - \alpha}}}{2}$

If the high-type firm gives up the tipping policy and tries to signal itself with a non-tipping policy, when $\alpha \leq 1 - \frac{4V(s_H - s_L)}{(s_H - s_L + V)^2 - c^2}$, the high-type cannot effectively signal its type by non-tipping policy together with the full information price p^{Hn*} since the low-type can profitably imitate it. Similar as the price distortion in the tipping policy case, the high-type can also separate itself with a distorted price with non-tipping policy when the full information price can not do so. I can show that the high-type's profit under distorted price with tipping policy is higher than the one under distorted price with non-tipping policy.

When $\alpha > 1 - \frac{4V(s_H - s_L)}{(s_H - s_L + V)^2 - c^2}$, the high-type can also signal its type with non-tipping policy together with the full information price p^{Hn*} . The question then is the high-type should signal with tipping policy and distorted price or with non-tipping and full information price. I compare the high-type's profits under two situations and reach the following conclusion.

Proposition 2. *When $0 < \beta < 1$, $(1 - \beta)(s_H - s_L) > V - c$ and $\alpha < \bar{\alpha}$, the strategy pair $\{(tipping, \bar{p}), (non - tipping, V)\}$ or $\{(tipping, \underline{p}), (non - tipping, V)\}$, is a separating equilibrium satisfying intuitive criterion with the uninformed consumers' updated beliefs $b^*(tipping, \bar{p}) = 1$ and $b^*(non - tipping, V) = 0$.*

Proposition 2 shows that when the proportion of the informed consumers

is low, $\alpha < \bar{\alpha}$, the high-type cannot signal its type with the tipping policy together with the full information price. To prevent the low-type's imitation, the high-type distorts its full information price upwards to \bar{p} or downwards to \underline{p} . The distorted price together with the tipping policy still gives the high-type a higher profit than the one the full information price (or distorted price) with the non-tipping policy can lead to. One can notice the higher the α is, the less the high-type firm needs to distort its retail price. This is because the higher the α , the more informed consumers among all the consumers, the more the low-type will lose when mimicking the high-type's strategy with a retail price higher than V . So the less the the high-type needs to change away from its optimal strategy to discourage the low-type to imitate. Although the high-type may be able to signal its type by adopting a non-tipping policy together with full information price under certain conditions, i.e., $\alpha > 1 - \frac{4V(s_H - s_L)}{(s_H - s_L + V)^2 - c^2}$, the high-type is still better off by signaling with tipping policy and distorted retail price.

So far, I have discussed all the cases where the high-type firm would prefer a tipping policy under complete information. In the following, I look at the cases where the high-type firm would prefer a non-tipping policy under complete information to examine whether the high-type will be induced to use the tipping policy to signal its type.

When $\frac{3}{2} + \frac{V-c}{s_H - s_L} - \frac{(V-c)^2}{2(s_H - s_L)^2} < \beta < 2$ and $V - c < s_H - s_L$, according to Lemma 1, the high-type firm's optimal policy is non-tipping under complete information. It can distinguish itself from low-type by its optimal decision (*non-tipping*, p^{Hn*}) under complete information when the proportion of informed consumers is high, that is, $\alpha > 1 - \frac{4V(s_H - s_L)}{(s_H - s_L + V)^2 - c^2}$. However, when the proportion of informed consumers is low, $\alpha \leq 1 - \frac{4V(s_H - s_L)}{(s_H - s_L + V)^2 - c^2}$, the high-type firm can no longer separate itself by the optimal decision (*non-tipping*, p^{Hn*}) under complete information since the low-type will not lose too much from losing the informed consumers. In order to successfully signal its type, the high-type firm can either distort its retail price and keep the non-tipping policy or change to tipping policy with the appropriate retail price. I compare the high-type firm's profits between these two choices, and have the following conclusion.

Proposition 3. *When $\frac{3}{2} + \frac{V-c}{s_H - s_L} - \frac{(V-c)^2}{2(s_H - s_L)^2} < \beta < \bar{\beta}$, $s_H - s_L > V - c$, $\alpha \leq 1 - \frac{4V(s_H - s_L)}{(s_H - s_L + V)^2 - c^2}$ and $c < \sqrt{(s_H - s_L + V)^2 - \frac{4V(s_H - s_L)}{1-\alpha}}$, the high-type*

firm strategically signals itself with the strategy (tipping, p^{Ht}) rather than using the non-tipping policy, although it is better off with non-tipping policy under complete information.*¹⁵

Surprisingly, Proposition 3 shows that a high-type firm may strategically choose to adopt a tipping policy in order to distinguish itself from low-type, although this strategy is not its optimal decision even under complete information. The driving forces are as follows. As stated in Lemma 1, when consumers' generosity is high $\beta > \frac{3}{2} + \frac{V-c}{s_H-s_L} - \frac{(V-c)^2}{2(s_H-s_L)^2}$ and the service quality difference is relatively high $s_H - s_L > V - c$, the high-type firm's optimal decision is to adopt the non-tipping policy and charge a retail price of $p^{Hn*} = \frac{V+c+s_H-s_L}{2} > V$. The tipping policy is no longer efficient for the high-type firm because it needs to sacrifice its retail price substantially to accommodate consumers' tips as well as to attract the high-end consumers (i.e., with high θ) in the market. However, the high-type's optimal policy, the non-tipping policy, also makes it easier for the low-type to pretend to be high-type. This is because when the uninformed consumers observe a non-tipping policy and believe it as high-type, they do not need to consider the payment of tips when they make purchasing decision. Hence the retail price can be higher. Therefore, it is more profitable for the low-type to mimic, especially when the proportion of the informed consumers is low so there will not be much loss from losing the informed consumers by charging a high retail price. On the other hand, it is relatively more difficult for the low-type to pretend when the high-type adopts a tipping policy. Therefore, there is a tradeoff for the high-type between a less effective but more difficult to be imitated policy, i.e., tipping policy, and a more effective but less difficult to be imitated policy, i.e., non-tipping policy. When the proportion of the informed consumers is low, it is even more attractive for the low-type to pretend to be high-type when it adopts non-tipping policy. Hence, to separate itself from the low-type, the high-type strategically adopts a less effective policy, tipping policy.

Above I have examined the cases where pricing alone can not signal the service quality. In the following, I briefly discuss the cases where pricing alone can separate different types of service quality. If a separating equilibrium

$${}^{15}\bar{\beta} = 2 - \frac{2\alpha V}{(1-\alpha)(s_H-s_L)} - \frac{c[s_H-s_L-V+\sqrt{(s_H-s_L+V)^2-\frac{4V(s_H-s_L)^2}{1-\alpha}}]}{(s_H-s_L)^2}$$

exists with $X_H = X_L = \text{non-tipping}$, then pricing alone can be an effective signal. The strategy pair $\{(\text{Non-tipping}, p^{Hn*}), (\text{Non-tipping}, V)\}$ is a separating equilibrium with uninformed consumers' updated beliefs $b(\text{Non-tipping}, p^{Hn*}) = 1$ and $b(\text{Non-tipping}, V) = 0$ when (1) $\frac{3}{2} + \frac{V-c}{s_H-s_L} - \frac{(V-c)^2}{2(s_H-s_L)^2} < \beta < \bar{\beta}$, $s_H - s_L > V - c$ and $\alpha < 1 - \frac{4V(s_H-s_L)}{(s_H-s_L+V)^2-c^2}$, $c \geq \sqrt{(s_H - s_L + V)^2 - \frac{4V(s_H-s_L)}{1-\alpha}}$; (2) $\bar{\beta} < \beta < 2$, $s_H - s_L > V - c$; or (3) $\beta > \frac{3}{2} + \frac{V-c}{s_H-s_L} - \frac{(V-c)^2}{2(s_H-s_L)^2}$, $s_H - s_L > V - c$ and $\alpha > 1 - \frac{4V(s_H-s_L)}{(s_H-s_L+V)^2-c^2}$. The high-type would prefer non-tipping policy when it needs to lower its retail price substantially to use tipping policy, because of the high consumer generosity and relatively high quality difference. Especially, when the proportion of the informed consumers is high, that is, $\alpha > 1 - \frac{4V(s_H-s_L)}{(s_H-s_L+V)^2-c^2}$, the low-type will not find it profitable to pretend to be high-type due to the loss of the informed consumers in case of mimicking with a high retail price p^{Hn*} .

Proposition 4. *When $\beta > 2$ and $s_H - s_L < V - c$, there does not exist a separating equilibrium satisfying intuitive criterion. The strategy pair $\{(\text{non-tipping}, V), (\text{non-tipping}, V)\}$ is a pooling equilibrium together with the uninformed consumers' updated beliefs $b(\text{non-tipping}, V) = \gamma$.*

According to Lemma 1, when consumers' generosity level is high $\beta > 2$ and quality difference is relatively low $s_H - s_L < V - c$, the high-type firm's optimal decisions under complete information are to adopt a non-tipping policy and charge retail price $p^{Hn*} = V$, which is the same as the low-type firm's decisions when revealing its true type. So the high-type would not benefit if it deviates from this strategy in order to prevent the low-type to imitate. Hence, no separating equilibrium satisfying intuitive criterion exists and $\{(\text{non-tipping}, V), (\text{non-tipping}, V)\}$ is the pooling equilibrium strategy, with the uninformed consumers' posterior beliefs the same as their prior beliefs, that is, $b(\text{non-tipping}, V) = \gamma$.

4.3 MODEL EXTENSION

4.3.1 ENDOGENOUS DECISION ON SERVICE QUALITY

In the main model of this chapter, I assume that service quality is exogenously determined. In this model extension section, I allow a firm to endogenously

decide its service quality before it makes the decision on its tipping/non-tipping policy. In doing so, the firm incurs a fixed cost of offering the service quality s . Following the literature on cost of product quality (e.g. Moorthy 1988; Desai 2001; Tyagi 2004), I assume this cost is a quadratic function of service quality, that is, $f = s^2$. To simplify the analysis, I normalize the low service quality $s_L = 0$. To focus on the effect of consumers' generosity β on the high-type firm's service quality decision and simplify the analysis, I assume that $V - c = 0$ to concentrate on the cases where the service quality is relatively high comparing to the product quality, such as $(1 - \beta)(s_H - s_L) \geq V - c = 0$ in Equations (10) and (11).

Unlike the main model with exogenous service quality, when firms endogenously decide the service quality, this decision affects the subsequent decisions on tipping or non-tipping policy and the corresponding retail price. Stated differently, the high-type firm decides its tipping or non-tipping policy and retail price given its decision on its service quality. Under complete information, the high-type firm will choose to adopt a tipping policy when $s_H > 0$ and $0 < \beta < \frac{3}{2}$, and choose to adopt a non-tipping policy when $s_H > 0$ and $\beta > \frac{3}{2}$. Based on backwards induction, I work one step further to maximize the high-type firm's profit with respect to the service quality s_H given what we have in the main model. Hence the optimal service quality is $s_H^* = \frac{1}{4(2-\beta)}$, when $\beta \leq 1$ and is $s_H^* = \frac{1}{2} - \frac{\beta}{4}$ when $1 < \beta < \frac{3}{2}$. When $\beta > \frac{3}{2}$, its optimal service quality is $s_H^* = \frac{1}{8}$. I summarize the high-type firm's optimal decisions on service quality and tipping/non-tipping policy in the following Lemma.

Lemma 2. *When the high-type firm endogenously decides its service quality, under complete information, its service quality increases with the increase of consumers' generosity β when $\beta < 1$ and decreases with the increase of consumers' generosity β when $1 < \beta < \frac{3}{2}$, and the firm chooses to have a tipping policy when $0 < \beta < \frac{3}{2}$. When $\beta > \frac{3}{2}$, its service quality remains constant with the increase of consumers' generosity and the firm chooses to have a non-tipping policy.*

Next, I look at the case of incomplete information to examine the effect of the presence of the uninformed consumers on the high-type firm's decision on its service quality. First, under the conditions in Proposition 1, since the high-type firm can distinguish itself with its optimal strategy (*tipping*, p^{Ht*}) under complete information, its service quality should be the same as the

one under complete information, that is, $s_H^{i*} = s_H^*$. Secondly, under the conditions in Proposition 2, since the high-type firm has distorted its optimal retail price, its decision on service quality might consequently be affected. As stated earlier, the extent of the price distortion increases with the decrease of α . An extreme case is $\alpha = 0$ and $V = c = 0$. The high-type firm's profit function is $\pi = 0$ and the service quality is $s_H^* = 0$. Thirdly, under the conditions in Proposition 3, since the high-type firm's decision on tipping or non-tipping policy has changed, its service quality decision will also be influenced. The high-type firm's service quality decision under incomplete information is obtained by maximizing $\pi\{s_H, 1, p^{Ht*}, t\} = V - c + (1 - \frac{\beta}{2})s_H - s_H^2$ and $s_H^{i*} = \frac{1}{2} - \frac{\beta}{4}$. Comparing the high-type firm's service quality decision under incomplete information with the service quality under complete information, I find the following

Proposition 5. *When the high-type firm endogenously decides its service quality, its service quality under incomplete information s_H^{i*} is not higher than the one under complete information s_H^* , that is, $s_H^{i*} \leq s_H^*$.*

Proposition 5 shows that when there are uninformed consumers in the market, the high-type firm may lower its service quality in comparison to its decision when the market consists of only informed consumers. For example, when the high-type firm needs to distort its retail price and keep the tipping policy to signal its service quality under incomplete information, it does not have any incentive to offer the service quality as high as under complete information. This is because the distortion of retail price reduces the firm's capability to compensate for the cost incurred by offering a service quality as high as the one under complete information. Another case of lowering the service quality under incomplete information is when the high-type firm strategically uses the tipping policy to signal its service quality. Due to the high consumers' generosity, $\beta > \frac{3}{2}$, consumers' tipping behavior is significantly affected by the high type firm's decision on service quality as shown by the tip amount a consumer θ pays, i.e., $\theta\beta s_H$. Expecting such tipping behavior, the high-type firm has to lower its retail price more if it sets a higher service quality. Hence, together with the consideration of fixed cost $f = s^2$, the high-type firm has a lack of incentives to provide a service quality as high as the one under complete information and the optimal decision is to have a non-tipping policy.

4.3.2 BOTH FIRM AND SERVER CONTRIBUTE TO SERVICE QUALITY AND SHARE TIPS

In the main model of this chapter, I assume that the firm alone provides the service and receives consumers' tips. In this section, I consider the case where both the firm and server contribute to the service and share consumers' tips proportionally to their contribution. As presented by assumptions in the main model, the firm's service quality s_f is exogenously determined and can be either s_{fh} or s_{fl} . Besides the firm's contribution to service quality, the server's service quality is s_e , which can be either high s_{eh} or low s_{el} and $s_{eh} > s_{el}$. I assume the following sequence. First, given the exogenously determined firm's service quality s_f , the firm decides its retail price p and tipping or non-tipping policy. Secondly, the server exerts efforts to contribute to service quality, contingent on the firm's specific policy. I assume that the server can contribute two different levels of service quality depending on the firm's decision on tipping or non-tipping policy. When the firm chooses to have a tipping policy, the server contributes s_{eh} . When the firm chooses to have a non-tipping policy, the server contributes s_{el} . I normalize $s_{el} = 0$. Thirdly, consumers make purchasing decision and pay accordingly.

I. COMPLETE INFORMATION

To simplify the analysis, I normalize $s_{fl} = 0$. Hence the low-type firm's decision under complete information is to charge a retail price equal to V and adopt a non-tipping policy. The high-type firm's decision on tipping/non-tipping policy depends on the comparison of its profits under each policy. I save the derivations in the Technical Appendix and report the high-type firm's decision here. I obtain results similar to those shown in Lemma 1. Under complete information, when both the firm and server contribute to the service quality and share tips, the high-type firm should choose a tipping policy when consumers' generosity is low, i.e., $0 < \beta < \frac{4s_{eh}+3s_{fh}}{4s_{eh}+2s_{fh}} + \frac{V-c}{2s_{eh}+s_{fh}} - \frac{(V-c)^2}{2s_{fh}^2+4s_{eh}s_{fh}}$ if $s_{fh} \geq V-c$ and $0 < \beta < \frac{2s_{eh}+2s_{fh}}{2s_{eh}+s_{fh}}$ if $s_{fh} < V-c$. It should choose a non-tipping policy when consumers' generosity is high, i.e., $\beta > \frac{4s_{eh}+3s_{fh}}{4s_{eh}+2s_{fh}} + \frac{V-c}{2s_{eh}+s_{fh}} - \frac{(V-c)^2}{2s_{fh}^2+4s_{eh}s_{fh}}$ if $s_{fh} \geq V-c$ and $\beta > \frac{2s_{eh}+2s_{fh}}{2s_{eh}+s_{fh}}$ if $s_{fh} < V-c$.

It is noteworthy to mention that when both the firm and server contribute to the service quality and share tips, the high-type firm's optimal profit under

complete information (π^{ht*}) can be either higher or lower than the one under complete information (π^{Ht*}) when the firm alone contributes to the service quality and receives the tips. Specifically, when $\beta < 1$, $\pi^{ht*} \geq \pi^{Ht}$ and when $\beta > 1$, $\pi^{ht*} < \pi^{Ht*}$.

II. INCOMPLETE INFORMATION

When there is incomplete information, I mean that some consumers in the market, i.e., the uninformed consumers, cannot ascertain a firm's service quality. I assume that the server knows the firm type before he/she exerts efforts to contribute to service quality. Basically, the derivation of the high-type firm's signaling strategy follows the same procedure as in the main model. In this section, I mainly examine whether the findings in the main model still hold when both the firm and server contribute to the service quality and share tips if the firm chooses to have a tipping policy. I derive the conditions under which the main findings hold in the Technical Appendix. Comparing these conditions to those when the firm alone contributes to the service quality and receives the tips, I have the following finding

Proposition 6. *When both the firm and server contribute to the service quality and share tips, comparing to the signaling strategies when the firm alone contributes to the service quality and receives tips, the high-type firm (i) is less able to signal its service quality with its optimal decision under complete information (tipping, p^{ht*}) as in Proposition 1; (ii) is more likely to signal its service quality with distorted retail price with the tipping policy as in Proposition 2; and (iii) is less likely to strategically signal its service quality with tipping policy when its optimal decision is the non-tipping policy under complete information as in Proposition 3.*

Proposition 6 shows the effect of the server's contribution to the service quality and sharing of tips on the high-type firm's signaling strategy. The reasons behind the finding (i) are as follows. When $\beta < 1$ and $(1 - \beta)(s_{eh} + s_{fh}) \geq V - c$, the contribution of the server's service s_{eh} increases the optimal retail price the high-type firm charges, which makes it more attractive for the low-type firm to imitate. This attractiveness of high retail price leads to the situation that the low-type firm can afford to lose more informed consumers to profitably mimic the high-type firm's strategy. In other words,

the threshold value of α has to be higher than $\bar{\alpha}$ as in the main model. When $\beta < 1$ and $(1 - \beta)(s_{eh} + s_{fh}) < V - c$, since $s_{eh} > 0$, the parameter area is more restrictive than the one $(1 - \beta)s_H$ as in the main model. For the cases when $1 < \beta < \frac{4s_{eh}+3s_{fh}}{4s_{eh}+2s_{fh}} + \frac{V-c}{2s_{eh}+s_{fh}} - \frac{(V-c)^2}{2s_{fh}^2+4s_{eh}s_{fh}}$ and s_{fh} and $1 < \beta < \frac{2s_{eh}+2s_{fh}}{2s_{eh}+s_{fh}}$ and $s_{fh} < V - c$, because of $s_{eh} > 0$, the parameter area of β gets tighter. The reason the finding (ii) is complementary to the reason for the case when $\beta < 1$ and $(1 - \beta)(s_{eh} + s_{fh}) \geq V - c$ as explained for the finding (i). For the finding (iii), it is because the involvement of the server's contribution to the service quality decreases the high-type firm's profit under complete information if it chooses to have a tipping policy, which makes it easier for the low-type firm to mimic. Therefore, it is more difficult for the high-type firm to strategically use the tipping policy to signal its service quality.

4.4 CONCLUSION

Tipping is a widely observed phenomenon guided by social norms. Across different service industries, there may exist various levels of consumers' generosity. Managers and executives have been actively managing the tipping behavior in the market. This chapter offers explanations on how firms can signal their service quality with this special policy by transferring part of the decision of the final price to consumers. In particular, I investigate how consumers' generosity and the ratio of informed consumers to uninformed consumers affect firms' signaling strategy.

There are several interesting results which contribute to the existing signaling literature with important managerial implications for marketing practice. First, I show that under certain conditions the high-type firm can signal its service quality to the uninformed consumers with a tipping policy on top of the retail price which is its optimal strategy under complete information. Different from the literature where pricing alone can signal the product quality (e.g. Bagwell and Riordan 1991), the research in this chapter shows that under certain conditions it is not necessarily true that pricing alone can signal the service quality when the tipping policy is banned. With the assistance of tipping policy, the high-type firm can distinguish itself from the low-type firm. An important managerial implication is that a marketing manager of a high-type firm may want to transfer part of its price decision to consumers

to “show” their true service quality when the industry level tipping practice shows low consumers’ generosity.

Secondly, I show that a firm with high service quality may want to keep the tipping policy and increase or decrease its retail price, despite its optimal decision under complete information, to prevent the low-type from imitating. When consumers overall are not so generous and the ratio of informed consumers to uninformed consumers is too low, it is rather beneficial for the low-type to mimic the high-type. The high-type chooses to increase or decrease its retail price but still takes advantage of the tipping policy.

Thirdly, even when tipping policy is not preferable under complete information, a high-type firm may strategically choose to adopt it to send signals about its high service quality to uninformed consumers. When a manager of a high service provider makes decision on tipping/non-tipping policy, he/she should also consider how to distinguish itself from the low service providers and send signals to those consumers who could not directly tell its type. The best strategy might be different from the one when all consumers know its service type.

I acknowledge some limitations of the research in this chapter. Here, I only consider the signaling issue with tipping policy in a monopoly context. In the future, it would be interesting to investigate this issue in a duopoly context. In addition, I assume that product quality and service quality are independent, and consumers pay tips based on the service quality only. Future research can examine the scenarios where consumers’ tip amount is affected by both service quality and product quality. Furthermore, I assume that the two types of firms are different only in the dimension of service quality, future research can study the case when two types are different on both the service quality dimension and the product quality dimension.

CHAPTER 5

CONCLUSION

In this dissertation, I study firms' decision-making on marketing mix variables with the considerations of (1) consumers' uncertainty on product/service; (2) consumers' one or two-dimensional heterogeneity; and (3) their interactions with other firms in the market.

Specifically, Chapter 2 studies firms' advertising content decision in distribution channels and concludes that (1) a retailer may be more likely to advertise or include more information in its advertisement in a decentralized channel than in a centralized channel; (2) in a decentralized channel where the retailer makes the advertising decision before its upstream manufacturer makes the wholesale price decision, there may be less price-only advertising and more price-product advertising than in a centralized channel; (3) when a retailer makes the advertising decision prior to the wholesale price decision, the commitment to the advertising content may even hurt itself as well as the manufacturer; and (4) channel decentralization may increase consumer welfare.

Chapter 3 studies a manufacturer's product quality decision in distribution channels and concludes that (1) when consumers are heterogeneous either vertically on willingness-to-pay for product quality or horizontally on transaction costs, channel decentralization leads to same or lower product quality, however, when consumers are heterogeneous on two dimensions, channel decentralization may lead to higher product quality; (2) when consumers are heterogeneous on both dimensions, the decrease of consumer transaction cost does not necessarily increase a firm's profit; and (3) when consumers are heterogeneous on two dimensions, the decrease of consumer transaction cost does not necessarily benefit consumers.

Chapter 4 studies a firm with high service quality relies on tipping policy to distinguish itself from those with low service quality and concludes that: (1) under certain conditions, the high-type firm can signal its service quality

to the uninformed consumers with a tipping policy on top of the retail price under complete information; (2) a firm with high service quality may want to keep the tipping policy and increase or decrease its retail price under complete information, to prevent the low-type from imitating; and (3) even when tipping policy is not preferable under complete information, a high-type firm may strategically choose to adopt it to send signals about its high service quality to uninformed consumers.

APPENDIX A

APPENDIX FOR CHAPTER 2

Proof of Proposition 1: Based on the retailer's decision in the first stage, there exist four sub-games: no-advertising, price-only advertising, product-only advertising, and price-product advertising. Since product-only advertising leads to consumers' hold-up problem, there is zero demand for the product and zero profit for the firms.

I. No advertising

Given a retail price r , the probability that a consumer will buy the product is $Prob(v \geq r) = 1 - r$. Hence, the expected number of consumers that will purchase the product is $1 - r$. Given the wholesale price of w_{dc}^n , the retailer maximizes its expected profit $E(\pi_{dcR}^n) = (r_{dc}^n - w_{dc}^n)(1 - r_{dc}^n)$ and charges $r_{dc}^n = \frac{1+w_{dc}^n}{2}$, where the subscript dc refers to a decentralized channel with the retailer's earlier decision on its advertising content. Anticipating the retailer's decision of $r_{dc}^n = \frac{1+w_{dc}^n}{2}$, the upstream manufacturer maximizes its expected profit $E(\pi_{dcM}^n) = w_{dc}^n(1 - r_{dc}^n)$. Hence the price decisions are $w_{dc}^{n*} = \frac{1}{2}$ and $r_{dc}^{n*} = \frac{3}{4}$ and the expected profits are $E(\pi_{dcM}^{n*}) = \frac{1}{8}$ and $E(\pi_{dcR}^{n*}) = \frac{1}{16}$.

Similar as in the centralized channel, the condition under which all consumers will search is

$$c \leq E(\max\{v - r_{dc}^{n*}, 0\}) = \frac{1}{32} \quad (\text{A.1})$$

When the retailer does no-advertising, if $c \leq \frac{1}{32}$, consumers will rationally form expectations of the retail price and search for the product and price information. If $c > \frac{1}{32}$, however, consumers will not search because the expected benefit of doing it does not offset the cost of doing it.

II. Price-only advertising

When the retailer makes the decision of doing price-only advertising prior to the manufacturer's wholesale price decision, the retail price is set in such a way that a consumer's expected benefit of searching equals her search cost,

which leads to $r_{dc}^{p*} = 1 - \sqrt{2c}$. However, with the anticipation of the retailer's decision of r_{dc}^{p*} , the manufacturer will charge a wholesale price $w_{dc}^{p*} = r_{dc}^{p*} = 1 - \sqrt{2c}$. Therefore, the retailer's expected profit is $E(\pi_{dcR}^{p*}) = 0$ and the manufacturer's expected profit is $E(\pi_{dcM}^{p*}) = \sqrt{2c} - 2c$.

III. Price-product advertising

The manufacturer's profit and the retailer's profit are $\pi_{dcM}^{pp} = w_{dc}^{pp}(1 - r_{dc}^{pp} - c)$ and $\pi_{dcR}^{pp} = (r_{dc}^{pp} - w_{dc}^{pp})(1 - r_{dc}^{pp} - c)$. Following backward induction, I first maximize the retailer's profit and get $r_{dc}^{pp} = \frac{1-c+w_{dc}^{pp}}{2}$. Then I maximize the manufacturer's profit and get $w_{dc}^{pp*} = \frac{1-c}{2}$ and $r_{dc}^{pp*} = \frac{3(1-c)}{4}$. The channel members' optimal profits are $\pi_{dcM}^{pp*} = \frac{(1-c)^2}{8}$ and $\pi_{dcR}^{pp*} = \frac{(1-c)^2}{16}$.

Now, I solve the retailer's decision on advertising content. By comparing its profits across four sub-games, the retailer's advertising strategy in a decentralized channel where it makes its advertising decision prior to the wholesale price decision is: When $c \leq \frac{1}{32}$, the retailer will not advertise; When $\frac{1}{32} < c < 1$, the retailer will advertise both product and price information.

Therefore, I compare the advertising strategies in Table 1.2 to that in Table 1.1 and conclude the following: When $\frac{1}{32} < c < 0.4075$, a retailer does price-product advertising in a decentralized channel where the retailer makes the advertising decision prior to its upstream manufacturer's wholesale price decision, but it conducts no-advertising or price-only advertising in a centralized channel. \square

Proof of Proposition 2: Based on backward induction, given any wholesale price (w_d), the retailer decides the advertising content and its retail price (r_d). It can choose to have no-advertising, price-only advertising, product-only advertising, or price-product advertising.

When the retailer chooses not to advertise at all, its expected profit is $E(\pi_{dR}) = (r_d - w_d)(1 - r_d)$ with the optimal price $r_d = \frac{1+w_d}{2}$ if $\int_{\frac{1+w_d}{2}}^1 (r - \frac{1+w_d}{2}) = \frac{(1-w_d)^2}{8} \geq c$. The retailer's expected profit is $\pi_{dR} = \frac{(1-w_d)^2}{4}$. When the retailer chooses to have price-only advertising, its expected profit is $E(\pi_{dR}) = (r_d - w_d)(1 - r_d)$ with the optimal price $r_d = 1 - \sqrt{2c}$ such that the consumers' expected surplus equals to their search cost. The retailer's profit is $\pi_{dR} = (1 - \sqrt{2c} - w)\sqrt{2c}$. When the retailer chooses to have product-only advertising, due to the consumers' hold-up problem, there is no demand for the product and zero profit for the retailer. When the retailer chooses to have price-product advertising, its expected profit is $E(\pi_{dR}) = (r_d - w_d)(1 - r_d - c)$

with the optimal price $r_d = \frac{1+w_d-c}{2}$. The retailer's profit is $\pi_{dR} = \frac{(1-c-w_d)^2}{4}$.

By comparing the retailer's profits across above four options, its best response of advertising content and retail price is

$$\begin{cases} (\text{No - advertising}, r_d = \frac{1+w_d}{2}), & \text{if } w_d \leq 1 - 2\sqrt{2c}; \\ (\text{price - only}, r_d = 1 - \sqrt{2c}), & \text{if } 1 - 2\sqrt{2c} < w_d \leq 1 - 2\sqrt{2c} + 2^{5/4}c^{3/4} - c; \\ (\text{price + product}, r_d = \frac{1+w_d-c}{2}), & \text{if } w_d > 1 - 2\sqrt{2c} + 2^{5/4}c^{3/4} - c. \end{cases} \quad (\text{A.2})$$

With the anticipation of the retailer's best response, the manufacturer maximizes its expected profit

$$E(\pi_{dM}) = \begin{cases} w_d \times \frac{1-w_d}{2}, & \text{if } w_d \leq 1 - 2\sqrt{2c}; \\ w_d \times \sqrt{2c}, & \text{if } 1 - 2\sqrt{2c} < w_d \leq 1 - 2\sqrt{2c} + 2^{5/4}c^{3/4} - c; \\ w_d \times \frac{1-w_d-c}{2}, & \text{if } w_d > 1 - 2\sqrt{2c} + 2^{5/4}c^{3/4} - c. \end{cases} \quad (\text{A.3})$$

I solve each of the three constrained optimization problems for the manufacturer and compare its optimal profits under each optimization problem, and obtain the manufacturer's optimal wholesale price

$$w_d^* = \begin{cases} \frac{1}{2}, & \text{if } c \leq 0.0139; \\ 1 - 2\sqrt{2c} + 2^{5/4}c^{3/4} - c, & \text{if } 0.0139 < c \leq 0.3447; \\ \frac{1-c}{2}, & \text{if } c > 0.3447. \end{cases} \quad (\text{A.4})$$

Hence, based on the retailer's best response, its retail price and advertising content decisions are

$$\begin{cases} (\text{no - advertising}, r_d^* = \frac{3}{4}), & \text{if } c \leq 0.0139; \\ (\text{price - only}, r_d^* = 1 - \sqrt{2c}), & \text{if } 0.0139 < c \leq 0.3447; \\ (\text{price - product}, r_d^* = \frac{3(1-c)}{4}), & \text{if } c > 0.3447. \end{cases} \quad (\text{A.5})$$

Therefore, I compare the retailer's advertising strategy in the decentralized channel to that in the centralized channel and conclude the following: When $0.0139 < c < \frac{1}{8}$ ($0.3447 < c < 0.4075$), the retailer does price-only advertising (price-product advertising) in a decentralized channel where it makes advertising decision after its upstream manufacturer's wholesale price decision, but it conducts no-advertising (price-only advertising) in a centralized channel. \square

Proof of Proposition 3: When an upstream manufacturer chooses not to advertise its product information, given any wholesale price, by comparing its profits across the following two options: (1) no-price advertising and $r_{ds}^{nn} = \frac{1+w_{ds}^n}{2}$, which gives $\pi_{dsR}^{nn} = \frac{(1-w_{ds}^n)^2}{4}$; and (2) price-advertising and $r_{ds}^{np} = 1 - \sqrt{2c}$, which gives $\pi_{dsR}^{np} = (1 - \sqrt{2c} - w_{ds}^n)\sqrt{2c}$, the retailer's best response is (*no - advertising*, $p_{ds}^{nn} = \frac{1+w_{ds}^n}{2}$) when $w_{ds}^n < 1 - 2\sqrt{2c}$ and (*price - advertising*, $r_{ds}^{np} = 1 - \sqrt{2c}$) when $1 - 2\sqrt{2c} < w_{ds}^n < 1 - \sqrt{2c}$. The manufacturer then maximizes its profit under the option of no product advertising with the anticipation of the retailer's best response and its optimal decision is: $w_{ds}^n = \frac{1}{2}$ when $c < 0.011$ with $\pi_{dsM}^n = \frac{1}{8}$, and $w_{ds}^n = 1 - \sqrt{2c}$ when $0.011 < c < 0.5$ with $\pi_{dsM}^n = \sqrt{2c} - 2c$.

When an upstream manufacturer chooses to advertise its product information, given any wholesale price, the retailer can only choose to advertise the retail price because of the hold-up problem otherwise. The retailer maximizes its profit $\pi_{dsR}^{pp} = (r_{ds}^{pp} - w_{ds}^{pp})(1 - r_{ds}^{pp} - c)$ and obtains $r_{ds}^{pp} = \frac{1+w_{ds}^{pp}-c}{2}$ as its best response when given any wholesale price. Then the manufacturer maximizes its profit with the anticipation of the retailer's best response and obtains the optimal wholesale price $w_{ds}^{pp} = \frac{1-c}{2}$ with the optimal profit $\pi_{dsM}^{pp} = \frac{(1-c)^2}{8}$.

Hence, the manufacturer compares its profits across two different options of with and without product advertising and gets the final advertising decisions for the distribution channel as follows: when $c < 0.011$, there is no advertising on either product or price; When $0.011 < c < 0.463$, there is price-only advertising; when $0.463 < c < 1$, there is price and product advertising.

Therefore, I compare the optimal advertising strategy in the decentralized channel to that in the centralized channel, and conclude the following: When $0.011 < c < \frac{1}{8}$, the retailer does price-only advertising in a decentralized channel where an upstream manufacturer decides on product advertising and a downstream retailer decides on price advertising, but it conducts no advertising in a centralized channel. \square

Proof of Proposition 4: In a decentralized channel where the retailer makes the advertising decision prior to the manufacturer's wholesale price decision, the channel members' profits are:

$$\pi_{dcM}^* = \begin{cases} \frac{1}{8}, & \text{if } c \leq \frac{1}{32}; \\ \frac{(1-c)^2}{8}, & \text{if } \frac{1}{32} < c < 1. \end{cases} \quad (\text{A.6})$$

$$\pi_{dcR}^* = \begin{cases} \frac{1}{16}, & \text{if } c \leq \frac{1}{32}; \\ \frac{(1-c)^2}{16}, & \text{if } \frac{1}{32} < c < 1. \end{cases} \quad (\text{A.7})$$

In a decentralized channel where the retailer makes the advertising decision after the manufacturer's wholesale price decision, the channel members' profits are:

$$\pi_{dM}^* = \begin{cases} \frac{1}{8}, & \text{if } c \leq 0.0139; \\ (1 - 2\sqrt{2c} + 2^{5/4}c^{3/4} - c)\sqrt{2c}, & \text{if } 0.0139 < c \leq 0.3447; \\ \frac{(1-c)^2}{8}, & \text{if } c > 0.3447. \end{cases} \quad (\text{A.8})$$

$$\pi_{dR}^* = \begin{cases} \frac{1}{16}, & \text{if } c \leq 0.0139; \\ (\sqrt{2c} - 2^{5/4}c^{3/4} + c)\sqrt{2c}, & \text{if } 0.0139 < c \leq 0.3447; \\ \frac{(1-c)^2}{16}, & \text{if } c > 0.3447. \end{cases} \quad (\text{A.9})$$

The retailer's earlier decision on its advertising strategy hurts the manufacturer when $0.0139 < c < 0.3447$ since $\pi_{dcM}^* = \frac{1}{8} < \pi_{dM}^* = (1 - 2\sqrt{2c} + 2^{5/4}c^{3/4} - c)\sqrt{2c}$ when $0.0139 < c < \frac{1}{32}$ and $\pi_{dcM}^* = \frac{(1-c)^2}{8} < \pi_{dM}^* = (1 - 2\sqrt{2c} + 2^{5/4}c^{3/4} - c)\sqrt{2c}$ when $\frac{1}{32} < c < 0.3447$.

The retailer's earlier decision on its advertising strategy benefits the retailer when $0.0139 < c < 0.0886$ since $\pi_{dcR}^* = \frac{1}{16} > \pi_{dR}^* = (\sqrt{2c} - 2^{5/4}c^{3/4} + c)\sqrt{2c}$ when $0.0139 < c < \frac{1}{32}$ and $\pi_{dcR}^* = \frac{(1-c)^2}{16} > \pi_{dR}^* = (\sqrt{2c} - 2^{5/4}c^{3/4} + c)\sqrt{2c}$ when $\frac{1}{32} < c < 0.0886$. The earlier decision hurts the retailer when $0.0886 < c < 0.3447$ since $\pi_{dcR}^* = \frac{(1-c)^2}{16} < \pi_{dR}^* = (\sqrt{2c} - 2^{5/4}c^{3/4} + c)\sqrt{2c}$. \square

Proof of Proposition 5: When $\frac{1}{8} < c < 0.4075$ ($0.3447 < c < 0.4075$), in the decentralized channel where the retailer makes the advertising decision prior to (after) the manufacturer's wholesale price decision, price-product advertising will be practiced and only consumers with non-negative consumers will visit the store to purchase the information. So, at an aggregate level, consumers receive positive welfare. However, in the centralized channel, when $\frac{1}{8} < c < 0.4075$ ($0.3447 < c < 0.4075$), only price-advertising is practiced which means that consumers expected benefit of visiting the store equals to the potential cost. So at an aggregate level, consumer welfare equals to zero. Hence, channel decentralization leads to higher consumer welfare and the first half of Proposition 6 is proved.

Next, I prove the second half of Proposition 5. In a decentralized channel where the retailer makes its advertising decision prior to the manufacturer's wholesale price decision, consumer and social welfare are given by

$$CS_{dc}^* = \begin{cases} \frac{1}{32} - c, & \text{if } c \leq \frac{1}{32}; \\ \frac{(1-c)^2}{32}, & \text{if } \frac{1}{32} < c < 1. \end{cases} \quad (\text{A.10})$$

$$SW_{dc}^* = \begin{cases} \frac{7}{32} - c, & \text{if } c \leq \frac{1}{32}; \\ \frac{7(1-c)^2}{32}, & \text{if } \frac{1}{32} < c < 1. \end{cases} \quad (\text{A.11})$$

In a decentralized channel where the retailer makes the advertising decision after the manufacturer's wholesale price decision, consumer and social welfare are given by

$$CS_d^* = \begin{cases} \frac{1}{32} - c, & \text{if } c \leq 0.0139; \\ 0, & \text{if } 0.0139 < c \leq 0.3447; \\ \frac{(1-c)^2}{32}, & \text{if } c > 0.3447. \end{cases} \quad (\text{A.12})$$

Social welfare is

$$SW_d^* = \begin{cases} \frac{7}{32} - c, & \text{if } c \leq 0.0139; \\ \sqrt{2c} - 2c, & \text{if } 0.0139 < c \leq 0.3447; \\ \frac{7(1-c)^2}{32}, & \text{if } c > 0.3447. \end{cases} \quad (\text{A.13})$$

Hence, $CS_{dc}^* = \frac{1}{32} - c > CS_d^* = 0$ when $0.0139 < c < \frac{1}{32}$ and $CS_{dc}^* = \frac{(1-c)^2}{32} > CS_d^* = 0$ when $\frac{1}{32} < c < 0.3447$. $SW_{dc}^* = \frac{7}{32} - c > SW_d^* = \sqrt{2c} - 2c$ when $0.0139 < c < \frac{1}{32}$ and $SW_{dc}^* = \frac{7(1-c)^2}{32} > SW_d^* = \sqrt{2c} - 2c$ when $\frac{1}{32} < c < 0.0394$. $SW_{dc}^* = \frac{7}{32} - c < SW_d^* = \sqrt{2c} - 2c$ when $0.0394 < c < 0.3447$. \square

APPENDIX B

APPENDIX FOR CHAPTER 3

Proof of Proposition 1: When consumers are vertically heterogeneous, the manufacturer's product quality decisions in the centralized and decentralized channels are shown in Equations (1) and (3) respectively. By comparing q_{vc}^* and q_{vd}^* , when $a \leq \frac{2}{3}$, $q_{vc}^* = q_{vd}^* = \frac{1}{3}$; when $a > \frac{2}{3}$, $q_{vc}^* > q_{vd}^*$ since $q_{vc}^* = \frac{a}{2} > q_{vd}^* = \frac{1}{3}$ if $\frac{2}{3} < a < \frac{5}{6}$ and $q_{vc}^* = \frac{a}{2} > q_{vd}^* = \frac{2a-1}{2}$ if $\frac{5}{6} < a < 1$. When consumers are horizontally heterogeneous, the manufacturer's product quality decisions in the centralized and decentralized channels are shown in Equations (6) and (9). Obviously, $q_{hc}^* = q_{hd}^* = \frac{1}{2}$.

(Retailer's profit) When consumers are vertically heterogeneous and consumer heterogeneity is low, $a > \frac{5}{6}$, in the decentralized channel $\frac{d\pi_{vr}^*}{da} = \frac{d(2a-1)(1-a)/2}{da} = \frac{3}{2} - 2a < 0$. When consumers are horizontally heterogeneous and consumer heterogeneity is low, $t < \frac{1}{16}$, in the decentralized channel $\frac{d\pi_{hr}^*}{dt} = 1 > 0$.

(Consumer welfare) When consumers are vertically heterogeneous and consumer heterogeneity is low $a > \frac{2}{3}$ ($a > \frac{5}{6}$) in the centralized channel (decentralized channel), $\frac{dCS_{vc}^*}{da} = \frac{1}{4} - \frac{a}{2} < 0$ ($\frac{dCS_{vd}^*}{da} = \frac{3}{4} - a < 0$). When consumers are horizontally heterogeneous and consumer heterogeneity is low $t < \frac{1}{8}$ ($t < \frac{1}{16}$) in the centralized channel (decentralized channel), $\frac{dCS_{hc}^*}{dt} = \frac{1}{2} > 0$ ($\frac{dCS_{hd}^*}{dt} = \frac{1}{2} > 0$). \square

Proof of Proposition 2: To compare the optimal product quality in different distribution channels, I first solve the profit-maximization problem in each distribution channel. In a centralized channel, maximizing the manufacturer's profit $\pi = (p - q^2) \times D$, where $D = \frac{1}{1-a}(1 - \frac{p}{q} - \frac{t}{2q})$ if $q - p \geq t$ and $D = \frac{(q-p)^2}{(1-a)2qt}$ if $q - p < t$, with respect to p and q , I obtain the optimal product quality q_C^* in the centralized channel

$$q_C^* = \begin{cases} \frac{1+\sqrt{1+6t}}{6}, & \text{if } t < \frac{4}{25}; \\ \frac{2}{5}, & \text{if } t \geq \frac{4}{25}. \end{cases} \quad (\text{B.1})$$

In a decentralized channel, the manufacturer's profit is $\pi(M) = (w - q^2) \times D$ and the retailer's profit is $\pi(R) = (p - w) \times D$, where $D = \frac{1}{1-a}(1 - \frac{p}{q} - \frac{t}{2q})$ if $q - p \geq t$ and $D = \frac{(q-p)^2}{(1-a)2qt}$ if $q - p < t$. I solve the game based on backward induction and maximize the retailer's profit $\pi(R)$ with respect to the retail price p . The retailer's best responses are

$$p = \begin{cases} \frac{2q+2w-t}{4}, & \text{if } q - w \geq \frac{3t}{2}; \\ \frac{q+2w}{3}, & \text{if } q - w < \frac{3t}{2}. \end{cases} \quad (\text{B.2})$$

Then given the retailer's best responses, I maximize the manufacturer's profit $\pi(M)$ with respect to w and q , and obtain the optimal product quality q_D^* in the decentralized channel

$$q_D^* = \begin{cases} \frac{1+\sqrt{1+6t}}{6}, & \text{if } t \leq \frac{3}{32}; \\ \sqrt{\frac{3t}{2}}, & \text{if } \frac{3}{32} < t < \frac{8}{75}; \\ \frac{2}{5}, & \text{if } t \geq \frac{8}{75}; \end{cases} \quad (\text{B.3})$$

When $t \in (\frac{3}{32}, \frac{8}{75})$, I have $q_D^* - q_C^* = \sqrt{\frac{3t}{2}} - \frac{1+\sqrt{1+6t}}{6} > 0$. When $t \in [\frac{8}{75}, \frac{4}{25})$, $q_D^* - q_C^* = \frac{2}{5} - \frac{1+\sqrt{1+6t}}{6} > 0$. \square

Proof of Proposition 3: In the decentralized channel, when $\frac{3}{32} < t < \frac{8}{75}$, marginal consumers are $\theta_D(t, x) = \frac{p}{q} + \frac{tx}{q}$. Since the marginal consumer line crosses the consumer $(\theta, x) = (1, 1)$, the total demand of the product is $D = \frac{(q-p)^2}{2qt(1-a)} = \frac{1}{1-a}(1 - \frac{p}{q} - \frac{t}{2q}) = \frac{\sqrt{6t}}{6(1-a)}$, which increases with the increase of t . The retailer's profit margin $p - w = t/2$ also increases with the increase of t . However, for the manufacturer, its profit margin $w - q^2 = \sqrt{\frac{3t}{2}} - 3t$ decreases with the increase of t and this effect outperforms the positive effect of demand, because $D \frac{\Delta(w-q^2)}{\Delta t} + (w - q^2) \frac{\Delta D}{\Delta t} = \frac{\sqrt{6t}}{6(1-a)}(\sqrt{\frac{3}{8t}} - 3) + (\sqrt{\frac{3t}{2}} - 3t) \frac{\sqrt{6t}}{12t(1-a)} = \frac{1}{4(1-a)}(2 - 3\sqrt{6t}) < 0$. The total channel profit increases with the increase of t when $t \in [\frac{3}{32}, \frac{8}{75}]$ because when $t \in [\frac{3}{32}, \frac{8}{75}]$, $\frac{\Delta\pi(M)}{\Delta t} = \frac{1}{2(1-a)} - \frac{3\sqrt{6t}}{4(1-a)} < 0$ and $\frac{\Delta\pi(R)}{\Delta t} = \frac{\sqrt{6t}}{8(1-a)} > 0$, and $\frac{\Delta[\pi(M)+\pi(R)]}{\Delta t} = \frac{1}{2(1-a)} - \frac{3\sqrt{6t}}{4(1-a)} + \frac{\sqrt{6t}}{8(1-a)} \geq 0$.

When $t \leq \frac{3}{32}$, since $\frac{\Delta\pi(M)}{\Delta t} = \frac{-3t+18t^2-(1+\sqrt{1+6t})}{6\sqrt{1+6t}(1+\sqrt{1+6t})^2(1-a)} < 0$ and $\frac{\Delta\pi(R)}{\Delta t} = \frac{-3t+18t^2-(1+\sqrt{1+6t})}{12\sqrt{1+6t}(1+\sqrt{1+6t})^2(1-a)} < 0$, both the manufacturer's and retailer's profits increase with the decrease of t . Similarly, when $t \geq \frac{8}{75}$, since $\frac{\Delta\pi(M)}{\Delta t} = -\frac{32}{28125t^2(1-a)} < 0$ and $\frac{\Delta\pi(R)}{\Delta t} = -\frac{64}{84375t^2(1-a)} < 0$, both the manufacturer's and retailer's profits increase with the decrease of t .

In the centralized channel, when $t \leq \frac{4}{25}$, $\frac{\Delta\pi_C}{\Delta t} = \frac{-3t+18t^2-(1+\sqrt{1+6t})}{3\sqrt{1+6t}(1+\sqrt{1+6t})^2(1-a)} < 0$, and when $t > \frac{4}{25}$, $\frac{\Delta\pi_C}{\Delta t} = -\frac{8}{3125t^2(1-a)} < 0$; thus, the profit increases with the decrease of t . \square

Proof of Proposition 4:

In a decentralized channel, based on the optimal price and quality, the individual consumer surplus $S_D(t, x)$ for consumers located at x with willingness-to-pay θ can be described as:

$$S_D(t, x) = \begin{cases} \frac{1+\sqrt{1+6t}}{6}\theta - \frac{5-12t+5\sqrt{1+6t}}{36} - tx, & \text{if } 0 < t \leq \frac{3}{32}; \\ \sqrt{\frac{3t}{2}}\theta - (\sqrt{\frac{3t}{2}} - t) - tx, & \text{if } \frac{3}{32} < t < \frac{8}{75}; \\ \frac{2}{5}\theta - \frac{22}{75} - tx, & \text{if } t \geq \frac{8}{75}. \end{cases} \quad (\text{B.4})$$

The marginal consumers who are indifferent between buying and not buying are located at:

$$\theta_D(x) = \begin{cases} \frac{5}{6} - \frac{6tx-2t}{1+\sqrt{1+6t}}, & \text{if } 0 < t \leq \frac{3}{32}; \\ 1 + (x-1)\sqrt{\frac{3t}{2}}, & \text{if } \frac{3}{32} < t < \frac{8}{75}; \\ \frac{11}{15} + \frac{5tx}{2}, & \text{if } t \geq \frac{8}{75}. \end{cases} \quad (\text{B.5})$$

By summing up the individual consumer surpluses, I obtain the following consumer welfare:

$$CS_D^* = \begin{cases} \frac{1-36t+(1+24t)\sqrt{1+6t}}{432(1-a)}, & \text{if } t \leq \frac{3}{32}; \\ \frac{t\sqrt{6t}}{18(1-a)}, & \text{if } \frac{3}{32} < t < \frac{8}{75}; \\ \frac{128}{253125t(1-a)}, & \text{if } t \geq \frac{8}{75}. \end{cases} \quad (\text{B.6})$$

Since when $\frac{3}{32} < t < \frac{8}{75}$, $\frac{\Delta CS_D^*}{\Delta t} = \frac{\sqrt{6t}}{12(1-a)} > 0$, consumer welfare increases with the increase of t . But when $\frac{8}{75} \leq t < \frac{4}{25}$, $\frac{\Delta CS_D^*}{\Delta t} = -\frac{128}{253125t^2(1-a)} < 0$, consumer welfare decreases with the increase of t .

Social welfare consists of two parts, total consumer surplus and the channel profit. In the decentralized channel, given the product quality and price, I have:

$$SW_D^* = \begin{cases} \frac{1-36t+(1+24t)\sqrt{1+6t}}{432(1-a)} + \frac{(1-6t+\sqrt{1+6t})^2}{72(1+\sqrt{1+6t})(1-a)}, & \text{if } 0 < t \leq \frac{3}{32}; \\ \frac{t}{18(1-a)}\sqrt{6t} + \frac{t}{2(1-a)} - \frac{5t}{12}\sqrt{6t(1-a)}, & \text{if } \frac{3}{32} < t < \frac{8}{75}; \\ \frac{128}{253125t(1-a)} + \frac{32}{28125t(1-a)} + \frac{64}{84375t(1-a)}, & \text{if } t \geq \frac{8}{75}; \end{cases} \quad (\text{B.7})$$

$$\frac{\partial SW_D^*}{\partial t} = \begin{cases} < 0, & \text{if } 0 < t \leq \frac{3}{32}; \\ \frac{1}{2(1-a)} - \frac{13\sqrt{6t}}{24(1-a)} > 0, & \text{if } \frac{3}{32} < t < \frac{8}{75}; \\ < 0, & \text{if } t \geq \frac{8}{75}. \end{cases} \quad (\text{B.8})$$

Thus, one can see that when $t \in (\frac{3}{32}, \frac{8}{75})$, social welfare increases with the increase of t . When $t \leq \frac{3}{32}$ or $t \geq \frac{8}{75}$, social welfare decreases with the increase of t .

In a centralized channel, based on the optimal product quality and price, the surplus of individual consumer (θ, x) is

$$S_C(t, x) = \begin{cases} \frac{1+\sqrt{1+6t}}{6}\theta - \frac{2-3t+2\sqrt{1+6t}}{18} - tx, & \text{if } 0 < t \leq \frac{4}{25}; \\ \frac{2}{5}\theta - \frac{6}{25} - tx, & \text{if } t > \frac{4}{25}. \end{cases} \quad (\text{B.9})$$

Thus, the marginal consumers $(\underline{\theta}_C(t, x))$ who are indifferent between buying and not buying are located at

$$\underline{\theta}_C(t, x) = \begin{cases} \frac{2-3t+2\sqrt{1+6t}}{3(1+\sqrt{1+6t})} + \frac{6tx}{1+\sqrt{1+6t}}, & \text{if } 0 < t \leq \frac{4}{25}; \\ \frac{3}{5} + \frac{5tx}{2}, & \text{if } t > \frac{4}{25}. \end{cases} \quad (\text{B.10})$$

By summing up the individual consumer surpluses, I calculate consumer welfare in the centralized channel as

$$CS_C^* = \begin{cases} \frac{2-45t+(2+21t)\sqrt{1+6t}}{216(1-a)}, & \text{if } 0 < t \leq \frac{4}{25}; \\ \frac{16}{9375t(1-a)}, & \text{if } t > \frac{4}{25}. \end{cases} \quad (\text{B.11})$$

Since when $t \leq \frac{4}{25}$, $\frac{\Delta CS_D^*}{\Delta t} = \frac{3+21t-5\sqrt{1+6t}}{24\sqrt{1+6t}(1-a)} < 0$, and when $t > \frac{4}{25}$, $\frac{\Delta CS_D^*}{\Delta t} = -\frac{16}{9375t^2(1-a)} < 0$, consumer welfare always decreases with the increase of t .

Social welfare always decreases with the increase of t because

$$SW_C^* = \begin{cases} \frac{2-45t+(2+21t)\sqrt{1+6t}}{216(1-a)} + \frac{(1-6t+\sqrt{1+6t})^2}{54(1+\sqrt{1+6t})(1-a)}, & \text{if } 0 < t \leq \frac{4}{25}; \\ \frac{16}{9375t(1-a)} + \frac{8}{3125t(1-a)}, & \text{if } t > \frac{4}{25}; \end{cases} \quad (\text{B.12})$$

$$\frac{\partial SW_C^*}{\partial t} = \begin{cases} < 0, & \text{if } 0 < t \leq \frac{4}{25}; \\ < 0, & \text{if } t > \frac{4}{25}. \end{cases} \quad (\text{B.13})$$

□

APPENDIX C

APPENDIX FOR CHAPTER 4

Proof of Proposition 1: To prove that whether the strategy pair $\{(tipping, p^{Ht*}), (Non-tipping, V)\}$ is a separating equilibrium satisfying intuitive criterion, I check whether the strategy pair together with the uninformed consumers' updated beliefs $b * (tipping, p^{Ht*}) = 1$ and $b * (Non - tipping, V) = 0$ maximizes the high-type firm's profit subject to two constraints. Constraint 1 is $\pi\{s_L, 1, p^{Ht*}, t\} \leq (\max\{\pi\{s_L, 0, p, x\} = V\})$ and constraint 2 is $\pi\{s_H, 1, p^{Ht*}, t\} \geq \max\{\pi\{s_H, 0, p, x\}$.

Since the strategy $(tipping, p^{Ht*})$ maximizes the high-type's profit under complete information, I check whether the strategy also satisfies the two constraints.

(1) Condition (i)

When $\beta < 1$ and $(1 - \beta)(s_H - s_L) > V - c$, to satisfy Constraint 1, I need $\pi\{s_L, 1, p^{Ht*}, t\} = p^{Ht*}(1 - \alpha)(1 - \frac{p^{Ht*} - V}{(s_H - s_L)(1 - \beta)}) \leq (\max\{\pi\{s_L, 0, p, x\} = V\})$, that is, $\alpha > 1 - \frac{(2 - \beta)^2(s_H - s_L)V}{[V + (1 - \beta)c + (1 - \beta)^2(s_H - s_L)](s_H - s_L + V - c)}$. To satisfy Constraint 2, we need $\pi\{s_H, 1, p^{Ht*}, t\} \geq \max\{\pi\{s_H, 0, p, x\}$, which means $\pi\{s_H, 1, p^{Ht*}, t\} \geq \max\{\pi\{s_H, 0, V, t\}, \pi\{s_H, 0, V, n\}\}$ and $\frac{(V - c + s_H - s_L)^2}{2(2 - \beta)(s_H - s_L)} \geq \max\{(V - c) + \int_0^1 \beta(s_H - s_L)\theta d\theta, V - c\}$. This holds under $\beta < 1$ and $s_H - s_L > V - c$. Hence, I have condition (i) $\beta < 1$, $V - c < (1 - \beta)(s_H - s_L)$ and $\alpha > 1 - \frac{(2 - \beta)^2(s_H - s_L)V}{[V + (1 - \beta)c + (1 - \beta)^2(s_H - s_L)](s_H - s_L + V - c)}$.

(2) Condition (ii) When $\beta < 1$ and $(1 - \beta)(s_H - s_L) < V - c$, to satisfy Constraint 1, I need $\pi\{s_L, 1, p^{Ht*}, t\} = V \leq (\max\{\pi\{s_L, 0, p, x\} = V\})$. It holds under $\beta < 1$ and $(1 - \beta)(s_H - s_L) < V - c$. To satisfy Constraint 2, we need $\pi\{s_H, 1, p^{Ht*}, t\} \geq \max\{\pi\{s_H, 0, p, x\}$, which means $\pi\{s_H, 1, p^{Ht*}, t\} \geq \max\{\pi\{s_H, 0, V, t\}, \pi\{s_H, 0, V, n\}\}$ and $V - c + \frac{\beta}{2}(s_H - s_L) \geq \max\{(V - c) + \int_0^1 \beta(s_H - s_L)\theta d\theta, V - c\}$. It holds under $\beta < 1$ and $(1 - \beta)(s_H - s_L) < V - c$. Hence, I have condition (ii) $\beta < 1$ and $(1 - \beta)(s_H - s_L) < V - c$.

(3) Condition (iii) and condition (iv)

When $1 < \beta < \frac{3}{2} + \frac{V-c}{s_H-s_L} - \frac{(V-c)^2}{2(s_H-s_L)^2}$ and $s_H - s_L > V - c$ or $1 < \beta < 2$ and $s_H - s_L < V - c$, to satisfy Constraint 1, I need $\pi\{s_L, 1, p^{Ht*}, t\} = p^{Ht*}[\alpha + (1 - \alpha)] \leq (\max \pi\{s_L, 0, p, x\} = V)$ which means $V - (\beta - 1)(s_H - s_L) \leq V$. It holds under $1 < \beta < \frac{3}{2} + \frac{V-c}{s_H-s_L} - \frac{(V-c)^2}{2(s_H-s_L)^2}$ and $s_H - s_L > V - c$ or $1 < \beta < 2$ and $s_H - s_L < V - c$. To satisfy Constraint 2, we need $\pi\{s_H, 1, p^{Ht*}, t\} \geq \max \pi\{s_H, 0, p, x\}$, which means $\pi\{s_H, 1, p^{Ht*}, t\} \geq \max\{\pi\{s_H, 0, V, t\}, \pi\{s_H, 0, V, n\}\}$ and $V - c + (1 - \frac{\beta}{2})(s_H - s_L) \geq \max\{(V - c)(1 - \alpha) + (1 - \alpha) \int_0^1 \beta(s_H - s_L)\theta d\theta, V - c\}$. It holds under $1 < \beta < \frac{3}{2} + \frac{V-c}{s_H-s_L} - \frac{(V-c)^2}{2(s_H-s_L)^2}$ and $s_H - s_L > V - c$ or $1 < \beta < 2$ and $s_H - s_L < V - c$. Therefore, I have condition (iii) $1 < \beta < \frac{3}{2} + \frac{V-c}{s_H-s_L} - \frac{(V-c)^2}{2(s_H-s_L)^2}$ and $s_H - s_L > V - c$ and condition (iv) $1 < \beta < 2$ and $s_H - s_L < V - c$. \square

Proof of Proposition 2: I take three steps to prove Proposition 2. In Step 1, I find the high-type firm's pricing decision and its consequent profit under tipping policy to separate itself from low-type. In Step 2, I find the high-type firm's pricing decision and its consequent profit under non-tipping policy to separate itself from low-type. In Step 3, I compare the high-type firm's profits in Step 1 and Step 2.

To have $\bar{\alpha} = 1 - \frac{(2-\beta)^2(s_H-s_L)V}{[V+(1-\beta)c+(1-\beta)^2(s_H-s_L)](s_H-s_L+V-c)} \in [0, 1]$, I need to have $(1 - \beta)(s_H - s_L) > V + (1 - \beta)c$. So, in the following, I focus on the situations where $(1 - \beta)(s_H - s - L) > V + (1 - \beta)c$.

Step 1: If the high-type firm adopts a tipping policy, when $\alpha < \bar{\alpha}$, since $\pi\{s_L, 1, p^{Ht*}, t\} = p^{Ht*}(1 - \alpha)(1 - \frac{p-V}{(s_H-s_L)(1-\beta)}) \geq (\max \pi\{s_L, 0, p, x\} = V)$, it is profitable for the low-type firm to mimic the high-type's strategy. So, the high-type firm needs to distort its retail price to ensure that the low-type firm will not imitate. That is, to satisfy constraint 1, $\pi\{s_L, 1, p, t\} = p(1 - \alpha)(1 - \frac{p-V}{(s_H-s_L)(1-\beta)}) \leq (\max \pi\{s_L, 0, p, x\} = V)$, it must set the retail price such that $p \leq \underline{p} = \frac{V+(s_H-s_L)(1-\beta) - \sqrt{[V+(s_H-s_L)(1-\beta)]^2 - \frac{4V(s_H-s_L)(1-\beta)}{1-\alpha}}}{2}$ or $p \geq \bar{p} = \frac{V+(s_H-s_L)(1-\beta) + \sqrt{[V+(s_H-s_L)(1-\beta)]^2 - \frac{4V(s_H-s_L)(1-\beta)}{1-\alpha}}}{2}$. When $V + (1 - \beta)c < (1 - \beta)(s_H - s_L) < V + \frac{(2-2\beta)c}{\beta}$, the high-type firm distorts its retail price upwards to \bar{p} since $\frac{(1-\beta)c+V+(1-\beta)^2(s_H-s_L)}{2-\beta} > \frac{(s_H-s_L)(1-\beta)+V}{2}$. When $(1 - \beta)(s_H - s_L) > V + \frac{(2-2\beta)c}{\beta}$, the high-type firm distorts its retail price downwards to \underline{p} . In both cases, when α is closer to $\bar{\alpha}$, \bar{p} (or \underline{p}) is closer to p^{Ht*} . When α is closer to zero, \bar{p} (or \underline{p}) is farer from p^{Ht*} . The extent of distortion gets stronger

with the decrease of α .

Step 2: If the high-type firm adopts a non-tipping policy, it can not distinguish itself from low-type with the strategy (*non-tipping*, p^{Hn*}) when $\alpha < 1 - \frac{4V(s_H - s_L)}{(s_H - s_L + V)^2 - c^2}$ because $\pi\{s_L, 1, p^{Hn*}, n\} \geq V$. Then the high-type can choose to distort its retail price under non-tipping policy to signal itself. The optimal distorted price is $\bar{p} = \frac{V + s_H - s_L + \sqrt{(V + s_H - s_L)^2 - \frac{4V(s_H - s_L)}{1 - \alpha}}}{2}$ and its consequent profit is $\pi\{s_H, 1, \bar{p}, n\} = (\bar{p} - c)(1 - \frac{\bar{p} - V}{s_H - s_L})$.

When $\alpha > 1 - \frac{4V(s_H - s_L)}{(s_H - s_L + V)^2 - c^2}$, the high-type firm can distinguish itself from low-type with the strategy (*non-tipping*, p^{Hn*}), and its profit is $\pi\{s_H, 1, p^{Hn*}, n\} = \frac{(V - c + s_H - s_L)^2}{4(s_H - s_L)}$.

To have $1 - \frac{4V(s_H - s_L)}{(s_H - s_L + V)^2 - c^2} < \alpha < 1 - \frac{(2 - \beta)^2(s_H - s_L)V}{[V + (1 - \beta)c + (1 - \beta)^2(s_H - s_L)](s_H - s_L + V - c)}$, it requires $\frac{V}{1 - \beta} - \frac{c}{1 - \beta} < s_H - s_L < \frac{(4 - \beta)V}{4 - 3\beta} - \frac{\beta c}{4 - 3\beta}$. Since $(1 - \beta)(s_H - s_L) > V + (1 - \beta)c$ means $s_H - s_L > \frac{V}{1 - \beta} + c$, it contradicts with $s_H - s_L < \frac{(4 - \beta)V}{4 - 3\beta} - \frac{\beta c}{4 - 3\beta}$ because $\frac{V}{1 - \beta} > \frac{(4 - \beta)V}{4 - 3\beta}$. So the case that the high-type firm can distinguish itself with the strategy (*non-tipping*, p^{Hn*}) when $1 - \frac{4V(s_H - s_L)}{(s_H - s_L + V)^2 - c^2} < \alpha < \bar{\alpha}$ and $0 < \bar{\alpha} < 1$ does not exist.

Step 3: When $0 < \beta < 1$, $(1 - \beta)(s_H - s_L) > V + (1 - \beta)c$, and $\alpha < \bar{\alpha}$, I compare the high-type firm's profits under two situations: the distorted price together with tipping policy $\pi\{s_H, 1, \bar{p}, t\}$ (or $\pi\{s_H, 1, \underline{p}, t\}$) and distorted price together with non-tipping policy $\pi\{s_H, 1, \bar{p}, n\}$ when $\alpha = 0$. When $(1 - \beta)(s_H - s_L) > \frac{V}{2} + (1 - \beta)c$, the one under tipping policy, that is, $\pi\{s_H, 1, \bar{p}, t\}$ (or $\pi\{s_H, 1, \underline{p}, t\}$), is higher than the one under non-tipping policy, that is, $\pi\{s_H, 1, \bar{p}, n\}$. Since I have $(1 - \beta)(s_H - s_L) > V + (1 - \beta)c > \frac{V}{2} + (1 - \beta)c$ and the price distortion is the most when $\alpha = 0$, it means that the high-type firm is better off with distorted price and tipping policy when $\alpha < \bar{\alpha}$. □

Proof of Proposition 3: Similar as the proof of Proposition 2, I also take three steps to prove Proposition 3. In Step 1, I show the high-type firm's pricing decision and its consequent profit under non-tipping policy when it can successfully separate itself. In Step 2, I show the high-type firm's pricing decision and its consequent profit under tipping policy when it can successfully separate itself. In Step 3, I compare the high-type firm's profits in Step 1 and Step 2.

Step 1: When $\frac{3}{2} + \frac{V-c}{s_H-s_L} - \frac{(V-c)^2}{2(s_H-s_L)^2} < \beta < 2$ and $s_H - s_L > V - c$, it cannot separate itself from low-type by its optimal decision (*non-tipping*, p^{Hn*}) under complete information when the low-type can mimic it. That is, when $\alpha \leq 1 - \frac{4V(s_H-s_L)}{(s_H-s_L+V)^2-c^2}$, $\pi\{s_L, 1, p^{Hn*}, \text{non-tipping}\} = p^{Hn*}(1-\alpha)(1 - \frac{p^{Hn*}-V}{s_H-s_L}) = \frac{V+c+s_H-s_L}{2}(1-\alpha)(1 - \frac{V+c+s_H-s_L-V}{s_H-s_L}) \geq V$. The high-type distorts its price such that the low-type does not have incentive to imitate it. The retail price should be set to satisfy $\pi(s_L, 1, p, \text{non-tipping}) = p(1-\alpha)(1 - \frac{p-V}{s_H-s_L}) \leq V$. Let \underline{p} and \bar{p} be the solutions for $\pi\{s_L, 1, p, \text{non-tipping}\} = V$. Then $\underline{p} = \frac{V+s_H-s_L-\sqrt{(V+s_H-s_L)^2-\frac{4V(s_H-s_L)}{1-\alpha}}}{2}$ and $\bar{p} = \frac{V+s_H-s_L+\sqrt{(V+s_H-s_L)^2-\frac{4V(s_H-s_L)}{1-\alpha}}}{2}$. The high-type firm is better off with \bar{p} than with \underline{p} since $\frac{V+c+s_H-s_L}{2} \geq \frac{V+s_H-s_L}{2}$.

Step 2: When $\frac{3}{2} + \frac{V-c}{s_H-s_L} - \frac{(V-c)^2}{2(s_H-s_L)^2} < \beta < 2$ and $s_H - s_L > V - c$, the high-type firm can separate itself from low-type with the strategy (*tipping*, p^{Ht*}), and its profit is $\pi\{s_H, 1, p^{Ht*}, t\} = V - c + (1 - \frac{\beta}{2})(s_H - s_L)$.

Step 3: When $\frac{3}{2} + \frac{V-c}{s_H-s_L} - \frac{(V-c)^2}{2(s_H-s_L)^2} < \beta < 2 - \frac{2\alpha V}{(1-\alpha)(s_H-s_L)} - \frac{c[s_H-s_L-V+\sqrt{(s_H-s_L+V)^2-\frac{4V(s_H-s_L)}{1-\alpha}}]}{(s_H-s_L)^2}$, $s_H - s_L > V - c$, $\alpha \leq 1 - \frac{4V(s_H-s_L)}{(s_H-s_L+V)^2-c^2}$ and $c < \sqrt{(s_H - s_L + V)^2 - \frac{4V(s_H-s_L)}{1-\alpha}}$, $\pi\{s_H, 1, \bar{p}, n\} < \pi\{s_H, 1, p^{Ht*}, t\} = V - c + (1 - \frac{\beta}{2})(s_H - s_L)$. □

Proof of Proposition 4: When $\beta > 2$ and $s_H - s_L < V - c$, the high-type firm's optimal decision under complete information is (*non-tipping*, V), which is the same decision as the low-type firm's. When there is uninformed consumers in the market, the high-type firm can not get higher profit by choosing any strategy other than (*non-tipping*, V) to separate itself from the low-type firm. So, both types of firms choose the same strategy and the uninformed consumers will maintain their prior beliefs as $b(\text{non-tipping}, V) = \gamma$. □

This following consists of two major parts. In the first part, I derive the high-type firm's optimal decision on tipping/non-tipping policy under complete information when both firm and server contribute to the service quality and share tips. In the second part, I derive the conditions under which the main findings hold when both firm and server contribute to the service quality and share tips.

I. The high-type firm's decision when both firm and server contribute to the service quality and share tips

When the high-type firm chooses to have a non-tipping policy, its profit function is similar the firm's profit as presented in the main model. Replacing $s_H - s_L$ with s_{fh} , I have

$$\pi^{hn} = (p - c) \left(1 - \frac{p - V}{s_{fh}}\right) \quad (\text{C.1})$$

The optimal retail price and profits are

$$p^{hn*} = \begin{cases} \frac{V+c+s_{fh}}{2}, & \text{if } s_{fh} \geq V - c; \\ V, & \text{if } s_{fh} < V - c; \end{cases} \quad \pi^{hn*} = \begin{cases} \frac{(V-c+s_{fh})^2}{4s_{fh}}, & \text{if } s_{fh} \geq V - c; \\ V - c, & \text{if } s_{fh} < V - c. \end{cases} \quad (\text{C.2})$$

When the high-type firm chooses to have a tipping policy, its profit function is

$$\pi^{ht} = \begin{cases} (p - c) \left(1 - \frac{p - V}{(s_{fh} + s_{eh})(1 - \beta)}\right) + \frac{s_{fh}}{s_{fh} + s_{eh}} \int_0^1 \frac{p - V}{(s_{fh} + s_{eh})(1 - \beta)} \beta (s_{fh} + s_{eh}) \theta d\theta, & \text{if } \beta < 1; \\ (p - c) \frac{V - p}{(s_{fh} + s_{eh})^{(\beta - 1)}} + \frac{s_{fh}}{s_{fh} + s_{eh}} \int_0^1 \frac{V - p}{(s_{fh} + s_{eh})^{(\beta - 1)}} \beta (s_{fh} + s_{eh}) \theta d\theta, & \text{if } \beta > 1; \end{cases} \quad (\text{C.3})$$

Its optimal price and profits are

$$p^{ht*} = \begin{cases} \frac{(1 - \beta)^2 (s_{eh} + s_{fh})^2 + c(1 - \beta)(s_{eh} + s_{fh}) + [(1 - \beta)s_{eh} + s_{fh}]V}{2(1 - \beta)s_{eh} + (2 - \beta)s_{fh}}, & \text{if } \beta < 1, (1 - \beta)(s_{eh} + s_{fh}) \geq V - c; \\ V, & \text{if } \beta < 1, (1 - \beta)(s_{eh} + s_{fh}) < V - c; \\ V - (\beta - 1)(s_{eh} + s_{fh}), & \text{if } 1 \leq \beta \leq \frac{2s_{eh} + 2s_{fh}}{2s_{eh} + s_{fh}}; \\ \frac{(1 - \beta)c(s_{eh} + s_{fh}) + [(1 - \beta)s_{eh} + s_{fh}]V}{2(2 - \beta)s_{fh} + 2(1 - \beta)s_{eh}}, & \text{if } \beta > \frac{2s_{eh} + 2s_{fh}}{2s_{eh} + s_{fh}}, (\beta - 2)(s_{eh} + s_{fh}) \geq V - c; \\ V - (\beta - 1)(s_{eh} + s_{fh}), & \text{if } \beta > \frac{2s_{eh} + 2s_{fh}}{2s_{eh} + s_{fh}}, (\beta - 2)(s_{eh} + s_{fh}) < V - c. \end{cases} \quad (\text{C.4})$$

$$\pi^{ht*} = \begin{cases} \frac{[V - c + (1 - \beta)s_{eh} + s_{fh}]^2}{4(1 - \beta)s_{eh} + 2(2 - \beta)s_{fh}}, & \text{if } \beta < 1, (1 - \beta)(s_{eh} + s_{fh}) \geq V - c; \\ V - c + \frac{\beta}{2}s_{fh}, & \text{if } \beta < 1, (1 - \beta)(s_{eh} + s_{fh}) < V - c; \\ V - c - (\beta - 1)s_{eh} + (1 - \frac{\beta}{2})s_{fh}, & \text{if } 1 \leq \beta \leq \frac{2s_{eh} + 2s_{fh}}{2s_{eh} + s_{fh}}; \\ \frac{(V - c)^2}{4(\beta - 1)s_{eh} + 2(\beta - 2)s_{fh}}, & \text{if } \beta > \frac{2s_{eh} + 2s_{fh}}{2s_{eh} + s_{fh}}, (\beta - 2)(s_{eh} + s_{fh}) \geq V - c; \\ V - c - (\beta - 1)s_{eh} + (1 - \frac{\beta}{2})s_{fh}, & \text{if } \beta > \frac{2s_{eh} + 2s_{fh}}{2s_{eh} + s_{fh}}, (\beta - 2)(s_{eh} + s_{fh}) < V - c. \end{cases} \quad (\text{C.5})$$

Comparing the high-type firm's profits under tipping/non-tipping policy, we have its optimal decision as follows. Under complete information, when the firm and server(s) both contribute to the service quality and share tips, the high-type firm should choose a tipping policy when consumers' generosity is low, i.e., $0 < \beta < \frac{4s_{eh} + 3s_{fh}}{4s_{eh} + 2s_{fh}} + \frac{V - c}{2s_{eh} + s_{fh}} - \frac{(V - c)^2}{2s_{fh}^2 + 4s_{eh}s_{fh}}$ if $s_{fh} \geq V - c$ and

$0 < \beta < \frac{2s_{eh}+2s_{fh}}{2s_{eh}+s_{fh}}$ if $s_{fh} < V - c$. It should chooses a non-tipping policy when consumers' generosity is high, i.e., $\beta > \frac{4s_{eh}+3s_{fh}}{4s_{eh}+2s_{fh}} + \frac{V-c}{2s_{eh}+s_{fh}} - \frac{(V-c)^2}{2s_{fh}^2+4s_{eh}s_{fh}}$ if $s_{fh} \geq V - c$ and $\beta > \frac{2s_{eh}+2s_{fh}}{2s_{eh}+s_{fh}}$ if $s_{fh} < V - c$.

II. The conditions under which the main findings hold

The conditions under which the results in Proposition 1 hold are:

- (i) $0 < \beta < 1$, $(1-\beta)(s_{eh}+s_{fh}) \geq V-c$ and $\alpha > \max\left\{\frac{(p^{ht*}-V)[(1-\beta)(s_{eh}+s_{fh}-p^{ht*})]}{p^{ht*}[V+(1-\beta)(s_{eh}+s_{fh})-p^{ht*}]}, 0\right\}$ where $p^{ht*} = \frac{(1-\beta)^2(s_{eh}+s_{fh})^2+c(1-\beta)(s_{eh}+s_{fh})+[(1-\beta)s_{eh}+s_{fh}]V}{2(1-\beta)s_{eh}+(2-\beta)s_{fh}}$;
- (ii) $0 < \beta < 1$ and $(1-\beta)(s_{eh}+s_{fh}) < V-c$;
- (iii) $1 < \beta < \frac{4s_{eh}+3s_{fh}}{4s_{eh}+2s_{fh}} + \frac{V-c}{2s_{eh}+s_{fh}} - \frac{(V-c)^2}{2s_{fh}^2+4s_{eh}s_{fh}}$ and $s_{fh} \geq V-c$;
- (iv) $1 < \beta < \frac{2s_{eh}+2s_{fh}}{2s_{eh}+s_{fh}}$ and $s_{fh} < V-c$.

The conditions under which the results in Proposition 2 hold are: when $0 < \beta < 1$, $(1-\beta)(s_{eh}+s_{fh}) > V-c$, and $\frac{(1-\beta)^2(s_{eh}+s_{fh})^2+c(1-\beta)(s_{eh}+s_{fh})+[(1-\beta)s_{eh}+s_{fh}]V}{2(1-\beta)s_{eh}+(2-\beta)s_{fh}}$, the high-type firm will distort its retail price and keep the tipping policy to effectively signal its service quality.

The conditions under which the results in Proposition 3 hold are: when $\frac{4s_{eh}+3s_{fh}}{4s_{eh}+2s_{fh}} + \frac{V-c}{2s_{eh}+s_{fh}} - \frac{(V-c)^2}{2s_{fh}^2+4s_{eh}s_{fh}} < \beta < \frac{2[\tilde{p}^2+c(V-\tilde{p})-\tilde{p}(V+s_{fh})+(V+s_{eh}+s_{fh})s_{fh}]}{s_{fh}(2s_{eh}+s_{fh})}$, $s_{fh} \geq V-c$ and $\alpha < \frac{(V-s_{fh}+c)(V-s_{fh}-c)}{(V+s_{fh})^2-c^2}$ where \tilde{p} is the bigger solution to $\pi\{s_L, 1, p, n\} = p(1-\alpha)(1-\frac{p-V}{s_{fh}}) = V$, the high-type firm will strategically choose to have a tipping policy to signal its service quality even it optimally chooses to have a non-tipping policy under complete information.

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