THREE ESSAYS ON RETAILER BRAND INTRODUCTION, QUALITY INFORMATION DISCLOSURE AND DISTRIBUTION CHANNEL

BY

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DISSERTATION

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Business Administration in the Graduate College of the University of Illinois at Urbana-Champaign, 2012

Urbana, Illinois

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This dissertation consists of three essays studying the impact of retailer store brand introduction to the upstream manufacturer, channel quality disclosure and the overall distribution channel efficiency. Chapter 2 studies the retailer brand introduction strategy with consumer evaluation cost. In the marketplace, there is a growing trend for retailers to introduce premium store brands to complement manufacturer brands. In this chapter, I study the effects of a retailer premium brand on the profitability of a manufacturer and a retailer when consumers do not have full information about the brands and have to incur a cost to evaluate the products. I show that a manufacturer can benefit when the retailer introduces a retailer brand, and the benefit may increase with the rising popularity of the retailer brand. This happens when the introduction of a retailer brand motivates the retailer to induce consumer evaluation and the manufacturer can take advantage of that to charge a high wholesale price for the manufacturer brand. Depending on the level of consumer evaluation cost, a retailer brand is more likely to be introduced in either a decentralized or a centralized channel. Furthermore, consumer welfare can be higher in a decentralized channel than in a centralized channel.

Chapter 3 studies the benefits of a decentralized channel with voluntary quality disclosure. Traditional distribution channel literature suggests that a centralized channel structure is more efficient than a decentralized channel structure. In this chapter, I find that a decentralized channel can sometimes outperform a centralized channel structure, and the aggregated channel profit in a decentralized channel can be higher disregarding the negative impact from channel double marginalization. This occurs when the product quality information is private and the manufacturer incurs a substantial cost to disclose product quality information. I also show that the distribution of product quality plays a role in shaping consumer beliefs about product quality, leading to a more efficient decentralized channel performance.
Chapter 4 combines chapter 2 and chapter 3 to study the quality disclosure strategy with a store brand introduction. In chapter 3, I study a manufacturer’s strategy to disclose product quality with a passive retailer. In this essay, I extend the model to investigate the strategic quality disclosure from both a manufacturer and a retailer when the retailer introduces a retailer brand. I find that a manufacturer has reduced incentive to conduct quality disclosure with a store brand introduction. This incentive is also affected by asymmetric disclosure costs as well as the average retailer brand quality. Unlike in the competition case, the retailer chooses a disclosure strategy to leverage the sales for both manufacturer brand and the retailer, leading to a higher incentive to disclose when the disclosure costs are the same. The profit and channel efficiency implications are also discussed.
To my parents, my husband, for their love and support.
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CHAPTER 1

INTRODUCTION

In this dissertation, I study different types of information asymmetry at different levels and how firms, an upstream manufacturer and a downstream retailer, in a decentralized distribution channel work to resolve or promote this information asymmetry in order to obtain optimal individual payoffs.

The first essay (chapter 2) deals with consumer level information uncertainty regarding product preferences. The seller has incentive to induce consumer evaluation to resolve their preference uncertainties in order to exploit the elevated willingness to pay from consumers. The conduct to facilitate consumer evaluation depends on the cost of evaluation and the size of the demand segment. The second essay (chapter 3) examines the manufacturer level quality information asymmetry and the manufacturers decision to disclose the private information of product quality. Unlike the consumers who are passively induced by sellers to resolve information uncertainty in chapter 2, the manufacturer undertakes an active part leveraging information revelation and product pricing to shape the perception of product quality received by buyers. The likelihood of quality disclosure depends on the public information of the quality distribution and more importantly, the structure of product distribution. In the third essay (chapter 4), the retailer can introduce a retailer brand to affect the quality disclosure intention from the manufacturer. There are two levels of information uncertainties, the manufacturer level and the retailer level. The incentive for a channel member to disclose product quality is not only a reaction to shape buyer perception of product quality, but also to manage the competition intensity between the manufacturer and the retailer. In reality, the three levels of information uncertainty may coexist in any distribution channel. This dissertation singles out the different types of information asymmetry into three essays to help with the understanding of the information dissemination in distribution channels.

The dissertation also illustrates how different marketing mix helps to re-
duce information asymmetry and to direct buyers purchase decisions. In chapter 2, the product variety and pricing strategies impact consumers expected payoff from conducting evaluation to resolve preference uncertainty and their reservation price for a preferred product. In chapter 3, buyers can infer the product quality from the channel structure and quality advertising activity from the manufacturer. In chapter 4, the quality disclosure activities from both the manufacturer and the retailer determine how buyers perceive the product quality from a manufacturer brand and a retailer brand respectively. Although the cost to resolve information uncertainty does not add to the social surplus since all the gains are all private, the matching between product and consumers are improved as a result of resolved information asymmetry.
2.1 Introduction

In many product categories, there is a growing trend for retailers to introduce premium store brands. Unlike traditional copycat store brands, these premium retailer brands offer high quality and represent unique products which are differentiated explicitly from manufacturer brands in the same product category. For instance, Sears offers premium branded home appliances such as Kenmore, Diehard and Craftsman, with unique product features and design. Macy’s launches several product lines in clothing, such as Style&co, Alfani and Charter Club, to target consumers with different lifestyles. Supermarket retailer Kroger introduces the “Disney Magic” product line of child-oriented food, and Whole Foods also sells its premium brand “365 Everyday Value” and “365 Organic Everyday Value”. Premium store brands are an important source of revenue to retailers. JCPenney, for example, has a very high level of store brand penetration accounting for 40 percent of its sales Kumar and Steenkamp (2007).

Premium store brands, on the one hand, complement the brands from manufacturers by choosing unique product positioning and targeting heterogeneous consumer needs. Sephora, the cosmetic retail chain store, sells the Sephora store brand as well as manufacturer branded cosmetics. While manufacturer brands offer eyeshadow palettes with limited but popular colors, the Sephora brand complements them by offering 98 different colors, including some unusual ones to satisfy the needs of those niche market consumers. Sainsbury, the U.K. supermarket giant, sells a “Be Good to Yourself” premium store brand to target working female consumers, while manufacturer brands target average consumers. Those premium retailer brands have comparable quality but are positioned horizontally different from manufacturer
brands. This is in contrast with copycat store brands which have inferior quality and only focus on low prices. On the other hand, the presence of premium retailer brands makes it more desirable for consumers to refine their purchase choices by finding out the best matched products. This is especially the case when consumers do not have full information about the products in a product category, and have to conduct evaluation through which product information is collected, processed and evaluated by consumers in order to find the products matching their needs (Villas-Boas, 2009). From consumers’ perspectives, the introduction of a complementary retailer brand enriches the product variety offered in the store and motivates consumers to refine their purchase choices by finding out the better matched products. This is achieved by conducting consumer evaluation through which product information is collected, processed and evaluated by consumers in order to discover the exact value derived from the product upon purchase. By conducting product evaluation, consumers become more certain about their brand choice and their preferences become more heterogeneous. This evaluation is an endogenous choice of action by consumers and is not always costless (Guo and Zhang, 2010; Kuksov, 2004; Villas-Boas, 2009; Wathieu and Bertini, 2007). In many cases, consumers need to incur evaluation costs to get full information and resolve their product value uncertainties. Without this evaluation process, consumers hold only superficial information of products, such information includes product prices and relative brand popularities, and they can form only general preference beliefs based on the information. The action of purchase without evaluation is similar to impulse buying, where the ex post risk of preference mismatch associated with purchase is high, but the economic loss is relatively low. In practice, whether consumers initiate product evaluation depends on the cost of evaluation, the expected match/mismatch of a product, as well as the ex post financial risk associated with purchase. Retailers can thus influence buyers’ product evaluation and purchase decisions through strategically choosing the brands and the retail prices to offer.

Manufacturers’ reactions to retailer store brands are often mixed. Although a store brand may weaken the manufacturer’s relative marketing power and intensify price competition in the product category, it may also

1Firms may use advertising or free samples to facilitate consumer evaluation of their products. However, this does not eliminate consumers’ own efforts to process product information and evaluate to find their best-matched products.
expand the existing product assortment and attract more consumers to the market, which may benefit the manufacturers especially when the retailer brands and the manufacturer brands are horizontally differentiated and target different niche markets. As quoted by a category manager, the success of retailer store brands has benefited major candy and snack suppliers by bringing new customers to the category (Fleenor, 2010). Soberman and Parker (2006) also find that the launch of a quality-equivalent store brand by a retailer can benefit both the retailer and the manufacturer.

To study the effects of premium retailer brands, I develop a model of one manufacturer which sells its product through a retailer. The retailer has the option to introduce a premium retailer brand which is horizontally differentiated from the manufacturer’s brand. Consumers have heterogeneous preferences for the brands, and have to evaluate the brands to find the best matched product, for which consumers must incur an evaluation cost.

2.1.1 Summary of Results

I have obtained a few interesting results. First, I show that the manufacturer can, interestingly, benefit from the introduction of a premium retailer brand. When the retailer introduces a premium retailer brand, it has a stronger incentive to induce consumer evaluation. This is because the premium retailer brand is horizontally differentiated from the manufacturer brand. After conducting product evaluation, some consumers will find the retailer brand better matched with their needs, and the retailer can charge a high retail price to exploit those consumers. The manufacturer, in turn, can free ride on the retailer’s efforts to induce consumer evaluation and raise its wholesale price to exploit consumers whose needs are better matched with the manufacturer brand after conducting product evaluation induced by the retailer. This benefiting mechanism is different from that described in the past literature, which claims that the manufacturer brand only indirectly benefits from a retailer brand when the retailer brand helps increase store traffic or create competition against other manufacturer brands (Pauwels and Srivastava, 2004; Sudhir and Talukdar, 2004). I show that the benefit for the manufacturer happens only when the consumer evaluation cost is low. With high evaluation cost, the retailer has less incentive to induce consumer evalu-
ation. Instead, it utilizes the retailer brand to create competition against the manufacturer brand. In response to the threat of competition, the manufacturer has to lower its wholesale price and no longer benefits from the retailer brand.

Second, I also show that a retailer’s incentive to introduce a retailer brand depends on the level of consumer evaluation cost. To the retailer, the benefit of using the retailer brand to induce consumer evaluation decreases, while the benefit of using the retailer brand as a competitive threat against the manufacturer brand increases with the evaluation cost. With those two effects combined, the retailer’s incentive to offer the retailer brand first decreases and then increases with the evaluation cost. In addition, the manufacturer may become better off when the retailer brand becomes more popular. At equilibrium, the retailer’s brand introduction strategy is affected by the relative popularity of the retailer brand. With increasing retailer brand popularity, the retailer receives a higher profit by introducing the retailer brand, and may switch from its initial strategy of not introducing a retailer brand to introducing. This action leads to a greater product variety in the channel and may benefit the manufacturer.

Third, I show that the retailer brand is more likely to be introduced in either a centralized channel or a decentralized channel. When the consumer evaluation cost is low, the retailer brand is more likely to be introduced in a centralized channel. This is because in a decentralized channel, the manufacturer free rides on the retailer’s efforts to induce consumer evaluation, which reduces the incentive for the retailer to introduce the retailer brand. When consumer evaluation cost is high, the retailer brand is more likely to be introduced in a decentralized channel. This happens when the retailer strategically uses the retailer brand as a competitive threat against the manufacturer, and such an effect is absent in a centralized channel.

Lastly, I study the welfare implications of premium retailer brand introduction in either a centralized or a decentralized channel. Interestingly, I find that consumer welfare can be higher in a decentralized channel than in a centralized one. This happens when the retailer brand is introduced in a centralized but not in a decentralized channel in equilibrium. In this case, consumer surpluses are more likely to be exploited when the retailer effectively uses both the retailer brand and the manufacturer brand to induce consumer evaluation.
2.1.2 Related Literature

This chapter is related to past literature on store brands. Traditionally, store brands are viewed as the low-quality versions of manufacturer brands and are usually positioned to copycat their counterpart manufacturer brands (Scott Morton and Zettelmeyer, 2004). For instance, a retailer may want to introduce a store brand if there is a higher unit margin to be drawn (Raju et al., 1995; Chintagunta et al., 2002; Sayman et al., 2002; Ailawadi and Harlam, 2004; Yehezkel, 2008). The retailer can also rely on the retailer brand to strengthen its bargaining power (Mills, 1995; Steenkamp and Dekimpe, 1997; Narasimhan and Wilcox, 1998; Sudhir, 2001; Meza and Sudhir, 2006). In recent years, retailers have emphasized the “value” that can be derived from a retailer brand, and it is claimed that retailer brands may have high quality and can be used as differentiation tools by retailers (Dhar and Hoch, 1997; Corstjens and Lal, 2000; Bonfrer and Chintagunta, 2004). This chapter fills the gap by studying the effects of premium retailer brands which have comparable product quality but are horizontally differentiated from manufacturer brands. According to the past literature, manufacturers are usually negatively impacted by the retailer brands, due to brand cannibalization and price competition (Connor and Peterson, 1992; Sudhir, 2001; Ailawadi and Harlam, 2004). Therefore, it is suggested that manufacturers enforce exclusive dealing to prevent the introduction of retailer brands and to protect their own profits (Yehezkel, 2008; Groznik and Heese, 2010). Some researchers propose that a retailer brand might positively affect a manufacturer brand by attracting more one-stop shoppers (Geylani et al., 2009) or creating competition against other more susceptible manufacturer brands (Pauwels and Srinivasan, 2004; Sudhir and Talukdar, 2004). This only suggests that a manufacturer brand might indirectly benefit from the retailer brand introduction when there are other market externalities. That a retailer can strategically induce consumer evaluation after introducing a retailer brand and its impact on the manufacturer-retailer relationship have not been explored. In this paper, we propose a new mechanism through which a retailer brand introduction may benefit the manufacturer.

Researchers have long realized that consumers need to incur a search cost or an evaluation cost to resolve purchase uncertainties when they lack product information (Diamond, 1971; Anderson and Renault, 1999; Kuksov, 2004).
The search or evaluation cost can be interpreted as the time and money spent by consumers to build their knowledge of the products. Firms can thus orchestrate product prices and offerings to affect consumer evaluation behavior. Wathieu and Bertini (2007) consider the pricing of a product with an additional novel feature, and they demonstrate that with overpricing, consumers become more willing to think about the possible personal benefits from the new feature. It is also suggested that there is an optimal number of alternative products to induce consumer evaluation (Villas-Boas, 2009; Kuksov and Villas-Boas, 2010), and a firm may choose a long product line to encourage consumer evaluation or a short product line to prevent consumer evaluation (Guo and Zhang, 2010). However, that research does not study the conflicts between a retailer and a manufacturer when the retailer introduces its premium store brand and how the conflicts are affected by consumer evaluation behavior.

The results in this chapter also contribute to the literature on product line design. It has been documented that the product line in a decentralized channel is shorter than in a centralized channel due to channel inefficiency (Villas-Boas, 1998). Liu and Cui (2010) show that a manufacturer can provide either a longer or shorter product line in a decentralized channel than in a centralized channel, depending on whether or not the market is fully covered. In this chapter, I further show that whether there is greater product variety in a decentralized channel or a centralized channel depends on consumer evaluation cost.

The rest of the chapter is organized as follows. Section 2.2 introduces the basic model setting and studies the impact of consumer evaluation on the retailer brand introduction strategy as well as the profits of the manufacturer and the retailer. Section 2.3 discusses the impact of channel structure on the introduction of a retailer brand and explores the welfare implications for consumers. Section 2.4 extends the basic model in several directions. I conclude in section 2.5.

2.2 The Model

I consider an upstream manufacturer that distributes its branded product $M$ through a downstream retailer. The retailer has an option to introduce its
own premium retailer brand $R$ at a fixed cost $F$. The variable production costs of $M$ and $R$ are normalized to zero. $M$ and $R$ are horizontally differentiated such that some consumers prefer $M$, and some consumers prefer $R$. However, consumers are uncertain about their actual preferences unless they incur a cost $c$ prior to purchase to evaluate the products.\(^2\)

Consumers voluntarily make the product evaluation decision. If they choose to evaluate the products by incurring a cost $c$, a proportion of $\alpha$ consumers will find $M$ preferred, and attain a value of 1 from $M$ and 0 from $R$. The rest $(1 - \alpha)$ will find $R$ preferred, and attain a value of 1 from $R$ and 0 from $M$. If consumers choose not to evaluate the products, they do not know whether they prefer $M$ or $R$, and only hold a general belief that they will prefer $M$ with probability $\alpha$ and prefer $R$ with probability $(1 - \alpha)$. This setup implicitly assumes that $M$ and $R$ are horizontally differentiated, and consumers obtain the same value from purchasing their preferred brand, either $M$ or $R$. In the model extension, I study the case where consumers who prefer $R$ may obtain a lower value. In addition, the parameter $\alpha$ captures the relative popularity of the manufacturer brand compared with the retailer brand. In the main model, I focus on the case where the manufacturer brand is more popular than the retailer brand, where $\alpha > \frac{1}{2}$. The case with $\alpha < \frac{1}{2}$ will be discussed in the model extension.

Consumers make a two-stage purchase decision. In the first stage, consumers observe the products available as well as the retail price(s) and decide whether to incur an evaluation cost $c$ to resolve their preference uncertainty. I focus on the most interesting case where $c < 2\alpha(1 - \alpha)$. In the second stage, consumers make purchase decisions conditioning on their actions in the first stage. I define consumers’ action space by $\{E_i, \overline{E}_i\}$. $E$ and $\overline{E}$ represent consumers’ actions of evaluation and no evaluation in the first stage, and the subscript $i$ stands for the type of product consumers decide to purchase at the second stage. For instance, $i = \{M, R, 0\}$ denotes the purchase of the manufacturer brand, of the retailer brand, and no purchase.

\(^2\)In practice, consumers do not always possess expertise in every product category. For instance, a consumer who is not familiar with organic food prior to purchase may need to spend time collecting and processing relevant information on this product category, which helps the consumer figure out the product matching her personal taste. In my model, the time, effort or money that a consumer spends in building knowledge of the organic food category is summarized to an evaluation cost $c$, which is consistent with Villas-Boas (2009). In the model extension, I will study the case that the evaluation cost $c$ depends on the number of products in the same product category.
<table>
<thead>
<tr>
<th>Retailer introduction</th>
<th>Manufacturer wholesale $w$</th>
<th>Retailer $p_M(p_R)$</th>
<th>Consumer evaluate and purchase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>Stage 2</td>
<td>Stage 3</td>
<td>Stage 4</td>
</tr>
</tbody>
</table>

Figure 2.1: Game sequence

This model assumes that consumers may choose to evaluate both the manufacturer brand and the retailer brand in all occasions, even when consumers possess some pre-existing knowledge of the manufacturer brand. This assumption is valid for the purchase of durable products where the time between purchase is long and consumers only have limited experience with each brand. Even for the more frequently purchased product categories, there is an evidence for continuous evaluation as consumers undertake a learning curve to accumulate knowledge (Erdem and Keane, 1996). What is more, consumers are not always involved in an extensive evaluation all the time. The extent of evaluation in which consumers are engaged may be affected when there is a change in the market conditions (Murthi and Srinivasan, 1999). The introduction of a new premium store brands may as well promote consumer to evaluate the brands more thoroughly. I also assume the same evaluation cost for all consumers. The case of different evaluation costs across consumers does not affect the main results qualitatively.

I analyze a three-stage Stackelberg game between the retailer and the manufacturer (Figure 2.1). In the first stage, the retailer decides whether to introduce a retailer brand $R$ at a fixed cost $F$ ($F \leq (1 - \alpha)$). In the second stage, the manufacturer determines the wholesale price $w$ for the manufacturer brand. In the third stage, the retailer decides on the retail prices for the manufacturer brand $p_M$ and the retailer brand $p_R$ (if $R$ is introduced). I examine two subgames with and without the introduction of $R$, and compare the retailer’s profits in those two subgames to obtain the subgame perfect equilibrium.

### 2.2.1 Manufacturer Brand Only

When the retailer brand $R$ is not introduced, consumers have only limited purchasing options. When consumers choose to incur an evaluation cost
to resolve their preference uncertainty, they only purchase if they find $M$ is the preferred product with the utility $U^E = 1 - p_M$ and $p_M \leq 1$. Note that consumers have to incur a sunk cost $c$ on product evaluation. Therefore, at the evaluation stage where consumers are still uncertain about their preferences, their expected utility from conducting product evaluation is

$$E(U^E) = \begin{cases} \alpha(1 - p_M) - c & \text{if } p_M \leq 1; \\ -c & \text{otherwise.} \end{cases}$$  (2.1)

When consumers do not incur the evaluation cost $c$ to resolve preference uncertainty, their utility from purchase becomes $U^E = 1 - p_M$ if $M$ turns out to be their preferred product, and $U^E = -p_M$ otherwise. Because consumers do not know their actual preferences without evaluation, their purchase decision is based on the expected value of $M$. Hence, consumers purchase $M$ if and only if $p_M \leq \alpha$. At the evaluation stage, consumers’ expected utility from not conducting product evaluation becomes

$$E(U^E) = \begin{cases} \alpha - p_M & \text{if } p_M \leq \alpha; \\ 0 & \text{otherwise.} \end{cases}$$  (2.2)

Consumers make evaluation decisions by comparing their expected payoffs ($E(U^E)$ and $E(U^E)$). For a consumer to choose evaluation, a condition that must be satisfied is that $E(U^E) \geq E(U^E)$. This requires that $\alpha(1 - p_M) - c \geq \alpha - p_M$ for $p_M \leq \alpha$; or $\alpha(1 - p_M) - c \geq 0$ for $\alpha < p_M \leq 1$. Therefore, if $c \leq \alpha(1 - \alpha)$ and $\frac{c}{1 - \alpha} \leq p_M \leq 1 - \frac{c}{\alpha}$, consumers choose to evaluate the product, and purchase when they find the product preferred (denoted as $E_M$) or do not purchase when the product is not preferred (denoted as $E_0$). If $p_M < \min\{\frac{c}{1 - \alpha}, \alpha\}$, consumers choose not to evaluate and buy $M$ (denoted as $E_M$). Otherwise, consumers will neither evaluate nor purchase $M$.

The retailer can induce consumer evaluation and purchase behavior by setting an appropriate price $p_M$. When the retailer induces $E_M$, it receives a profit $\pi_R = p_M^{EM} - w$; when the retailer induces $E_M$, it receives $\pi_R = \alpha(p_M^{EM} - w)$. Here, $p_M^{EM}$ and $p_M^{EM}$ are the retail prices to induce $E_M$ and $E_M$ respectively. When $c \leq \alpha(1 - \alpha)$, the retailer can induce $E_M$ by charging a high price $p_M^{EM} = 1 - \frac{c}{\alpha}$. Alternatively, the retailer may charge a low price $p_M^{EM} = \frac{c}{1 - \alpha}$ to induce $E_M$. When $c > \alpha(1 - \alpha)$, evaluation becomes too expensive to induce, and the retailer charges $p_M^{EM} = \alpha$ and consumers will
purchase without evaluation.

Whether it is optimal for the retailer to induce $E_M$ or $E_R$ depends on the wholesale price $w$. To make the retailer induce $E_M$, the manufacturer should charge a wholesale price satisfying $p_M^E - w \geq \max\{\alpha(p_M^E - w), 0\}$, which requires that $w \leq \min\{(2-\alpha)c\alpha(1-\alpha)\}, \alpha\}$. In this case, the manufacturer receives a profit $\pi_M = w^M = \min\{(2-\alpha)c\alpha(1-\alpha)\}, \alpha\}$. Alternatively, to make the retailer induce $E_R$, the manufacturer should charge a $w$ satisfying $\alpha(p_R^E - w) \geq \max\{p_R^E - w, 0\}$, and receive $\pi_M = \alpha w^E = \alpha - c$. Notice that when $c > \alpha(1-\alpha)$, the evaluation becomes too expensive for consumers, and consumers will never choose to evaluate.

The manufacturer chooses $w$ to maximize its profit, and the optimal $w$ and $p_M$ are:

$$w^E_M = 1 - \frac{c}{\alpha}, p_M^E = 1 - \frac{c}{\alpha} \quad \text{if } c \in [0, \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}];$$

$$w^E_M = \frac{(2-\alpha)c\alpha(1-\alpha)}{(1-\alpha)^2}, p_M^E = \frac{c}{1-\alpha} \quad \text{if } c \in (\frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}, \alpha(1-\alpha));$$

$$w^E_M = \alpha, p_M^E = \alpha \quad \text{otherwise.}$$

The corresponding channel members’ profits are:

$$\pi_M^E = \alpha - c, \pi_R^E = 0 \quad \text{if } c \in [0, \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}];$$

$$\pi_M^E = \frac{(2-\alpha)c\alpha(1-\alpha)}{(1-\alpha)^2}, \pi_R^E = \frac{\alpha(1-\alpha)-c}{(1-\alpha)^2} \quad \text{if } c \in (\frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}, \alpha(1-\alpha));$$

$$\pi_M^E = \alpha, \pi_R^E = 0 \quad \text{otherwise.}$$

(2.4)

### 2.2.2 Manufacturer Brand and Retailer Brand

Now I consider the subgame where the retailer introduces $R$ at a fixed cost $F$ and sells both $M$ and $R$ to consumers. When consumers incur a sunk cost $c$ to evaluate the products and resolve the preference uncertainty, some consumers will find $M$ preferred with the utility $U_M = 1 - p_M^E$, others will find $R$ preferred with the utility $U_R = 1 - p_R^E$. Therefore, a consumer will purchase $M$ if and only if $M$ is preferred and $p_M \leq 1$; or she will purchase $R$ if and only if $R$ is preferred and $p_R \leq 1$. Accordingly, the expected utility
from conducting evaluation is:

\[
E(U^E) = \begin{cases} 
\alpha(1 - p_M - c) + (1 - \alpha)(1 - p_R - c) & \text{if } p_M \leq 1, p_R \leq 1; \\
\alpha(1 - p_M) - c & \text{if } p_M \leq 1, p_R > 1; \\
(1 - \alpha)(1 - p_R) - c & \text{if } p_M > 1, p_R \leq 1; \\
-c & \text{otherwise}. 
\end{cases} 
\]  

(2.5)

The utility function suggests that when one of the retail prices is above consumers’ reservation price (e.g. \( p_i > 1 \)), consumers ignore the presence of brand \( i \), because the product is not affordable anyway. The problem is then degenerated to the single product case analyzed previously.

When consumers choose not to incur the evaluation cost to resolve preference uncertainty, the expected consumer utility is given by

\[
E(U^{\overline{E}}) = \begin{cases} 
\alpha - p_M & \text{if } p_M \leq \min\{2\alpha - 1 + p_R, \alpha\}; \\
(1 - \alpha) - p_R & \text{if } p_R < \min\{1 - 2\alpha + p_M, 1 - \alpha\}; \\
0 & \text{otherwise}. 
\end{cases} 
\]  

(2.6)

Again, consumers will adopt the evaluation and purchasing strategy that generates the highest nonnegative expected utilities. Therefore, consumers compare their expected payoffs from \( E(U^E) \) and \( E(U^{\overline{E}}) \) to determine their action to evaluate products.

Figure 2.2 illustrates consumers’ evaluation and purchasing decisions as a function of \( p_M \) and \( p_R \) \((p_M \leq 1 \text{ and } p_R \leq 1)\). Prior to making the product evaluation decisions, consumers jointly consider the retail prices of the two brands to determine their expected payoff with and without product evaluation. When the retail prices are not balanced \((p_M - p_R > 1 - \frac{c}{\alpha})\) with \( p_R < (1 - \alpha) \) or \( p_R - p_M > 1 - \frac{c}{1 - \alpha} \) with \( p_M < \alpha \), i.e. one brand is significantly cheaper than the other, consumers choose to purchase the cheaper brand without conducting product evaluation \((E_R \text{ or } E_M)\). Upon evaluation, consumers expect to pay a leveraged price \( \alpha p_M + (1 - \alpha) p_R \). Hence, when the retail prices are balanced \((\alpha p_M + (1 - \alpha) p_R \leq 1 - c \text{ and } \frac{c}{1 - \alpha} - 1 \leq p_M - p_R \leq 1 - \frac{c}{\alpha})\), consumers choose to evaluate the products \((E_i)\). The overall incentive to evaluate is also related to the evaluation cost. With an increase of evaluation cost \( c \), consumers have less incentive to evaluate products. Therefore, the area of \( \{E_i\} \) shrinks; this indicates that it becomes more difficult to induce consumer evaluation. When \( c \) is close to \( 2\alpha(1 - \alpha) \),
Figure 2.2: Consumer evaluation and purchase decision at given $p_M$ and $p_R$ with $c \in [\alpha(1 - \alpha), 2\alpha(1 - \alpha)]$. When $c$ increases(decreases), the $E_i$ region shrinks(expands).

evaluation can never be induced and the \{\{E_i\}\} area is degenerated to a line. With a decrease of evaluation cost $c$, consumers are more willing to conduct product evaluation, and the area of \{\{E_i\}\} expands. At the extreme, when $c$ approaches zero, consumers will always adopt the evaluation strategy.

Comparing consumers’ evaluation and purchasing strategy under low and high levels of product variety, I find that consumers are more likely to evaluate with high product variety. Consumers’ expected benefit from conducting evaluation rises ($U_{E|M&R} > U_{E|M}$) when they see more brand choices, leading to higher tolerance of the evaluation cost. For instance, in the absence of $R$, consumers will never evaluate when $c > \alpha(1 - \alpha)$. However, with the presence of $R$, under proper pricing, consumers will still choose to evaluate products as long as $c \leq 2\alpha(1 - \alpha)$. What is more, because there are more products to meet their heterogeneous preferences, with a high level of product variety, consumers are better matched with the products after evaluation.

Based on the above rationale, there are four actions that the retailer may want to induce from consumers: $E_i(i = M \text{ or } R)$, $E_R$, $E_M$ and $E_R$. Again the retailer can use the prices of $M$ and $R$ to affect consumer evaluation and purchase behavior. The retailer receives $\pi_{E_i} = \alpha(p_{M}^{E_i} - w) + (1 - \alpha)p_{R}^{E_i} - F$, $\pi_{E_R} = (1 - \alpha)p_{R}^{E_R} - F$, $\pi_{E_M} = p_{M}^{E_M} - w - F$, and $\pi_{E_R} = p_{R}^{E_R} - F$ when each consumer reaction is induced, respectively. The manufacturer foresees
the retailer’s pricing reactions and chooses $w$ to optimize $\pi_M$. The optimal wholesale price is:

$$
\begin{align*}
& w^{E_i} = 1 & \text{if } c \in [0, \frac{a(1-a)}{1+a}]; \\
& w^{E_i} = \frac{a-(1+a)c}{a^2} & \text{if } c \in (\frac{a(1-a)}{1+a}, a(1-a)]; \\
& w^{E_i} = 1 - \frac{c}{a} & \text{if } c \in (a(1-a), \frac{1-a^2}{2-a}]; \\
& w^{E_M} = \frac{c}{1-a} - 1 & \text{if } c \in (\frac{1-a^2}{2-a}, 2a(1-a)).
\end{align*}
$$
(2.7)

At equilibrium, the profits of the manufacturer and the retailer are:

$$
\begin{align*}
\pi^{E_i}_M &= \alpha, \quad \pi^{E_i}_R = 1 - c - \alpha - F & \text{if } c \in [0, \frac{a(1-a)}{1+a}]; \\
\pi^{E_i}_M &= 1 - \frac{1+a}{a} c, \quad \pi^{E_i}_R = \frac{c}{a} - F & \text{if } c \in (\frac{a(1-a)}{1+a}, a(1-a)); \\
\pi^{E_i}_M &= \alpha - c, \quad \pi^{E_i}_R = 1 - \alpha - F & \text{if } c \in (a(1-a), \frac{1-a^2}{2-a}]; \\
\pi^{E_M}_M &= \frac{c}{1-a} - 1, \quad \pi^{E_M}_R = 1 + \alpha - \frac{c}{1-a} - F & \text{if } c \in (\frac{1-a^2}{2-a}, 2a(1-a)).
\end{align*}
$$
(2.8)

I compare the manufacturer’s profits before and after the retailer introduces $R$, and summarize the main result in the following proposition.

**Proposition 2.1** The introduction of a retailer brand benefits the manufacturer ($\pi_M|_{M&R} \geq \pi_M|_M$) when $0 < c \leq \frac{a(1-a)}{a(1-a)^2+1}$.

Interestingly, I find that the manufacturer can directly benefit when the retailer introduces the retailer brand. With the introduction of $R$, the retailer can charge a high retail price $p_R$ to consumers who prefer the retailer brand after conducting product evaluation. In order to exploit consumer surpluses for those consumers who prefer $R$, the retailer has a stronger incentive to induce consumer evaluation of the products. As a result, the manufacturer can free ride on the retailer’s incentive, charging a higher wholesale price for the manufacturer brand and achieving a higher profit with the presence of the retailer brand. To see this, notice that the manufacturer charges $w^{E_i}|_{M&R} = 1 > w^{E_i}|_M = 1 - \frac{c}{a}$ when $0 < c \leq \frac{a(1-a)}{1+a}$, and $w^{E_i}|_{M&R} = \frac{a-(1+a)c}{a^2} > w^{E_i}|_M = 1 - \frac{c}{a}$ when $\frac{a(1-a)}{1+a} < c < \frac{a(2-a)(1-a)}{(2-a)(1-a)^2}$.

It is important to note that the manufacturer’s benefit from the retailer brand comes from the free-riding on the retailer’s efforts to induce consumer evaluation. When $c$ is sufficiently low $0 < c < \frac{a(2-a)(1-a)}{(2-a)(1-a)^2}$, consumers always evaluate with and without the presence of $R$. The sole driving force behind the benefit is that the manufacturer takes advantage of the retailer’s stronger incentive to induce consumer evaluation after $R$ is introduced.
This beneficial effect can also be interpreted from the interaction between the manufacturer and the retailer compensating for the consumer evaluation cost. Consumers are aware of the sunk cost entailed to conduct product evaluation. Therefore they will decline to evaluate if their expected surpluses are completely exploited through high retail prices. To induce consumer evaluation, the retailer needs to lower the retail prices to subsidize for $c$, ensuring that consumers receive nonnegative expected payoffs. In the absence of $R$, the retailer lowers $p_M$ by $\frac{c}{\alpha}$ to compensate for evaluation. With the presence of $R$, consumers consider $p_M$ and $p_R$ jointly before making evaluation decisions, and the retailer can induce consumer evaluation by lowering the “leveraged retail price” $(\alpha p_M + (1 - \alpha)p_R)$ by the amount of $c$. Because of the extra profit the retailer can earn by selling $R$, the retailer predominantly prefers to induce consumer evaluation $E_i$ even if the manufacturer charges a high $w$. Hence, when evaluation cost is low ($0 < c < \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}$), the retailer incurs the cost of compensating for consumer evaluation, while the manufacturer charges a high wholesale price and benefits from the higher price margin.

I also acknowledge that the manufacturer may benefit from greater consumer evaluation at higher $c$ when $R$ is introduced. Consistent with this claim, when $\frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2} < c \leq \frac{\alpha(1-\alpha)}{\alpha(1-\alpha)^2+1}$, consumers in equilibrium choose to evaluate products with the presence of both $M$ and $R$, but not to evaluate when there is only $M$ in the market. This implies that although the manufacturer brand exists before the retailer brand is introduced, consumer preference uncertainty may not be resolved until a retailer brand is introduced. Therefore, after the retailer brand is introduced, the manufacturer can charge a higher $p_M$ to exploit consumers who prefer $M$ after resolving their preference uncertainty, and so can make a higher profit.

2.2.3 Equilibrium Introduction of Retailer Brand

I now compare the retailer’s profits before and after the retailer introduces $R$ to obtain the retailer’s optimal brand introduction decision. The retailer’s profits before and after $R$ is introduced are given in equation (2.4) and equation (2.8) respectively. When $\pi_R|_{M\&R} \geq \pi_R|_M$, the retailer chooses to introduce $R$; when $\pi_R|_{M\&R} < \pi_R|_M$ the retailer chooses not to introduce $R$. The
The following proposition summarizes the retailer’s optimal decision on retailer brand introduction.

**Proposition 2.2** In equilibrium, the retailer chooses to introduce $R$ when $c \leq \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)}$ and $F \leq \max\{1-\alpha-c, \frac{c}{\alpha}\}$, or when $c > \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)}$ and $F \leq \frac{\alpha^2 - \alpha + 1}{\alpha(1-\alpha)^2}$. 

(i) The retailer’s incentive to introduce $R$ first decreases then increases with $c$ when $c < \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)}$.

(ii) The manufacturer can be better off when $R$ becomes more popular ($\alpha$ decreases) at low evaluation cost ($c \leq \min\left\{\frac{\alpha^2(1-\alpha)}{2\alpha^2-(1-\alpha)^2}, \frac{\alpha(1-\alpha)}{\alpha(1-\alpha)^2+1}\right\}$).

The introduction of a retailer brand can benefit the retailer in two ways. First, the retailer can enjoy the high price margin from $R$ by selling to consumers who prefer $R$ to $M$ after conducting product evaluation, the *evaluation effect*. Second, the retailer can use the retailer brand to create product competition against $M$ in order to acquire a lower $w$ from the manufacturer, the *competition effect*. Therefore, the retailer’s decision to introduce $R$ depends on whether the benefits exceed the fixed introduction cost $F$.

When $c$ is low ($c \leq \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)}$), the *evaluation effect* is strong and the retailer has a stronger incentive to induce consumer evaluation after introducing the retailer brand. However, recall from proposition 2.1 that the manufacturer free rides on the retailer’s stronger incentive, and the retailer has to compensate for the consumer evaluation cost. As $c$ increases, the retailer suffers more from compensating for consumer evaluation cost, which reduces the benefit from the *evaluation effect*. Alternatively, the retailer can switch to the strategy of selling only $R$ without inducing consumer evaluation, leading to a stronger *competition effect* against $M$. To account for this threat, the manufacturer has to motivate the retailer to continue selling $M$ by charging a lower wholesale price. Since the *evaluation effect* decreases with $c$ and the *competition effect* increases with $c$, combining the two effects, I show that the retailer’s incentive to introduce $R$ first decreases and then increases with $c$.

With the introduction of the retailer brand, the manufacturer’s profit changes from $\pi_M|_M$ to $\pi_M|_{M&R}$, indicating that a change to the equilibrium

---

3When $\frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)} < c < \frac{\alpha(1-\alpha)^2}{\alpha(1-\alpha)^2 + 1 - \alpha + F}$ the retailer strategically chooses not to offer $R$. Under this condition, the retailer’s profit from selling $M$ alone exceeds that from selling both $M$ and $R$. 

---
product introduction strategy may increase/decrease the manufacturer’s profit. Therefore, a change of brand popularity ($\alpha$) which influences the retailer brand introduction decision may affect the manufacturer profit. Interestingly, the manufacturer can be better off when $R$ becomes more popular, as shown in proposition 2.2(ii). From the retailer’s perspective, its profit always increases as $R$ becomes more popular. In the range of evaluation cost defined in Proposition 2.2(ii), the retailer has an incentive to switch from not offering $R$ to the strategy of introducing $R$ as $(1 - \alpha)$ increases. As discussed in proposition 2.1, the manufacturer benefits from the introduction of a retailer brand ($\pi_{M|R} > \pi_{M|M}$) when $c \leq \frac{\alpha(1-\alpha)}{\alpha(1-\alpha)^2 + 1}$. Therefore, it is not necessarily bad news for the manufacturer when the retailer brand becomes more popular among consumers.

2.3 Retailer Brand Introduction and Channel Structure

In section 2.2, I study the retailer brand introduction strategy in a decentralized channel. In this section, we compare that with a centralized channel where a manufacturer owns the retailer. In the model, the manufacturer first decides whether to introduce $R$ in addition to $M$ with a fixed cost $F$, then decides on the retail price(s). As in the previous section, I identify the equilibrium product introduction strategy by comparing the manufacturer’s profit before and after introducing $R$ (see the appendix). The manufacturer chooses to introduce $R$ when $F \leq \max\{1 - \frac{2 - \alpha}{1 - \alpha} c, 1 - c - \alpha, 0\}$, and the equilibrium product introduction strategy is illustrated by the thin line in Figure 2.3.

I now compare the equilibrium product introduction strategy with that in a decentralized channel. In Figure 2.3, the thin line intersects with the thick line at three points: point 1, 2 and 3, where $c_1 < c_2 < c_3$. The three intersects are: $(c_1, F_1) = \left(\frac{\alpha(1-\alpha)}{1 + \alpha - \alpha^2}, \frac{1 - \alpha}{1 + \alpha - \alpha^2}\right)$, $(c_2, F_2) = \left(\frac{\alpha(2 - \alpha)(1 - \alpha)}{(2 - \alpha)(1 - \alpha)^2}, \frac{(3 - \alpha)(1 - \alpha)^2}{(2 - \alpha)(1 - \alpha)^2}\right)$, $(c_3, F_3) = \left(\frac{\alpha(1 - \alpha)}{\alpha(1 - \alpha)^2 + 1}, \frac{(1 - \alpha)^2}{\alpha(1 - \alpha)^2 + 1}\right)$. I then define four regions $(A, B, C, D)$ in
Figure 2.3: Retailer brand introduction strategy with $\alpha = 0.6$. The thick (thin) line identifies the retailer brand introduction in a decentralized (centralized) channel.
Figure 2.3 where

\[
\begin{align*}
A & : \max\{1 - \alpha - c, \frac{c}{\alpha}\} \leq F \leq 1 - \frac{2 - \alpha}{1 - \alpha}c, \quad c < c_1; \\
B & : 1 - \frac{2 - \alpha}{1 - \alpha}c \leq F \leq \frac{c}{\alpha}, \quad c_1 \leq c < c_2; \\
C & : \max\{1 - \frac{2 - \alpha}{1 - \alpha}c, 1 - \alpha - c\} \leq F \leq \frac{\alpha^2 - \alpha + 1}{\alpha(1 - \alpha)}c - \frac{\alpha}{1 - \alpha}, \quad c > c_3; \\
D & : \frac{\alpha^2 - \alpha + 1}{\alpha(1 - \alpha)}c - \frac{\alpha}{1 - \alpha} \leq F \leq 1 - \frac{2 - \alpha}{1 - \alpha}c, \quad c_2 \leq c \leq c_3.
\end{align*}
\]

(2.9)

The following proposition summarizes the main findings:

**Proposition 2.3** The retailer brand \( R \) is more (less) likely to be introduced in a centralized channel than in a decentralized channel in regions \( A \) and \( D \) (\( B \) and \( C \)).

Interestingly, proposition 2.3 shows that \( R \) is more likely to be introduced in either a centralized or a decentralized channel. In the region defined by \( A \) where the evaluation cost is low (\( c \leq c_1 \)), the manufacturer in a decentralized channel takes advantage of retailer compensation for the evaluation cost, lowering the retailer’s incentive to introduce \( R \). However, in a centralized channel, there is not such interaction between the manufacturer and the retailer, and \( R \) is more likely to be introduced. In regions defined by \( B \) and \( C \) where the evaluation cost is high, \( R \) is more likely to be introduced in a decentralized channel than in a centralized one. This is due to the fact that the retailer in a decentralized channel can rely on the competition effect brought in by \( R \) in order to acquire a low \( w \) from the manufacturer when \( c \) is high. However, in the centralized channel, this motivation is absent. \( R \) is also more likely to be introduced in the centralized channel in the region defined by \( D \). In this region, the retailer in the decentralized channel strategically chooses not to introduce \( R \), which allows the retailer to benefit from the manufacturer’s incentive to lower the wholesale price in order to align the retailer’s incentive on consumer evaluation.

I also study the welfare implications of retailer brand introduction under different channel structures. Consumer welfare is defined by the utility gain from purchasing a product, subtracting the price paid. Without consumer evaluation, the overall consumer welfare is defined by \( CS^E = \alpha - p_M \) if \( \bar{E}_M \) is induced, or \( CS^E = (1 - \alpha) - p_R \) if \( \bar{E}_R \) is induced. With consumer evaluation, the consumer welfare becomes \( CS^{E_i} = 1 - \alpha p_M - (1 - \alpha)p_R - c \) if \( R \) is introduced, or \( CS^{E_M} = \alpha(1 - p_M) - c \) if \( R \) is not introduced.
In a decentralized channel, consumer welfare is:

\[
\begin{align*}
CS^E_i|_{M&R} &= 0, \ CS^E_M|_M = 0 & \text{if } c \in \left[0, \frac{\alpha^2}{(2-\alpha)(1-\alpha)^2}\right]; \\
CS^E_i|_{M&R} &= 0, \ CS^E_M|_M = \alpha - \frac{c}{1-\alpha} & \text{if } c \in \left(\frac{\alpha^2}{(2-\alpha)(1-\alpha)^2}, \alpha(1-\alpha)\right]; \\
CS^E_i|_{M&R} &= 0, \ CS^E_M|_M = 0 & \text{if } c \in \left(\alpha(1-\alpha), \frac{1-\alpha^2}{2-\alpha}\right]; \\
CS^E_M|_{M&R} &= 0, \ CS^E_M|_M = 0 & \text{if } c \in \left(\frac{1-\alpha^2}{2-\alpha}, 2\alpha(1-\alpha)\right].
\end{align*}
\] (2.10)

In a centralized channel, consumer welfare is:

\[
\begin{align*}
CS^E_i|_{M&R} &= 0, \ CS^E_M|_M = 0 & \text{if } c \in \left[0, \frac{\alpha(1-\alpha)}{2-\alpha}\right]; \\
CS^E_i|_{M&R} &= 0, \ CS^E_M|_M = \alpha - \frac{c}{1-\alpha} & \text{if } c \in \left(\alpha(1-\alpha), \alpha(1-\alpha)\right]; \\
CS^E_i|_{M&R} &= 0, \ CS^E_M|_M = 0 & \text{if } c \in \left(\alpha(1-\alpha), 2\alpha(1-\alpha)\right].
\end{align*}
\] (2.11)

I compare consumer welfare in a decentralized channel with that in a centralized channel, and report the most interesting result in the following proposition.

**Proposition 2.4** Consumer welfare is higher in a decentralized channel than in a centralized channel when

\[
\frac{\alpha^2}{(2-\alpha)(1-\alpha)^2}c - \frac{\alpha}{1-\alpha} \leq F \leq 1 - \frac{2-\alpha}{1-\alpha}c \quad \text{and} \quad \frac{\alpha^2}{(2-\alpha)(1-\alpha)^2}c < c < \frac{\alpha(1-\alpha)}{2-\alpha}.
\]

Proposition 2.4 contrasts with the well-known belief that a centralized channel leads to higher consumer welfare than a decentralized channel. In the parameter space defined in proposition 2.4, \(R\) is introduced in a centralized channel but not in a decentralized channel. In the decentralized channel, the retailer charges a low retail price and consumers do not evaluate due to the high evaluation cost. In contrast, in the centralized channel, \(R\) is introduced and consumers choose to evaluate the products in equilibrium. Consumers’ preference uncertainty is resolved and their surpluses are extracted. Consequently, consumer welfare is lower in the centralized channel than in the decentralized channel.
2.4 Model Extension

2.4.1 Quality Difference Between $M$ and $R$

In previous studies, I have assumed that consumers gain a value of 1 after purchasing a preferred brand, regardless of $M$ or $R$. This assumption implies that there is no quality difference between $M$ and $R$ such that consumers get the same value from their preferred brands. I now relax this assumption to incorporate quality differences in the model. So I assume that consumers who prefer $M$ will gain a value of 1 upon purchase, while consumers who prefer $R$ will get a value of $\gamma$ ($\gamma < 1$). I focus on the most interesting case where $\gamma$ is not too small ($\frac{\alpha}{(2-\alpha)+(1-\alpha)^2} \leq \gamma < 1$) to rule out the uninteresting case that $R$ will never be introduced.\footnote{In addition, the fixed cost $F$ and the consumer evaluation cost $c$ are not too high ($F < \gamma(1-\alpha)$ and $c < (1+\gamma)\alpha(1-\alpha)$).}

I identify the equilibrium product introduction strategy and pricing strategies following the analysis similar to that in section 2.2. In equilibrium, the manufacturer and retailer’s profits are functions of $\gamma$ (see the appendix). By observation, $\pi_R$ increases weakly with $\gamma$, indicating that the retailer benefits with its brand quality increase. Interestingly, when $c \in (\frac{\alpha(1-\alpha)\gamma}{1+\alpha}, \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2})$, $\pi_M$ also increases with $\gamma$ ($\frac{\partial \pi_M}{\partial \gamma} = (1-\alpha) > 0$). This implies that the manufacturer can benefit when the quality of $R$ increases.

**Proposition 2.5** When $\frac{\alpha(1-\alpha)\gamma}{1+\alpha} < c \leq \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}$, the manufacturer brand benefits from a retailer brand quality increase ($\frac{\partial \pi_M}{\partial \gamma} = (1-\alpha) > 0$).

With the increase of $\gamma$, the retailer can charge higher retail prices if $R$ is introduced ($\alpha p_M + (1-\alpha)p_R = \alpha + \gamma(1-\alpha) - c$, which increases with $\gamma$), since consumers are willing to pay more for $R$. Therefore, the retailer has a greater incentive to introduce the retailer brand and induce consumer evaluation. The manufacturer can then take advantage of the retailer’s incentive to induce consumer evaluation and charge a higher wholesale price with the increase of $\gamma$. Consequently, the manufacturer may benefit with higher retailer brand quality.
2.4.2 Brand $R$ Introduced by Manufacturer

In the main model, $R$ is introduced by the retailer. In this subsection, I study the case when $R$ is introduced by the manufacturer instead of the retailer in a decentralized channel. This allows us to see whether the benefit of $R$ for the manufacturer comes from greater consumer evaluation caused by $R$ itself or the retailer's incentive to induce consumer evaluation. In the model, the manufacturer decides whether to introduce $R$ in addition to $M$ with a fixed cost $F$. All other setups are the same as in the main model. It is straightforward to see that in equilibrium when the manufacturer introduces $R$, the sole purpose is to induce consumer evaluation for the products, otherwise it is strictly better for the manufacturer to distribute the more popular brand $M$. In addition, the manufacturer should motivate the retailer to sell both products. Assume that the manufacturer charges wholesale prices $w_M$ and $w_R$ for $M$ and $R$ respectively. As shown in the appendix, $w_M$ and $w_R$ should satisfy $\left(\frac{2-\alpha}{\alpha}c-(1-\alpha)\right) \leq w_M - w_R \leq \frac{\alpha(1+\alpha)c}{\alpha^2}$, $w_M \leq 1$ and $w_R \leq 1$ with $c \leq \frac{\alpha(1-\alpha)}{1+\alpha-\alpha^2}$ to induce consumer evaluation. Hence, the optimal prices are $w_M = 1$ and $w_R = \frac{\alpha(1-\alpha)+(1-\alpha)c}{\alpha^2}$. I compare the manufacturer’s profit with the case when $R$ is introduced by the retailer in section 2.2, and summarize the main results in the following proposition.

**Proposition 2.6** In a decentralized channel, the manufacturer's profit is lower when $R$ is introduced by the manufacturer itself instead of the retailer. This happens when $c \leq \frac{\alpha(1-\alpha)}{1+\alpha-\alpha^2}$ and $2-\frac{1}{\alpha}-\alpha+c \frac{(1-\alpha^2)}{\alpha^2} < F < \min\{1-\alpha-c, \frac{c}{\alpha}\}$; or when $\frac{\alpha(1-\alpha)}{1+\alpha-\alpha^2} < c < \frac{\alpha(1-\alpha)}{1+\alpha(1-\alpha)^2}$ and $F < \frac{c}{\alpha}$.

Interestingly, proposition 2.6 shows that the manufacturer benefits more from $R$ when $R$ is introduced by the retailer instead of the manufacturer itself. The intuition is as follows. When $R$ is introduced by the manufacturer, the retailer is less motivated to carry both $M$ and $R$. Consequently, the manufacturer has to lower its wholesale prices to motivate the retailer to carry the whole product line and induce consumer evaluation. In contrast, when $R$ is introduced by the retailer, the retailer has a stronger incentive to carry both $M$ and $R$ and induce consumer evaluation. Therefore, the manufacturer is more likely to benefit from $R$ when $R$ is introduced by the retailer, and the benefit of $R$ to the manufacturer comes from the strategic interaction between the manufacturer and the retailer rather than the greater consumer evaluation caused by $R$. 

23
2.4.3 Higher Retailer Brand Popularity

Our main model assumes that the manufacturer brand is a more popular brand ($\alpha > \frac{1}{2}$). I now extend the model to study the case when the retailer brand is more popular than the manufacturer brand ($\alpha < \frac{1}{2}$). As shown in the Appendix, when $R$ becomes more popular, $R$ is more likely to be introduced in both a centralized and a decentralized channel. In addition, now it is likely that only $R$ is sold when $R$ is sufficiently popular, which is in contrast to the main model when $M$ is more popular.

On one hand, in a decentralized channel, I find that product introduction strategy is the same with section 2.2.1, where $\alpha > \frac{1}{2}$. This indicates that the retailer follows the same rule to introduce $R$ when $\alpha < \frac{1}{2}$. The retailer’s selling strategy is different at high evaluation cost ($c \geq \alpha$), where it will induce $\{E_R\}$ instead of $\{E_M\}$. As a result, the retailer receives $\pi_R = 1 - \alpha - F$, and the manufacturer receives $\pi_M = 0$ (compared with $\pi_R = 1 + \alpha - \frac{c}{1-\alpha} - F$ and $\pi_M = \frac{c}{1-\alpha} - 1$). This is because the retailer is inclined to promote the sales of $R$ due to its high popularity (hence high demand) when consumer evaluation is too costly to induce. And the manufacturer loses its stand to induce the sales of the less popular manufacturer brand. On the other hand, in a centralized channel, the firm follows a different retailer brand introduction strategy when $\alpha < \frac{1}{2}$. The product introduction strategy is the same for low evaluation cost ($c < \alpha$). When $c \geq \alpha$, the firm introduces $R$ if and only $F \leq 1 - 2\alpha$ (compared with $F \leq \max\{1 - c - \alpha, 0\}$). Hence, when $R$ becomes more popular than $M$, the firm alters the brand introduction strategy to increase the likelihood of having a retailer brand in a centralized channel. Also, with the presence of $R$, the firm will induce $\{E_R\}$ instead of $\{E_M\}$ at a high cost of evaluation ($c > c'$), leading to channel profit $\pi = 1 - \alpha$ (compared to $\pi = \alpha$). In summary, when $R$ becomes more popular than $M$, the product introduction strategy in a decentralized channel is unaffected, while in a centralized channel, the firm is more likely to introduce $R$ when $c \geq \alpha$ and $F \leq 1 - 2\alpha$.

2.4.4 Cost to Evaluate Multiple Products

In this main model, I assume that the evaluation cost $c$ does not depend on the number of products in a product category. In this subsection, we examine
the case where \( c \) is higher with more products in the product category. In
the model, when only \( M \) is in the market, consumer evaluation cost is still \( c \). However, when both \( M \) and \( R \) are in the market, consumer evaluation cost becomes \( c + k \) where \( k > 0 \). With the increase of the incremental evaluation cost \( k \), it is more difficult for the retailer to induce consumer evaluation. It is straightforward to see this does not affect my main conclusions as long as \( k \) is sufficiently low.

2.4.5 Revenue Sharing Contract

In the main model, we used a leader-follower model to capture the interactions between manufacturer and retailer sequential pricing. Now I extend the model to another type of manufacturer-retailer interaction of revenue sharing. The revenue sharing model can be a Nash bargaining solution where the more powerful party in the channel get hold of a larger proportion of the channel profit. Assume that the manufacturer gets a \( \delta \) proportion from the profit of the manufacturer brand \( \pi_M = \delta p_M D_M \) and the retailer gets \( \pi_R = (1 - \delta)p_M D_M \) where \( D_M \) is the demand for the manufacturer brand at given \( p_M \) and \( p_R \). The parameter \( \delta \) measures the relative power of the manufacturer over retailer and is fixed disregarding the retailer’s activity of retailer brand introduction.

Based on this set up, in the subgame where a retailer brand is not introduced, the manufacturer and the retailer gets:

\[
\begin{align*}
\pi_{EM}^E &= (\alpha - c)\delta, \quad \pi_{EM}^R = (\alpha - c)(1 - \delta) \quad \text{if } c \in [0, \frac{\alpha(1-\alpha)}{2-\alpha}]; \\
\pi_{EM}^E &= \delta \frac{c}{1-\alpha}, \quad \pi_{EM}^R = (1 - \delta)\frac{c}{1-\alpha} \quad \text{if } c \in (\frac{\alpha(1-\alpha)}{2-\alpha}, \alpha(1 - \alpha)]; \\
\pi_{EM}^E &= \delta\alpha, \quad \pi_{EM}^R = (1 - \delta)\alpha \quad \text{otherwise}.
\end{align*}
\]

(2.12)

In another subgame, where the retailer brand \( R \) has been introduced, the retailer predominantly prefers to induce \( E_i \) and \( \overline{E}_R \) from consumers. To induce \( E_i \), the retailer charges \( p_{EM}^{E_i} = \alpha \) and \( p_{EM}^{E_i} = 1 - \alpha - \frac{c}{1-\alpha} \). To induce \( \overline{E}_R \), the retailer charges \( p_{EM}^{\overline{E}_R} = \infty \) and \( p_{EM}^{\overline{E}_R} = \frac{c}{\alpha} \).

\[
\begin{align*}
\pi_{EM}^{E_i} &= \delta \alpha^2, \quad \pi_{EM}^{E_i} = 1 - c - \alpha^2 \delta - F \quad \text{if } c \in [0, \frac{\alpha(1-\alpha^2\delta)}{1+\alpha}]; \\
\pi_{EM}^{\overline{E}_R} &= 0, \quad \pi_{EM}^{\overline{E}_R} = \frac{c}{\alpha} - F \quad \text{otherwise}.
\end{align*}
\]

(2.13)
Unlike in the pricing leader-follower game, when the manufacturer and the retailer employ the revenue sharing configuration, the manufacturer never benefits from a retailer brand introduction. To see this, notice that with the leader-follower interaction, the retailer receives \( \pi_R^{E_i} = 1 - c - \alpha w \) when \( E_i \) is induced with a retailer brand introduction. The retailer accepts a high wholesale price \( w \) from the manufacturer as long as \( w \) is not too high to price \( M \) remove the extra benefits from inducing consumer evaluation. The manufacturer’s profit is irrelevant of \( p_M \) since the sales of \( M \) is fixed (\( \pi_M = \alpha w \)). On the other hand, under the profit sharing configuration, \( \pi_R^{E_i} = 1 - c - \alpha \delta p_M \), while leveraging the retailer prices to induce consumer evaluation, the retailer lowers the price of the manufacturer’s brand as much as possible so it may take advantage of the higher margin from the sales of a retailer brand. In this case, the manufacturer’s profit is directly determined by \( p_M \) (\( \pi_M = \delta \alpha p_M \)), and decreases as \( p_M \) decreases. The revenue sharing contracts manifest higher power to retailers in pricing, which leaves the manufacturer with no opportunity to free ride on the retailer’s high incentive to induce consumer evaluation.

2.5 Conclusion

In many product categories, it has become a growing trend for retailers to introduce premium retailer brands which have unique features, designs and styles, leading to a new manufacturer-retailer dynamic in retailing. Not only can premium retailer brands impact manufacturer brands, they also affect consumer decisions to evaluate products. With a retailer brand adding product choices in store, consumers are more motivated to evaluate products to resolve their preference uncertainties. My results provide guidelines for retailers on adjusting the retailer brand introduction strategy to account for consumer evaluation behavior. The findings also have implications for manufacturers in terms of how they should react in response to retailer brand introduction.

Our results suggest that a manufacturer can earn a higher profit when a retailer introduces a retailer brand. The presence of a retailer brand promotes the retailer’s incentive to induce consumer evaluation, and the manufacturer can take advantage of this incentive and charge a higher wholesale price.
for the manufacturer brand. This finding is different from what is in the extant literature, which claims that without other marketing externalities, the manufacturer is always worse off with retailer brands. What is more, the manufacturer may be better off when the retailer brand becomes more popular. This is because the increasing retailer brand popularity further promotes the retailer’s incentive to introduce a retailer brand, which again benefits the manufacturer. Therefore, a manufacturer may not want to go against the introduction of a retailer brand, especially in a product category where the retailer brand complements the manufacturer brand and consumers have to evaluate to find their preferred brands.

I show a retailer brand can be more likely to be introduced in either a centralized or a decentralized channel depending on the difficulty for consumers to evaluate the products. When product evaluation is relatively easy, a retailer can charge higher retail prices to exploit consumer surpluses but is subject to exploitation by the manufacturer. When evaluation is difficult, the retailer can use a retailer brand to compete against the manufacturer brand. Such issues do not appear in a centralized channel. Therefore, the retailer brand is more likely to be introduced in a centralized channel when consumer evaluation is easy, but less likely when consumer evaluation becomes more difficult for consumers.

I also show that a retailer brand has important implications for consumer welfare, and consumers may prove better off in a decentralized channel than in a centralized one. This happens when the retailer brand is introduced in a centralized channel but not in a decentralized channel. Although consumers are more likely to find their preferred brands with more brands to choose from, they suffer welfare losses due to the high retail prices. This finding sends a warning message to public policy makers, alerting them to the negative effects of centralized or coordinated channels.

This research highlights the important effects of premium retailer brands on consumers and channel relationships. There are some limitations to the current model. For instance, the product preference assumes either zero/one utility for non-preferred/preferred product from consumers. Also, the model assumes homogenous consumer evaluation cost while in reality, the evaluation cost can be heterogenous across consumers. These limitations can be addressed through relaxing the constraints, but my main findings are still valid with the robustness checks. In the current paper, the popularities of
the retailer brand and the manufacturer brand are exogenous. For future research, it is interesting to study the case when a retailer and a manufacturer can invest in product popularity or quality to affect consumer evaluation. In this model, I assumed a Stackelberg leadership between the manufacturer and the retailer. Future research can examine the implications of different game structures such as Vertical Nash. It will also be interesting to explore the effects of premium retailer brands in a competitive channel structure where consumers can evaluate products from competing manufacturers and retailers. Furthermore, a retailer and a manufacturer may induce consumer evaluation at different degrees which may resolve partial or complete preference uncertainty for consumers.
CHAPTER 3

THE BENEFITS OF A DECENTRALIZED CHANNEL WITH VOLUNTARY QUALITY DISCLOSURE

3.1 Introduction

Traditional literature on distribution channels unanimously suggests that in the absence of retailer marketing skills, a vertically integrated channel represents a more efficient way of distribution compared with a decentralized channel structure. That is, the vertically integrated profit is the maximum aggregate profit that a vertical channel structure can obtain (Tirole, 1994). This is because decentralized channels generate channel inefficiencies when manufacturers and retailers price independently to optimize their individual profits. However, this literature does not consider the effect of distribution channel on overall channel efficiency when it is costly to observe and verify some decision variables, which create information asymmetries among manufacturers, retailers and consumers. In this paper, I consider the channel efficiency in a centralized channel versus in a decentralized channel when the product quality information is only privately known by the manufacturer, and the manufacturer needs to incur a non-negligible cost to disclose its product quality. The cost to disclose product quality information is a type of cost to deliver product related information to consumers. Examples of marketing activities that may incur such costs are advertising, product sampling and acquiring third-party certification.\(^1\)

I show that contrary to the conventional wisdom, the decentralized channel may outperform the centralized channel, and the aggregate channel profit can be higher in a decentralized channel than in a centralized channel. This

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\(^1\)A firm may need to pay for third parties to certify product quality due to credibility issues, and this may incur an even higher cost. For instance, automotive manufacturers have to pay high costs to have their new models certified for safety. Pharmaceutical companies also need to spend a significant amount of money conducting clinical trials to collect safety and efficacy data of a new drug even after the quality of the drug has been tested.
is because the channel structure and the product quality distribution affect
the manufacturer’s decisions on quality disclosure as well as consumer per-
ception of product quality. Consumers can infer product quality even when
the manufacturer does not disclose quality-related information. They are
aware of the means of distribution for the products, whether the products
are indirectly sold by a retailer or sold through an integrated channel. When
receiving little or no product quality information, consumers then make ra-
tional predictions of product quality based on channel structure as well as
product quality distribution. Since the manufacturer in a decentralized chan-
nel is subject to channel inefficiency caused by the double marginalization
problem, consumers perceive the given disclosure cost being less affordable to
the manufacturer if the product is distributed indirectly. Consumers then at-
tribute the non-disclosure behavior of the manufacturer to the decentralized
channel rather than to low product quality.

Consistent with consumers’ belief, the manufacturer chooses a credible dis-
closure strategy depending on the structure of the channel. Thanks to the
arising channel inefficiency, the manufacturer in a decentralized channel is
able to commit to a partial disclosure strategy revealing less product infor-
mation than in a centralized channel. This helps the manufacturer keep the
image of a decent product quality producer without incurring an expensive
disclosure cost. As a result, the overall channel can be better off when the
channel is decentralized.

A more efficient decentralized channel performance also relies on the prob-
ability distribution of product quality. While most literature assumes a uni-
form distribution of product quality (Board, 2009; Guo, 2009; Levin et al.,
2009), I show that this result does not arise unless the distribution is non-
uniform. In reality, some firms are better known as producing better quality
products than others. For instance, when General Mills, one of the world’s
leading food companies, launches its new yogurt line “FiberOne”, consumers
are likely to have faith in the high quality of the new product given the
company’s premium brand name and its long experience in the food indus-
try. Hence this assumption of a general product quality distribution better
captures the practice in most industries. Under the general distribution of
product quality, the decentralized channel profit can be higher than in the
centralized channel, both \textit{ex post} and \textit{ex ante}. Although the \textit{ex post} decen-
tralized channel profit can be the maximum when the product quality is more
likely to be high in distribution, the *ex ante* channel profit can be improved only when there is sufficient likelihood for the manufacturer to obtain the *ex post* benefits from channel decentralization, i.e., there is sufficient probability for the manufacturer to withhold product information.

3.1.1 Related Literature

This chapter is related to the literature on channel coordination and channel double marginalization. Extant literature investigates the external instrumentalations to resolve the double marginalization issue and improve channel performance (Jeuland and Shugan, 1983; Moorthy, 1987; Jeuland and Shugan, 1988; Lal, 1990; Ingene and Parry, 1995; Gerstner and Hess, 1995; Iyer, 1998). The goal is to bring up the channel profit in a decentralized channel close to the profit in a centralized channel by implementing different pricing and non-pricing schemes. This implies that a centralized channel is always a superior structure to achieve channel efficiency. However, in this paper, I find that the centralized channel can be less efficient than a decentralized one when there exists information uncertainty on product quality. Without adopting any outside instrumentation, the decentralized channel structure can indeed outperform the centralized one.

Notice the intuition of this research is different from the literature on strategic channel decentralization (McGuire and Staelin, 1983; Moorthy, 1988; Coughlan and Wernerfelt, 1989; Choi, 1991; Desai et al., 2004). For instance, McGuire and Staelin (1983) find that strategic decentralization occurs when there is intense product market competition. Moorthy (1988) further adds that channel decentralization may be the equilibrium outcome, depending on the substitutability and complementarity of products at retail and manufacturer level. This chapter provides a new mechanism under which a decentralized channel can outperform a centralized channel even where competition is absent.

This research is also related to the literature of voluntary quality disclosure. In this chapter, we mainly focus on verifiable quality information disclosure as a form of quality assurance mechanism. We define quality disclosure as the most direct way to acknowledge the public of product quality related information. Among numerous forms to convey product quality in-
formation, such as industry sponsored voluntary disclosure, private party certification, warranties, money-back guarantee, prices, advertising expenditure and brand name, only the industry sponsored voluntary disclosure conducted by the producer itself as well as the third-party quality certification are deemed as quality disclosure by definition. Economics literature predicts that sellers will always disclose their private information about the quality of products as long as the disclosure cost is negligible (Grossman and Hart, 1980; Grossman, 1981; Milgrom, 1981). The unraveling result may not occur when the disclosure is costly (Viscusi, 1978; Grossman and Hart, 1980; Jovanovic, 1982; Guo, 2009; Dranove and Jin, 2010) and firms may adopt a partial disclosure strategy to only disclose favorable product information. In this paper, I study the effects of distribution channel structure instead of the disclosure cost for a manufacturer’s disclosure strategy.

The notion of quality disclosure is also related to the broad class of quality signaling literature. In signaling games, signals sent by senders do not have to depend on the senders’ true type. Quality disclosure, however, is a special type of signaling with verifiable information, where each type has a signal that can only be sent by that specific type. In other words, the costs of sending certain types of signal not pertaining to the sender’s true type are so large that those signals can be ruled out, and lying becomes impossible. It is shown that the verifiable information can be voluntarily revealed if the sender and the receiver share the same ranking over the quality information, leading to a full or partial revelation with dissipative disclosure cost (Grossman, 1981; Seidmann and Winter, 1997).

Our study also sheds light on the level of advertising in distribution channels. Consistent with most theoretical and empirical findings (Michael, 1999; Huang et al., 2002), I find the advertising level is lower in a decentralized channel than in a centralized one. While studying the level of advertising from the lens of product quality disclosure, I further suggest that when the manufacturer is more likely to produce a high quality product, the manufacturer becomes even less likely to disclose quality information. What is more, the difference of advertising level between a centralized channel and a decentralized channel will increase as the quality distribution is more likely to be on the high end.
3.2 Model

Our model considers a manufacturer that sells its product through a retailer. The product quality $v$ distributes from zero to one following a cumulative distribution function $F(v)$. $F(v)$ is a nondecreasing continuous function with $F(0) = 0$ and $F(1) = 1$. The probability density function is $f(v) = F'(v)$, which is a positive continuous function ($f(v) > 0$). When $f(v)$ increases with $v$ ($f'(v) > 0$), the product quality is more likely to be high, so the manufacturer is known for producing high quality product; when $f(v)$ decreases with $v$ ($f'(v) < 0$), the product quality is more likely to be low, so the manufacturer is known for producing low quality product. This setup captures the fact that some manufacturers are known for and are more experienced at producing high (low) quality products. I further assume that the quality information is privately known by the manufacturer unless the manufacturer chooses to disclose the quality to the public by incurring a disclosure cost $c$. This disclosure cost represents the cost of general technology such as advertising, sampling, and third-party certificates, to deliver information associated with product quality. I also assume that the manufacturer can always credibly and truthfully disclose the private information of product quality. Untruthful quality disclosure is unlikely due to legal restrictions or public monitoring, and can be detrimental to the firm’s long-term welfare (Grossman, 1981; Jovanovic, 1982).

Consumers have heterogenous tastes for product quality. Following Mussa and Rosen (1978), I use an index $\theta$ to capture consumers’ heterogenous willingness to pay for a unit of product quality, which follows the distribution $\theta \sim U[0, 1]$. Therefore, consumers get a utility of $u = \theta v - p$ from purchasing the product. While the distribution of product quality $F(v)$ is public information, consumers do not know the true quality of the product unless it is revealed by the manufacturer. I define the consumers’ belief about the product quality by $\tilde{v}$. $\tilde{v}$ is equal to the true quality $v$ if the quality information is disclosed. Otherwise, consumers update their belief about the product quality and $\tilde{v}$ is equal to the expected product quality $\bar{v}$ conditioning on the non-disclosure action by the manufacturer. At the purchase stage, consumers make purchase decisions based on $\tilde{v}$.

I analyze a two-stage game. In the first stage, the manufacturer chooses to disclose or withhold product information depending on the realized product
quality \( v \), and then charges a wholesale price \( w \) to the retailer. In the second stage, the retailer sets the retailer price \( p \). Consumers observe the product quality \( \tilde{\nu} \) as well as the retail price \( p \) and choose to purchase the product if they derive a nonnegative utility from the product. I first study the case of a centralized channel, where the manufacturer owns the retailer. Then I compare the results with the case of a decentralized channel.

In the model setup, I assume the realized quality is independent from the production cost, which is normalized to zero. This applies to the situation where the manufacturer invests in R&D, but there is uncertainty associated with the realized product quality. As a result, a higher investment in R&D may only affect the quality distribution \( F(v) \) and increase the probability of produce high quality products.

3.3 Analysis

3.3.1 Centralized Channel

In a centralized channel, the pricing decision is made to optimize the overall channel profit. Consumers observe the manufacturer’s behavior as to disclosing its product quality and form a belief. I denote the cutoff quality to disclose in the centralized channel by \( \hat{\nu}_c \) at which the manufacturer is indifferent between disclosing or not. If \( v > \hat{\nu}_c \), the manufacturer chooses to disclose the product information, whereas when \( v \leq \hat{\nu}_c \), the quality information is not revealed. This partial disclosure strategy has been verified by Jovanovic (1982). Consumers are aware of the optimal partial disclosure strategy, and will update their belief about product quality, conditioning on the action of disclosure by the manufacturer. The observed quality \( \tilde{\nu}_c \) can be expressed by

\[
\tilde{\nu}_c = \begin{cases} 
  v & \text{if disclose (} v > \hat{\nu}_c) \text{;} \\
  E(v|v \leq \hat{\nu}_c) = \hat{\nu}_c & \text{if no disclose (} v \leq \hat{\nu}_c) \text{,}
\end{cases}
\]

where \( \hat{\nu}_c = E(v|v \leq \hat{\nu}_c) = \frac{1}{F(\hat{\nu}_c)} \int_{0}^{\hat{\nu}_c} v f(v) \, dv = \hat{\nu}_c - \int_{0}^{\hat{\nu}_c} F(v)/F(\hat{\nu}_c) \, dv \).

Given that consumers’ belief as to quality is \( \tilde{\nu}_c \), and the demand is \( D(p, \tilde{\nu}_c) = 1 - \frac{p}{\tilde{\nu}_c} \), the manufacturer then optimizes its profit \( \pi^c = pD(p, \tilde{\nu}_c) \). At equilibrium, \( p^* = \tilde{\nu}_c/2 \), and the optimized channel profit gross the cost of disclosure.
is $\pi^c = \frac{\bar{v}}{4}$.

In the first stage, the manufacturer discloses or withholds product information according to a partial disclosure strategy. A credible disclosure strategy depends on the cost of disclosure as well as the channel profit, and must ensure that the manufacturer has no incentive to deviate. By adopting the disclosure strategy, $\tilde{v}_c = v$, and the manufacturer gets $\pi^c = \frac{\bar{v}}{4}$. By keeping silent, $\bar{v}_c = \bar{v}$, and $\pi^c = \frac{\bar{v}}{4}$. Since the manufacturer is indifferent between disclosure or not at $v = \hat{v}_c$, it follows that $\pi^c (v = \hat{v}_c) - c = \pi^c (v = \bar{v}_c)$, and I have $\bar{v}_c - c = \frac{\bar{v}}{4}$. Therefore, the disclosure cutoff point $\hat{v}_c$ must satisfy:

$$\int_0^{\hat{v}_c} F(v) \, dv = 4F(\hat{v}_c)c.$$  \hfill (3.2)

Notice that to guarantee a unique solution of $\hat{v}_c$ from equation (3.2), it is required that $G(v) = \frac{\int_0^{v} F(x) \, dx}{F(v)}$ be a monotonically increasing function of $v$ ($dG(v)/dv > 0$) (see proof in the appendix). Otherwise the manufacturer is unable to commit to a unique disclosure strategy. This implies that when consumers are forming expectations of product quality, the expected quality conditioning on no disclosure behavior does not increase as fast as the realized quality ($G(v) = v - \bar{v}$ and increases with $v$).

The ex ante profit that the manufacturer expects to gain prior to the realization of the product quality can be expressed by $E(\pi^c) = \int_0^{\hat{v}_c} \frac{\bar{v}}{4} f(v) \, dv + \int_{\hat{v}_c}^{1} (\frac{v}{4} - c) f(v) \, dv$. By replacing $\bar{v}_c = \hat{v}_c - 4c$, I get $E(\pi^c) = \int_0^{\hat{v}_c} \frac{\bar{v}}{4} f(v) \, dv + \int_{\hat{v}_c}^{1} \frac{v}{4} f(v) \, dv - c \int_0^{\hat{v}_c} f(v) \, dv$. The ex ante profit of the centralized channel is

$$E(\pi^c) = \begin{cases} \frac{K}{4} + \frac{1}{4} \int_0^{\hat{v}_c} F(v) \, dv - c & \text{if } c < \frac{1-K}{4}; \\ \frac{K}{4} & \text{if } c \geq \frac{1-K}{4}, \end{cases}$$  \hfill (3.3)

where $K = 1 - \int_0^{1} F(v) \, dv$, which is the average quality of the product. The manufacturer adopts a partial disclosure strategy ($\hat{v}_c < 1$) when $c < \frac{1-K}{4}$ with $\hat{v}_c$ defined by equation (3.2). When $c \geq \frac{1-K}{4}$, the manufacturer adopts a complete non-disclosure strategy ($\hat{v}_c = 1$).

### 3.3.2 Decentralized Channel

Now I consider the case of a decentralized channel where the manufacturer and the retailer make decisions independently. The manufacturer first de-
cides whether to disclose product quality and charges a wholesale price $w$. The retailer then decides on the retail price $p$. I denote consumers’ belief as to product quality in a decentralized channel by $\tilde{v}_d$. The demand in a decentralized channel becomes $D(\tilde{v}_d, p) = 1 - \frac{p}{\tilde{v}_d}$. The retailer optimizes its profit $\pi_r = (p - w)(1 - \frac{p}{\tilde{v}_d})$, which generates $p^* = \frac{\tilde{v}_d + w}{2}$. The manufacturer optimizes $\pi_m = w\tilde{v}_d$. It follows that $w^* = \tilde{v}_d/2$, and depending on the cost of disclosure as well as the channel profit, the retailer and the manufacturer receive $\pi_r = \tilde{v}_d/16$ and $\pi_m = \tilde{v}_d/8$ respectively.

Similar to the analysis in section 3.3.1, the manufacturer adopts a partial disclosure strategy with cutoff quality $\hat{v}_d$ at which the manufacturer is indifferent between disclosure or not. Therefore, $\tilde{v}_d = v$ if $v > \hat{v}_d$ and $\tilde{v}_d = \hat{v}_d = \hat{v}_d - \int_0^{\hat{v}_d} F(v)/F(\hat{v}_d) \, dv$ if $v \leq \hat{v}_d$. The equilibrium $\hat{v}_d$ is identified by equating the manufacturer’s profits $\pi^d_m$ with and without disclosure at $v = \hat{v}_d$. This requires that $\pi^d_m(v = \hat{v}_d) - c = \pi^d_m(v = \bar{v}_d)$ and $\frac{\bar{v}_d}{8} - c = \frac{\hat{v}_d}{8}$. Hence the optimal disclosure cutoff point ($\hat{v}_d$) should satisfy:

$$\int_0^{\hat{v}_d} F(v) \, dv = 8cF(\hat{v}_d). \quad (3.4)$$

Equations (3.2) and (3.4) are equivalent to $G(\hat{v}_c) = 4c$ and $G(\hat{v}_d) = 8c$ with $G(v) = \int_0^v F(x) \, dx/F(v)$. Since $G(v)$ increases monotonically with $v$, and with $8c > 4c$, the manufacturer in a decentralized channel is less likely to disclose its product quality information than in a centralized channel ($\tilde{v}_c < \tilde{v}_d$). This tendency can be attributed to the fact that the manufacturer needs to share the channel profit with a retailer and is subjected to the double marginalization effect in a decentralized channel. As a result of that, the manufacturer is less likely to afford the cost of disclosure unless the product quality is high enough to entail a disclosure. This adjustment of disclosure strategy with channel structure may have two impacts: firstly, it helps the manufacturer save the cost to disclose when the quality information is unfavorable; secondly, it may impede the efficiency of transaction since less information is revealed. I later show in section 3.3.3 that the positive effect may dominate, and the channel efficiency may be improved in a decentralized channel.

The ex ante manufacturer’s profit in a decentralized channel is $E(\pi^d_m) = \int_0^{\hat{v}_d} \frac{\tilde{v}_d}{8} f(v) \, dv + \int_{\hat{v}_d}^1 (\frac{v}{8} - c) f(v) \, dv = \frac{1}{8} - \frac{1}{8} \int_{\hat{v}_d}^1 F(v) \, dv - c$. The ex ante retailer’s profit is defined by $E(\pi^d_r) = \int_0^{\hat{v}_d} \frac{\tilde{v}_d}{16} f(v) \, dv + \int_{\hat{v}_d}^1 \frac{v}{16} f(v) \, dv = \frac{K}{16}$. Hence the
expected overall channel profit $E(\pi^d) = E(\pi^d_m) + E(\pi^d_r)$ and can be expressed as

$$E(\pi^d) = \begin{cases} \frac{3K}{16} + \frac{1}{8} \int_0^{\hat{v}_d} F(v) \, dv - c & \text{if } c < \frac{1-K}{8}; \\ \frac{3K}{16} & \text{if } c \geq \frac{1-K}{8}. \end{cases}$$ (3.5)

Similar to the case in the centralized channel, this channel profit is contingent on partial disclosure strategy when $c < \frac{1-K}{8}$, where $K = 1 - \int_0^1 F(v) \, dv$. When $c \geq \frac{1-K}{8}$, the manufacturer adopts a complete non-disclosure strategy.

### 3.3.3 The Effects of Channel Structure

**Effect on Disclosing Strategy**

I compare the optimal channel disclosure strategy in a centralized channel and a decentralized channel and summarize the results in the following lemma.

**Lemma 3.1** *(a)* When the product quality is more likely to be low ($f'(v) < 0$), the manufacturer chooses a lower cutoff disclosure quality ($\hat{v}_d$ and $\hat{v}_c$ both decrease) in both a centralized and a decentralized channel. The difference between the two disclosure strategies ($\hat{v}_d - \hat{v}_c$) decreases.

*(b)* When the product quality is more likely to be high ($f'(v) > 0$), the manufacturer chooses a higher cutoff disclosure quality ($\hat{v}_d$ and $\hat{v}_c$ both increase) in both a centralized and a decentralized channel. The difference between the two disclosure strategies ($\hat{v}_d - \hat{v}_c$) increases.
Lemma 3.1 describes the trend with which \( \hat{v}_d \) and \( \hat{v}_c \) change with the quality distribution \( F(v) \). Figure 3.1 illustrates the shape of \( f(v) \) with different types of quality distribution. When \( f'(v) < 0 \), the probability decreases as \( v \) increases, indicating that the product quality is more likely to be at the low end side. When \( f'(v) > 0 \), the probability increases with \( v \), and there is an increasing probability for the product quality to be at the high end side. Interestingly, when the product quality is likely to be low (\( f'(v) < 0 \)), the manufacturer is more likely to adopt a lower \( \hat{v}_c(\hat{v}_d) \) and disclose more product information at equilibrium. This is in contrast with the literature which claims that high-quality firms would always gain from revealing the true quality of their products in order to distinguish themselves from low-quality firms and charge higher prices, and only those with the lowest quality would choose not to reveal the quality of their products (Grossman, 1981; Milgrom, 1981). My results show that a high quality firm (a firm which is more likely to produce high quality product) will disclose less product information than a low quality firm (a firm which is more likely to produce lower quality product) in equilibrium. This is because consumer perception of product quality varies with \( F(v) \). When \( f'(v) > 0 \), consumers expect product quality to be decently high even when no information is revealed. Then the manufacturer has higher incentive to withhold information by choosing a higher \( \hat{v} \) and save the cost to disclose. When \( f'(v) > 0 \), consumers, who know about the quality distribution, will significantly downgrade the product quality when they observe no information is disclosed. In reaction, the manufacturer chooses to compensate for that by revealing the product information even with lower product quality (by choosing a lower cutoff disclosure quality \( \hat{v} \)).

Effect on Channel Profit

Now I compare the overall channel profits in the centralized and the decentralized channel. The channel profit difference is given by \( \Delta \pi = \pi^c - \pi^d \). I first discuss the \textit{ex post} channel profit difference when the quality of the product has been realized, and then examine the \textit{ex ante} profit difference, which measures the channel performance in general. The \textit{ex post} profit difference between the centralized and the decentralized channel is \( \pi^c - \pi^d = \frac{\tilde{v}_c}{4} - \frac{3\tilde{v}_d}{16} \), where \( \tilde{v}_c \) and \( \tilde{v}_d \) are the observed product quality by consumers in the centralized and decentralized channel respectively. According to the definition
of $\hat{v}_c$ and $\hat{v}_d$, and with $c < (1 - K)/8$, I have

$$\pi^c - \pi^d = \begin{cases} \frac{v}{16} & \text{if } \hat{v}_d < v \leq 1; \\ \frac{v}{4} - c - \frac{3}{16}(\hat{v}_d - 8c) & \text{if } \hat{v}_c < v \leq \hat{v}_d; \\ \frac{1}{4}\hat{v}_c - \frac{3}{16}\hat{v}_d + \frac{c}{2} & \text{if } v \leq \hat{v}_c. \end{cases}$$

(3.6)

I compare the ex post channel profits in the centralized and the decentralized channel, and summarize the results in the following proposition.

**Proposition 3.1** The ex post channel profit is higher in a decentralized channel than in a centralized one ($\Delta \pi = \pi^c - \pi^d < 0$) when the realized product quality is low ($v < \frac{3}{4}\hat{v}_d - 2c$) and when the disclosure cutoff points are sufficiently different in the centralized and the decentralized channel ($3\hat{v}_d - 4\hat{v}_c > 8c$).

Proposition 3.1 shows that interestingly, the ex post channel profit can be higher in a decentralized channel than in a centralized channel. This is because the channel structure affects consumer perception of product quality. In a decentralized channel, consumers perceive that the manufacturer’s profit is impacted by the negative effect of channel double marginalization, and the cost to disclose becomes less affordable to the manufacturer. Consumers will then attribute the non-disclosure behavior of the manufacturer to the inefficiency arising from channel decentralization instead of low product quality. But this effect is absent in a centralized channel. Therefore, when the manufacturer does not disclose product quality information in both distribution channel structures due to the low realized product quality ($v \leq \hat{v}_c$), consumers believe that the expected product quality in a decentralized channel is always higher than in a centralized channel ($\hat{v}_d > \hat{v}_c$). Under this condition, the decentralized channel will outperform the centralized channel ($\pi^c - \pi^d < 0$) as long as $3\hat{v}_d - 4\hat{v}_c > 8c$. In addition, when the realized product quality is moderately high ($\hat{v}_c < v \leq \hat{v}_d$), the manufacturer can keep silent in a decentralized channel, but has to disclose product quality in a centralized channel due to different consumer perceptions caused by channel structure differences. The manufacturer in the decentralized channel can save the cost to reveal quality information while still maintaining consumers’ expectation of decent quality even when no information is revealed, which improves the overall channel profit when $v < \frac{3}{4}\hat{v}_d - 2c$. When $\hat{v}_d < v \leq 1$, the realized
quality $v$ is high enough such that the manufacturer discloses the quality information in both channels. In this case, the decentralized channel profit is always lower than the centralized channel, due to the double marginalization effect.

Moreover, the product quality distribution further moderates consumer perceptions of product quality under different channel structures. For instance, when the manufacturer’s product quality is more likely to be high ($f'(v) > 0$), consumers perceive that the manufacturer distributing the high quality product in a decentralized channel suffers even more from the double marginalization effect. Hence when consumers observe the manufacturer withholding product quality information, their perceived quality increases if the product quality is more likely to be high ($f'(v) > 0$). When the product quality is more likely to be low ($f'(v) < 0$), the effect of double marginalization is less severe, and consumers attribute the non-disclosure of product information by the manufacturer more to the low product quality rather than the double marginalization caused by the decentralized channel. Consequently, the manufacturer’s optimal disclosing strategy is affected by the product quality distribution function $F(v)$, and the difference between the disclosure cutoff points ($\hat{v}_d - \hat{v}_c$) is higher when $f'(v) > 0$, and smaller when $f'(v) < 0$.

I now consider the \textit{ex ante} profit difference between a centralized channel and a decentralized channel when the product quality has not been realized. While the \textit{ex post} profit difference only describes possible realized quality with which a decentralized channel may achieve a higher channel profit, the overall performance of a centralized channel compared to a decentralized channel can be evaluated by the \textit{ex ante} channel profit difference, which is defined by the weighted sum of \textit{ex post} profit differences. The \textit{ex ante} profit difference ($E(\pi^c) - E(\pi^d)$) can be obtained by comparing the profits in equation (3) and equation (5) respectively, and can be expressed by

$$E(\pi^c) - E(\pi^d) = \begin{cases} 
\frac{K}{16} - (F(\hat{v}_d) - F(\hat{v}_c))c & \text{if } c < \frac{1-K}{8}; \\
\frac{K}{16} - (1 - F(\hat{v}_c))c & \text{if } \frac{1-K}{8} \leq c \leq \frac{1-K}{4}; \\
\frac{K}{16} & \text{otherwise.}
\end{cases} \quad (3.7)$$

**Proposition 3.2** The \textit{ex ante} channel profit can be higher in a decentralized channel than in a centralized channel if $F(v)$ satisfies $\int_{\hat{v}_c}^{\hat{v}_d} F(v) \, dv > \ldots$
\[ \int_0^{\hat{v}_c} F(v) \, dv + \frac{K}{2}, \text{ where } c < \frac{1-K}{8} \text{ and } \hat{v}_d \text{ and } \hat{v}_c \text{ are defined by equations (3.2) and (3.4).} \]

Proposition 3.2 shows that the \textit{ex ante} channel profit may also be higher in a decentralized channel than in a centralized one. Since the \textit{ex ante} profit is the weighted sum of the \textit{ex post} profits, the rationale behind proposition 3.2 is similar to that for proposition 3.1, where consumers attribute the non-disclosing behavior of the manufacturer to the double marginalization problem in the decentralized channel rather than to low product quality. On the one hand, a necessary condition for this to occur is the \textit{ex post} channel profit in a decentralized channel being higher than in the centralized one, which requires that the realized product quality is low \( (v < \frac{3}{4} \hat{v}_d - 2c) \), and the disclosure strategies being sufficiently different \( (3\hat{v}_d - 4\hat{v}_c > 8c) \), as described in proposition 3.1. Based on Lemma 3.1, the \textit{ex post} benefit for a decentralized channel can be higher when the quality is more likely to be distributed on the high end side \( (f'(v) > 0) \). On the other hand, the \textit{ex post} decentralized benefit is realized when the product quality is low, which requires that the product quality has sufficient distribution at the low end side so that the manufacturer can glean the benefits from the higher \textit{ex post} profit. Hence, when the product quality is more likely to be low \( f'(v) < 0 \), the manufacturer has higher probability of realizing the \textit{ex post} benefit from a decentralized channel and suffers less from the negative effect of channel decentralization. The distribution function \( F(v) \) that is likely to generate higher \textit{ex ante} channel profit in a decentralized channel, as described in proposition 3.2, should compromise the \textit{ex post} channel profit (quality distribution more likely to be high) with the probability of realizing the benefit (quality distribution more likely to be low).

### 3.3.4 Power Distribution of Quality

In the previous sections, I used the general function \( F(v) \) to derive equilibrium outcomes. Now I assume the quality follows an power distribution function \( F(v) = v^t \) and \( f(v) = tv^{t-1} \), where \( t > 0 \), to illustrate the model solutions and implications. According to equations (3.2) and (3.4), \( \hat{v}_c = 4(t+1)c \), \( \hat{v}_d = 8(t+1)c \) and \( K = 1 - \frac{1}{t+1} \). The \textit{ex ante} profit difference between a
centralized and a decentralized channel defined by (3.7) becomes:

\[ E(\pi^c) - E(\pi^d) = \frac{t}{16(t + 1)} + (4(t + 1))^t(1 - 2^t)c^{t+1}, \]  

(3.8)

where \( c \leq (1 - K)/8 = \frac{1}{8(t+1)} \). I have \( E(\pi^c) - E(\pi^d) < 0 \) when \( t < 1 \) and \( c_1 < c \leq \frac{1}{8(t+1)} \), where \( c_1 = \frac{1}{4(t+1)}(\frac{t}{4(2^t-1)})^{1/t} \). This is summarized in the following proposition.

**Proposition 3.3** When the quality follows an power distribution \( F(v) = v^t \) (\( t > 0 \)), the *ex ante* channel profit is higher in a decentralized channel than in a centralized channel \( (E(\pi^c) - E(\pi^d) < 0) \) when \( t < 1 \) and \( c_1 < c \leq \frac{1}{8(t+1)} \).

Proposition 3.3 indicates that with the power quality distribution \( (F(v) = v^t) \), the decentralized channel may outperform the centralized channel if the product quality is more likely to be low \( (t < 1 \) and \( f'(v) = t(t-1)v^{t-2} < 0 \).

In this case, when the manufacturer does not disclose the product quality in a decentralized channel, consumers may attribute it to the double marginalization problem rather than to low quality and expect the product quality to be high. Therefore, the benefit from withholding unfavorable information in a decentralized channel outweighs the loss from double marginalization, leading to a higher channel profit in a decentralized channel. When the product quality is more likely to be high \( (t > 1 \) and \( f'(v) = t(t-1)v^{t-2} > 0 \), consumers perceive the quality of the product being even higher in a decentralized channel than in a centralized one without product quality information \( (\bar{v}_d - \bar{v}_c = 8tc \) and increases with \( t ) \), and the *ex post* profit in a decentralized channel is higher when the realized product quality is low \( (v < (6t + 4)c) \).

However, the probability for the *ex post* decentralized channel profit to be higher is small, and the decentralized channel also suffers more from channel double marginalization. Overall, the *ex ante* channel profit is lower in a decentralized channel than in a centralized channel when \( t > 1 \).

Notice that the decentralized channel has the highest potential to outperform the centralized channel \( (E(\pi^c) - E(\pi^d) \) is lowest) when \( t = 0.39 \). When \( t \) approaches 0, consumers infer the quality to be very low in either a decentralized or a centralized channel without product information from the manufacturer. They also infer the expected qualities in the two channels to be similar \( (\bar{v}_d = 8tc \) and \( \bar{v}_c = 4tc \) become more nearly the same as \( t \) approaches 0). As a result, consumers do not prefer the product in a decen-
Figure 3.2: Quality distribution $F(v) = v^t$ at different levels of $t$ ($t = 2, 1, 1/2$).

tralized channel much more than the product in a centralized channel when information is withheld by the manufacturer in either channel structure. In fact, when $t$ approaches zero, $3\hat{v}_d - 4\hat{v}_c = 8(t + 1)c \simeq 8c$, indicating the ex post benefit from a decentralized channel is eliminated as $t$ approaches zero. With some dispersion of quality at the low quality side ($t \sim 0.39$), consumers perceive the product quality in the decentralized channel being sufficiently different from the quality in the centralized channel. While double marginalization does not seriously impact the decentralized channel profit, the higher perceived product quality in a decentralized channel contributes to a higher ex ante decentralized channel profit. In essence, for $F(v) = v^t$, hiding information is most beneficial for the decentralized channel when the quality is likely to be low but still with some degree of dispersion.

**General quality distribution function**

I now illustrate proposition 3.3 by examining the distribution function $F(v) = v^t$ with $t = 1, 1/2$ and 2 respectively. The results are discussed as follows and are also plotted in Figure 3.2 and Figure 3.3.

**1) Uniform quality distribution**

Assume that the quality is uniformly distributed from zero to one. This is the setting adopted by most literature (Board, 2009; Guo, 2009; Levin et al., 2009). Then $F(v) = v$ and $f(v) = 1$. The cutoff quality $\hat{v}_c = 8c$ and $\hat{v}_d = 16c$, with $K = 1 - \int_0^1 F(v) \, dv = \frac{1}{2}$. The channel profit difference $E(\pi^c) - E(\pi^d) = \frac{1}{32} + (\hat{v}_c - \hat{v}_d)c = \frac{1}{32} - 8c^2$, where $c \leq (1 - K)/8 = 1/16$. The profit change $E(\pi^c) - E(\pi^d)$ is always positive (see Figure 3.3). Hence,
Figure 3.3: Change of channel profit \((E(\pi_c) - E(\pi_d))\) with respect to the disclosure cost \(c\). \((F(v) = v^t, t = 2, 1, 1/2)\)

when the quality of the product is uniformly distributed, the decentralized channel will never outperform the centralized one.

\[\text{(2) Quality concentrated on the low end side}\]

When \(t = 1/2\), I have \(F(v) = \sqrt{v}\) and \(f(v) = \frac{1}{2\sqrt{v}}\). The cutoff qualities are \(\hat{v}_c = 6c\) and \(\hat{v}_d = 12c\), with \(K = 1 - \int_0^1 \sqrt{v} \, dv = \frac{1}{3}\). Then \(E(\pi_c) - E(\pi_d) = \frac{1}{18} + (\sqrt{6c} - \sqrt{12v})c\) where \(c \leq \frac{1}{12}\). It can then be proved that \(E(\pi_c) - E(\pi_d) > 0\) when \(c < c^* < \frac{1}{12}\) where \(c^* = \frac{1}{24}(3 + 2\sqrt{2})^{1/3}\); and \(E(\pi_c) - E(\pi_d) \leq 0\) when \(c^* \leq c \leq \frac{1}{12}\). This is consistent with proposition 3.3, which states that the decentralized channel may outperform the centralized one when the power distribution form satisfies \(t < 1\).

\[\text{(3) Quality concentrated on the high end side}\]

When \(t = 2\), I have \(F(v) = v^2\) and \(f(v) = 2v\). The cutoff qualities are \(\hat{v}_c = 12c\) and \(\hat{v}_d = 24c\), with \(K = 1 - \int_0^1 v^2 \, dv = \frac{2}{3}\). Then \(E(\pi_c) - E(\pi_d) = \frac{1}{24} + ((12c)^2 - (24c)^2)c = \frac{1}{24} - 432c^3\) where \(c \leq \frac{1}{24}\). For this type of quality distribution, the decentralized channel profit is always lower.

3.4 Conclusion

Does a centralized channel always outperform a decentralized channel, as suggested by most marketing literature on distribution channels? The answer is no. In this paper, I show that a decentralized channel may out-
perform a centralized channel in achieving higher *ex post* or *ex ante* overall channel profits disregarding the inefficiency brought about by the double marginalization problem. This happens when a manufacturer has private information on its product quality, and consumers have to infer the product quality from the manufacturer’s behavior as to disclosing the product quality in both a centralized and a decentralized channel. When a manufacturer’s product quality is low and the manufacturer chooses not to disclose the product quality information in a decentralized channel, consumers may attribute information-withholding behavior of the manufacturer to the double marginalization problem rather than the low product quality. Therefore, the manufacturer can then keep the image of producing higher product quality, which leads to a higher channel profit in a decentralized channel than in a centralized channel. This finding has important implications for marketing managers when they choose their channel structures, especially in industries where manufacturers often have private information on the quality of their products.

The beneficial channel decentralization and the degree of channel profit improvement are also contingent on the public information of quality distribution. When the product quality is more likely to be high, a manufacturer that is characterized as a high-quality manufacturer may commit to the strategy of disclosing less product information in a decentralized channel. This may benefit the channel by improving consumer perception of the product quality and saving the cost to disclose unfavorable product quality information. Hence I show that the decentralized channel may gain higher *ex post* and *ex ante* benefits when the quality distribution is more concentrated on the high quality side but when the realized product quality turns out to be low. This finding also has profound implications for manufacturers on improving their images of producing higher product quality.
CHAPTER 4

CHANNEL QUALITY DISCLOSURE WITH RETAILER BRAND INTRODUCTION

4.1 Introduction

In chapter 3, I show that a manufacturer may adopt a partial disclosure strategy to reveal the information of its product. I also show that a channel double marginalization affects the manufacturer’s profit, leading to a reduced incentive for the upstream manufacturer to reveal its product information. In that model setting, the retailer is purely the distributor of the manufacturer brand and passively observes the manufacturer’s product quality only when it has been disclosed. In this chapter, I examine the effect of a store brand introduction and how it influences the manufacturer’s incentive to disclose the private information of product quality.

The introduction of store brands/retailer brands has become a common practice in the retailing industry. Retailer brands are brands which are owned and managed by the store retailers, and are introduced to attract more value conscious consumers. For instance, almost all pharmacy stores such as Walgreen, CVS have introduced store branded medicine; chain stores like Target, Walmart and Aldi are filling their shelves with store brands in categories such as prepared food, skincare and personal care. Even online retailers such as Amazon.com are selling house brand electronics, kitchen tools and outdoor furniture. The presence of retailer brands naturally enriches consumers’ purchase option and also creates competition against national brands/manufacturer brands. In response to the retailer brands entry, manufacturers may take drastic measures (such as reducing the price, in-store/out-store promotion) to engage in head-to-head competition or to shirk by targeting the product to less competitive market segments. However, few literature has specifically addressed the change of manufacturer’s incentive to disclose product quality information in presence of retailer brands.
Quality disclosure is a type of informative advertising to communicate product quality information with potential buyers. Commodity producers usually have better information of their own product qualities than others as they routinely invest to acquire accurate product information. The information is privately known by producers or brand owners and can be known to the public if producers choose to voluntarily disclose the information or if quality disclosure is mandated by law (Jovanovic, 1982; Matthews and Postlewaite, 1985; Gavazza and Lizzeri, 2007). Although buyers can refer to online forum or consumer report for better understanding of the product, compared with manufacturers, they do not possess the necessary resources to invest and acquire more precise quality information. Even in the B-to-B context, contracting firms do not have accurate information regarding other firms’ product quality. For instance, the upstream manufacturer in a distribution channel have private information of its product quality which is not necessarily known by the downstream retailer, as the manufacturer has more expertise in production and testing. If sellers decide to reveal their product quality, the quality information can be credibly disclosed to the public at a cost. There are many forms of credible and truthful quality disclosure. For instance, manufacturer can rely on independent third-party certification or distribute testing products to deliver verifiable product information. Hotels can enroll in star rating classification system to reveal the service qualities, consumer packaged goods manufacturers can send out try-out samples to potential buyers.

The focus of this chapter is to study the quality information disclosure for a manufacturer and a retailer in a channel with the retailer introducing a retailer brand in addition to the manufacturer brand. I want to address research three questions. First, in the context of a retailer brand introduction, what are the manufacturer’s and the retailer’s decision to disclose product quality information? Second, how do asymmetries between manufacturer and retailer impact the information disclosure strategy? Third, what is wholesale pricing by the manufacturer and its implication to distribution channel efficiency?

Past literature on voluntary quality disclosure have examined sellers’ incentive to reveal product quality for monopolist and duopolists. In a monopoly setting, sellers adopt partial disclosure strategy when it is costly to disclose product information (Grossman, 1981; Milgrom, 1981; Jovanovic, 1982). In a
duopoly setting, firms engaged in competition reveal less quality information (Board, 2009; Guo and Zhao, 2009). Nevertheless, if firms disclose information in a sequential fashion compared to a simultaneous disclosure, the leader will be even less likely to disclose (Guo and Zhao, 2009). In this chapter, I investigate a manufacturer’s incentive to conduct quality disclosure when the downstream retailer introduces a store brand. While channel inefficiencies dampens the manufacturer’s incentive to reveal product information (see chapter 3), I am interested in whether the addition of a retailer brand reduces or promotes such incentive. I am also interested in the retailer brand quality disclosure conducted by the retailer, which is not studied previously.

I also model the asymmetries between the manufacturer and the retailer to account for the impact from disclosure costs and quality distribution differences. Guo and Zhao (2009) study a model with symmetric duopoly. However, in reality firms may incur different costs to disclose product qualities. For instance, manufacturers usually convey product information through traditional media such as television advertising and newspaper, which may incur higher disclosure cost; retailers can use more direct disclosure through on-site testing, sampling or in-store education to achieve more cost efficient quality unraveling. Since the manufacturer will take the retailer’s quality disclosure strategy into account when making decisions, a change of the retailer’s disclosure cost might impact the manufacturer’s incentive to disclose as well. The chapter also analyzes different quality distributions between the manufacturer and the retailer brand with retailer brand possessing a lower product quality on average. This configuration is consistent with the common notion that a retailer brand being a low quality substitute to the manufacturer brand. I then analyze the condition under which manufacturer quality disclosure becomes more sensitive to the change retailer brand quality distribution.

This study also sheds light on the efficiency of manufacturer brand distribution in distribution channels. A retailer can mitigate channel double marginalization in distributing the manufacturer brand by providing a lower quality product (Mills, 1995; Yehezkel, 2008). This is because the downstream competition motivates the manufacturer to reduce the wholesale price which translates to lowered retail price and improved channel efficiency. The similar mechanism may apply in the context of this model, but it is unclear whether the change of the manufacturer’s quality disclosure will cause the
manufacturer charge a lower wholesale price and what is the implication to channel performance.

To answer the proposed research questions, I examine a model of a monopolist manufacturer and a retailer who distribute a manufacturer brand and a retailer brand respectively to heterogenous consumers in a decentralized distribution channel. The retailer brand is only vertically differentiated from the manufacturer brand, and quality information is privately known by product owners (the manufacturer and the retailer). The manufacturer and the retailer voluntarily reveal the product information sequentially at different costs. Following the basic model by Jovanovic (1982), I study the manufacturer and the retailer equilibrium strategy to disclose/withhold product information.

In general, I find that manufacturer reveals less product information when a retailer brand is introduced. The cannibalization effect from a retailer brand undermines the manufacturer expected payoff from selling the manufacturer brand, and makes it more costly to disclose. Suffering from the inability to extract more surpluses through information disclosure, the manufacturer has less desire to conduct information disclosure. The retailer can be more(less) likely to disclose when the cost to disclose is low (high) compared with the manufacturer. Interestingly, unlike demonstrated by Guo and Zhao (2009), the retailer’s equilibrium disclosure strategy does not always depend on the observed quality from the manufacturer, although the retailer is able to strategically adjust the disclosure behavior. This happens when the observed manufacture brand quality is very low or high. The vertical relationship between a manufacturer and a retailer entails both competition and collaboration. On one hand, the retailer brand cannibalizes sales for the manufacturer brand, creating downstream competition. On the other hand, the dynamics can not be completely explained by a simple head-to-head competition between duopoly firms. When the manufacturer brand quality is very low or high, the retailer strategically leverages the final retail prices for the two brands to account for the relative quality levels instead of focusing on undercutting the other brand. Consistent with this notion, the retailer unambiguously has higher incentive to disclose product information when disclosure costs are the same across the manufacturer and the retailer. This is in contrast to the result discussed by Guo and Zhao (2009) who show that the retailer has less incentive to disclose when the cost to disclose is low.
The manufacturer’s incentive to disclose also depends on the disclosure costs incurred by the manufacturer and the retailer respectively. Manufacturer is less likely to disclose as the cost increases. Interestingly, I show that the manufacturer’s incentive to disclose first weakly decreases then increases with the retailer’s disclosure cost. This occurs since the retailer’s disclosure costs partial defines the competitiveness of the retailer brand and in turn affects the manufacturer’s strategy. I also find the manufacturer is less willing to disclose when the average quality from the retailer brand increases, and the disclosure strategy becomes most sensitive to the retailer quality distribution with moderate low disclosure cost.

Finally, I demonstrate that the ex post wholesale price charged by the manufacturer can be higher than the price charged in absence of a retailer brand. However, the competition of a retailer brand lowers the ex ante expected wholesale price, leading to a improved retailer performance in distributing the manufacturer brand at the expense of the manufacturer.

4.1.1 Literature

Information disclosure is one way to resolve market inefficiencies caused by asymmetric information (Akerlof, 1970). Sellers may apply numerous “quality assurance” mechanism such as industry-sponsored voluntary quality disclosure, private third-party certifiers, warranties and branding to establish verifiable quality information (Dranove and Jin, 2010). Quality disclosure is a direct way to deliver quality information, which includes the systematic report from certification agency and the direct information provided by sellers, provided that the information is verifiable. The rationale that underlies quality disclosure is for a high quality seller to distinguish itself from other competitors. A large body of literature has devoted to examine firms incentives to conduct voluntary quality disclosure to less informed buyers. The product quality disclosure theory discusses the unraveling results where the best quality firm has higher incentive to disclose. In case of zero disclosure cost, sellers will always disclose since rational consumers may infer lowest qualities from sellers which do not disclose (Grossman, 1981; Milgrom, 1981). This result depend on some strong assumptions such as the monopoly market structure, costless revelation and homogenous consumer.
Other quality disclosure strategy may emerge some of the aforementioned assumptions are relaxed. If there is a positive cost associated with information disclosure then sellers may credibly engage in partial information disclosure (Grossman and Hart, 1980; Jovanovic, 1982). With partial disclosure, more favorable product information is revealed while less favorable information will be credibly withheld by the seller. The change of market structure also play a role. Board (2009) demonstrates that competitive duopoly tends to hide more product information to avoid intensified competition even if the cost to disclose is negligible. This is further shown by Guo and Zhao (2009) who studied the simultaneous and sequential information disclosure between duopoly with positive disclosure cost. The competition yields less incentive to disclose for both firms, because the competitive pressure restricts their abilities to extract extra surplus from buyers through information disclosure. Moreover, the disclosure leader always discloses less information while the follower discloses less or more depending on the disclosure cost. Other studies also show that when products differ in both vertical and horizontal dimensions and with heterogenous consumers duopoly sellers tend to hide quality information to avoid intensified competition.

The research is also related to the literature which examines firms’ action to signal private information of product quality. Firms with cost advantage may signal product quality or low cost through low pricing (Milgrom and Roberts, 1986; Bagwell and Ramey, 1988), nevertheless, high quality firms which incur higher production cost may signal quality by distorting the price upward (Wolinsky, 1983; Bagwell and Riordan, 1991). There are other ways to deliver quality signal, including product warranty (Gal-Or, 1989; Balachander, 2001), money back guarantee (Moorthy and Srinivasan, 1995), planned scarcity (Stock2005) and advertising (Milgrom and Roberts, 1986; Zhao, 2000; Daughety and Reinganum, 2008). This research is related to signaling product quality through advertising. It is established that advertising spending can signal quality when it is too costly for the low quality firm to mimic the high quality one (Nelson, 1974; Milgrom and Roberts, 1986). In this case, advertising is purely dissipative expense and the content of advertising does not matter. When advertising raises awareness, high quality firm may spend less on advertising to signal quality (Zhao, 2000). Daughety and Reinganum (2008) consider a unified model of quality disclosure and signaling as two forms of communication which complement each other when
quality is exogenous. Firms may use advertising to directly disclose product quality to inform fractions of consumers (Moraga-Gonzalez, 2000), and price signal can substitute information disclosure. My research differs from the past advertising and signaling literature in the following ways: firstly, the advertising spending is exogenously determined by technology, sellers are subject to different costs to conduct quality disclosure; secondly, disclosure informs all consumers, there is no need to use price signals as complements or substitutes.

Lastly, there are studies on channel advertising and promotional activity associated with a store brands introduction. When a manufacturer distributes a product through retailers, it conduct less of advertising activity due to channel conflicts (Michael, 1999; Huang et al., 2002; Shaffer and Zettelmeyer, 2004). The introduction of store brands general introduce competition against national brands. As a result the store retailer receives higher retail margin and establish market power (Pauwels and Srinivasan, 2004; Ailawadi and Harlam, 2004). Empirical literature focuses on the promotional price competition between store brands and national brands. As a result of the competing promotional activities, competing promotional activities, the national brands to adopt the Hi/Lo pricing promotion while the store brands stick to the EDLP (everyday low price) (Dhar and Hoch, 1997; Ailawadi et al., 2001). Advertising costs and advertising intensity also affects the margin drawn by manufacturers and retailers, while retailers earn a higher margin from the national brand with a strong store brand presence, the manufacturer may command higher wholesale from the retailer through heavy advertising (Ailawadi and Harlam, 2004). Since the advertising costs is positively related to the advertising level, Abe (1995) suggests that national brand owner may choose a higher advertising level than store brands, to signal superior quality. Contrary to the previous literature, this paper investigates the act of manufacturer and retailer quality advertising as a form of informative advertising rather than price promotion or uninformative advertising to simply signal product quality.
4.1.2 Model

Consider in a distribution channel where a monopolist manufacturer sells a manufacturer brand (M) through a single retailer. The retailer also introduces a retailer brand (R). The product quality of the manufacturer brand \((v_m)\) and the retailer brand \((v_r)\) are uniformly distributed between zero and one \((U[0,1])\). The quality information is privately known by each of the brand owner unless it choose to disclose the quality to the public. I also assume that both manufacturer and retailer can credibly reveal the private information on product quality.

Consumers have heterogeneous tastes for product quality. Following Mussa and Rosen (1978), the parameter \(\theta\) is used to capture consumer’s heterogeneous willingness to pay for a unit of product quality, which follows a uniform distribution \(\theta \sim U[0,1]\). Buyers who purchased from any of the brands receive a surplus of \(\theta v_i - p_i, i = m,r\). Since the quality of each brand is privately known by the manufacturer and the retailer respectively, it may not be observed by the public unless the information has been disclosed. The manufacturer and the retailer incur a fixed disclosure cost \(c_m\) and \(c_r\) to conduct information revelation. \(c_m\) and \(c_r\) represent the costs of general marketing devices, such as advertising, requesting the third-party certification or providing samples, to disseminate information associated with product quality. To simplify the analysis, I assume the costs are small enough \((c_m, c_r \leq 3/32)\).

I use \(d_i (i = m, r)\) to denote the action of quality disclosure. \(d_i = 1\) indicates that quality is disclosed, and \(d_i = 0\) indicates that no information is revealed by \(i\). Assume that consumers’ beliefs of the product qualities of are \(\bar{v}_m\) and \(\bar{v}_r\) respectively. \(\bar{v}_i (i = m, r)\) is equal to the true quality \(v_i\) if the quality information is disclosed, or \(\bar{v}_i\) if no information is disclosed \((\bar{v}_i \in \{v_i, \bar{v}_i\})\). Similar to chapter 3, \(\bar{v}_i\) is the inferred quality of product \(i\) conditioning on the no disclosure activity from the seller. The values of \(\bar{v}_i\) are observed by all parties at the time when the retail prices are set.

Consider the following five-stage game. In the first stage, the manufacturer distributes a brand \(M\) through the retailer, and the retailer introduces a retailer brand at a cost \(F\) with \(F\) normalized to zero (so \(R\) is always introduced). All product qualities are realized upon production. In the second stage, the manufacturer makes a decision on disclosure based on the optimal disclosure strategy defined by the threshold quality level \(\hat{v}_m\). When \(v_m > \hat{v}_m\), the man-
manufacturer chooses to disclose the information of \( M \), whereas when \( v_m \leq \hat{v}_m \), the quality information is not revealed. Buyers, including the retailer and consumers, can infer from the non-disclosure action that the product quality is \( \bar{v}_m = \frac{\hat{v}_m}{2} \). In the third stage, the retailer determines whether to disclose the quality for \( R \) or not (\( \check{v}_r \in \{\bar{v}_r, v_r\} \)) based on the optimal disclosure strategy defined by \( \hat{v}_r \) after observing the quality from the manufacturer brand \( \check{v}_m \) where \( \check{v}_m \in \{v_m, \bar{v}_m\} \). In the fourth stage, the manufacturer charges a wholesale price \( w \) to the retailer for distributing the manufacturer product. In the last stage, the retailer sets the retailer prices \( p_m \) and \( p_r \). Consumers observe the product quality \( \check{v}_m \) and \( \check{v}_r \) as well as the retail prices \( p_m \) and \( p_r \), and purchase the product to maximize their individual utilities.

4.2 Analysis

4.2.1 Benchmark Case: No Retailer Brand

As a benchmark case, I first study the distribution of a manufacturer brand as a monopoly brand in the decentralized channel. Since the observed quality for \( M \) is \( \check{v}_m \), and the demand for the manufacturer brand is \( q_m = 1 - \frac{p_m}{\check{v}_m} \), the retailer optimizes its profit \( \pi_r = (p_m - w)(1 - \frac{p_m}{\check{v}_m}) \), which generates \( p_m^* = \frac{\check{v}_m + w}{2} \). The manufacturer optimizes \( \pi_m = wq_m - d_m c_m \), and the first order optimization leads to \( w^* = \check{v}_m/2 \). At the stage to make disclosure strategy, the manufacturer choose between withholding or disclosing product information. Following the same argument is chapter 3, to make the disclosing strategy credible, the manufacturer is indifferent between keeping silent or disclosing quality information when \( v_m = \hat{v}_m \), which requires that \( \hat{v}_m/8 - c = \check{v}_m/8 = \check{v}_m/16 \). Hence the optimal disclosure strategy \( \hat{v}_m^d = 16c_m \).

Compared with the optimal quality disclosure strategy in a coordinated channel, where \( \hat{v}_m^c = 8c_m \), the manufacturer reveals less information when it sells through a decentralized channel. This is because quality disclosure generates a lower marginal benefit for the manufacturer, reducing its incentive to reveal product information.

Based on the optimal disclosure strategy, in the decentralized channel, the retailer earns an ex post profit of \( \pi_r^d = \hat{v}_m/16 \), and the manufacturer gets \( \pi_m^d = \hat{v}_m/8 - d_m c_m \), with \( \check{v}_m \in \{v_m, \bar{v}_m\} \). The ex ante profit, which is the
profit retailer and manufacturer expect to receive prior to the realization of the actual product quality $v_m$, becomes

\[ E(\pi^d) = \int_{\tilde{v}_m}^{\hat{v}_m} \tilde{v}_m / 16 \, dv_m + \int_{\hat{v}_m}^{1} v_m / 16 \, dv_m = 1/32, \] (4.1)

\[ E(\pi^d_m) = \int_{0}^{\tilde{v}_m} \tilde{v}_m / 8 \, dv_m + \int_{\hat{v}_m}^{1} v_m / 8 - c \, dv_m = 1/16 - (1 - 16c_m)c_m. \] (4.2)

Similar to Guo and Zhao (2009), the manufacturer’s equilibrium ex ante profit first decreases then increases with $c_m$. At small $c_m$, $\hat{v}_m = 16c_m$ is small, and the manufacturer is likely to disclose product information, which always incurs a cost $c_m$. The negative effect of incurred disclosure cost dominates manufacturer’s payoff, hence $E(\pi_m)$ decreases with $c_m$. With the increase of $c_m$, the manufacturer can credibly withhold its quality information. Moreover, it is able to maintain a high average quality expectation from consumers ($\tilde{v}_m = 8c_m$ which increases with $c_m$) even no information is revealed. Hence the positive effect of information withholding overshadows the negative cost effect, leading to an increase of the manufacturer’s profit with disclosure cost $c_m$.

4.2.2 With Retailer Brand Introduction

Consider the case where a retailer brand $R$ has been introduced by the retailer at no cost. At the pricing stages where the manufacturer determines the wholesale price $w$ for brand $M$, and the retailers subsequently charges the retailer prices $p_m$ and $p_r$, I first assume that the observed quality for manufacturer brand is higher than the retailer brand ($\tilde{v}_m > \tilde{v}_r$). The market is segmented such that the consumers who are willing to pay more for quality would purchase the manufacturer brand, and the consumers who are willing to pay less for quality in trade for price would purchase the retailer brand. The demand for $M$ and $R$ are $q_m = 1 - \frac{p_m - p_r}{\tilde{v}_m - \tilde{v}_r}$ and $q_r = \frac{p_m \tilde{v}_r - p_r \tilde{v}_m}{(\tilde{v}_m - \tilde{v}_r)^2}$ respectively. By optimizing retailer’s profit $\pi_r = (p_m - w)q_m + p_r q_r - d_r c_r$ with respect to $p_m$ and $p_r$. It follows that the optimal prices are $p^*_m = \frac{\tilde{v}_m + w}{2}$ and $p^*_r = \frac{\hat{v}_r}{2}$. Observing the retailer’s optimal response, the manufacturer’s profit is given by $\pi_m = w(\frac{\tilde{v}_m - \tilde{v}_r - w}{2(\tilde{v}_m - \tilde{v}_r)}) - d_m c$. The optimized wholesale price is $w^* = \frac{\tilde{v}_m - \tilde{v}_r}{2}$. 55
If the observed manufacturer brand quality is lower than that for the retailer brand \( \tilde{v}_m \leq \tilde{v}_r \), the retailer prefers to carry the high quality retailer brand only and forgo the manufacturer brand since the marginal cost to sell \( R \) is always lower than that of \( M \). In this case, the retailer receives \( \pi_r = \frac{\tilde{v}_r}{2} - d_r c_r \) with \( p_r = \frac{\tilde{v}_r}{2} \). The manufacturer can not initiate any sales and gets \( \pi_m = 0 \).

Based on the above analysis, the retailer and the manufacturer’s optimal profit contingent on \( \tilde{v}_m \) and \( \tilde{v}_r \) are:

\[
\begin{align*}
\pi_m &= \begin{cases} 
\tilde{v}_m - b_m c_m, & \text{if } \tilde{v}_r < \tilde{v}_m; \\
0, & \text{if } \tilde{v}_r \geq \tilde{v}_m.
\end{cases}
\pi_r &= \begin{cases} 
\frac{\tilde{v}_m + 3\tilde{v}_r}{16} - b_r c_r, & \text{if } \tilde{v}_r < \tilde{v}_m; \\
\frac{\tilde{v}_r}{4} - b_r c_r, & \text{if } \tilde{v}_r \geq \tilde{v}_m.
\end{cases}
\end{align*}
\]

Retailer Brand Quality Disclosure

Knowing the retailer’s and the manufacturer’s pricing strategies at stage 4 and stage 5, I analyze the retailer’s optimal strategy to disclose \( v_r \) at stage 3. The retailer takes the advantage to observe the disclosure behavior from the manufacturer before it determines \( \hat{v}_r \). Consequently, its disclosure strategy is contingent on the observed quality from the manufacturer brand \( \tilde{v}_m \), where \( \tilde{v}_m \in \{ \bar{v}_m, v_m \} \). By withholding information, the observable quality of the retailer brand is the average quality contingent on the action of no disclosure \( (\tilde{v}_r = \tilde{v}_m, \text{ where } \tilde{v}_m = \frac{1}{\bar{v}_r} \int_0^{\bar{v}_r} v_r \, dv_r = \frac{\bar{v}_r}{2} \) \). The retailer gets:

\[
\pi_r \mid \text{silent} = \begin{cases} 
\frac{\tilde{v}_m + 3\tilde{v}_r}{16} & \text{if } \tilde{v}_r < \tilde{v}_m; \\
\frac{\tilde{v}_r}{4} & \text{if } \tilde{v}_r \geq \tilde{v}_m.
\end{cases}
\]

By disclosing quality information for \( R \), the observed quality for \( R \) is the actual quality \( (\tilde{v}_r = v_r) \). The retailer receives a profit:

\[
\pi_r \mid \text{disclose} = \begin{cases} 
\frac{\tilde{v}_m + 3\tilde{v}_r}{16} - c_r & \text{if } v_r < \tilde{v}_m; \\
\frac{v_r}{4} - c_r & \text{if } v_r \geq \tilde{v}_m.
\end{cases}
\]

To make the disclosure strategy credible, it must also be true that when \( v_r = \hat{v}_r \), the retailer is indifferent between keeping silent and disclosure. This translates to \( \pi_r \mid \text{silent} = \pi_r \mid \text{disclose} (v_r = \hat{v}_r) \).
Therefore, the optimal disclosure strategy for retailer is:

\[
\hat{v}_r^* = \begin{cases} 
8c_r & \text{if } \tilde{v}_m \leq 4c_r; \\
\frac{2}{5}\tilde{v}_m + \frac{32}{5}c_r & \text{if } 4c_r < \tilde{v}_m \leq \frac{32}{3}c_r; \\
\frac{32}{3}c_r & \text{otherwise.}
\end{cases}
\]  

(4.6)

\(v_r^*\) is the threshold quality beyond which retailer will disclose, that is, when \(v_r > \hat{v}_r^*\), the retailer chooses to disclose the quality information for its brand. When \(v_r \leq \hat{v}_r^*\), the retailer choose not to reveal any information, and keep silent.

**Lemma 4.1** The retailer’s optimal quality disclosure strategy \(\hat{v}_r^*\) does not depend on the observed quality from the manufacturer brand (\(\tilde{v}_m\)) when the observed manufacturer brand quality is low (\(\tilde{v}_m \leq 4c_r\)) or when the manufacturer brand quality is high (\(\tilde{v}_m > \frac{32}{3}c_r\)). Only when the observed manufacturer brand quality is intermediate (\(4c_r < \tilde{v}_m \leq \frac{32}{3}c_r\)) is the retailer’s optimal quality disclosure strategy contingent on \(\tilde{v}_m\). In this case, the retailer becomes less likely to reveal quality for the retailer brand with the increase of \(\tilde{v}_m\) \((\hat{v}_r^* = \frac{2}{5}\tilde{v}_m + \frac{32}{5}c_r)\).

Interestingly, the retailer’s strategy to disclose its product quality does not always depend on \(\tilde{v}_m\) even it has the advantage to make a decision after observing \(\tilde{v}_m\). In fact, \(\hat{v}_r\) depends on \(\tilde{v}_m\) only when \(\tilde{v}_m\) takes moderate values. When the retailer observes a higher manufacturer brand quality (\(\tilde{v}_m > \frac{32}{3}c_r\)), its interest is to keep \(M\) to target high segment consumers while targeting \(R\) to consumers who do not hold high valuation toward quality. Disregarding the retailer’s decision to withhold or disclose the information of its own brand \(R\), the incentive to sell \(M\) persists. More specifically, at \(v_r = \hat{v}_r\), the retailer’s strategy is to sell \(M\) no matter it keeps silent or not. Hence the retailer’s disclosure strategy becomes independent of \(\tilde{v}_m\). Likewise, when the observed manufacturer’s quality is very low \(\tilde{v}_m \leq 4c_r\), the retailer always rejects the manufacturer brand \(M\) but to sell the more efficient retailer brand \(R\) instead, and \(\hat{v}_r\) is not a function of \(\tilde{v}_m\) either. When the level of \(\tilde{v}_m\) is moderate \((4c_r < \tilde{v}_m \leq \frac{32}{3}c_r)\), the retailer’s decision is to keep \(M\) when its realized \(v_r\) is low \((v_r < \hat{v}_r)\), but to cut \(M\) when its realized \(v_r\) is high \((v_r > \hat{v}_r)\). The decision to keep or to forgo the manufacturer brand is closely associated with how much more profit can be generated when the retailer continues to sell...
Hence the decision to sell \( M \) is closely coupled with the retailer’s decision to disclose its product information, and \( \hat{v}_r \) becomes dependent on \( \tilde{v}_m \).

Also notice that this result is different from a sequential disclosure game in a duopoly competition as studied by Guo and Zhao (2009). In their cases, the disclosure follower (corresponds to the retailer here) adopts a disclosure strategy which is always a function of the disclosure leader (corresponds to the manufacturer here). The follower disclosure strategy is depends on the leader since the follower will receive zero profit if the leader’s product quality turns out to be high. However, in the channel context, the retailer also shares part of the manufacturer’s profit and is interested in leveraging the sales for all brands instead of always undercutting the manufacturer brand. Therefore there are conditions under which the retailer’s equilibrium disclosure strategy does not depend on the manufacturer brand quality. A further comparison with the duopoly sequential quality disclosure is illustrated in section 4.5.1.

**Manufacturer Brand Quality Disclosure**

The manufacturer predicts the reaction from the retailer to determine its equilibrium quality disclosure strategy \( \hat{v}_m \). The expected payoff (gross \( c_m \)) of the manufacturer conditioning on the disclosure strategy of the retailer can be expressed as the following:

\[
E(\pi_m) = \begin{cases} 
0 & \text{if } \tilde{v}_m \leq 4c_r; \\
\frac{1}{25}(\tilde{v}_m - 4c_r)(\tilde{v}_m + 16c_r) & \text{if } 4c_r < \tilde{v}_m \leq \frac{32}{3}c_r; \\
\frac{4}{21}(12c_r + 5\sqrt{21c_m - 48c_r^2}) & \text{if } c_m \in [448/75c_r^2, 64/3c_r^2]; \\
8\sqrt{c_m/3} & \text{otherwise.}
\end{cases}
\]  

(4.7)

To credibly commit to a disclosure strategy, it must be true that when \( v_m = \hat{v}_m \), the manufacturer becomes indifferent and \( E(\pi_m(\hat{v}_m)) - c_m = E(\pi_m(\tilde{v}_m)) \). Based on this notion, the optimal quality disclosure strategy for the manufacturer is:

\[
\hat{v}_m^* = \begin{cases} 
-6c_r + 5\sqrt{c_m + 4c_r^2} & \text{if } c_m \in [0, 96/25c_r^2]; \\
2\sqrt{25c_m/3 + 4c_r^2 - 4c_r} & \text{if } c_m \in [96/25c_r^2, 448/75c_r^2]; \\
\frac{4}{21}(12c_r + 5\sqrt{21c_m - 48c_r^2}) & \text{if } c_m \in [448/75c_r^2, 64/3c_r^2]; \\
8\sqrt{c_m/3} & \text{otherwise.}
\end{cases}
\]  

(4.8)
Figure 4.1: The optimal disclosure threshold $\hat{v}_m$ as a function of $c_m$ and $c_r$.

The top plot shows $\hat{v}_m$ as a function of $c_m$ with $c_r = \frac{1}{16}$. The solid line is with retailer brand, dashed line is the benchmark case where $R$ is absent. The bottom plot shows $\hat{v}_m$ as a function of $c_r$ with $c_m = \frac{1}{64}$.

It must also satisfy the constraint that $\hat{v}_m$ can not go beyond one ($\hat{v}_m \leq 1$), since $\hat{v}_m = 1$ represents no disclosure at all.

From figure 4.1(a), the manufacturer switch to a higher $\hat{v}_m$ with the introduction of a retailer brand, indicating that the manufacturer becomes more conservative towards information disclosure. Apparently, the optimal quality disclosure is also a function of both $c_m$ and $c_r$, except for higher $c_m$ where $\hat{v}_m = 8\sqrt{c_m}/3$ and is independent of $c_r$. The change of $\hat{v}_m$ as a function of
\( c_r \) is shown below:

\[
\frac{\partial \hat{v}_m^*}{\partial c_r} = \begin{cases} 
0 & \text{if } c_r \in [0, \sqrt{\frac{3c_m}{64}}); \\
12 - \frac{240c_r}{\sqrt{21c_m - 48c_r^2}} & \leq 0 & \text{if } c_r \in \left[ \sqrt{\frac{3c_m}{64}}, \sqrt{\frac{75c_m}{448}} \right); \\
-4 + \frac{8c_r}{\sqrt{25c_m + 4c_r^2}} & < 0 & \text{if } c_r \in \left[ \sqrt{\frac{75c_m}{448}}, \sqrt{\frac{25c_m}{96}} \right); \\
-6 + \frac{20c_r}{\sqrt{c_m + 4c_r^2}} & > 0 & \text{Otherwise.}
\end{cases}
\]  

(4.9)

**Proposition 4.1**  
(1) With the introduction of a retailer brand \( R \), the manufacturer becomes less likely to disclose quality information (\( \hat{v}_m > \hat{v}_m^d \)). The incentive to disclose also increases with the disclosure cost \( c_m (\frac{\partial \hat{v}_m}{\partial c_m} > 0) \).

(2) The manufacturer disclosure threshold (\( \hat{v}_m^* \)) first weakly decreases (\( \frac{96}{25} c_r^2 < c_m \)) and then increases (\( \frac{96}{25} c_r^2 \geq c_m \)) with retailer’s disclosure cost \( c_r \).

As shown in figure 4.1(a), I find the manufacturer becomes less likely to disclose product quality when a retailer brand is added to the product category. Without the introduction of a retailer brand, the manufacturer’s profit can be written as

\[
\pi_m = \int_0^{\hat{v}_m} \frac{v_m}{8} \, dv_m + \int_{\hat{v}_m}^{1} (\frac{v_m}{8} - c_m) \, dv_m.
\]

The first term is the manufacturer’s expected profit when it keeps silent, the second term is the profit gain from information revelation. Since \( \hat{v}_m(c_m) \) increases with \( c_m \), the first term increases with \( c_m \), while the second term decreases with \( c_m \). When a retailer brand is introduced, the profit becomes

\[
\pi_m = \int_0^{\hat{v}_m} \pi_m(\hat{v}_m) \, dv_m + \int_{\hat{v}_m}^{1} (\pi_m(v_m) - c_m) \, dv_m, \quad \text{with } \pi'(v_m) = \frac{v_m - \check{v}_r}{8} \text{ if } \check{v}_r < v_m; \quad \pi'(v_m) = 0 \text{ if } \check{v}_r \geq v_m.
\]

Apparently, the overall profit for the manufacturer decreases with the existence of a retailer brand encroaching the sales. Worse still, when the quality of the retailer brand exceeds that of the manufacturer brand, the manufacturer can not initiate any sales and ends up with zero payoffs. One might be tempted to think that the manufacturer will act more aggressively towards the retailer brand, leading to a lower \( \hat{v}_m \) and an elevated incentive to disclose information. However, the results show that less information is disclosed. By revealing information below \( \hat{v}_m \), the manufacturer may gain additional revenue through disclosure if there is no retailer brand. But with the presence of retailer brand competition, there is less gain of revenue, while the cost of revelation becomes more significant. In fact the manufacturer prefers to conceal more information to maintain the perceived quality when manufacturer is silent (\( \bar{v}_m \)).

I also find \( \hat{v}_m \) varies with both its own cost to disclose (\( c_m \)) as well as
the retailer’s cost of disclosure \( (c_r) \). First, I analyze the change of \( \hat{v}_m \) with \( c_m \). In general, the disclosure threshold \( \hat{v}_m \) increases with \( c_m \), indicating that the manufacturer would disclose less information when \( c_m \) increases. This is because the higher the \( c_m \), the more costly it becomes for the manufacturer to reveal product information. The manufacturer is able to credibly convince the other buyers that its non-disclosure action is mainly due to the high disclosure cost and commit to disclose less of product information.

In contrast to the monotonic relationship between \( \hat{v}_m \) and \( c_m \), \( \hat{v}_m \) may increase or decrease with the retailer’s disclosure cost \( c_r \). For very small \( c_r \) \( (c_r < \sqrt{\frac{3c_m}{64}}) \), \( \hat{v}_m \) is irrelevant of \( c_r \) \( (\partial \hat{v}_m / \partial c_r = 0) \); for intermediate \( c_r \) \( (\sqrt{\frac{3c_m}{64}} \leq c_r < \sqrt{\frac{25c_m}{96}}) \), \( \hat{v}_m \) decreases with \( c_r \) \( (\partial \hat{v}_m / \partial c_r < 0) \); and for large \( c_r \) \( \hat{v}_m \) increases with \( c_r \) \( (\partial \hat{v}_m / \partial c_r > 0) \). A forward-looking manufacturer predicts the possible move from the retailer in disclosing or concealing product information. Because the threat of competition is severe if \( \tilde{v}_m < \tilde{v}_r \), the manufacturer responds by increasing the probability leading to \( \tilde{v}_m > \tilde{v}_r \) to secure its stand in the market. For very low \( c_r \), the manufacturer knows that the retailer is likely to engage in information revealing due to low cost. Then \( \tilde{v}_m \) is independent of \( c_r \) since the retailer’s decision to disclose does not affect the manufacturer’s choice to disclose or reveal product information.

For moderate retailer disclosure cost \( (\sqrt{\frac{3c_m}{64}} \leq c_r < \sqrt{\frac{25c_m}{96}}) \), \( \hat{v}_m \) decreases with \( c_r \), indicating that the manufacturer is willing to disclose more information as \( c_r \) increases. In this range, \( E(\pi_m) = \frac{v^2_m}{16} - c_m \) or \( \frac{1}{16} \hat{v}_r (2v_m - \hat{v}_r) \) when it discloses product quality \( (d_m = 1) \), and \( E(\pi_m) = \frac{1}{16} \hat{v}_r (2\tilde{v}_m - \hat{v}_r) \) when it keeps silent \( (d_m = 0) \). It is easy to see that \( E(\pi_m) \) is irrelevant of \( c_r \) or decreases less with \( c_r \) when the manufacturer reveals quality, but \( E(\pi_m) \) decreases more rapidly with \( c_r \) when \( d_m = 0 \). Hence with the increase of \( c_r \), the manufacturer expected profit is unchanged when with disclosure but decreases with information concealing. This motivates the manufacturer to decrease \( \hat{v}_m \), resulting in a higher likelihood for the manufacturer to disclose product information. With high retailer disclosure cost \( (c_r > \sqrt{\frac{25c_m}{96}}) \), \( E(\pi_m) = \frac{1}{16} \hat{v}_r (2v_m - \hat{v}_r) \) when \( d_m = 1 \) and \( E(\pi_m) = 0 \) when \( d_m = 0 \). Since \( E(\pi_m) \) decreases faster with \( c_r \) when \( d_m = 1 \), the manufacturer will suffer from a greater profit loss with disclosure than with concealing when \( c_r \) increases. Hence, the manufacturer has higher incentive to hide more product information other than revealing them.
This finding can also be interpreted from the relative competitiveness from the retailer brand. With moderate relative $c_r$, the retailer brand poses a threat to the manufacturer brand only when the realized quality $v_m < \hat{v}_m$, at which $M$ will be sold only when the retailer does not disclose ($v_r < \hat{v}_r$). When $c_r$ becomes higher, so does $\hat{v}_r$, and the retailer brand becomes higher of a threat as the perceived retailer brand quality $\bar{v}_r$ increases. To deal with the competition, the manufacturer reduces the likelihood to hide product information. With high relative $c_r$, the retailer brand quality is only relevant when the manufacturer discloses information, since when $v_m < \hat{v}_m$, the manufacturer can never initiate any sales due to the low quality image. With the increase of $c_r$, the threat from the retailer brand is greater, and the manufacturer become less willing to disclose. This result also implies that when the cost to disclose for the retailer is moderately low such that retailer is likely to disclose, the perceived quality from the manufacturer brand surpasses the retailer only when both keep silent or the manufacturer discloses while the retailer conceals information. With higher retailer disclosure cost, the retailer keeps a high quality image even it does not reveal information, and the manufacturer can deliver a high quality image only when it discloses information.

I also analyze the retailer’s equilibrium disclosure strategy. Compared with the disclosure strategy ($\hat{v}_m$) from the manufacturer, the retailer may or may not disclose more product information depending on the relative cost of disclosure. Retailer’s likelihood to disclose compared with the manufacturer is shown in the following table.

<table>
<thead>
<tr>
<th>$\hat{v}_m$</th>
<th>$\frac{v_m}{c_r^2}$</th>
<th>$\hat{v}_r$ (if $\hat{v}_m = \frac{v_m}{2}$)</th>
<th>$\hat{v}_r$ (if $\hat{v}_m = v_m \geq \frac{v_m}{2}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$[0, 8c_r)$</td>
<td>$[0, \frac{96}{25})$</td>
<td>$\hat{v}_m$</td>
<td>$\hat{v}_m$</td>
</tr>
<tr>
<td>$[8c_r, \frac{32}{3} c_r)$</td>
<td>$[\frac{96}{25}, \frac{448}{75})$</td>
<td>$&lt; \hat{v}_m$</td>
<td>$\hat{v}_m$</td>
</tr>
<tr>
<td>$[32/3 c_r, \frac{64}{3} c_r)$</td>
<td>$[\frac{448}{75}, \frac{64}{3})$</td>
<td>$&lt; \hat{v}_m$</td>
<td>$&lt; \hat{v}_m$</td>
</tr>
<tr>
<td>$[64/3 c_r, 1]$</td>
<td>$[\frac{64}{3}, \frac{64}{3c_r^2})$</td>
<td>$&lt; \hat{v}_m$</td>
<td>$&lt; \hat{v}_m$</td>
</tr>
</tbody>
</table>

**Proposition 4.2** Compared with the manufacturer’s disclosure strategy, the retailer is less likely to disclose product quality ($\hat{v}_r > \hat{v}_m$) when $0 < \hat{v}_m < \frac{32}{3} c_r$, and with the manufacturer revealing its product quality; or when $0 < \hat{v}_m < 8c_r$, and with the manufacturer withholding product information. Otherwise, the retailer is more likely to disclose product quality compared with the manufacturer ($\hat{v}_r < \hat{v}_m$).
Figure 4.2: Manufacturer ex ante profit change with $c_m$ ($c_r = \frac{1}{32}$), and $c_r$ ($c_m = \frac{1}{32}$).

In general, the retailer becomes more willing to disclose product quality relative to the manufacturer with the increase of $\hat{v}_m$. The increase of $\hat{v}_m$ corresponds to the increase of $c_m$ relative to $c_r$. The incentives to disclose are driven by the costs of disclosure. With smaller (large) $\frac{c_m}{c_r}$, the retailer (manufacturer) may be able to commit to less information disclosure due to the higher disclosing expenditure. More interestingly, I observe action for the retailer to disclose product quality is closely related to the manufacturer’s action of concealing or disclosing product information. Especially when $8c_r < \hat{v}_m < \frac{32}{3}c_r$, the retailer becomes more willing to reveal if the manufacturer keeps silent, but less willing to disclose when the manufacturer discloses information, indicating that the retailer has a tendency to differentiate.

Profit Implications

**Manufacturer ex ante profit**

Prior to realizing the quality of either manufacturer brand or the retailer brand, the manufacturer and retailer approximate the ex ante expected profits according to the distribution of the product quality. The ex ante profit is a measure of how much payoffs the manufacturer and the retailer expect to receive by distributing the manufacturer and the retailer brands prior to engaging in such marketing activity. The ex ante profit for the manufacturer is:
The manufacturer ex ante profit $E(\pi_m)$ first decreases then increases with $c_m$. This “U” shape relationship is similar to the benchmark case. By the same argument, at lower $c_m$, the manufacturer suffers from the cost to disclose and $E(\pi_m)$ decreases with $c_m$. At higher $c_m$, the disclosure cost helps the manufacturer credibly hide unfavorable information to maintain a quality image even when no information is revealed. This positive effect from $c_m$ becomes dominant as $c_m$ increases, resulting in the “U” shape relationship between $E(\pi_m)$ and $c_m$.

I also find $E(\pi_m)$ weakly decreases with $c_r$ ($\partial E(\pi_m)/\partial c_r \leq 0$), indicating that the manufacturer loses profit as retailer disclosure cost increases. This is counterintuitive as one would expect that the manufacturer will receive higher payoff when it becomes more expensive for the retailer to disclose.

When $c_r$ is small compared with $c_m$ ($c_r < \sqrt{\frac{3}{64} c_m}$), the manufacturer’s payoff is unaffected by $c_r$ ($\partial E(\pi_m)/\partial c_r = 0$). This is also reflected from the fact that $\hat{v}_m$ is independent of $c_r$, where the retailer is much likely to disclose compared with the manufacturer, and manufacturer ex ante payoff is independent of the retailer’s disclosure decisions.

Interestingly, when $c_r$ is relatively high, the manufacturer ex ante profit decreases with $c_r$. With the increase of $c_r$, the retailer becomes less likely to ex post disclose product quality. This reduces the retailer’s action of creating product differentiation through disclosure, but also boosts buyers’ perceived quality of the retailer brand when the retailer keeps silent, creating severe cannibalization against the manufacturer brand. I find this negative effect dominating the manufacturer’s profit as $c_r$ increases. An examination of the manufacturer’s expected profit conditioning on $v_r$ confirms with this finding. The manufacturer’s expected profit is irrelevant of $\hat{v}_r$ when $\hat{v}_m \leq 4c_r$ and when $\hat{v}_m > \frac{32}{3} c_r$. However, for $4c_r < \hat{v}_m \leq \frac{32}{3} c_r$, $E_{v_r}(\pi_m) = \frac{1}{16} \hat{v}_r (2\hat{v}_m - \hat{v}_r)$ and

<table>
<thead>
<tr>
<th>$c_m$</th>
<th>$E(\pi_m)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$[0, \frac{96}{25} c_r^2]$</td>
<td>$\frac{1}{48} - \frac{272}{9} c_r^3 + \frac{10}{3} c_m \sqrt{c_m} + 4c_r^2 + \frac{40}{3} c_r^2 \sqrt{c_m} + 4c_r^2 - c_m (1 + 6c_r)$</td>
</tr>
<tr>
<td>$[\frac{96}{25} c_r^2, \frac{448}{75} c_r^2]$</td>
<td>$\frac{1}{48} - \frac{8}{3} c_m c_r - c_m - \frac{1856}{225} c_r^3 + \frac{16}{27} c_m \sqrt{75c_m} + 36c_r^2 - \frac{32}{225} c_r^2 \sqrt{75c_m} + 36c_r^2$</td>
</tr>
<tr>
<td>$[\frac{448}{75} c_r^2, \frac{64}{3} c_r^2]$</td>
<td>$\frac{1}{48} - c_m + \frac{500}{147} c_m c_r - \frac{4096}{343} c_r^3 + \frac{1000}{1323} c_m \sqrt{21c_m} - 48c_r^2 - \frac{10240}{9261} c_r^2 \sqrt{21c_m} - 48c_r^2$</td>
</tr>
<tr>
<td>$[\frac{64}{3} c_r^2, \frac{3}{64} c_r^2]$</td>
<td>$\frac{1}{48} + \frac{64}{9 \sqrt{3} c_m} c_r - c_m$</td>
</tr>
<tr>
<td>$[\frac{3}{64}, \frac{3}{32} c_r^2]$</td>
<td>$\frac{1}{64}$</td>
</tr>
</tbody>
</table>
decreases as $\hat{v}_r$ becomes higher. Therefore, when the retailer conceals product quality, the negative cannibalization effect drives down the manufacturer’s payoff as $c_r$ increases.

**Retailer ex ante profit**

The retailer’s ex ante profit is also a function of $c_m$ and $c_r$.

$$E(\pi_r) = \begin{cases} \frac{13}{96} - c_r - 5c_m c_r + \frac{32}{3} c_r^2 - \frac{224}{3} c_r^3 - \frac{5}{6} c_m \sqrt{c_m + 4c_r^2} + \frac{80}{75} c_r^2 \sqrt{c_m + 4c_r^2} & \text{for } [0, \frac{96}{25} c_r, \frac{448}{75} c_r^2, \frac{64}{3} c_r^3] \\ \frac{13}{96} - c_r + \frac{32}{3} c_r^2 - \frac{2048}{75} c_r^3 - \frac{1}{2025} \left( -6c_r + \sqrt{75c_m + 36c_r^2} \right)^3 & \text{for } [\frac{448}{75} c_r^2, \frac{64}{3} c_r^3, \frac{64}{3} c_r^3] \\ \frac{32}{9261} c_r^2 \left( -3087 + 1084 \sqrt{21c_m - 48c_r^2} \right) & \text{for } [\frac{64}{3} c_r^2, \frac{3}{32}] \\ \frac{13}{96} - c_r + \frac{32}{3} c_r^2 - \frac{1}{9} \sqrt{\frac{3}{2}} c_m & \text{for } [c_r, \frac{1}{32}] \end{cases}$$

By the same argument, the retailer’s payoff $E(\pi_r)$ assemble a “U” shape curve with $c_r$. Unlike in the benchmark case where $E(\pi_r) = \frac{1}{32}$ and is irrelevant of $c_m$, I find that $E(\pi_r)$ decreases with $c_m$ except when $8.17c_r^2 < c_m < \frac{64}{3} c_r^2$. Though the manufacturer gets worse off when quality of $R$ becomes higher, the retailer benefits from a strong manufacturer brand, and its profit increases with $\tilde{v}_m$ when $\tilde{v}_m > \tilde{v}_r$. When $c_m$ increases, $\tilde{v}_m = \tilde{v}_m$ increases if the manufacturer keeps silent, hence may benefit the retailer when $\tilde{v}_m > \tilde{v}_r$. However, there is smaller chance for the manufacturer to realize higher $\tilde{v}_m = v_m$ and differentiate from the retailer brand, which negatively affects the retailer’s profit. Another negative effect arises when $\tilde{v}_m = \tilde{v}_m$ becomes very high and the retailer is not able to justify the higher quality of a retailer brand against the manufacturer brand. Therefore, for $c_m \leq 8.17c_r^2$, the
retailer suffers from not being able to differentiate high quality manufacturer brand, but for $8.17c_r^2 < c_m < \frac{64}{3}c_r^2$, the retailer benefits when $c_m$ increases as the positive effect from concealing surpass the negative effect. When $c_m$ is very high ($c_m \geq \frac{64}{3}c_r^2$), the retailer suffers from the manufacturer being able to differentiate its own brand, and $E(\pi_r)$ again decreases with $c_m$.

### 4.3 Discussion

#### 4.3.1 Lower Quality Retailer Brand

Retailer brands are usually perceived as lower quality substitutes compared with manufacturer brand. To account for the effect of lower retailer brand quality, I examine a more general case where the average quality of a retailer brand $R$ is generally lower than the quality of the manufacturer brand. I assume that the quality of a retailer brand is uniformly distributed from 0 to $a$ with $a < 1$ and with probability density function $f(.) = \frac{1}{a}$. For the ease of exposition, I consider the case if the cost to reveal product quality is the same across manufacturer and the retailer ($c_m = c_r = c$).

$$
\hat{v}_m^* = \begin{cases} 
8\sqrt{ca}/3 & \text{if } c \in [0, \frac{3a}{64}); \\
\frac{1}{4}(-48c + 25a - 5\sqrt{256c^2 - 160ac + 21a^2}) & \text{if } c \in \left[\frac{3a}{64}, \min\left\{\frac{5a}{12}, c_1\right\}\right]; \\
\min\{16c, 1\} & \text{Otherwise.}
\end{cases}
$$

Where $c_1 = \frac{1}{128}(6 + 25a - 5\sqrt{4 - 20a + 41a^2})$ which is the cost beyond which $\hat{v}_m^* = 1$ and the manufacturer always withholds quality information.

The optimal quality disclosure is a function of both $c$ and $a$. $\hat{v}_m$ increases with $c$, since the incentive to disclose decreases when the cost becomes higher. Compare with the case where the retailer brand is not introduced and $\hat{v}_m^d = 16c$, the manufacturer have less incentive to disclose its quality information whenever $c < \min\left\{\frac{5a}{12}, c_1\right\}$. Otherwise, the disclosure strategy converges to the benchmark case ($\hat{v}_m = \hat{v}_m^d$).

Keeping the quality distribution of the retailer brand constant, the probability for the manufacturer to disclose first decreases rapidly, then decreases slowly with $c$ ($\hat{v}_m$ is a concave function of $c$ with $\frac{\partial^2 \hat{v}_m}{\partial c^2} < 0$). This indicates
that the impact of a retailer brand is most salient when disclosure cost is relatively low.

The distribution of the retailer brand quality \( a \) also plays a role in determining the equilibrium disclosure strategy \( \hat{v}_m \).

\[
\frac{\partial \hat{v}_m^*}{\partial a} = \begin{cases} 
4 \sqrt{\frac{c}{3a^3}} > 0 & \text{if } c \in \left[0, \frac{3a}{64}\right); \\
\frac{1}{4}(25 - \frac{5(21a - 80c)}{\sqrt{21a^2 - 160ac + 256c^2}}) > 0 & \text{if } c \in \left[\frac{3a}{64}, \min\{\frac{5a}{48}, c_1\}\right]; \\
0 & \text{Otherwise}.
\end{cases}
\]

(4.11)

**Proposition 4.3** (1) With the presence of a retailer brand \( R \), the manufacturer becomes less likely to disclose quality information when \( c < \min\{\frac{5a}{48}, c_1\} \). Otherwise, the manufacturer chooses the same disclosure strategy with/without a retailer brand.

(2) The equilibrium disclosure threshold \( \hat{v}_m \) increases with \( a (\partial \hat{v}_m/\partial a \geq 0) \), indicating that the manufacturer has less incentive to disclose as the average quality of the retailer brand increases. \( \hat{v}_m \) is most sensitive to \( a \) when the cost to disclose is moderately high \( (c = \frac{3a}{64}) \).

With a fixed disclosure cost \( c \), the probability to disclose for the manufacturer decreases as \( a \) increases \( (\frac{\partial \hat{v}_m}{\partial a} \geq 0) \), indicating that as the averaging retailer quality increases, the manufacturer becomes less likely to reveal its quality information. This is intuitive since with the increases of \( a \), the manufacturer perceives that the retailer brand will likely to bear a higher quality.
which poses a more compelling competitive threat to the manufacturer brand, and the expected payoff of manufacturer decreases in general. Moreover, \( \hat{v}_m \) is most sensitive to \( a \) (\( \partial \hat{v}_m / \partial a \) is the highest) when the cost \( c = \frac{3a}{64} \). This shows that when \( c \) is moderately low, the manufacturer is most susceptible to the quality distribution of the retailer brand, but with very low or high disclosure cost, the disclosure strategy is less sensitive to \( a \). With very low \( c \), the manufacturer can not credibly engage itself into withholding much product information due to the low disclosure cost. The threat of increased retailer brand quality is outweighed by the urge to disclose product quality. To another extreme, when \( c \) is very high (\( c > \min\{\frac{5a}{48}, c_1\} \)), manufacturer has very low incentive to disclose since information disclosure incurs a significant cost, and the change of retailer brand quality does not dominate the disclosure strategy from the manufacturer. With moderately low \( c \), the manufacturer profit changes drastically with \( a \), leading to a greater change of the equilibrium disclosure strategy.

**Retailer’s optimal quality disclosure strategy**

In reaction to the quality disclosure action from the manufacturer, the retailer decides its own quality disclosure strategy. When the manufacturer reveals quality information (\( d_m = 1 \)), \( v^*_r = \min\{\frac{32}{3} c, a\} \). When the manufacturer keeps silence (\( d_m = 0 \)), then \( v^*_r \) becomes

\[
\hat{v}^*_r = \begin{cases} 
\frac{32}{3} c & \text{if } c \in [0, \frac{3a}{64}); \\
\frac{2}{5} \hat{v}_m + \frac{32}{5} c & \text{if } c \in [\frac{3a}{64}, \frac{5a}{48}]; \\
\end{cases}
\]

(4.12)
As shown in Figure 4.5, when the manufacturer keeps silence \((d_m = 0)\), the retailer has higher incentive to reveal more information if the disclosure cost \(\frac{3a}{32} < c < \frac{5a}{48}\).

**Proposition 4.4** With same disclosure cost \(c\), the retailer always has a higher incentive to disclose its brand quality at any given product quality level \((\hat{v}_r < \hat{v}_m)\).

In contrast to Proposition 4.2 which shows that the retailer can be more (less) likely to disclose product quality when \(c_r\) is relatively low (high), I find when \(c_m = c_r = c\), the retailer has higher incentive to disclose compared with the manufacturer \((\hat{v}_r < \hat{v}_m)\) at a given product quality level. This implies that if the cost and technology to conduct product quality disclosure are the same across the manufacturer and the retailer, the retailer, given the same quality level, is more willing to disclose than the manufacturer. The retailer utilizes the second-mover advantage, and is more motivated to differentiate from the manufacturer brand which leads to a higher incentive to disclose its product quality. This result also differs from Guo and Zhao (2009) who claims that the disclosure follower has less incentive to disclose compared with the leader \((\hat{v}_{follower} > \hat{v}_{leader})\) for small \(c\), but has higher incentive \((\hat{v}_{follower} < \hat{v}_{leader})\) for higher \(c\). To see the difference, notice that the nature of competition in the manufacturer-retailer setting is different from the sequential disclosure game described by Guo and Zhao (2009). In their cases, the disclosure follower’s optimal disclosure strategy is always an increasing function of the observed quality from the leader \((\hat{v}_{follower} = \min\{\hat{v}_{leader} + c, 1\})\). When \(c\) is small, the leader is likely to reveal quality information \((\hat{v}_{leader} = v_{leader})\) and the follower has incentive to hide information to avoid head-to-head competition. However, in this setting, the retailer also gains from the sales of manufacturer brand, and whenever \(\hat{v}_m\) is very high, the incentive of the retailer is to sell \(M\) to consumers with higher requirement for product quality while target \(R\) to the lower segment consumers. Since it is always the interest of the retailer to carry the high quality \(M\), the retailer only leverages the sales of retailer brand and manufacturer brand. In reaction to the manufacturer’s high incentive to disclose at low \(c\), the retailer’s disclosure strategy \(\hat{v}_r = \frac{32}{3} c\), which is independent of \(\hat{v}_m\), and the retailer can have higher incentive to disclose its product quality compared with the manufacturer.
If I define the probability to disclose on the whole quality spectrum, and the likelihood to reveal quality information for the retailer is \( \text{Prob}(v_r > \hat{v}_r^*) = 1 - \frac{\hat{v}_r^*}{a} \), and for the manufacturer it is \( P(v_m > \hat{v}_m^*) = 1 - \frac{\hat{v}_m^*}{a} \). According to this definition, the retailer can be less likely to reveal quality information when its average quality is low and at higher disclosure cost (i.e. \( a < \frac{1}{2} \) and \( c > \frac{3a^3}{16} \) or \( a < \frac{28}{41} \) with \( c > c_2 \), and \( c_2 = \frac{15(-20a^2 + 15a^4 + a^2 \sqrt{3(112 - 248a + 123a^2)})}{120(-4 - 9a + 9a^2)} \)).

### 4.3.2 Wholesale Price Change and Channel Efficiency Implication

Channel inefficiencies may occur when the manufacturer brand is distributed through the decentralized channel, where the manufacturer and the retailer’s interests are not well aligned. Because the retailer is optimizing its own profit at a cost of the wholesale price charged by the manufacturer, channel decentralization results in higher retail price and decreased overall channel profit. Mills (1995) show that by carrying a substitutable store brand, a retailer is able to lower the wholesale price charged for the national brand, and the net effect improves the overall channel performance. However, does store brand introduction always reduce the wholesale price and mitigate double marginalization? In the context of retailer brand introduction, I examine the wholesale price in a decentralized channel (\( w^d \)) with the wholesale price \( w \) where a retailer brand \( R \) has been introduced. In a decentralized channel, the wholesale charged by the manufacturer and the retailer margin are:

\[
\begin{align*}
\text{ex post wholesale price} \\
& w^d = \begin{cases} 4c & \text{if } v_m \leq 16c; \\ \frac{v_m}{2} & \text{otherwise.} \end{cases} \tag{4.13}
\end{align*}
\]

If the retailer brand is introduced the wholesale price becomes \( w = \max\{\frac{\tilde{v}_m - \tilde{v}_r}{2}, 0\} \), and the margin for retailer is \( p_m - w = \frac{\tilde{v}_m + \tilde{v}_r}{4} \) if \( \tilde{v}_m \geq \tilde{v}_r \) or \( \infty \) if \( \tilde{v}_m < \tilde{v}_r \).

Now I compare \( w \) with \( w^d \).

1. If \( 0 \leq c < \frac{3a}{41} \),

\[
\begin{align*}
& w = \begin{cases} 2\sqrt{\frac{2c}{3}} - \frac{8}{3}c & \text{if } d_m = 0, d_r = 0; \\ \max\{2\sqrt{\frac{2c}{3}} - \frac{\hat{v}_r}{2}, 0\} & \text{if } d_m = 0, d_r = 1; \\ \max\{\frac{\tilde{v}_m - \tilde{v}_r}{2}, 0\} & \text{if } d_m = 1, d_r = 1. \end{cases} \tag{4.14}
\end{align*}
\]
I find $w > w^d$ when $d_m = 0, d_r = 0$ and $c < \frac{3a}{100}$, or when $d_m = 0, d_r = 1$ and $c < \frac{1}{24}(a - \sqrt{a(a - 6v_r) - 3v_r})$ for $v_m \leq 16c$ and $c < \frac{3a}{16}(vm + vr)^2$ for $16c < v_m < 8\sqrt{ac}$. Otherwise $w \leq w^d$.

(2) If $\frac{3a}{64} \leq c < \min\{\frac{5a}{38}, c_1\}$,

$$w = \begin{cases} \frac{3}{10} \tilde{v}_m - \frac{16}{5}c & \text{if } d_m = 0, d_r = 0; \\ \max\{\frac{1}{2} \tilde{v}_m - \frac{v_r}{2}, 0\} & \text{if } d_m = 0, d_r = 1; \\ \max\{\frac{v_m - v_r}{2}, 0\} & \text{if } d_m = 1, d_r = 1. \end{cases}$$ (4.15)

Where $\tilde{v}_m = \frac{1}{8}(-48c + 25a - 5\sqrt{256c^2 - 160ac + 21a^2})$. I find within the range it is always the case that $w < w^d$.

(3) If $c \geq \min\{\frac{5a}{38}, c_1\}$, then $w = w^d - \frac{a}{4}$, the introduction of a retailer brand does not affect the manufacturer’s disclosure strategy, however, $w < w^d$.

In summary, from the ex post wholesale price change show that $w > w^d$ when $d_m = 0, d_r = 0$ and $c < \frac{3a}{100}$, or when $d_m = 0, d_r = 1$ and $c < \frac{1}{24}(a - \sqrt{a(a - 6v_r) - 3v_r})$. This shows that the manufacturer may charge a higher wholesale, instead of a lower wholesale in face of downstream competition from the retailer brand. There are two interplaying mechanism which determines $w$. The competition effect from a retailer brand, and the manufacturer’s tendency to withhold information as a consequence of the profit reduction. In reaction to the direct competition from a retailer brand, the manufacturer lowers its price to motivate the retailer. However, due to the competition, the manufacturer has a higher incentive to withhold product information ($\tilde{v}_m > v_m^d$). This is demonstrated in the ex post wholesale price charged by the manufacturer when the manufacturer chooses to conceal the product information, it then charges $w = \frac{v_m - \tilde{v}_r}{2}$, which can be higher than $w^d$ if $c$ is small. As previously stated, $\tilde{v}_m$ is most sensitive to the threat of a retailer brand introduction when $c$ is low, and $\tilde{v}_m$ increases significantly with the retailer brand introduction. Although $w$ decreases by $\frac{\tilde{v}_r}{2}$ to account for competition, the manufacturer can credibly raise the price by $\frac{v_m - \tilde{v}_r}{2} - 4c$ and the overall ex post wholesale price can be higher than $w^d$.

**ex ante wholesale price**

The ex ante wholesale price change for the manufacturer measures the overall wholesale price change with respect to all possible $\tilde{v}_r$. For instance,
the expected $w$ conditioning on all possible $v_r$ is

$$E(w) = \begin{cases} \frac{v_r^2}{4a} & \text{if } \hat{v}_r \leq \bar{v}_m \leq a; \\ \frac{4}{25a}(\bar{v}_m - 4c)(\bar{v}_m + 16c) & \text{if } \bar{v}_r < \bar{v}_m < \hat{v}_r \leq a; \\ \bar{v}_m^2 - \frac{a}{4} & \text{if } a < \bar{v}_m < 1. \end{cases}$$ \hspace{1cm} (4.16)

I find that the ex ante wholesale price when a retailer brand introduction is always lower than the wholesale price in the monopoly decentralized channel ($E(w) < E(w^d)$), and the retailer receives higher gross margin from distributing the manufacturer brand. This indicates that aside from the profit from the retailer brand, the retailer performance in distributing the manufacturer brand improves at the expense of the manufacturer. This result also implies that the although the manufacturer quality disclosure incentive is lower with a retailer brand introduction, this does not offset the channel efficiency brought about by the retailer brand competition.

### 4.3.3 Different Disclosure Sequence

Consider a different disclosure sequence where the retailer discloses the product quality first, followed by the manufacturer who determines the equilibrium disclosure strategy based on observation from the retailer. From the manufacturer’s perspective, the best reaction is:

$$\hat{v}_m^* = \begin{cases} 16c_m & \text{if } \bar{v}_r \leq 8c_m; \\ \min\{8c_m + \bar{v}_r, 1\} & \text{otherwise}. \end{cases} \hspace{1cm} (4.17)$$

The retailer’s disclosure strategy $\hat{v}_r$ becomes:

$$\hat{v}_r^* = \begin{cases} \frac{32}{3}c_r & \text{if } c_r \leq \frac{3}{4}c_m; \\ \frac{1}{2}(-3 + \sqrt{9 + 256c_m^2 + 128c_r}) & \text{if } \frac{3}{4}c_m < c_r \leq \frac{3}{2}(1 + 4c_m)c_m; \\ 2\sqrt{1 + \frac{32}{3}c_r - 2} & \text{otherwise}. \end{cases} \hspace{1cm} (4.18)$$

The manufacturer’s reaction to the retailer’s quality disclosure shows that $\hat{v}_m > \hat{v}_m^d = 16c_m$. Hence even with a different sequence of disclosure, the manufacturer still has a reduced incentive to disclose compared with the benchmark case.

In a special case when $c_m = c_r = c$, $\hat{v}_r^* = \frac{1}{2}(-3 + \sqrt{9 + 256c^2 + 128c}) < 16c$, \hspace{1cm} (4.19)
and $\hat{v}_m^* = 16c$ if $d_r = 0$ or $\hat{v}_m^* = \min\{8c + \tilde{v}_r, 1\}$ if $d_r = 1$. In all these cases $\hat{v}_m \geq 16c > \hat{v}_r$. Even with reversed disclosure sequence, the manufacturer has reduced incentive to disclose compared with the retailer.

### 4.4 Conclusion

It has become a popular trend for retail stores to introduce retailer brands, creating competition against the manufacturer brands. However, little has been studied on how manufacturers and retailers act on product quality information disclosure with the presence of retailer store brands. In this chapter, I study the manufacturer’s voluntary quality disclosure when a retailer introduces a retailer brand. In general, I find that the introduction of a retailer brand creates competition against the manufacturer brand, making it more costly for the manufacturer to conduct quality disclosure. As a result, the manufacturer is less likely to reveal product quality. The equilibrium quality disclosure strategy of the manufacturer is a function of the disclosure cost from the manufacturer as well as from the retailer. As disclosure gets more expensive, the manufacturer is less likely to disclose. However, when the disclosure cost from the retailer increases, the manufacturer’s incentive to disclose first weakly increases then decreases. This implies that depending on the magnitude of the retailer disclosure cost, a manufacturer may react differently in revealing information. The retailer’s disclosure strategy depends on the observed quality from the manufacturer only when the cost to disclose is moderate. With very small or high cost, the retailer’s disclosure strategy becomes independent of the manufacturer. Compared with the manufacturer, the retailer has higher incentive to disclose when its disclosure cost is relatively low, while when the cost to disclose becomes higher for the retailer, it has less incentive to disclose.

Manufacturer and retailer ex ante profits are also functions of the disclosure costs. Both manufacturer and retailer payoffs are “U” shape functions of its own cost to disclose ($c_m$ and $c_r$ respectively). When the cost to disclose becomes high, the manufacturer and the retailer can save the cost to disclose while still take advantage of consumers higher willingness to pay when they keep silent. However, I find manufacturer profit decreases with the retailer disclosure cost, while the retailer profit first decreases then increases and
decreases again with the manufacturer’s disclosure cost.

I also examine the effect of a lower quality retailer brand distribution with all disclosure costs being equal. Not surprisingly, the manufacturer is more willing to disclose when the average retailer brand quality is low, and the manufacturer’s disclosure strategy is most sensitive if the size of disclosure cost is relatively low. Interestingly, given the disclosure costs are homogenous, the retailer always has higher incentive to disclose compared with the manufacturer. Unlike in the duopoly competition where the retailer reveals less information with low cost of disclosure to avoid direct competition with the manufacturer, in the channel setting, the retailer leverages the information from the retailer brand to optimize its joint profits from selling both the manufacturer brand and the retailer brand, resulting in a different incentive to disclose.

This research has managerial implications on channel quality advertising in the context of a retailer brand introduction. While past literature mainly focuses on price promotion of manufacturer brands and store brands, this study show that manufacturer may have a different incentive to advertise for product quality with/without a store brand introduction. The strategic disclosure strategy changes with marketing variables such as the disclosure costs, quality distribution and the market structure.
In the three essays, I study the retailer brand introduction and its impact on information asymmetry under decentralized distribution channels. It has become a popular trend for the in-store retailers to introduce store brands. Through managing and selling brands of their own, retailers may enjoy the higher price margin as well as increased bargaining power against other manufacturer brand. This dissertation focuses on the condition under which a store brand introduction interacts with channel members incentive to resolve information asymmetry as well as the payoff implications.

In general, retailers introduce two types of store brands - premium store brand and copycat store brand. The premium store brand is quality equivalent to the manufacturer brand, but is horizontally differentiated to target untapped consumer segments. The copycat store brand, also known as the traditional house brand, is merely the low quality alternative compared with manufacturer brands. It is only vertically differentiated from the manufacturer brand. In the dissertation, I examine the two types of store brand introduction and their implication to the distribution channel information dissemination.

In essay 1, I study the impact of a premium store brand to consumer incentives to evaluate in order to resolve preference uncertainty. When retailer brings this type of store brand into the product category, consumers perceive higher benefit from conducting product evaluation, and the firm can take advantage of that to exploit increased reservation price from consumers as they eliminate preference uncertainty. Surprisingly, a manufacturer also benefit from a premium store brand introduction from free riding on the retailers heightened interest to induce consumer evaluation.

In essay 2 and essay 3, I examine the manufacturers incentive to reveal private information of product information in a decentralized channel and in a channel with downstream threat from a retailer brand. Conventional
wisdom suggests that a manufacturer suffers from channel inefficiencies arise from the channel decentralization. Essay 2 shows that under some product quality distribution, a manufacturer may benefit from channel decentralization since the channel inefficiencies facilitate information withholding when the manufacturer brand quality is less favorable. Essay 3 shows that the manufacturer incentive to withhold is further reduced when a retailer introduces a copycat retailer brand. The result implies that a manufacturer will be more conservative in quality advertising when the retailer introduces a retailer brand. What is more, the manufacturer and the retailer interaction in a distribution channel manifests both collaboration and competition. As a result, the retailer does not act adversely when the manufacturer is likely to disclose quality with low disclosure cost, and the retailer always has a higher incentive to advertise quality compared with the manufacturer.

Although a body of literature has theoretically and empirically tested the impact of store brand introduction and channel member reaction, my dissertation specifically deals with its impact to the flow of information in a distribution channel. I hope this dissertation can add to our understanding the research of retailer brand introduction and channel information asymmetry.
APPENDIX A

Proof of Proposition 2.1:

Consumers make evaluation decisions by comparing their expected payoffs \(E(U^E)\) and \(E(U^\bar{E})\) at the first stage. For a consumer to choose evaluation, it must be satisfied that \(E(U^E) \geq E(U^\bar{E})\). This requires that \(\alpha(1-p_M) - c \geq \alpha - p_M\) for \(p_M \leq \alpha\); or \(\alpha(1-p_M) - c \geq 0\) for \(\alpha < p_M \leq 1\). Therefore, when \(c \leq \alpha(1-\alpha)\) and \(\frac{c}{1-\alpha} \leq p_M \leq 1 - \frac{c}{\alpha}\), consumers choose to evaluate the product in the first stage. Otherwise, consumers will choose not to conduct product evaluation. After product evaluation, only consumers with who prefers \(M\) will choose to purchase. Without product evaluation, consumers purchase \(M\) if and only if \(p_M < \min\{\frac{c}{1-\alpha}, \alpha\}\). The results can be summarized as follows:

\[
\begin{align*}
E_M & \quad \text{if prefer and } \frac{c}{1-\alpha} \leq p_M \leq 1 - \frac{c}{\alpha}, c \leq \alpha(1-\alpha); \\
E_0 & \quad \text{if donot prefer and } \frac{c}{1-\alpha} \leq p_M \leq 1 - \frac{c}{\alpha}, c \leq \alpha(1-\alpha); \\
E_M & \quad \text{if } p_M < \min\{\frac{c}{1-\alpha}, \alpha\}; \\
E_0 & \quad \text{otherwise.}
\end{align*}
\]

(A.1)

Given consumers’ optimal choice sets, consider the subgame where the retailer only sells \(M\). We first identify the retailer’s optimal price, then I find the equilibrium \(w\) charged by the manufacturer to optimize the profit given the retailer’s pricing reaction function. Since \(\pi_R^{E_M} = p_M - w = \min\{\frac{c}{1-\alpha}, \alpha\} - w\) and \(\pi_R^{E_M} = \alpha(p_M - w) = \alpha(1 - \frac{c}{\alpha} - w)\), the retailer chooses to induce \(E_M\) with a low price if and only if \(\pi_R^{E_M} \geq \max\{\pi_R^{E_M}, 0\}\). This requires that \(w \leq \min\{\frac{(2-\alpha)c-a(1-\alpha)^2}{(1-\alpha)^2}, \alpha\}\), and the manufacturer receives profit \(\pi_M^{E_M} = wE_M = \min\{\frac{(2-\alpha)c-a(1-\alpha)^2}{(1-\alpha)^2}, \alpha\}\). The retailer chooses to induce \(E_M\) with a high price if and only if \(\pi_R^{E_M} \geq \max\{\pi_R^{E_M}, 0\}\). This requires that \(\alpha(p_M^{E_M} - w) \geq \max\{p_M^{E_M} - w\}\), hence \(w^{E_M} = 1 - \frac{c}{\alpha}\). In this case, the manufacturer receives \(\pi_M^{E_M} = \alpha w^{E_M} = \alpha - c\). The manufacturer’s profit is the \(w\) that optimizes \(\pi_M\), and hence the optimal channel members’ profits are
Consider the other subgame where \( R \) is introduced at a cost \( F \). The retailer’s profit is \( \pi_R = \alpha(p^E_M - w) + (1 - \alpha)p^E_i - F \) if \( E_i \) is induced; \( \pi_R = (1 - \alpha)p^E_R - F \) if \( E_R \) is induced; \( \pi_R = p^E_R - w - F \) if \( E_M \) is induced; and \( \pi_R = p^E_R - F \) if \( \overline{E}_R \) is induced. The optimal \( p^E_M \) and \( p^E_R \) should satisfy \( \alpha p^E_M + (1 - \alpha)p^E_i = 1 - c \) and \( \frac{c}{1 - \alpha} - 1 \leq p^E_i - p^E_R \leq 1 - \frac{c}{\alpha} \). To induce \( E_R \), the retailer charges \( p^E_R = 1 - \frac{c}{1 - \alpha} \) where \( c \leq \alpha(1 - \alpha) \), and a high price for \( M \) (\( p_M > 1 \)) such that consumers ignore the existence of \( M \). To induce \( \overline{E}_M \), the optimal \( p^E_M = \min\{\alpha, \frac{c}{1 - \alpha}\} \) and \( p^E_R = \min\{1 - \alpha, \frac{c}{\alpha}\} \).

The manufacturer’s profit is \( \pi_M = \alpha w \) if \( E_i \) is induced; \( \pi_M = w \) if \( \overline{E}_M \) is induced; otherwise, the manufacturer only receives \( \pi_M = 0 \). Hence, the manufacturer sells \( M \) only when the retailer chooses to induce \( E_i \) or \( \overline{E}_M \). In order for the retailer to induce \( E_i \), the manufacturer charges a \( w \) that satisfies \( \alpha(p^E_M - w) + (1 - \alpha)p^E_i - F \geq \max\{(1 - \alpha)p^E_R - F, p^E_M - w - F, p^E_R - F, 0\} \). Therefore,

\[
w^{E_i} = \begin{cases} 
1 & \text{if } c \in [0, \frac{\alpha(1-\alpha)}{1+\alpha}]; \\
\frac{\alpha(1+\alpha)c}{\alpha^2} & \text{if } c \in \left(\frac{\alpha(1-\alpha)}{1+\alpha}, \alpha(1-\alpha)\right]; \\
1 - \frac{c}{\alpha} & \text{otherwise.} 
\end{cases}
\]  

(A.3)

Similarly, to induce \( \overline{E}_M \), \( w \) must satisfy \( p^E_M - w - F \geq \max\{(1 - \alpha)p^E_R - F, (1 - \alpha)p^E_R - F, p^E_R - F, 0\} \). This requires that \( w^{E_M} = \frac{c}{1 - \alpha} - 1 \) for \( c > (1 - \alpha) \). The manufacturer chooses the \( w \) that optimizes its profit \( \pi_M \). The equilibrium manufacturer’s and retailer’s profits are:

\[
(\pi_M, \pi_R) = \begin{cases} 
(\alpha, 1 - c - \alpha - F) & \text{if } c \in [0, \frac{\alpha(1-\alpha)}{1+\alpha}]; \\
(1 - \frac{1+\alpha}{\alpha}c, \frac{c}{\alpha} - F) & \text{if } c \in \left(\frac{\alpha(1-\alpha)}{1+\alpha}, \alpha(1-\alpha)\right]; \\
(\alpha - c, 1 - \alpha - F) & \text{if } c \in \left(\alpha(1-\alpha), \frac{1-\alpha^2}{2-\alpha}\right]; \\
\left(\frac{c}{1 - \alpha} - 1, 1 + \alpha - \frac{c}{1 - \alpha} - F\right) & \text{otherwise.} 
\end{cases}
\]  

(A.4)

Comparing the manufacturer’s profit with the subgame where only \( M \) is in the market (equation A.2), I find that the manufacturer is better off with the introduction of \( R \) (\( \pi_M|M \leq \pi_M|M&R \)) when \( c \leq \frac{\alpha(1-\alpha)}{\alpha(1-\alpha)^2 + 1} \). For \( c \leq
Comparing equation (A.5) with (A.6). The retailer introduces the manufacturer’s profit is close to \( \pi \), and \( F \) when \( \alpha \leq \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+\alpha(1-\alpha)^2} \); for \( \alpha \leq \frac{(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2} \leq c \leq \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+\alpha(1-\alpha)^2+1} \), \( \pi_M|_M = \alpha - c \leq \pi_M|_{M&R} = \alpha \); for \( \frac{\alpha(1-\alpha)}{1+\alpha} \leq c \leq \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+\alpha(1-\alpha)^2} \), \( \pi_M|_M = \alpha - c \leq \pi_M|_{M&R} = 1 - \frac{1+\alpha}{\alpha} c \); for \( \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2} \leq c \leq \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+\alpha(1-\alpha)^2+1} \), \( \pi_M|_M = \frac{(2-\alpha)c-\alpha(1-\alpha)}{(1-\alpha)^2} \leq \pi_M|_{M&R} = 1 - \frac{1+\alpha}{\alpha} c \).

**Proof of Proposition 2.2:**

If the retailer does not introduce \( R \), I have

\[
\begin{align*}
\pi^E_M &= \begin{cases} 
0 & \text{if } c \in [0, \frac{\alpha(1-\alpha)}{1+\alpha}]; \\
\frac{\alpha(1-\alpha)-c}{(1-\alpha)^2} & \text{if } c \in \left(\frac{(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}, \alpha(1-\alpha)\right]; \\
0 & \text{otherwise}.
\end{cases} \tag{A.5}
\end{align*}
\]

When the retailer introduces \( R \), I have

\[
\begin{align*}
\pi^E_R &= 1 - c - \alpha - F & \text{if } c \in [0, \frac{\alpha(1-\alpha)}{1+\alpha}]; \\
\pi^E_R &= \frac{c}{\alpha} - F & \text{if } c \in \left(\frac{(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}, \alpha(1-\alpha)\right]; \\
\pi^E_R &= 1 - \alpha - F & \text{if } c \in \left(\alpha(1-\alpha), \frac{1+\alpha}{2-\alpha}\right]; \\
\pi^E_M &= 1 + \alpha - \frac{c}{1-\alpha} - F & \text{otherwise}.
\end{align*} \tag{A.6}
\]

The equilibrium retailer brand introduction strategy can be obtained by comparing equation (A.5) with (A.6). The retailer introduces \( R \) in equilibrium if and only if \( c \leq \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2} \) and \( F \leq \max\{1-c-\alpha, \frac{c}{\alpha}\} \), or \( c > \frac{(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2} \) and \( F \leq \min\{\frac{\alpha^2-\alpha+1}{\alpha(1-\alpha)^2}c - \frac{\alpha}{1-\alpha}, 1-\alpha\}\).

Note that when \( c < \frac{\alpha(1-\alpha)}{1+\alpha} \), at the indifference curve, \( \frac{\partial F}{\partial c} = -1 < 0 \); while when \( \frac{\alpha(1-\alpha)}{1+\alpha} < c < \frac{(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2} \), \( \frac{\partial F}{\partial c} = 1/\alpha > 0 \). This indicates that the likelihood of introducing \( R \) first decreases then increases with \( c \).

There can be a change of the retailer’s brand introduction strategy at \( (c^*, F^*) \) with the change of \( \alpha \), where \( (c^*, F^*) \) defines the indifference curve. When \( c \leq \frac{\alpha(1-\alpha)}{\alpha(1-\alpha)^2+1} \), the manufacturer’s profit increases when the retailer chooses to introduce \( R \) (proposition 2.1). This implies that when the manufacturer’s profit is close to \( \pi_M(c^*, F^*) \), \( \pi_M \) may change if the retailer brand popularity increases ((1-\alpha) increases) and the retailer has a greater incentive to introduce \( R \). Also notice that when \( R \) is not introduced,

\[
\frac{\partial \pi_R|_M}{\partial (1-\alpha)} = \begin{cases} 
0 & \text{if } c \in [0, \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}]; \\
\frac{\alpha+2c-1}{(1-\alpha)^3} & \text{if } c \in \left(\frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}, \frac{\alpha(1-\alpha)}{(2-\alpha)+\alpha(1-\alpha)^2}, \frac{\alpha(1-\alpha)}{\alpha(1-\alpha)^2+1}\right].
\end{cases} \tag{A.7}
\]
When $R$ is introduced,

$$
\frac{\partial \pi_{R|M\&R}}{\partial (1 - \alpha)} = \begin{cases} 
1 & \text{if } c \in [0, \frac{\alpha(1-\alpha)}{1+\alpha}]; \\
\frac{c}{\alpha} & \text{if } c \in (\frac{\alpha(1-\alpha)}{1+\alpha}, \frac{\alpha(1-\alpha)}{1+\alpha}^2+1].
\end{cases}
\quad \text{(A.8)}
$$

Comparing equation (A.7) with equation (A.8), I find that (A.7)<(A.8) when $c \leq \min\{\frac{\alpha^2(1-\alpha)}{2\alpha^2-(1-\alpha)^3}, \frac{\alpha(1-\alpha)}{\alpha(1-\alpha)^2+1}\}$. This suggests that the marginal increase in $\pi_{R|M\&R}$ with $(1 - \alpha)$ exceeds the marginal increase of $\pi_R|M$, further confirming the retailer’s increased incentive to introduce $R$ when $R$ becomes more popular. Hence, at $(c^*, F^*)$, the manufacturer may benefit by getting $\pi_M|M\&R$ instead of $\pi_M|M$ with the increasing popularity of $R$.

**Proof of Proposition 2.3:**

In a centralized channel, the equilibrium product introduction strategy is obtained following the same procedure as in the proof of proposition 2.1 and proposition 2.2. In the subgame where the retailer only sells $M$, the overall channel profit is $\pi = \alpha P_M^{EM}$ if $E_M$ is induced, or $\pi = \overline{P}_M^{EM}$ if $\overline{E}_M$ is induced. Hence, in equilibrium

$$
\begin{cases} 
\pi^{EM}_E = \alpha - c & \text{if } c \in [0, \frac{\alpha(1-\alpha)}{2-\alpha}]; \\
\pi^{EM}_M = \frac{c}{(1-\alpha)} & \text{if } c \in (\frac{\alpha(1-\alpha)}{2-\alpha}, \alpha(1 - \alpha)]; \\
\pi^{EM}_M = \alpha & \text{otherwise}.
\end{cases}
\quad \text{(A.9)}
$$

In the other subgame where $R$ is introduced, in equilibrium, the overall channel gets

$$
\begin{cases} 
\pi^{EM}_E = 1 - c - F & \text{if } c \in [0, 1 - \alpha]; \\
\pi^{EM}_M = \alpha - F & \text{otherwise}.
\end{cases}
\quad \text{(A.10)}
$$

The overall equilibrium product introduction strategy is obtained by comparing the profits in the two subgames. At equilibrium, $R$ is introduced if and only if $\pi_M|M\&R \geq \pi_M|M$. This is equivalent to $F \leq \max\{1 - \frac{2-\alpha}{1-\alpha}c, 1 - c - \alpha, 0\}$. Also notice that $R$ is introduced to induce $E_i$ from consumers. When $R$ is not introduced, the firm will induce $\overline{E}_M$.

I compare the introduction strategy of $R$ with the one in a decentralized channel, in which $R$ is introduced if and only if $c \leq \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+1-\alpha}^2$ and $F \leq \max\{1 - \alpha - c, \frac{c}{\alpha}\}$, or when $c > \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+1-\alpha}^2$ and $F \leq \frac{\alpha^2-\alpha+1}{\alpha(1-\alpha)^2}c - \frac{\alpha}{1-\alpha}$. Define
the following regions,

\[
\begin{array}{ll}
A: & \max\{1 - \alpha - c, \frac{c}{\alpha}\} \leq F \leq 1 - \frac{2}{1-\alpha}c, \\
B: & 1 - \frac{2}{1-\alpha}c \leq F \leq c, \\
C: & \max\{1 - \frac{2}{1-\alpha}c, 1 - \alpha - c\} \leq F \leq \frac{2\alpha^2}{\alpha(1-\alpha)^2}c - \frac{\alpha}{1-\alpha}, \\
D: & \frac{2\alpha^2}{\alpha(1-\alpha)^2}c - \frac{\alpha}{1-\alpha} \leq F \leq 1 - \frac{2}{1-\alpha}c,
\end{array}
\]

where \((c_1, F_1) = (\frac{\alpha(1-\alpha)}{1+\alpha-\alpha^2}, \frac{1}{1+\alpha-\alpha^2}), (c_2, F_2) = (\frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}, \frac{(3-\alpha)(1-\alpha)^2}{(2-\alpha)+(1-\alpha)^2}), (c_3, F_3) = (\frac{\alpha(1-\alpha)}{(\alpha(1-\alpha)^2+1)}, \frac{(1-\alpha)^2(1+\alpha)}{\alpha(1-\alpha)^2+1})\). Then in the regions defined by A and D, \(R\) is less likely to be introduced in a decentralized channel, while in the regions defined by B and C, \(R\) is more likely to be introduced in the decentralized channel.

**Proof of Proposition 2.4:**

When consumers do not conduct product evaluation, \(CS^E = \alpha - p_M\) if \(E_M\) is induced, or \(CS^E = (1 - \alpha) - p_R\) if \(E_R\) is induced. When they conduct product evaluation, \(CS^{E_i} = 1 - \alpha p_M - (1 - \alpha)p_R - c\) if \(R\) is introduced, or \(CS^{E_M} = \alpha(1 - p_M) - c\) if \(R\) is not introduced. In a decentralized channel, \(CS^{E_i} = \max\{\alpha - \frac{c}{1-\alpha}, 0\}\) for \(c \geq \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}\). In a centralized channel, \(CS^{E_M} = \max\{\alpha - \frac{c}{1-\alpha}, 0\}\) for \(c \geq \frac{\alpha(1-\alpha)}{2-\alpha}\). Notice that \(CS^{E_M} \geq 0\) in a decentralized channel when \(\frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2} \leq c \leq \alpha(1 - \alpha)\); and \(CS^{E} \geq 0\) in a centralized channel when \(\frac{\alpha(1-\alpha)}{2-\alpha} \leq c \leq \alpha(1 - \alpha)\). In both cases, \(R\) is not introduced in equilibrium.

When consumers choose to evaluate both \(M\) and \(R\), \(CS^{E_i} = \alpha(1 - p_M) + (1 - \alpha)(1 - p_R) - c\). Recall that the retailer charges high prices of \(p_M\) and \(p_R\), which satisfy \(\alpha p_M^{E_i} + (1 - \alpha)p_R^{E_i} = 1 - c\) to induce \(E_i\). Hence in either a centralized or a decentralized channel, \(CS^{E_i} = 0\). Consumers choose to evaluate \(M\), if \(R\) is not introduced, and \(CS^{E_M} = \alpha(1 - p_M^{E_M}) - c\). In either a decentralized or a centralized channel, the retailer charges \(p_M^{E_M} = 1 - \frac{c}{\alpha}\); hence, \(CS^{E_M} = 0\). I summarize consumer welfare as follows.

In a decentralized channel, consumer welfare is:

\[
\begin{array}{ll}
CS^{E_i}|_{M\&R} = 0, \ CS^{E_M}|_{M} = 0 & \text{if } c \in \left[0, \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}\right]; \\
CS^{E_i}|_{M\&R} = 0, \ CS^{E_M}|_{M} = \alpha - \frac{c}{1-\alpha} & \text{if } c \in \left(\frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}, \alpha(1 - \alpha)\right]; \\
CS^{E_i}|_{M\&R} = 0, \ CS^{E_M}|_{M} = 0 & \text{if } c \in \left(\alpha(1 - \alpha), \frac{\alpha(2-\alpha)(1-\alpha)}{2-\alpha}\right]; \\
CS^{E_M}|_{M\&R} = 0, \ CS^{E_M}|_{M} = 0 & \text{if } c \in \left(\frac{1-\alpha^2}{2-\alpha}, 2\alpha(1 - \alpha)\right).
\end{array}
\]
In a centralized channel, consumer welfare is:

\[
\begin{array}{ll}
CSE_i|_{M&R} = 0, & CSE_M|_M = 0 \quad \text{if } c \in \left[0, \frac{\alpha(1-\alpha)}{2-\alpha}\right]; \\
CSE_i|_{M&R} = 0, & CSE_M|_M = \alpha - \frac{c}{1-\alpha} \quad \text{if } c \in \left(\frac{\alpha(1-\alpha)}{2-\alpha}, \alpha(1-\alpha)\right]; \\
CSE_i|_{M&R} = 0, & CSE_M|_M = 0 \quad \text{if } c \in (\alpha(1-\alpha), 2\alpha(1-\alpha)).
\end{array}
\]

(A.13)

Comparing consumer welfare in a decentralized channel with that in a centralized channel, I find consumers may receive higher payoff when \(\frac{a^2-\alpha+1}{\alpha(1-\alpha)^2}c - \frac{\alpha}{1-\alpha} \leq F \leq \frac{a^2-\alpha+1}{\alpha(1-\alpha)^2}c\) and \(\frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2} \leq c < \frac{\alpha(1-\alpha)}{2-\alpha}\).

**Proof of Proposition 2.5:**

Without the introduction of \(R\), the equilibrium is the same as in subsection 2.2.1. With the introduction of \(R\), the retailer receives \(\pi_R = \alpha + (1-\alpha)\gamma - c - F - \alpha w\) if \(E_i\) is induced; \(\pi_R = \gamma(1-\alpha) - c - F\) if \(E_R\) is induced; \(\pi_R = \min\{\frac{c}{1-\alpha}, \alpha\} - w - F\) if \(E_M\) is induced; and \(\pi_R = \min\{\frac{c}{1-\alpha}, \gamma(1-\alpha)\} - F\) if \(\bar{E}_R\) is induced. The equilibrium manufacturer and retailer profits are:

\[
\begin{array}{ll}
\pi^E_M = \alpha, & \pi^E_i = (1-\alpha)\gamma - c - F \quad \text{if } c \in [0, \frac{\alpha(1-\alpha)\gamma}{1+\alpha}]; \\
\pi^E_M = \alpha + (1-\alpha)\gamma - \frac{1+\alpha}{1-\alpha}c, & \pi^E_i = \frac{c}{\alpha} - F \quad \text{if } c \in \left(\frac{\alpha(1-\alpha)\gamma}{1+\alpha}, \alpha(1-\alpha)\gamma\right]; \\
\pi^E_M = \alpha - c, & \pi^E_i = \gamma(1-\alpha) - F \quad \text{if } c \in (\alpha(1-\alpha)\gamma, \frac{(\alpha(1-\alpha)\gamma)(1+\alpha)}{2-\alpha}); \\
\pi^E_M = \frac{c}{1-\alpha} - \gamma, & \pi^E_i = \gamma - c + \frac{c}{1-\alpha} - F \quad \text{if } c \in \left(\frac{\alpha(1-\alpha)(1+\gamma)}{2-\alpha}, (1+\gamma)\alpha(1-\alpha)\right].
\end{array}
\]

(A.14)

Comparing the two subgames, the subgame perfect equilibrium is:

\[
\begin{array}{ll}
\pi^E_M = \alpha, & \pi^E_i = (1-\alpha)\gamma - c - F \quad \text{if } c \in [0, \frac{\alpha(1-\alpha)\gamma}{1+\alpha}]; \\
\pi^E_M = \alpha + (1-\alpha)\gamma - \frac{1+\alpha}{1-\alpha}c, & \pi^E_i = \frac{c}{\alpha} - F \quad \text{if } c \in \left(\frac{\alpha(1-\alpha)\gamma}{1+\alpha}, \alpha(1-\alpha)\gamma\right]; \\
\pi^E_M = \frac{(2-\alpha)c}{(1-\alpha)^2} - \frac{\alpha}{1-\alpha}, & \pi^E_i = \frac{c}{1-\alpha} - \frac{c}{(1-\alpha)^2} \quad \text{if } c \in \left(\frac{(2-\alpha)c}{(1-\alpha)^2}, \frac{c}{1-\alpha}\right]; \\
\pi^E_M = \alpha - c, & \pi^E_i = \gamma(1-\alpha) - F \quad \text{if } c \in (\alpha, \frac{(1-\alpha)(1+\gamma)}{2-\alpha}); \\
\pi^E_M = \frac{c}{1-\alpha} - \gamma, & \pi^E_i = \gamma - c + \frac{c}{1-\alpha} - F \quad \text{if } c \in \left(\frac{(1-\alpha)(1+\gamma)}{2-\alpha}, (1+\gamma)\alpha(1-\alpha)\right].
\end{array}
\]

(A.15)

Here \(\bar{c} = \max\{\frac{\alpha(1-\alpha)^2}{1-\alpha} + F, (1-\alpha)^2(\frac{\alpha}{1-\alpha} + F)\}\). By observation, \(\frac{\partial \pi_M}{\partial \gamma} = (1-\alpha) > 0\) when \(c \in \left(\frac{(1-\alpha)\gamma}{1+\alpha}, \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}\right]\), indicating that \(\pi_M\) increases with increasing \(\gamma\).

**Proof of Proposition 2.6:**

When brand \(R\) is introduced by the manufacturer, the retailer chooses to induce \(E_i, E_R, E_M, \bar{E}_M\) and \(\bar{E}_R\) from consumers. When \(E_i\) is induced, the retailer carries both brands \(M\) and \(R\). In other cases, the retailer chooses to carry only the product that it plans to sell (\(M\) or \(R\)). Hence the retailer
receives $\pi^E_R = 1 - c - \alpha w_M - (1 - \alpha)w_R$, $\pi^{E_M} = 1 - \frac{c}{\alpha} - \alpha w_M$, $\pi^E_R = 1 - \frac{c}{1 - \alpha} - (1 - \alpha)w_R$, $\pi^{E_M} = \frac{c}{1 - \alpha} - w_M$ and $\pi^R = \frac{c}{\alpha} - w_R$ respectively. In order to motivate the retailer to choose $E_i$, $\pi^{E_i}_R > \max\{\pi^{E_M}_R, \pi^R, \pi^{E_M}, \pi^E_R\}$, which requires that \((\frac{2(\alpha - c) - (1 - \alpha)}{\alpha(1 - \alpha)^2}) \leq w_M - w_R \leq \frac{\alpha - c}{\alpha^2}, w_M \leq 1 \text{ and } w_R \leq 1\) with \(c \leq \frac{\alpha(1 - \alpha)}{1 + \alpha - \alpha^2}\). Hence $\pi^E_M = \alpha w_M + (1 - \alpha)w_R = 2 - \frac{\alpha - c}{\alpha^2} - F$.

When the manufacturer does not introduce $R$, it gets the same profit defined by equation (2.4) in subsection 2.2.1. Hence, at equilibrium, the manufacturer introduces $R$ when $F \leq 2 - \frac{1}{\alpha} - \alpha + \frac{c}{\alpha^2}$ and $c \leq \frac{\alpha(1 - \alpha)}{1 + \alpha - \alpha^2}$. Compared with the range in which $R$ will be introduced in proposition 2.2, $R$ will not be introduced by the manufacturer but will be introduced by a retailer when $c < \frac{\alpha(1 - \alpha)}{1 + \alpha - \alpha^2}$ and $2 - \frac{1}{\alpha} - \alpha + \frac{c}{\alpha^2} < F < \min\{1 - \alpha - c, \frac{c}{\alpha}\}$, or when $c > \frac{\alpha(1 - \alpha)}{1 + \alpha - \alpha^2}$. Since the range of $c$ in which the manufacturer introduces $R$ is smaller than the range at which the retailer will introduce $R$ and the manufacturer benefits from it ($c \leq \frac{\alpha(1 - \alpha)}{\alpha(1 - \alpha)^2} + 1$), $R$ is more likely to be introduced by the retailer than by the manufacturer. Even when the manufacturer introduces $R$, its profit may still be lower than when the retailer introduces $R$ when $F > 2 - \frac{1}{\alpha} - \alpha + \frac{(1 - \alpha^2)c}{\alpha^2}$. In summary, when the manufacturer introduces $R$, its profit will be lower than when the retailer introduces $R$ when $c \leq \frac{\alpha(1 - \alpha)}{1 + \alpha - \alpha^2}$ and $2 - \frac{1}{\alpha} - \alpha + \frac{(1 - \alpha^2)c}{\alpha^2} < F < \min\{1 - \alpha - c, \frac{c}{\alpha}\}$; or when $\frac{\alpha(1 - \alpha)}{1 + \alpha - \alpha^2} < c < \frac{\alpha(1 - \alpha)}{1 + \alpha(1 - \alpha)\alpha}$ and $F < \frac{c}{\alpha}$.

**Higher Brand Popularity for $R$:**

Consider the case when $\alpha < 1/2$ and $R$ is more popular than $M$. In a decentralized channel, following the same analysis as shown in proposition 2.1 and proposition 2.2, I find that the equilibrium brand introduction strategy is unchanged. That is, $R$ is introduced if and only if $c \leq \frac{\alpha(2 - \alpha)(1 - \alpha)}{(2 - \alpha)(1 - \alpha)^2}$ and $F \leq \max\{1 - c - \alpha, \frac{c}{\alpha}\}$, or $c > \frac{\alpha(2 - \alpha)(1 - \alpha)}{(2 - \alpha)(1 - \alpha)^2}$ and $F \leq \min\{\frac{\alpha^2 - \alpha + 1}{\alpha(1 - \alpha)}, c - \frac{\alpha}{1 - \alpha}, 1 - \alpha\}$. However, the retailer’s selling strategy is different at high evaluation cost ($c \geq \alpha$), where it will induce $E^*_R$ instead of $E^*_M$. As a result, the retailer receives $\pi_R = 1 - \alpha - F$ and the manufacturer receives $\pi_M = 0$. In a centralized channel, following the same analysis as in the proof of proposition 2.3, I find $R$ is introduced if and only if $F \leq \max\{1 - \frac{2 - \alpha}{1 - \alpha}c, 1 - c - \alpha, 1 - 2\alpha\}$. Hence the introduction strategy of $R$ is different when $c > \alpha$.

**Consumer Evaluation Cost for Multiple Products:**

Assume that when there are two products in a product category, consumers incur a cost of $c + k$ ($k > 0$) to evaluate both $M$ and $R$, or consumers incur
a cost of $c$ when there is only one product in the product category. When $R$ is not introduced, consumers’ reactions, the manufacturer and retailer’s profits are the same as in subsection 2.2.1. When $R$ is introduced, consumers incur a higher cost to evaluate the products, and the manufacturer’s and the retailer’s profit becomes:

\[
\begin{align*}
\pi^E_M &= \alpha, \quad \pi^E_R = 1 - c - k - \alpha - F & \text{if } c + k \in [0, \frac{\alpha(1-\alpha)}{1+\alpha}]; \\
\pi^E_M &= 1 - \frac{1+\alpha}{\alpha}(c + k), \quad \pi^E_R = \frac{c+k}{\alpha} - F & \text{if } c + k \in (\frac{\alpha(1-\alpha)}{1+\alpha}, \alpha(1 - \alpha)]; \\
\pi^E_M &= \alpha - c - k, \quad \pi^E_R = 1 - \alpha - F & \text{if } c + k \in (\alpha(1 - \alpha), \frac{1-\alpha^2}{2-\alpha}); \\
\pi^E_M^M &= \frac{c+k}{1-\alpha} - 1, \quad \pi^E_R^M = 1 + \alpha - \frac{c+k}{1-\alpha} - F & \text{if } c + k \in (\frac{1-\alpha^2}{2-\alpha}, 2\alpha(1 - \alpha)).
\end{align*}
\]

(A.16)

At equilibrium, the retailer brand will be introduced when $c \leq \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}$ and $F \leq \max\{1 - \alpha - c - k, \frac{c+k}{\alpha}\}$, or when $c > \frac{\alpha(2-\alpha)(1-\alpha)}{(2-\alpha)+(1-\alpha)^2}$ and $F \leq \frac{\alpha^2-\alpha+1}{\alpha(1-\alpha)^2}c - \frac{\alpha}{1-\alpha} + \frac{k}{\alpha}$.
APPENDIX B

Condition to support unique solution of $\hat{v}_c(\hat{v}_d)$:

Define $G(v) = \int_0^v F(x) \, dx / F(v)$. Then equations (3.2) and (3.4) become $G(\hat{v}_c) = 4c$ and $G(\hat{v}_d) = 8c$ respectively. A necessary condition to generate a unique solution of $\hat{v}_c$ and $\hat{v}_d$ is that $G(v)$ changes monotonically with respect to $v$. Since $\frac{dG(v)}{dv} = \frac{F(v)^2-f(v)\int_0^v F(x) \, dx}{F(v)^2}$ and $\frac{dG(v)}{dv} > 0$ for $v \sim 0$, $G(v)$ is increasing at least for very small $v$. Combining the monotonicity condition, $G(v)$ must be monotonically increasing to support the unique solution of $\hat{v}_c(\hat{v}_d)$.

Proof of Lemma 3.1: According to Taylor Expansion, when the convexity/concavity of $F(v)$ is small, that is $f'(v)$ is significantly small ($f'(0) \sim 0$), and $f^n(v) \sim O(f'(v))$, I may write $F(v) \simeq F(0) + f(0)v + \frac{1}{2}f'(0)v^2 = (1 - f'(0)/2)v + \frac{1}{2}f'(0)v^2$ (since $F(0) = 0$ and $F(1) = 1$, I have $f(0) = (1 - f'(0)/2)$). Similarly, $\int_0^v F(v) \, dv \simeq \frac{(1-f'(0)/2)v^2 + f'(0)v^3}{6}$. More specifically, $K = 1 - \int_0^1 F(v) \, dv = \frac{1}{2} + \frac{f'(0)}{12}$.

When $f'(0) \neq 0$, I can solve for $\hat{v}_d$ and $\hat{v}_c$ according to (2) and (4), which gives

\[
\hat{v}_c \simeq 8c + \frac{32}{3}f'(0)c^2, \quad \text{(B.1)}
\]
\[
\hat{v}_d \simeq 16c + \frac{128}{3}f'(0)c^2, \quad \text{(B.2)}
\]
\[
\hat{v}_d - \hat{v}_c = 8c + \frac{96}{3}f'(0)c^2. \quad \text{(B.3)}
\]

Hence, $\hat{v}_c$, $\hat{v}_d$ and $\hat{v}_d - \hat{v}_c$ increase as $f'(v) \simeq f'(0)$ increases; while $\hat{v}_c$, $\hat{v}_d$ and $\hat{v}_d - \hat{v}_c$ decrease as $f'(v) \simeq f'(0)$ decreases. More specifically, when $f'(v) > 0$, $\hat{v}_c$, $\hat{v}_d$ and $\hat{v}_d - \hat{v}_c$ are large; when $f'(v) < 0$, $\hat{v}_c$, $\hat{v}_d$ and $\hat{v}_d - \hat{v}_c$ become lower.

Proof of Proposition 3.1:

The ex post profit difference is $\pi^c - \pi^d = \hat{v}_c - \frac{3\hat{v}_d}{16}$. When $\hat{v}_d < v \leq 1$, $\pi^c - \pi^d = \frac{v}{4} - c - \left(\frac{3}{16}v - c\right) = \frac{v}{16} > 0$. When $\hat{v}_c < v \leq \hat{v}_d$, $\pi^c - \pi^d = $
\[ \frac{v}{4} - c - \frac{3}{16}(\hat{v}_d - 8c) = \frac{v}{4} - \frac{3}{16}\hat{v}_d + \frac{c}{2}, \] and is negative if and only if \( v < \frac{3}{4}\hat{v}_d - 2c \). Since \( v < \hat{v}_d \), this can only be true if \( 3\hat{v}_d - 4\hat{v}_c > 8c \). When \( v \leq \hat{v}_c \),

\[ \pi^c - \pi^d = \frac{1}{4}(\hat{v}_c - 4c) - \frac{3}{16}(\hat{v}_d - 8c) = \frac{v}{4} - \frac{3}{16}\hat{v}_d + \frac{c}{2}, \] and is negative if and only if \( 3\hat{v}_d - 4\hat{v}_c > 8c \). Hence the \textit{ex post} profit difference can be negative if and only if \( 3\hat{v}_d - 4\hat{v}_c > 8c \) and for \( v < \frac{3}{4}\hat{v}_d - 2c \).

**Proof of Proposition 3.2:**

Define \( E(\pi^c) - E(\pi^d) \) as the change of \textit{ex ante} channel profit when the channel structure changes from centralized to decentralized. For \( c > (1 - K)/4 \), \( E(\pi^c) - E(\pi^d) > 0 \); for \((1 - K)/8 \leq c \leq (1 - K)/4 \), \( E(\pi^c) - E(\pi^d) \) increases monotonically with \( c \). Hence \( E(\pi^c) - E(\pi^d) < 0 \) if and only if there exists \( E(\pi^c) - E(\pi^d) < 0 \) for \( c < (1 - K)/8 \). So I only focus the analysis for \( c < (1 - K)/8 \).

\[
\frac{\partial (E(\pi^c) - E(\pi^d))}{\partial c} = -(F(\hat{v}_d) - F(\hat{v}_c)) - (f(\hat{v}_d) \frac{\partial \hat{v}_d}{\partial c} - f(\hat{v}_c) \frac{\partial \hat{v}_c}{\partial c})c \\
= -\frac{F(\hat{v}_d)^2}{F(\hat{v}_d) - 8cf(\hat{v}_d)} + \frac{F(\hat{v}_c)^2}{F(\hat{v}_c) - 4cf(\hat{v}_c)}. 
\] (B.4)

When the disclosure cost is negligible \((c \sim 0)\), \( \frac{\partial (E(\pi^c) - E(\pi^d))}{\partial c} \sim -F(\hat{v}_d) + F(\hat{v}_c) < 0 \), hence \( E(\pi^c) - E(\pi^d) \) decreases with the disclosure cost. When the disclosure cost is high, \( c \sim (1 - K)/8 \), \( \frac{\partial \Delta \pi}{\partial c} \) is undetermined, indicating that the \( \Delta \pi \) may decrease or increase with \( c \) when \( c \) becomes significant. Therefore, when there exists a distribution \( F(v) \) that satisfies

\[
\frac{K}{16} - (F(\hat{v}_d) - F(\hat{v}_c))c = \frac{1}{8}(\int_0^{\hat{v}_c} F(v) dv + \frac{K}{2} - \int_{\hat{v}_c}^{\hat{v}_d} F(v) dv) < 0 \] for \( c < (1 - K)/8 \), the decentralized channel can outperform the centralized one in achieving a higher \textit{ex ante} channel profit.

**Proof of Proposition 3.3:**

When \( F(v) = v^t, G(v) = \int_0^v \frac{F(x)}{F(v)} dx = v/(t + 1) \) monotonically increases with \( v \), which guarantees the unique solutions of \( \hat{v}_d \) and \( \hat{v}_c \). According to equations (3.2) and (3.4), \( \hat{v}_c = 4(t + 1)c, \hat{v}_d = 8(t + 1)c \) and \( K = 1 - \frac{1}{t+1} \).

The \textit{ex post} profit differences between the decentralized and the centralized channel are expressed by

\[
\pi^c - \pi^d = \begin{cases} 
\frac{v}{16} & \text{if } 8(t + 1)c < v \leq 1; \\
\frac{v}{4} - c - \frac{3}{2}tc & \text{if } 4(t + 1)c < v \leq 8(t + 1)c; \\
-\frac{1}{2}tc & \text{if } v \leq 4(t + 1)c.
\end{cases} 
\] (B.5)
The *ex ante* profit difference is the expectation of the *ex post* profit difference, which is expressed by $E(\pi^c) - E(\pi^d) = \frac{t}{16(t+1)} + (4(t+1))^t(1-2^t)c^{t+1}$, where $c \leq (1 - K)/8 = \frac{1}{8(t+1)}$. Since $1 - 2^t < 0$, the channel profit difference decreases with $c$. For any $t > 0$, the channel profit is lowest when $c = \frac{1-K}{8}$. In this case $E(\pi^c) - E(\pi^d) = \frac{1}{8(t+1)}(\frac{t}{2} + \frac{1}{2t} - 1)$, and is negative if and only if $t < 1$. I also have $\frac{d(E(\pi^c) - E(\pi^d))}{dt} = 0$ when $t = 0.39$, indicating that the lowest value is achieved when $t = 0.39$. 
APPENDIX C

Proof of Lemma 4.1:

A credible disclosure strategy is made where the retailer is indifferent between keeping silent or disclosure ($\pi_r|\text{silent} = \pi_r|\text{disclose}(v_r = \hat{v}_r)$).

(1) For $\hat{v}_m \leq \hat{v}_r < \hat{v}_r$, $\pi_r|\text{disclose}(v_r = \hat{v}_r) = \frac{\hat{v}_r}{4} - c_r$, $\pi_r|\text{silent} = \frac{\hat{v}_r}{4}$. Hence $\hat{v}_r = 4c_r + \hat{v}_m$. Since $\hat{v}_r = \frac{\hat{v}_r}{4}$, it follows that the optimal $\hat{v}_r^* = 8c_r$.

(2) For $\hat{v}_r < \hat{v}_m \leq \hat{v}_r$, $\pi_r|\text{disclose}(v_r = \hat{v}_r) = \frac{\hat{v}_r}{4} - c_r$, $\pi_r|\text{silent} = \frac{\hat{v}_m + 3c_r}{16}$. From $\hat{v}_r = \frac{\hat{v}_m + 3c_r}{4} + 4c_r$, it follows that the optimal $\hat{v}_r^* = \frac{2}{3} \hat{v}_m + \frac{32}{3} c_r$.

(3) For $\hat{v}_r < \hat{v}_r < \hat{v}_m$, $\pi_r|\text{disclose}(v_r = \hat{v}_r) = \frac{\hat{v}_m + 3c_r}{16} - c_r$ and $\pi_r|\text{silent} = \frac{\hat{v}_m + 3c_r}{16}$. Hence $\hat{v}_r = \frac{\hat{v}_r}{4} + \frac{16}{3} c_r$ and, it follows that the optimal $\hat{v}_r^* = \frac{32}{3} c_r$.

Proof of Proposition 4.1:

The manufacturer’s expected profit conditioning on $v_r$ is:

(1) If $\hat{v}_m \leq 4c_r$, then $E(\pi_m) = 0$;

(2) if $4c_r < \hat{v}_m \leq \frac{32}{3} c_r$, $\pi_m = \frac{1}{8}(\hat{v}_m - \hat{v}_r)$ if $v_r \leq \hat{v}_r$, or 0 if $v_r > \hat{v}_r$.

Consequently, $E(\pi_m) = \int_0^{\hat{v}_r} \frac{1}{8}(\hat{v}_m - \hat{v}_r) \ dv_r = \frac{1}{16} \hat{v}_r(2\hat{v}_m - \hat{v}_r) = \frac{1}{25}(\hat{v}_m - 4c_r)(\hat{v}_m + 16c_r)$;

(3) if $\hat{v}_m > \frac{32}{3} c_r$, then $E(\pi_m) = \int_0^{\hat{v}_r} \frac{1}{8}(\hat{v}_m - \hat{v}_r) \ dv_r + \int_{\hat{v}_r}^{\hat{v}_m} \frac{1}{8}(\hat{v}_m - \hat{v}_r) \ dv_r$. It follows that $E(\pi_m) = \frac{\hat{v}_m}{10}$.

Now the optimal equilibrium disclosure strategy for the manufacturer.

(i) Assume that $\frac{32}{3} c_r < \hat{v}_m < \hat{v}_r$, then when $d_m = 1$, $E(\pi_m) = \frac{\hat{v}_m}{10} - c_m$; when $d_m = 0$, $E(\pi_m) = \frac{\hat{v}_m^2}{16}$. Hence the optimal $\hat{v}_m = 8\sqrt{c_m/3}$, with $c_m > \frac{64}{3} c_r^2$.

(ii) Assume that $4c_r \leq \hat{v}_m < \frac{32}{3} c_r \leq \hat{v}_m$. If $d_m = 1$, $E(\pi_m) = \frac{\hat{v}_m}{10} - c_m$; $d_m = 0$, $E(\pi_m) = \frac{1}{25}(\hat{v}_m - 4c_r)(\hat{v}_m + 16c_r)$. Equating the two profit at $v_m = \hat{v}_m$, I get $\hat{v}_m = \frac{1}{21}(12c_r + 5\sqrt{21c_m - 48c_r^2})$ with $c_m \in [\frac{448}{75} c_r^2, \frac{64}{3} c_r^2]$.

(iii) Assume that $4c_r \leq \hat{v}_m < \frac{32}{3} c_r \leq \hat{v}_m$. If $d_m = 1$, then $E(\pi_m) = \frac{1}{25}(\hat{v}_m - 4c_r)(\hat{v}_m + 16c_r) - c_m$; $d_m = 0$, $E(\pi_m) = \frac{1}{25}(\hat{v}_m - 4c_r)(\hat{v}_m + 16c_r)$. The optimal $\hat{v}_m = 2\sqrt{25c_m/3 + 4c_r^2} - 4c_r$, with $c_m \in [\frac{96}{25} c_r^2, \frac{448}{75} c_r^2]$.

(iv) Assume that $\hat{v}_m < 4c_r \leq \hat{v}_m < \frac{32}{3} c_r$. If $d_m = 1$, then $E(\pi_m) = \ldots
\[
\frac{1}{25}(v_m - 4c_r)(v_m + 16c_r) - c_m; \quad d_m = 0, \quad E(\pi_m) = 0. \quad \text{The optimal } \hat{v}_m = -6c_r + 5\sqrt{c_m + 4c_r^2} \text{ with } c_m \in (0, \frac{96}{25}c_r^2).
\]

Proof of Proposition 4.2:

For \(c_m \in [0, \frac{96}{25}c_r^2), \hat{v}_m \in [0, 8c_r). \) If the manufacturer withholds information, \(\hat{v}_m = \bar{v}_m \in [0, 4c_r), \) then the best response from the retailer is \(\hat{r} = 8c_r > \bar{v}_m. \) If information is disclosed, then \(\bar{v}_m = v_m \geq \hat{v}_m. \) In this case, if \(\bar{v}_m \leq v_m \leq 4c_r, \) then \(\bar{r} = 8c_r > \bar{v}_m; \) or if \(v_m > 4c_r, \) then \(\hat{r} = \frac{2}{5}v_m + \frac{32}{5}c_r \geq \frac{2}{5}\bar{v}_m + \frac{32}{5}c_r > \bar{v}_m \) since \(\bar{v}_m < 8c_r < \frac{32}{3}c_r. \) If \(v_m > \frac{32}{3}c_r, \) then \(\hat{r} = \frac{32}{3}c_r > \bar{v}_m. \) Similarly, for \(c_m \in \left(\frac{96}{25}c_r^2, \frac{448}{75}c_r^2\right), \hat{v}_m \in \left[8c_r, \frac{32}{3}c_r\right). \) If the manufacturer withholds information, \(\hat{v}_m = \bar{v}_m \in [4c_r, \frac{16}{3}c_r), \) then the best response from the retailer is \(\hat{r} = \frac{1}{5}\bar{v}_m + \frac{32}{5}c_r \leq \bar{v}_m \) since \(\hat{v}_m > 8c_r. \) If information is disclosed, then \(\bar{v}_m = v_m \geq \bar{v}_m. \) In this case, if \(8c_r \leq \bar{v}_m \leq v_m < \frac{32}{3}c_r, \) then \(\hat{r} = \frac{2}{5}v_m + \frac{32}{5}c_r \geq \frac{2}{5}\bar{v}_m + \frac{32}{5}c_r > \bar{v}_m \) since \(\bar{v}_m < \frac{32}{3}c_r. \) Otherwise if \(8c_r \leq \bar{v}_m < \frac{32}{3}c_r < v_m, \) then \(\hat{r} = \frac{32}{3}c_r > \bar{v}_m. \)

for \(c_m \in \left(\frac{448}{75}c_r^2, \frac{64}{3}c_r^2\right), \hat{v}_m \in \left[\frac{32}{3}c_r, \frac{64}{3}c_r\right). \) If the manufacturer withholds information, \(\hat{v}_m = \bar{v}_m \in [\frac{16}{3}c_r, \frac{32}{3}c_r), \) then the best response from the retailer is \(\hat{r} = \frac{1}{5}\bar{v}_m + \frac{32}{5}c_r < \bar{v}_m, \) since \(\hat{v}_m > 8c_r. \) If information is disclosed, then \(\bar{v}_m = v_m \geq \bar{v}_m. \) In this case, \(\hat{r} = \frac{32}{3}c_r \leq \bar{v}_m. \)

for \(c_m \in \left(\frac{64}{3}c_r^2, 1\right], \hat{v}_m > \frac{64}{3}c_r. \) If the manufacturer withholds information, \(\hat{v}_m = \bar{v}_m \geq \frac{32}{3}c_r, \) then the best response from the retailer is \(\hat{r} = \frac{32}{3}c_r < \bar{v}_m. \) If information is disclosed, then \(\bar{v}_m = v_m \geq \bar{v}_m. \) In this case, \(\hat{r} = \frac{32}{3}c_r < \bar{v}_m. \)

This completes the proof for Proposition 4.2.

Proof of Manufacturer ex ante Profit

(1) if \(c_m \in [0, \frac{96}{25}c_r^2), E(\pi_m) = \int_{v_m}^{32c_r/3} \frac{1}{25}(v_m - 4c_r)(v_m + 16c_r) - c_m \, dv_m + \int_{32c_r/3}^{16c_r} \frac{1}{16} - c_m \, dv_m = \frac{1}{48} - \frac{272}{9}c_r^3 + \frac{10}{3}c_m\sqrt{c_m + 4c_r^2} + \frac{40}{3}c_r^2\sqrt{c_m + 4c_r^2} - c_m(1 + 6c_r);
\]

(2) if \(c_m \in \left[\frac{96}{25}c_r^2, \frac{448}{75}c_r^2\right), E(\pi_m) = \int_{v_m}^{\bar{v}_m} \frac{1}{25}(\bar{v}_m - 4c_r)(\bar{v}_m + 16c_r) \, dv_m + \int_{\frac{32}{3}c_r}^{\frac{32}{3}c_r} \frac{1}{16} - c_m \, dv_m = \frac{1}{48} - \frac{83}{3}c_r^3 - \frac{1856}{225}c_r^3 + \frac{16}{27}c_m\sqrt{75c_m + 36c_r^2} - \frac{32}{225}c_r^2\sqrt{75c_m + 36c_r^2};
\]

(3) if \(c_m \in \left[\frac{448}{75}c_r^2, \frac{64}{3}c_r^2\right), E(\pi_m) = \int_{v_m}^{\bar{v}_m} \frac{1}{25}(\bar{v}_m - 4c_r)(\bar{v}_m + 16c_r) \, dv_m + \int_{\frac{32}{3}c_r}^{\frac{64}{3}c_r} \frac{1}{16} - c_m \, dv_m = \frac{1}{48} - c_m + \frac{800}{147}c_m\sqrt{c_r} - \frac{4096}{343}c_r^3 + \frac{1000}{1323}\sqrt{21c_m - 48c_r^2} - \frac{9240}{261}c_r^2\sqrt{21c_m - 48c_r^2};
\]

(4) if \(c_m > \frac{64}{3}c_r^2, E(\pi_m) = \int_{v_m}^{\bar{v}_m} \frac{1}{16} - c_m \, dv_m + \int_{\frac{64}{3}c_r^2}^{\frac{64}{3}c_r^2} \frac{1}{16} - c_m \, dv_m = \frac{1}{48} + \frac{64}{9}\sqrt{3}c_r^3 - c_m.\)
It is easy to prove that $\partial E(\pi_m)/\partial c_m < 0$ for smaller $c_m$, $\partial E(\pi_m)/\partial c_r > 0$ for larger $c_m$ and $\partial E(\pi_m)/\partial c_r \leq 0$.

**Proof of Retailer ex ante profit**

To calculate the retailer’s ex ante profit, I first analyze the retailer’s ex ante profit at stage 3, when the quality of the manufacturer’s brand $\tilde{v}_m$ is observed.

(1) When $\tilde{v}_m < 4c_r$, $E(\pi_r) = \pi_r^{(1)}(\tilde{v}_m) = \int_{0}^{\tilde{v}_m} \tilde{v}_r/4 \, dv_r + \int_{\tilde{v}_m}^{1} (v_r/4 - c_r) \, dv_r = \frac{1}{8} - (1 - 8c_r)c_r$.

(2) When $4c_r \leq \tilde{v}_m \leq \frac{32}{3} c_r$, $E(\pi_r) = \pi_r^{(2)}(\tilde{v}_m) = \int_{0}^{\tilde{v}_m} \frac{\tilde{v}_m + 3\tilde{v}_r}{16} \, dv_r + \int_{\tilde{v}_m}^{1} (v_r/4 - c_r) \, dv_r = \frac{1}{8} - c_r + \frac{128}{25} c_r^2 + \frac{16}{25} \tilde{v}_m c_r + \frac{1}{50} \tilde{v}_m^2$.

(3) When $\tilde{v}_m > \frac{32}{3} c_r$, $E(\pi_r) = \pi_r^{(3)}(\tilde{v}_m) = \int_{0}^{\tilde{v}_m} \frac{\tilde{v}_m + 3\tilde{v}_r}{16} \, dv_r + \int_{\tilde{v}_m}^{1} (v_r/4 - c_r) \, dv_r + \int_{\tilde{v}_m}^{1} (v_r/4 - c_r) \, dv_r = \frac{1}{8} - c_r (1 - \frac{32}{3} c_r) + \frac{1}{32} \tilde{v}_m^2$.

Consequently, at the second stage when $\tilde{v}_m$ can not be observed by the retailer, the retailer’s ex ante profit is:

1. if $c_m \in [0, \frac{96}{25} c_r^2]$, $E(\pi_r) = \int_{0}^{\tilde{v}_m} \pi_r^{(1)}(\tilde{v}_m) \, dv_m + \int_{\tilde{v}_m}^{1} \pi_r^{(2)}(v_m) \, dv_m + \int_{\tilde{v}_m}^{1} \pi_r^{(3)}(v_m) \, dv_m$. By calculation, $E(\pi_r) = \frac{13}{96} - c_r - 5c_m c_r + \frac{32}{3} c_r^2 - \frac{224}{3} c_r^3 - \frac{5}{6} c_m \sqrt{c_m} + 4c_r^2 + \frac{80}{3} c_r^2 \sqrt{c_m} + 4c_r^2$.

2. if $c_m \in [\frac{96}{25} c_r^2, \frac{448}{75} c_r^2]$, $E(\pi_r) = \int_{0}^{\tilde{v}_m} \pi_r^{(2)}(\tilde{v}_m) \, dv_m + \int_{\tilde{v}_m}^{1} \pi_r^{(2)}(v_m) \, dv_m + \int_{\tilde{v}_m}^{1} \pi_r^{(3)}(v_m) \, dv_m$. Hence, $E(\pi_r) = \frac{13}{96} - c_r + \frac{32}{3} c_r^2 - \frac{2048}{75} c_r^3 - \frac{1}{2025} (-6c_r + \sqrt{75 c_m + 36 c_r^2})^3$.

3. if $c_m \in [\frac{448}{75} c_r^2, \frac{64}{3} c_r^2]$, $E(\pi_r) = \int_{0}^{\tilde{v}_m} \pi_r^{(2)}(\tilde{v}_m) \, dv_m + \int_{\tilde{v}_m}^{1} \pi_r^{(3)}(v_m) \, dv_m$. Hence $E(\pi_r) = \frac{13}{96} c_r + \frac{264}{49} c_m c_r - \frac{2064}{1029} c_r^3 - \frac{130}{441} c_m \sqrt{7c_m - 16c_r^2} - \frac{32}{9261} c_r^2 (-3087 + 1084 \sqrt{21c_m - 48c_r^2})$.

4. if $c_m > \frac{64}{3} c_r^2$, $E(\pi_r) = \int_{0}^{\tilde{v}_m} \pi_r^{(3)}(\tilde{v}_m) \, dv_m + \int_{\tilde{v}_m}^{1} \pi_r^{(3)}(v_m) \, dv_m$. By calculation, $E(\pi_r) = \frac{13}{96} - c_r + \frac{32}{3} c_r^2 - \frac{4 \sqrt{9c_m}}{9} \sqrt{c_m}$. It is easy to prove that $\partial E(\pi_r)/\partial c_r < 0$ for smaller $c_r$, $\partial E(\pi_r)/\partial c_r > 0$ for larger $c_r$. $\partial E(\pi_r)/\partial c_m \leq 0$ when $c_m \leq 8.17 c_r^2$ or $c_m \geq \frac{64}{3} c_r^2$, and when $8.17 c_r^2 < c_m < \frac{64}{3} c_r^2$, $\partial E(\pi_r)/\partial c_m > 0$.

**Proof of Proposition 4.3**

(i) Assume that $\frac{32}{3} c < \tilde{v}_m < \tilde{v}_m < a$, then when $d_m = 1$, the optimal $E(\pi_m) = \frac{\tilde{v}_m^2}{16a} - c$; when $d_m = 0$, $E(\pi_m) = \frac{\tilde{v}_m^2}{16a}$. Hence the optimal $\hat{v}_m = 8\sqrt{ca/3}$, with $c < \frac{3a}{40}$. It is not possible to credibly assign an optimal disclosure strategy for any $\hat{v}_m > a > \tilde{v}_m > \frac{32}{3} c$ and $\hat{v}_m > \tilde{v}_m > a > \frac{32}{3} c$.

(ii) Assume that $4c \leq \tilde{v}_m < \frac{32}{3} c < a \leq \hat{v}_m$. If $d_m = 1$, $E(\pi_m) = \frac{2\tilde{v}_m - a}{16} - c$; $d_m = 0$, $E(\pi_m) = \frac{1}{25a} (\tilde{v}_m - 4ac) (\tilde{v}_m + 16c)$. Equating the two profit at $\pi_m(\hat{v}_m) = \pi_m(\tilde{v}_m)$, I get $\hat{v}_m = \frac{1}{4} (-48c + 25a - 5034c^2 - 160ac + 21a^2)$ with $c \in [\frac{3a}{40}, \frac{5a}{48}]$. 

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The case of \(4c \leq \bar{v}_m < \frac{32}{3}c < \hat{v}_m < a\) is not possible.
REFERENCES


