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Price Discrimination on Complementary Goods: Evidence from the Men's Shaving Razor Market

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Price Discrimination on Complementary Goods: Evidence from the Men's Shaving Razor Market

DISSERTATION

A dissertation submitted in partial
fulfillment of the requirements for
the degree of Doctor of Philosophy
in the College of Business and
Economics at the University of
Kentucky

By
Zheng Yang
Lexington, Kentucky

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ABSTRACT OF DISSERTATION

Price Discrimination on Complementary Goods: Evidence from the Men's Shaving Razor Market

This dissertation analyzes the men's razor market to examine whether a monopolist can implement price discrimination for the complementary goods. I estimate a demand system for razors using the random coefficient logit model with market level sales data from the Nielsen Store Scanner dataset and individual demographic data from the March CPS. The estimated parameters are used to construct price-cost markups. By comparing the markups of different products, I find evidence that Gillette uses a two-part tariff strategy. This conclusion can be generalized as that of a monopolist setting the prices of tie-in products consistent with a two-part tariff.

KEYWORDS: two-part tariff; price discrimination; self-selection

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Date: July 27, 2019

Price Discrimination on Complementary Goods: Evidence from the Men's Shaving Razor Market

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Chapter 1 Introduction

This dissertation investigates the pricing problem of a multi-product firm that has the ability to price discrimination. Evidence from the men's shaving razor market confirms the hypothesis that tie-in sales can be used as a price discrimination device. Further, the pricing schedule in this market is consistent with the two-part tariff theory suggested by Oi (1971) and Schmalensee (1981, 2015). This conclusion is derived by a structural empirical approach. First, I estimate a random coefficient logit model with market level data from men's shaving razor market in United States between 2015 and 2016. The estimated parameters are used to compute the price-cost markup of each product. Then I compare the markups of different products. The results show that the dominant firm charged high markups for its disposable razors and low markups for its cartridges. Further, the markup differences contribute to most of the price differences. Last, the markup differences of the dominant firm's brands are more significant than those of a fringe competitor. The evidence suggests that the dominant firm intentionally lowered the cartridge prices to promote sales when it can use the price of the handle to extract the consumer surplus from the shaving service. In other words, the tie-in nature of the men's non-disposable razor system is used to practice a two-part tariff pricing strategy.

It is unusual to find a firm which sells a single type of product at a uniform price in practice. On the one hand, firms often provide more than one type of product. For example, Toyota produces Camrys and Corollas; Cannon sells cameras and compatible lenses; Sony provides a variety of products such as televisions, medical devices, movies, and even financial services.

Further, the demands for the commodities of a multi-product firm are often interrelated. When choosing between a Camry and a Corolla, consumers would compare their prices. To decide whether to buy a video game console, consumers would consider the prices of games. Thus, the pricing problem of a multi-product firm is different from that of a single-product firm; changing price for one product affects not only the sales volume of this product but also other interrelated products. For example, if Toyota cut the price for the Camry, it could collect more revenue from the increasing Camry sales. However, the price cutting could attract some of the potential Corolla buyers, and hence decreases Corolla sales. Thus, when making a pricing policy for Camry, Toyota must consider both the gain from Camry sales and the loss from Corolla sales. On the contrary, the products sold by a firm are sometimes complementary with each other. Take video game consoles and games as an example, a purchaser of a video game console also needs to buy video games sold by the same firm. Manufacturers of consoles and games know that price cutting on consoles boosts not only console sales but also game sales, so they sometimes lower the console price, even selling at a loss.

On the other hand, we often observe that the same or extremely similar products are sold at different prices. For example, students usually get discounts from computer sellers; restaurants have weekday specials; it is much cheaper to buy a pack of paper towels than to buy them roll-by-roll. Companies often defend their price dispersion as a reaction to cost differences; the unit cost of packaging and transporting paper towels in the large-size pack is lower than that in the one-roll pack. Also, firms know that students would be good customers in the future. So it would be profitable to offer a student discount and make students loyal customers in the future.

However, one cannot neglect that price dispersion could stem from a profitable marketing practice: price discrimination. A marketing brochure suggested that "A key step is to avoid average pricing. Pricing to specific customer groups should reflect the true competitive value of what is being provided" [Miles (1986), cited in Varian (1987)]. Consumers usually have different reservation prices for the same commodity.

Sometimes, a firm can identify the demand of its customers and, by which, segment the customers into different groups. Then, when this firm raises price for customers with high reservation prices, it will not lose low-type customers. It is obvious that a discriminatory pricing policy is more profitable than a uniform pricing policy.

In practice, a firm usually provides more than one product. Further, the customers of a firm often have different reservation prices for each of the products. Thus, a rational firm should simultaneously consider two aspects, multi-product pricing and discriminatory pricing, to maximize its profit. For example, Starbucks sells Espresso in different sizes at different per-ounce prices, which could be quantity-based price discrimination. Also, when setting the price schedule for Espresso, Starbucks should consider the sales of Americano and Latte; that is, practice multi-product pricing.

In the case above, the product line of Starbucks had already existed; Starbucks discriminates among consumers by price schedule on the product line. However, the product line itself could be designed as a price discrimination device.

Some firms produce close substitutes, which are only differentiated in quality. Then they can sell the high-quality and high-priced product to the consumers who are willing to spend more money on it, while retaining consumers with a low reservation price by selling them a low-quality and low-priced product. In this case, firms can sort and segment consumers without knowledge about consumers' types; given the price-quality schedule, each consumer is self-assigned to the product which maximizes his satisfaction. This type of price discrimination device, which involves a self-selection mechanism, is called "second-degree price discrimination".[1]

Further, for some complementary products, firms could design commodity bundles to differentiate consumers. In McDonald's, for example, customers can order the Big Mac meal, which includes a burger, a soft drink, and a box of fries. However, they can also buy those components separately at a slightly higher total price. By

[1]This dissertation uses Tirole (1988)'s classification for price discrimination. The different definitions regarding the second-degree price discrimination will be discussed in Chapter 2.

the commodity bundling, McDonald's can sort customers into groups with different reservation prices for those components, and hence extract more consumer surplus.

The burgers can be consumed without soft drinks or fries. However, some complementary commodities have to be used together. For example, printers cannot work without ink; video games must be played on consoles; razor handles are useless without cartridges. In this case, the demand for gaming, shaving, or printing has to be satisfied with a primary good (such as the printer, console, or handle) and an aftermarket good (such as the ink, game, or cartridge). Moreover, it is common that a firm forces the buyers of primary goods to purchase its aftermarket goods by arrangement or compatibility. This marketing practice is called "tie-in sale".[2]

According to tie-in sales, consumers demand the service generated by the tie-in commodities; they do not need any component without others. In addition, a consumer normally makes the purchase decision for the primary good before buying the aftermarket good. Further, each consumer needs one unit of the primary good, regardless of his demand for the service. The consumers who have a high demand for the service will buy more aftermarket goods. Lastly, once a consumer purchased a primary good, he is tied to the aftermarket goods provided by the same firm.[3]

Due to the nature of tie-in sale, the pricing problem of tie-in commodities can be explained by two-part tariff theory. A two-part tariff involves a lump-sum fee and a unit price; that is, the consumer must pay a lump-sum fee for the right to buy a product or service at a unit price. Take amusement parks as an example; a visitor is charged an admission fee to get in the park while he still has to pay for each ride. For the firm, the two-part tariff is superior to a unique price. If the amusement park manager only charged the admission fee, he cannot distinguish the ones who

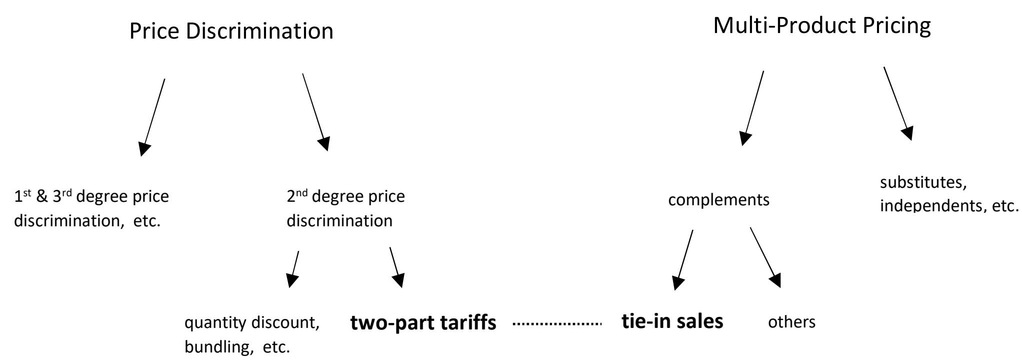
[2] There are different definitions of "tie-in sale". For example, "bundling" (selling one product with a fixed number of another product) is sometimes called "tie-in sale". Also, tie-in products are not necessarily complementary. This dissertation uses a narrow definition of "tie-in sale".

[3] It is not a strong assumption if this consumer signed a tie-in arrangement with the seller or the costs of switching to another tie-in system was too high.

are willing to pay for more rides from the ones who only want to play a few rides. On the other hand, if the manager only charged the visitors for each ride, he cannot extract consumer surplus, which is the part of the utility above the price for each ride. Therefore, the two-part tariff serves as an effective price discrimination device.

It is easy to find many common features between two-part tariffs and tie-in sales. First, to satisfy a single demand, a consumer is charged twice. Second, they both involve a one-shot payment and a repeated payment. Thus, firms could make the pricing policy for the tie-in commodities by way of the two-part tariff; pricing the primary good is equivalent to charging a lump-sum fee, and pricing the aftermarket good is equivalent to charging a unit price.

Figure 1.1: Taxonomies of Price Discrimination and Multi-Product Pricing



Sometimes, firms cannot employ the two-part tariff, even if they have been aware of the profitability of discriminatory pricing for tie-in sales. Antitrust authority does not permit tie-in practice in some markets. As a result, the manufacturer of primary goods has to allow other firms to produce compatible aftermarket goods[4]. Also, a firm must hold market power to employ a discriminatory pricing policy, while firms are often facing fierce competition from each other. Thus, it is unclear whether a tie-in sale is priced by way of the two-part tariff. Moreover, even if a tie-in sale was

[4]See in Eastman Kodak Co. v. Image Technical Servs., Inc., 504 U.S. 451 (1992); and Avaya Inc v. Telecom Labs Inc, No. 14-4174 (3d Cir. 2016).

priced by way of the two-part tariff, it is still unclear what the best pricing schedule is.

A common view says that a firm should set a low price on the primary good or even give it away and set a high price on the aftermarket good. Due to the low price, more consumers buy that primary good and are locked with this firm. Then the firm can set a high price on the aftermarket good. This view, which is named as the "razor-and-blades model", reveals the coordination between prices of the two products. However, Picker (2011) raised a critical view regarding the "razor-and-blades" model. He traced back the razor prices in the early 20$^{\text{th}}$ century with historical evidence, such as advertisements in magazines. It turns out that the Gillette company charged $5 for a razor handle with a pack of 12 cartridges and $1 for each additional pack of 12 blades when it monopolized this market with patents from 1904 to 1921. After its patents expired, Gillette lowered the price of the original handle set to $1 but offered a new, luxury, but compatible handle set at $5. On the contrary, the price of the blades did not change over time. Picker concluded that Gillette was not playing "razor-and-blades" strategy during its monopoly time. In other words, the "razor-and-blades" strategy might not apply to all tie-in products. The evidence provided by Picker is consistent with the predictions of Oi (1971) and Schmalensee (1981, 2015), who suggested that a monopolistic razor company should sell the handles at a high price and the cartridges at a low price. Facing a low cartridge price, a consumer would like to replace it more frequently. As his cartridge consumption increased, his willingness to pay for the razor handle also went up. Thus, the consumer would readily accept a high handle price. For the firm, a high handle price could not only compensate for the loss caused by lowering the cartridge price but also extract more consumer surplus.

The main difference between the "razor-and-blade" story and the "two-part tariff" theory arises from their assumptions about the market structure. There are two separat but interdependent markets: the handle market and the cartridge market. The "razor-and-blades" story implicitly assumes that the handle market is an ex-ante competitive market. Thus, each razor company would like to lower its razor price to compete with each other. However, if a consumer has purchased a handle, he is locked in to the cartridges of the same brand. Thus, each company is an ex-post monopolist in the cartridge market and can set a high cartridge price. On the contrary, Oi and Schmalensee assumed that a razor company is a monopolist in both the handle and the cartridge markets. Even if being charged a high handle price, the consumers would not switch to other brands.

When monopolizing this market (1904 – 1921), Gillette did not need to lower its handle price to compete with anyone. So, it was feasible to use a two-part tariff strategy during its monopoly period. However, when its patent expired, Gillette had to lower the handle price to compete with other firms. However, when the price of a handle was lowered, a consumer may not care about the switching cost; that is, purchasing a new handle from another company. Thus, the handle could not lock in the consumers. In other words, giving handles away could not help the companies raise the prices in the blade market.

The evidence provided by Picker(2011) was not thorough enough. Gillette did set a high handle price and a relatively low blade price during the monopolistic period. However, it is unclear what the costs of the handle and the blade were. It is possible that the cost made up a high percentage of the handle price but a low percentage of the blade price. In this case, even a high handle price and low blade price could be a "razor-and-blades" price strategy. Also, it is still unclear what pricing strategy Gillette is using nowadays.

This dissertation examines the pricing strategy on razor handles and cartridges. I find empirical evidence that tie-in sales (handle-and-cartridges) could be a device to practice a two-part tariff pricing strategy. Moreover, the pricing policy used by razor manufacturers is consistent with what Oi and Schmalensee suggested but opposite to the “razor-and-blade” model.

There is a small but growing body of literature regarding price discrimination on complementary commodities. Li (2015) studied the optimal intertemporal price discrimination schedule in the e-reader and e-books industry. She found that the optimal pricing schedule depended on the use intensity. For avid consumers, a firm should harvest (price-cutting over time) on the e-readers and invest (price-raising over time) in the e-books. For the general consumers, a firm should invest in the e-readers and harvest on the e-books. Chintagunta, Qin, and Vitorino (2018) investigated the single-serve coffee system industry, where the coffee machine manufacturer licensed other firms to produce coffee pods. They found the licensing agreement was associated with less price dispersion in the aftermarket and lower prices of the primary good. Gil and Hartman (2009) and Hartmann and Nair (2010)’s findings are closer to this dissertation. Gil and Hartman examined concession sales at movie theaters. They found that the demand conditions for movie tickets and concessions support the metering strategy (setting a low price for movie tickets and high prices for concessions). They also found that high-priced concessions extracted more surplus from the customers with a higher reservation price for tickets. Hartmann and Nair (2010) found the demand condition in the men’s razor market was feasible for setting a high price for handles and low price for cartridges. However, they did not further examine what pricing policy firms actually used.

Attempting to identify which pricing strategy is used by firms, Shepard (1991) uncovered evidence that gas stations used a quality scale to discriminate among consumers. The price difference of full-service gasoline between a multi-product gas station (providing both full-service gasoline and self-service gasoline) and a single product gas station (only providing self-service gasoline) was driven by the price discrimination. Verboven (1996, 2002) and Cohen (2008) found that the price difference across consumer groups could be explained by the markup difference, which is the evidence of the price discrimination. Lakdawalla and Sood (2013) compared the difference in the drug consumptions of insured and uninsured patients across the markets. They found that health insurance worked as a two-part tariff arrangement. Bonnet and Dubois (2010) examined the bottled water wholesale market and found evidence that there existed a two-part tariff arrangement between the manufacturers and the retailers.

This dissertation contributes the existing literature in two aspects. First, this dissertation confirms that a tie-in sale can be used to employ the two-part tariff strategy, and provides evidence to correct a common misunderstanding regarding the pricing policy of razors. Moreover, this dissertation enriches the empirical literature through the application of the random coefficient logit model in a price discrimination study.

The rest of this dissertation proceeds as follows. Chapter II surveys the literature in three fields. Chapter III presents a brief description of the men's shaving razor market. Chapter IV introduces the data and the variables. Chapter V presents the theoretical model of the firm pricing behavior. Chapter VI discusses the empirical strategy. Chapter VII presents the empirical results. And Chapter VIII presents the conclusion.

Chapter 2 Literature Review

This chapter reviews the theoretical and empirical literature regarding this dissertation. Section 2.1 surveys the development of price discrimination theory with an emphasis on self-selection price discrimination, price discrimination in competitive markets, and empirical tests for price discrimination in practice. Section 2.2 reviews the multi-product pricing literature, with a special emphasis on price discrimination used by multi-product firms supplying complementary commodities. Section 2.3 surveys the history of empirical industrial organization. The development of the empirical approach explains why empirical tests for price discrimination emerged and progressed in the recent decade, and why this dissertation can contribute to this trend.

2.1 A Survey on Price Discrimination

The traditional definition of price discrimination is that price discrimination occurs when two units of identical or largely similar goods are sold at different prices, either to the same consumer or to different consumers. However, this definition fails on two aspects. First, the price difference could reflect differences in transportation costs, marketing costs, or packaging costs. Thus, it does not necessarily result from price discrimination. On the other hand, even if there was no price difference, we could not say that price discrimination does not exist – the goods sold at the same price could be provided at different costs. Thus, a more strict definition of price discrimination is "price discrimination is present when two or more similar goods are sold at prices that are in different ratios to marginal costs" [Stigler (1987)].[1]

[1] Clerides (2002) compared the two definitions and studied the relevance of the difference in empirical studies.

Pigou (1920) provided the first careful analysis of price discrimination. The author stated that "discriminating power will sometimes exist alongside of monopolistic power" and "depend essentially upon the non-transferability of the commodities affected". Depending on the degree of transferability of the goods, Pigou (1920) classified price discrimination into three categories. A first-degree price discrimination involved "the charge of a different price against all the different units of commodity, in such wise that the price was equal to the reservation price for it". A second-degree occurred when a monopolist set a price schedule which involved different prices for different amounts of the good purchased. A third degree would be obtained if the monopolist could distinguish among his customers' preference by "practicable mark", separate them into different groups, and charge a separate monopoly price to each group. According to Pigou (1920), an important prerequisite to apply price discrimination is that the monopolist must have the ability for identifying and segmenting consumers into different groups. However, firms often encounter informational and legal obstacles to do this.

Leland and Meyer (1976) and Maskin and Riley (1984) demonstrated that even if only the distribution of preferences of consumers was known, a monopolist was able to sort and segment consumers by a well-designed pricing structure, called a self-selection mechanism. Many marketing practices were shown to be effective price discrimination in the form of self-selection, such as quality-differentiated product lines, bundling, menus of two-part tariffs, and intertemporal price discrimination.

A common self-selection device is vertically-differentiated product line. Mussa and Rosen (1978) demonstrated that when consumers had differentiated valuations on the quality of a good, a monopolist could provide a quality-differentiated spectrum of this good. Then "given this price-quality schedule, each consumer is self-assigned to the quality that maximizes utility". [2]

[2]Gabszewicz et al. (1986) further examined the optimal product range for quality-based price

Bundling, as a price discrimination device, was first suggested by Stigler (1968). Adams and Yellen (1976) provided a framework to explain the incentive of firms to sell complementary goods in bundles. They showed that the profitability of bundling could stem from its ability to sort consumers into groups with different reservation prices, and hence to extract consumer surplus. Moreover, Lewbel (1985) demonstrated that the bundled products were not necessarily complementary; a firm could sell goods in a bundle, even if they were substitutes. [3]

A two-part tariff is a type of price discrimination strategy that involves a lump-sum fee and a unit price. Oi (1971) provided a formal framework to investigate the mechanism by which a monopolist used a discriminatory two-part tariff to sort consumers and extract consumer surplus. Murphy (1977) demonstrated that menus of two-part tariffs were able to "cause consumers to identify themselves". [4]

Usually, products are pretty expensive when they first appear on the market; then, price declines over time. Stokey (1979) showed that some of the price fluctuations appeared to be for intertemporal price discrimination. That is, products were often introduced into the market at a high price, at what time the consumers with high reservation price bought them. When the price declined over time, the consumers with low reservation price made their purchase. [5]

Then, based on the ability for identifying and segmenting consumers, Tirole (1988) re-classified second-degree and third-degree price discrimination. The practice used by the monopolist who had information about consumers' reservation prices and had

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discrimination.

[3]Telser (1979) provided another analysis for bundling as price discrimination. Schmalensee (1984) improved Adams and Yellen's framework by introducing more thorough assumptions on demand. McAfee, McMillan, and Whinston (1989) investigated the conditions under which bundling was an optimal strategy.

[4]Two-part tariff is not necessary to be discriminating. Nevo (1971) demonstrated that even if consumers were homogeneous, a monopolist could be benefited by two-part tariffs. Ng and Weisser (1974) studied the case in which a two-part tariff was used to maximize social welfare. Schmalensee (1981, 2015) studied the optimal two-part tariff schedule under different assumptions on demand distribution.

[5]Conlisk, Gestner, and Sobel (1984) and Sobel (1984) further examined the optimal intertemporal price discrimination schedule under various assumptions.

the ability for segmenting consumers was classified as third-degree price discrimination. On the contrary, the pricing strategy involving the self-selection mechanism was classified as second-degree price discrimination.

Following Pigou (1920), the discussion of price discrimination had focused on monopolistic markets until the 1970s. However, in light of developments in oligopoly theory, research interest began to shift to price discrimination in competitive market. Among the very first papers, Spulber (1979) demonstrated that there existed a non-cooperative equilibrium for a group of firms who were able to practice price first-degree price discrimination. Neven and Phlips (1985) and Holmes (1989) examined third-degree price discrimination in duopolistic market. Stole (1995) studied quality-based price discrimination with oligopoly. Yin (2004), Griva and Vettas (2015), and Tamayo and Tan (2017) examined two-part tariffs in oligopolistic markets. Greenhut and Greenhut (1975), MacLeod, Norman, and Thisse (1988), and Borenstein (1985) studied competitive price discrimination within a spatial model. Those works showed that competition could not prevent price discrimination.

The practice of the pricing strategies mentioned above (such as bundling, two-part tariffs, quality-differentiated product lines, and price fluctuations) is not necessarily the sign of price discrimination. For example, price fluctuation of commodities may reflect the change in production costs; discount in a bundle may result from saving in packaging cost. Thus, the theory of price discrimination, especially within competitive markets, calls for empirical evidence.

Benefiting from the development of New Empirical Industrial Organization, many empirical works tested for the presence of price discrimination. Shepard (1991) examined quality-based price discrimination in a gasoline service station market. Verboven (1996) and Goldberg and Verboven (2005) examined international price discrimination in the car market. Verboven (2002) examined quality-based discrimination in the car market. Leslie (2004) examined quality-based price discrimination in the

Broadway theater ticket market. McManus (2007) examined quantity-based price discrimination in a specialty coffee market. Mortimer (2007) examined quality-based price discrimination in a VHS and DVD movie distribution market. Cohen (2008, 2011) examined quantity-based price discrimination in a paper towel market. Gil and Hartmann (2009) examined bundling in concession sales at a movie theater. Bonnet and Dubois (2010, 2015) examined two-part tariffs in a bottled water wholesale market. Hartmann and Nair (2010) examined two-part tariffs in a shaving razor market. Lakdawalla and Sood (2013) examined a two-part tariff strategy in the health insurance market. Li (2015) examined intertemporal price discrimination in an e-books and e-readers market.

2.2 A survey on Multi-Product Firm, Complementary Goods, and Price Discrimination

It is common that a firm produces more than one type of good. Further, the demands on the products provided by a single firm could be correlated; they could be complements or substitutes. Among the very first works, Coase (1946) provided a framework for analyzing the pricing problems of a multi-product firm facing interrelated demands. However, Coase only focused on uniform pricing for those products and neglected price discrimination case. Clements (1951) and Bailey (1954) related the pricing problem of multi-product firms with price discrimination. They argued that the pricing problem of a multi-product firm was theoretically equivalent to the pricing problem of a single-product firm employing price discrimination. However, they did not consider the case in which a firm was able to charge discriminating prices to each type of its products.

Stigler (1968) and Adams and Yellen (1976) demonstrated that a multi-product firm was able to discriminate among consumers by selling its products in bundles, no matter if the products were complements, substitutes, or unrelated. Calem and

Spulber (1984) and Scott and Morrell (1985) studied the pricing problem when a multi-product firm was able to employ two-part tariffs on each type of products to discriminate among consumers. They revealed how the best lump-sum fee and unit price for one product depend on the demand for another product.

In another case which this dissertation concerns, the two types of products provided by a single firm are tied-in. It is common that a firm produces a type of durable good, called the primary good, and a type of consumable good, called aftermarket good. To generate the whole service demanded, a consumer has to consume the primary good with the aftermarket goods and vice versa. Moreover, each consumer demanded only one primary good; the demand for the whole service was metered by the consumption on the aftermarket goods. Bowman (1957), Burstein (1960), and Blackstone (1975) demonstrated that a firm was able to use the nature of tie-in sales to employ price discrimination. According to their explanations, consumers differed in reservation price for the primary good. Even if the firm was not able to charge discriminatory prices for the primary good to consumers, it could discriminate among those consumers by selling them different units of aftermarket goods. Warhit (1980), Schmalensee (1985, 2015), and Ahmadi et al. (2015) explained the pricing problem of tie-in sales as a two-part tariff; a firm, who was providing a service, charged the lump-sum fee for the service by selling the primary good and charged the unit price by selling the aftermarket goods.

There is a small but growing literature regarding empirical examinations of the discriminating pricing policy of multi-product firms. Gil and Hartmann (2009) examined the sales of movie tickets and concessions at a movie theater. Hartman and Nair (2010) examined demand conditions in the men's shaving razor market. Derdenger and Kumar (2013) evaluated profitability of bundling console and video games in a handheld video game market. Chintagunta, Qin, and Vitorino (2018) studied single-serve coffee machines and the coffee pods market. Li (2019) examined intertemporal price discrimination for e-readers and e-books.

Table 2.1: Empirical Literature on Price Discrimination of Complementary Goods

Author	Market	Type of Price Discrimination
Gil & Hartmann (2009)	movie tickets and concessions	metering
Hartmann & Nair (2010)	razor	two-part tariff
Derdenger & Kumar (2013)	consoles and games	bundling
Chintagunta, Qin, & Vitorino (2018)	single-serve coffee	two-part tariff
Li (2019)	e-readers and e-books	intertemporal price discrimination

2.3 A Brief History of Empirical Industrial Organization

Before the 1930s, research on industries generally took the form of case studies, which usually surveyed the rise and decline of a specific industry and related that with the demand, costs, or other aspects of this industry. On the other hand, Walras and Marshall's perfect competition theory was prevalent at that time. However, this theory could hardly explain any phenomenon in the real world. Thus, formal economic theory was rarely, if ever, used in the industry studies.

Most economic historians see Chamberlin (1933), which introduced monopolistic competition theory into economics, as the beginning of industrial organization theory. In light of Chamberlin (1933), empirical industrial economists began to pay attention to the relationship between the market structure and performance of an industry. Wallace (1937) studied the Aluminum industry in the U.S. from 1888 to 1935. In this paper, he investigated the effectiveness of control policy by analyzing how profit, price, and capacity relied on the monopolistic elements of this industry. Wallace's research is among the very first studies of applying a formal economic theory to an industry study. Following the framework of Wallace (1937), empirical industrial organization became increasingly different from the industry studies of law schools or business schools.

However, people criticized those case studies from two aspects. First, those studies generally demonstrated their propositions by literal inference and rough data; that is, the conclusions were not based on thorough statistical evidence. Hence, those conclusions were more or less subjective and not fully persuasive. On the other hand, each of those studies focused on a particular industry in a particular geographic market. Thus, it is hard to generalize the conclusion to other industries or markets. In other words, even if a control policy was proved to be effective in the Aluminum industry, it is hard to say that the same policy could take effect in the bottled water industry.

Thus, mainstream empirical industrial organization studies switched from case-study to inter-industry studies in the 1950s, when industry-level cross-section data became available and computational costs fell off. For example, Bain (1951) found a positive relationship between the profit rate and market concentration by cross-section regression with the data of 42 industries from 1936 through 1940. Also, Ornstein (1977) studied concentration ratios and advertising intensity data of 44 industries in three years and found a negative correlation between the change in concentration and the change in advertising intensity.

Those studies, named as structure-conduct-performance (SCP) studies, differed from the case-study approach in three aspects. First, SCP investigates the general correlation between a particular aspect of market structure and performance (Bain, 1951, 1956), market structure and conduct (Ornstein, 1977), or conduct and performance (Comanor and Wilson, 1967). On the other hand, those studies used inter-industry cross-section data, including industry-level profit, market concentration, and other relevant information. Third, cross-section regressions were generally applied by the researchers. Thus, compared with the case-study approach, the SCP studies drew much more general and persuasive conclusions.

During the 1970s, critics of the inter-industry approach became prevalent. First, people argued that the econometric identification of causal effects used in empirical industrial organization was questionable. As Einav, Liran, and Levin (2010) said, "Since individual industries are sufficiently distinct, and industry details are sufficiently important, that cross-industry variation was often going to be problematic as a source of identification." Thus, the cross-section studies rarely yielded consistent estimates of structural parameters. Weiss (1974) discussed 46 inter-industry studies of seller concentration. Also, Gilbert (1984) surveyed such studies of the U.S. banking industry. They found that the conclusions among those studies were highly variable. Weiss (1971) pointed out that "perhaps the next step is back to the industry study, but this time with regression in hand." In addition, the same with the case-study approach, inter-industry studies lacked formal theoretical models, especially incomplete competition models. In other words, those studies discarded the powerful approach of neoclassical economics.

Meanwhile, researchers found the importance of intra-industry differences upon a firm's profitability. Hall and Weiss (1967) found that absolute firm size tended to result in high profit rates in the U.S. manufacturing industry. Gale (1972) found a positive correlation between the market share and profit rate in large U.S. firms. Moreover, Demsetz (1973) argued that, since firm size was correlated with profit rate, efficiency differences among firms provided an alternative explanation for the positive correlation between profit rates and concentration.

In the following decades, researchers stepped back to the intra-industry studies. However, they had more powerful tools in hands this time. First, firm-level data sets were growing since the late 1960s. For example, Hall and Weiss (1967) used the records of individual firms from "The Fortune directories of 500 largest industrial corporations". Gale (1972) used Standard and Poor's "Compustat" data which contained twenty years of balance sheet, income statement, and stock market data for over four hundred firms. With firm-level data sets, it was possible for researchers to investigate some issues within a particular industry.

Further, structural econometric models of industrial organization emerged in the 1970s. Among the very first papers, Iwata (1974) proposed a structural econometric approach to investigate the price determination in oligopoly. This paper derived conjectureal variation, which is a key concept in oligopoly, as a function of demand and cost parameters by solving a profit maximization problem of an oligopolist. The author measured those parameters by estimating demand and cost functions separately. Then he calculated the numerical valuation of the conjectural variation with parameters estimates. At last, this paper proposed a couple of hypotheses to test if there existed a certain type of collusion among oligopoly firms. This paper provided a framework for the following structural econometric models of empirical industrial organization.

Moreover, the theory of incomplete competition has developed a lot since the 1960s. Researchers connected the empirical findings of intra-industry studies with newly developed microeconomics theory, especially oligopoly theory.

Along with the advances in data, econometric methods, and economic theory, the research interest of empirical industrial organization changed a lot. From the 1950s through the 1960s, most of the papers focused on the correlation among market structure, firms' conducts, and performance. Since the 1970s, a growing number of papers have investigated particular aspects of firms' conducts. For example, Iwata (1974) studied collusive behavior in Japanese flat glass industry. Schmalensee (1985) studied the product proliferation problem in ready-to-eat breakfast cereals. Shepard (1991) found that price discrimination based on quality differences occurred in the gasoline retailing market.

In a review of this new trend, Bresnahan (1989) called the new form of empirical industrial organization studies as " New Empirical Industrial Organization" (NEIO). He said a typical NEIO paper was an econometric model of a particular industry in which the specification and inference were guided by economic theory. Further, it focused on the issues surrounding price and quantity determination in oligopoly.

In the recent thirty years, the progression in data sets and computational technology boosted the development of the New Empirical Industrial Organization.

Since the 1990s, a growing number of detailed datasets have become available to the researchers, making research on the behaviors of consumers or firms more convincing. Some public datasets document weekly transaction information of retailers or households on the product level. For example, Nevo (2001) used the store scanner data from International Resources Inc. (IRI) Infoscan Data Base to study collusion in the ready-to-eat breakfast cereal market. Bonnet and Dubois (2010) studied two-part tariff contracts between retailers and manufacturers in the bottled water market in France using household scanner data from TNS-World Panel. Further, some private datasets provide individual-level transaction data. Then the users can apply non-parametric tools using enormous observations. For example, Cohen, Hahn, Hall, Levitt, and Metcalfe (2016) estimated the consumer surplus of the taxi market using almost 50 million individual-level observations which provided by Uber.

Also, the advance in computer software and hardware greatly solved the computational issues of estimating a structural econometric model. Thus, complicated econometric approaches became increasingly prevalent. Particularly, Berry (1994) and Berry, Levinsohn, and Pakes (1995) proposed a numeric approach to solve the estimation issue in the structural demand estimation model. Nevo (2000) provided a Matlab package to make this approach much easier to use. Then, the Berry-Levinsohn-Pakes approach became a workhorse model of empirical industrial organization studies.

Chapter 3 Men's Shaving Razor Market

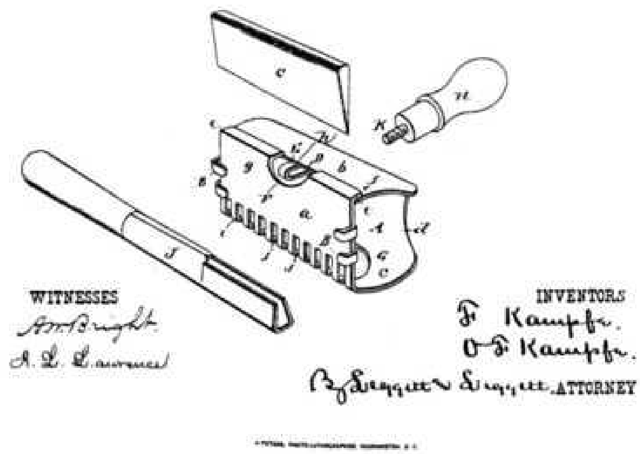
This Chapter introduces the the men's razor market. Section 3.1 reviews the origin of modern shaving razor with a particular emphasis on how the invention of Gillette's non-disposable razor system created a new business model. Section 3.2 introduces products and consumer preferences of the current razor market. Section 3.3 introduces the market structure. I find that Gillette dominates the high-end segment of this market and other firms are fringe competitors. Thus, Gillette can implement price discrimination in this market segment while other firms may not be able to do that. Section 3.4 presents some stylized facts regarding the pricing strategy in the high-end segment.

3.1 History

Untill the first half of the 19th century, the most popular shaving tool had been the straight razor, with a single-edge blade on a wooden or metallic handle. Shaving with the straight razor was a high-maintenance undertaking. Since the razor blade dulled easily, the use of it involved a considerable amount of trouble in keeping the blade sharp. The blade needed to be stropped and honed frequently, which was not easy for a user by himself. Also, the blades could be worn out by honing and had to be replaced at a considerable cost.

In 1847, William Henson invented the "hoe" style razor, with the blade perpendicular to the handle. The blade of hoe style razor was installed to the handle by a screw, and hence could be removed. In 1880, the Kampfe Brothers improved Henson's razor and invented the Star safety-razor. The Star razor had a removable wedge-shaped blade, which was held in place by metal clips. The Henson's and the Kampfe Brothers' razors were quite similar to modern design. However, their blade still required stropping before each use and occasional skillful honing.

Figure 3.1: Star Safety Razor

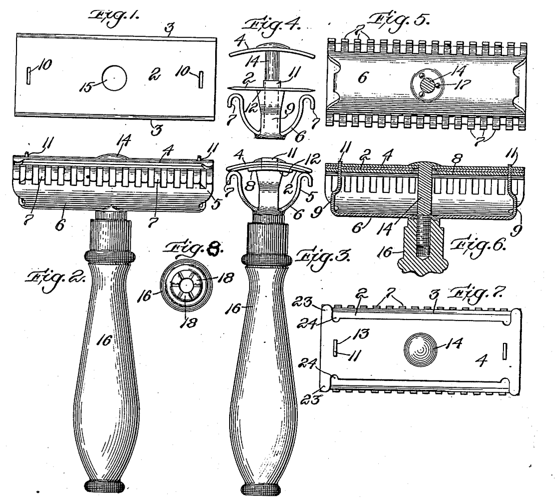


Sources: Kampfe, O.F., and F. Kampfe. U.S. Patent 228,904, issued June 15, 1880.

In 1904, King Camp Gillette patented his invention of a new hoe style razor. The novelty of the Gillette razor was that blades were made of very thin sheet-steel, unlike the bulky blade of the traditional hoe style razor. Thus, the blade required a small amount of material to manufacture, and hence could be produced and sold very cheaply. Then, consumers could buy them in quantities and throw them away when dulled; that is, stropping and honing were not needed anymore.

Gillette's razor not only changed men's shaving manner but also created a new business model. Prior to the invention of the Gillette razor, shaving razors had been a durable good. A razor could be used for a couple of years. People only replaced it when its blade wore out due to careless maintenance or over-honing. However, since the blade and handle of a Gillette razor were detachable and the blade was pretty cheap, users discarded the dulled blades frequently while keeping the handles for a longer time. Therefore, the sale of durable shaving razors was split into two parts: the sale of durable razor handles and the sale of consumable razor blades. Further, Gillette prevented other companies from producing compatible handles or blades by patent. As a result, the razor sales became similar to a tie-in arrangement.

Figure 3.2: Original Gillette Razor



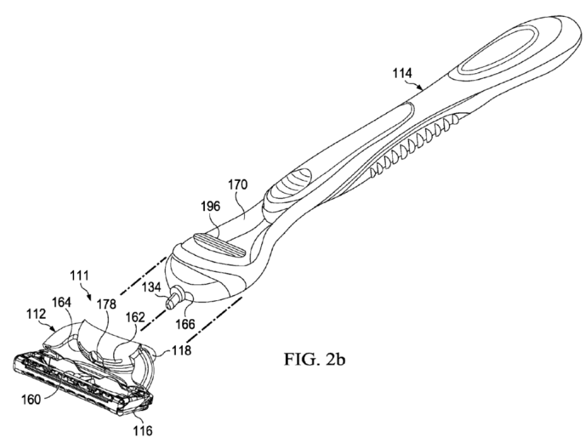
Sources: Gillette, King C. U.S. Patent 775,134, issued November 15, 1904.

Gillette applied a novel pricing strategy for its razors. The Kampfe Brothers sold a Star safety-razor for $1.50 and an extra blade for $1.00, which implied the Star handle alone cost 50 cents. On the contrary, Gillette charged $5.00 for a razor handle with a dozen blades and $1.00 for a pack of twelve blades, which implied the handle alone cost $4.00. Even though it is hard to estimate the exact product costs of handles, there is no doubt that Gillette razor handles were sold at a considerable margin at that time while its blades were sold at a lower markup.

In 1903, Gillette sold 51 razors and 168 blades. In 1904, razor sales jumped to 90 thousand, and blade sales jumped to 120 thousand. Moreover, 277 thousand razors and 1.188 million blades were sold in 1907. During World War I, Gillette got a big breakthrough on sales; the U.S. military started issuing Gillette razors to every U.S. serviceman. By the war's end, they had issued 3.5 million razors and more than 32 million blades. What was far more important than a short-term sales spurt was that millions of young males acquired the habit of home-shaving with Gillette razors. Therefore, Gillette could dominate this market even after the original patent expired and many competitors entered this market.

Since then, shaving razor has been changing over time. The razor head changed from double-edge blade to single-blade cartridge, and then to multi-blade cartridge. The handle changed from a round wooden or metallic shaft to an anti-slip rubber handle. Gillette and other companies started to sell disposable razors. Further, Gillette's main competitor changed from Auto Strop to Schick and BiC. However, there is something which has never changed. The business model founded by Gillette does not change at all. Nowadays, razor manufacturers still sell durable handles and consumable blades or cartridges separately. Moreover, Gillette still dominates this market, while the annual sales of men's shaving equipment in the U.S. is over 3 billion dollars.

Figure 3.3: Modern Razor (Non-Disposable)



Sources: Taub, et. al. U.S. Patent 8,793,880, issued August 5, 2014.

3.2 Products and Demand

Initially, the razors produced by Gillette and other companies were pretty similar. However, there are over two hundred highly differentiated brands in the current men's shaving razor market. The main quality difference among them is the number of blades built in a razor head, which ranges from one to six. The manufacturers claim that the more blades a razor has, the more comfortable the shave is. Compared with the count of blades, other quality differences are harder to observe or measure by researchers. For example, some brands have finer blades than the others. However, it is hard to measure the sharpness of the blades. Also, the perceived quality is affected by advertising. For example, by advertising, Gillette successfully sets its products apart from other brands. However, it is hard to find a valid measurement for the advertisements.

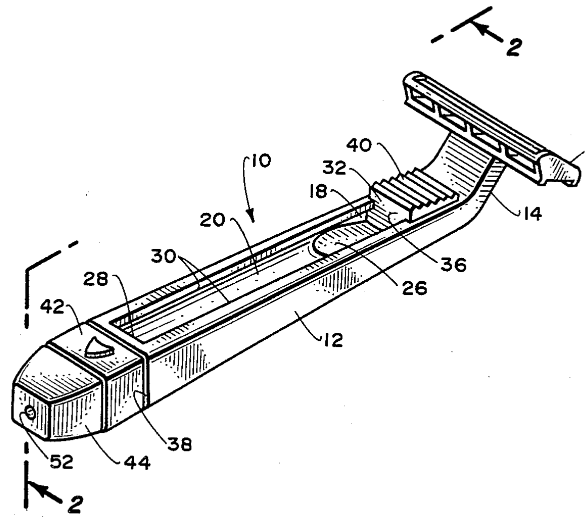
The brands are also differentiated horizontally. For example, Sensor 3 and Mach 3 are different brands sold by Gillette. However, there is no significant quality difference between them. Both of them have three blades, a built-in trimmer, and a lubrication stripe. The main differences are likely the name and the packaging design.

Another horizontal difference which this dissertation is concerned about is category; that is, disposable or non-disposable. A disposable razor is a razor head attached with a handle. A consumer would discard both the razor head and handle when replacing a disposable razor. A non-disposable system, which is pretty close to Gillette's original design, consists of a durable handle with a replaceable cartridge. A user of the non-disposable system can keep the handle for a long while and only replace the cartridge in the short term.

The average quality of the non-disposable brands is higher than that of the disposable brands. However, it does not mean that a non-disposable system is superior to a disposable razor. Some brands, such as Gillette's Mach 3 and Fusion, offer both the disposable razor and the non-disposable system, which have the same razor head. Since the consumers care more about the razor head rather than the handle, they might be indifferent between a disposable razor and a non-disposable system of the same brand.

Consumers have a variety of preferences according to those product characteristics. Further, ethnicity, age, and income affect preferences profoundly. For example,

Figure 3.4: Modern Razor (Disposable)



Sources:DeMars, Robert. U.S. Patent 4,635,361, issued January 13, 1987.

Mintel's research[1] says that the low-income group is partial to the disposable razors and that Hispanics are more likely to buy high-quality razors. Since the demographic makeups vary across areas and change over time, we can witness distinctive preferences in the markets.

The quantity demanded also depends on consumers' demographics. Shaving razors are non-durable; a blade wears out after some uses. A consumer would like to replace razor blade by weeks or by months, depending on use frequency and tolerance for a dull blade. The use frequency relates to consumer demographics, such as age, race, and occupation. For example, the elderly usually have little facial hair and shave less frequently than young men. Also, compared with manufacturing jobs, a service-based occupation forces one to pay more attention to appearance and, in turn, requires more razors. Another significant market driver is alternating fashion. When metrosexual is popular, men are encouraged to be as facial-hair free as possible. In contrast, when retrosexual dominates, facial hair is back to fashion. On the

[1]Mintel is a privately owned market search firm.

other hand, the tolerance for a dull blade is usually determined by income; that is, low-income people are likely to be more tolerant of a dull razor. Thus, demand may vary by income level.

3.3 Market Structure

The men's shaving razor market is highly concentrated. From 2015 through 2016, the top three companies, Gillette, Schick, and BiC, contributed 64.1% of the total sales volume. Gillette, the market leader, attained 39.0% of the total sales volume, while Schick and BiC acquired 10.7% and 14.4% respectively. As noted above, the count of blades is the main quality factor. Thus, I split the market into two segments by quality. The high-end segment consists of the razors with no less than three blades, while the low-end segment contains the razors with one or two blades.

The high-end segment is dominated by Gillette. Gillette sold 58.1% of the advanced razors; that is almost four times its largest opponent's market share. In contrast, the low-end segment is more competitive than the high-end. Gillette only attained 34.5% sales volume. Schick's market share shrank to 10.1%. And BiC acquired 16.1% of this market.

In the men's shaving market, the sales of the private-label brands are non-negligible.[2] They, as a whole, seized 35.9% of the low-quality segment. The private-label brands are often priced lower than the main-stream brands. In other words, they are price-takers rather than price-makers. Thus, they probably do not have any market power. However, if the purchasers of the low-quality razors are more sensitive to price, then Gillette would also lose its market power due to the existence of the private-label brands.

Competition also comes from outside. The established companies face increasing

[2] The private-label brands are the brands owned by the retailers while produced by the OEM companies. They are often positioned as low-cost alternatives of the named brands.

Table 3.1: Market Share

	Overall	Low-End	High-End
Gillette	39.0	34.5	58.1
Schick	10.7	10.1	13.5
BiC	14.4	16.1	7.1
Private Label	31.6	35.9	13.2
Generic Brands	4.3	3.4	8.1

Computed with Nielsen Store Scanner Dataset (2015-2016).

challenge from online subscription services.[3] Also, spas and salons offer professional services to customers who prefer old school grooming. Boutique retailers sell luxury shaving products to people who view shaving as more of a ritual. Moreover, some consumers prefer electric shavers. However, these competitors are not likely to affect the market power of Gillette.

3.4 Pricing

There are four brands which provide both the disposable razors and the non-disposable systems in all the markets in my sample. I can compare their prices to find some stylized facts on pricing strategy. As Table (3.2) shows, for all of Gillette's brands, the prices of the disposable razors are higher than those of the cartridges.

On average, a Mach 3 disposable razor is sold at $2.85, while a Mach 3 cartridge is sold at $2.58. A Mach 3 handle bundled with one cartridge is sold at $12.18, which implies the handle alone costs $9.60. For Gillette's premium brand Fusion, a disposable razor is sold at $5.05, and a cartridge at $4.06. The handle bundled with one cartridge is charged $14.79, and hence the implicit price for a Fusion handle is $10.73.

[3] This new distribution channel was launched by Dollar Shave Club (DSC) in 2012. Consumers can sign up through DSC's website and subscribe to shaving plans. Then DSC charges a subscription fee and delivers razors to the subscribers monthly. Through this marketing approach, DSC and other shaving clubs attained a small but increasing market share.

Table 3.2: Unit Price and Package Size

	Disposable		Cartridge		Handle
	Price ($)	Size (ct.)	Price ($)	Size (ct.)	Price ($)
Gillette Mach 3	2.85	3.08	2.58	7.53	9.60
Gillette Fusion	5.05	2.00	4.06	5.72	10.73
Schick Quattro	2.40	3.00	2.60	5.42	9.57
Schick Hydro 5	2.91	3.50	3.30	4.88	11.90

a. The values are computed with the data from Nielsen store scanner dataset.
b. The price variable indicates the weighted average unit price of each razor.
c. The package size indicates the weighted average package size of each brand.

d. The handle price indicates the prices of the handle-cartridge bundles.

In contrast, Schick sets a lower price for disposable razors than cartridges. A disposable razor of Quattro and Hydro 5 costs $2.40 and $2.91 respectively, while the cartridge costs $2.60 and $3.30 respectively. Schick also charges a high price for its handles. The implicit price for the handle of Quattro and Hydro 5 is $9.57 and $11.90, respectively.

I also find that the average package size of the cartridges is always larger than that of the disposable razors. The stylized facts are consistent with that Gillette applies a two-part tariff strategy while Schick does not. However, I cannot rule out the possibility that the price differences are driven by the package size difference.

Chapter 4 Theory Discussion

This chapter presents a theoretical model of two-part tariff based on Oi (1971)'s framework to solve the pricing problem of a razor manufacturer. This model assumes that a firm which possesses monopoly power in the razor market produces three types of products: handle, cartridge, and disposable razor. The handle and cartridge, combined as a non-disposable system, are complementary with each other, while the disposable razor is a substitute to the non-disposable system.

This dissertation assumes that consumers have different quantity demand for razors. Section 4.1 assumes that the demand is continuously distributed. On the contrary, Section 4.2 assumes that there are two types of consumers: the high demand and low demand.

Section 4.1 shows the difference between the two-part tariff strategy and linear pricing strategy with three cases. In the first case, this firm sells the handle and cartridge of non-disposable system using two-part tariff strategy. In the second case, the firm sells the handle and cartridge without coordinating their prices. In the third case, this firm only sells disposable razor. The optimal pricing policies under the three cases show that this firm should charge a lower price for the cartridge when practicing two-part tariffs, compared with the case without coordinating the prices of handle and cartridge. Further, the optimal price of the cartridge in the second case equals the optimal price of the disposable razor in the third case.

In Section 4.2, this firm simultaneously sells cartridge, handle, and disposable razor and employs "self-selection" mechanism. This firm is assumed to have no information about the identity of each consumer but knows the distribution of tastes. To sort and segment the consumers, this firm must induce the high-demand consumers to buy non-disposable system and the low-demand ones to buy disposable razor, which puts "incentive compatibility" constraints on the pricing problem. The optimal pricing policy shows that the firm should charge a low price for the cartridge and a high price for the disposable razor.

Based on the conclusions of Section 4.1 and Section 4.2, this chapter derives a testable hypothesis: if the firm is practicing two-part tariff pricing policy on cartridge and handle and using "self-selection" mechanism, the price of the cartridge is lower than the price of the disposable razor.

4.1 A Continuum Model

Consider a market in which each consumer has a linear demand function for the shaving service, $q = -\alpha p + \lambda$. Without loss of generality, suppose that $\alpha = 1$ and λ is uniformly distributed between 0 and 1. Then we get a continuous distribution of consumers whose demand curves are parallel. Facing a two-part tariff, each consumer will choose the quantity of cartridge at first, and then compare the consumer surplus he can get from the cartridges with the price of a handle. If the consumer surplus exceeds the handle price, then he will purchase both the handle and the cartridges. Otherwise, he will not purchase anything. In other words, the individual rationality condition is

$$\frac{1}{2}(\lambda - p_c)^2 - R \geq 0, \tag{4.1}$$

where p_c stands for the cartridge price and R stands for the handle price. Since each consumer who stays in the market purchases one handle, the demand function of the handle is $N = 1 - \hat{\lambda}$, where $\hat{\lambda}$ stands for the marginal consumer.

A monopolist should maximize its profit from the cartridges and the handles subject to the consumers' individual rationality condition; that is,

$$\begin{aligned} \max_{p_c, R} \quad & \int_{\hat{\lambda}}^{1} (\lambda - p_c) p_c d\lambda + (1 - \hat{\lambda}) R, \\ \text{s.t.} \quad & \frac{1}{2}(\lambda - p_c)^2 - R \geq 0, \qquad \text{for any } \lambda \in [\hat{\lambda}, 1]. \end{aligned} \tag{4.2}$$

The marginal cost of the handles and the cartridges are assumed to be zero. By the individual rationality condition, the marginal consumer is determined with

$$\hat{\lambda} = p_c + \sqrt{2R}. \tag{4.3}$$

Solving equation (4.2) and use of (4.3) yields

$$\begin{aligned} p_c^{2PT} &= \frac{1}{5}, \\ R^{2PT} &= \frac{2}{25}. \end{aligned} \tag{4.4}$$

Now suppose that this monopolist does not use the two-part tariff to price the handles and the cartridges (in other words, this firm is using the linear pricing strategy). In other words, it sets the price of cartridge first without taking the handles into account, and then sets handle price taking cartridge price as given. Then, this firm's problem becomes

$$\max_{p_c} \quad \int_{\hat{\lambda}}^{1} (\lambda - p_c) p_c d\lambda, \tag{4.5}$$

and

$$\begin{aligned} \max_{R} \quad & (1 - \hat{\lambda}) R, \\ \text{s.t.} \quad & \frac{1}{2}(\lambda - p_c)^2 \geq R \qquad \text{for any } \lambda \in [\hat{\lambda}, 1]. \end{aligned} \tag{4.6}$$

Solving for this problem yields the optimal price schedule

$$\begin{aligned} p_c^{LP} &= \frac{1}{3}, \\ R^{LP} &= \frac{8}{81}. \end{aligned} \tag{4.7}$$

Last, suppose this monopolist does not offer the non-disposable system, it sells the disposable razors as instead, then this firm's problem becomes

$$\begin{aligned} \max_{p_d, R} \quad & \int_{\hat{\lambda}}^{1} (\lambda - p_d) p_d d\lambda, \\ \text{s.t.} \quad & \frac{1}{2}(\lambda - p_d)^2 \geq 0 \qquad \text{for any } \lambda \in [\hat{\lambda}, 1]. \end{aligned} \tag{4.8}$$

where p_d stans for the price of a disposable razor. Solving for this problem yields

$$p_d^* = \frac{1}{3}. \tag{4.9}$$

Equation (4.4), (4.7), and (4.9) establish that

Proposition 1 *Serving the same demand, the cartridge price under the two-part tariff is above the cartridge price under the linear pricing. The cartridge price under the linear pricing is equal to the price of disposable razor.*

$$p_c^{2PT} < p_c^{LP} = p_d \tag{4.10}$$

The reason that the monopolist charges a smaller markup for the cartridge is: when a consumer buys the cartridges, he also need to buy a handle to get the shave service. Thus, the monopolist earns profits from not only the cartridges but also the handles. Further, if the monopolist lowers the price of the cartridge, the buyer will consume more. Then his consumer surplus from the cartridges and willingness to pay for the handle goes up. And the monopolist can charge a higher price for the handles.

4.2 A Two-Type Model

Now consider a market with two types of consumers whose demand functions for shaving are $q_L = \lambda_L - p$ and $q_H = \lambda_H - p$, where $\lambda_L < \lambda_H$. A monopolist offers the disposable razor or the non-disposable system to each consumer. Also, this monopolist is implementing a self-selection mechanism: the price scheme is designed to induce the high-demand consumers to buy the non-disposable system and the low-demand consumers to buy the disposable razor. In other words, the incentive compatibility conditions must hold

$$\begin{aligned} \frac{1}{2}(\lambda_L - p_d)^2 &\geq \frac{1}{2}(\lambda_L - p_c)^2 - R, \\ \frac{1}{2}(\lambda_H - p_c)^2 - R &\geq \frac{1}{2}(\lambda_H - p_d)^2. \end{aligned} \tag{4.11}$$

The first equation means the low-demand consumers have no incentive to buy the cartridges while the second equation means the high-demand consumers have no incentive to buy the disposable razors.

Now, the firm's problem is

$$\begin{aligned} \max_{p_d, p_c, R} \quad & n(p_d - c_d)(\lambda_L - p_d) + (1-n)(p_c - c_c)(\lambda_H - p_c) + (1-n)R, \\ \text{s.t.} \quad & \frac{1}{2}(\lambda_L - p_d)^2 \geq 0, \\ & \frac{1}{2}(\lambda_H - p_c)^2 - R \geq 0, \\ & \frac{1}{2}(\lambda_L - p_d)^2 \geq \frac{1}{2}(\lambda_L - p_c)^2 - R, \\ & \frac{1}{2}(\lambda_H - p_c)^2 - R \geq \frac{1}{2}(\lambda_H - p_d)^2, \end{aligned} \tag{4.12}$$

where n stands for the fraction of the low-demand consumers. The first two constraints are the individual rationality conditions as in equation (4.2), while the last two are the incentive compatibility conditions. Solving equation (4.12), we get the optimal pricing scheme as

$$\begin{aligned} p_d &= \frac{n}{1+n}\lambda_L + \frac{1-n}{1+n}\lambda_H + \frac{n}{1+n}c_d, \\ p_c &= c_c, \\ R &= (\lambda_H - c_c)^2 - (\frac{n}{1+n})^2(2\lambda_H - \lambda_L - c_d)^2. \end{aligned} \tag{4.13}$$

The result establishes that

Proposition 2 *When a firm sets the prices of cartridges and handles as the two-part tariff and sells the disposable razors to sort the low-demand consumers from the* *high-demand, then the price of cartridges is below that of disposables under regular cases.*[1]

$$p_c < p_d \tag{4.14}$$

[1]That is, $\lambda_L > c_d$ and $\lambda_H > c_d$. The condition means both types of consumers are potential buyers of disposable razors.

Chapter 5 Empirical Strategy

5.1 Testing the Pricing Strategy

Generally, there are two ways to identify if a firm is using two-part tariff pricing strategy. The first is to perform tests of nonnested hypotheses to select the pricing model which makes best prediction to the accounting price-cost margin (for example, Bonnet and Dubois (2010, 2015)). This method requires not only accounting data but also strong assumptions on the supply equation. Thus, it is not feasible for this dissertation. The identifying method I will use is similar to Shepard (1991) and Lakdawalla and Sood (2013). As discussed, the optimal cartridge price under linear pricing is equal to the optimal disposable razor price if a monopolist sells them to the same consumer group. Thus, the disposable razor price can be used as a benchmark to examine the pricing on cartridges. If a firm sets the cartridge price quite lower than the disposable razor price, it may be using two-part tariff strategy. But it is not necessary.

The price difference is driven by three factors: demand difference, cost difference, and pricing strategy difference. If the marginal cost of offering a cartridge is lower than a disposable razor, then the observed price difference might result from the cost difference. Thus, I use the ratio of markup difference to price difference to measure to what extent the price difference can be explained by markup difference. On the other hand, the firm may sell cartridges and disposable razors to different consumer groups. For example, the disposable razor customers might be light users and so they have less willingness to pay. The quality of disposable razors might be superior to cartridges. In this dissertation, I will only compare disposable razors and cartridges of the same brands. Thus I can control for quality differences. It is hard to decompose the contribution of quantity discount from the markup difference. But I can partially solve this problem by comparing the pricing schedule of Gillette and Schick. Schick, as a fringe competitor, is assumed to use a linear pricing strategy on cartridges. The markup difference between disposable razors and cartridges offered by Schick can be viewed as being driven by demand differences. So if Gillette is using a two-part tariff strategy, we should observe that

- For Gillette, the price-cost markup of a disposable is higher than markup of a cartridge of the same brand.
- For Gillette, the price difference between disposable razor and cartridge can be mostly explained by markup difference between them.
- The ratio of markup difference to price difference of Gillette is significantly higher than that of Schick.

5.2 Price-Cost Markup

The variable which this dissertation is concerned with is the price-cost markup, which is calculated as:

$$markup = p - mc. \tag{5.1}$$

But, it has been known that price data are accessible while marginal cost data are not. A straightforward way to measure the marginal cost in equation (5.1) is using accounting cost. However, this measurement is not valid in most cases. First, accounting data are at firm-level rather than product-level. Thus, it is hard to estimate the cost of each product for a multi-product company like the razor manufacturers. Also, the input price can be used as a proxy for production cost. However, since the observed input price might not vary across firms, the firm-level cost variation is ignored.[1] Besides that, packaging costs, transportation costs, and marketing costs

[1]As firms with low production costs could set a lower price, using input prices as a proxy would underestimate their markup and get a misleading conclusion.

could not be captured by input prices. Furthermore, even if appropriate accounting data are available, it is still challenging to convert accounting cost into the economic costs and to convert average cost into marginal cost.

This dissertation applies an indirect way to estimate price-cost markups: recovering them from estimated demand elasticities. Assuming that a multi-product firm f is maximizing its profit through

$$\max_{p_j} \sum_{j \in \mathcal{F}_f} (p_j - mc_j) M_t s_j, \tag{5.2}$$

where M stands for market size, s_j stands for market share of product j, and $\mathcal{F}_f$ stands for product set of firm f. Solving this problem, the price-cost markup of brand j is

$$p_j - mc_j = [\Omega^{-1} s]_{(j,1)}, \tag{5.3}$$

where

$$\Omega_{jr} = \begin{cases} -\partial s_r / \partial p_j, & \text{if } \exists\ r, j \in \mathcal{F}_f, \\ 0, & otherwise, \end{cases}$$

s is a J-by-1 array of market shares, and $\mathcal{F}_f$ indicates the product set of firm f. Thus, the price cost markup can be recovered with the price sensitivity, $\partial s_r / \partial p_j$.

5.3 Conditional Logit Model

Discrete Choice Model

Generally, $\partial s_r / \partial p_j$ can be estimated by regressing s_r on p_j. However, since the demands for all the products are interactive, the market share of each product depends on not only its own price but also the prices of all other brands. Thus, the curse of dimensionality arises: if there are J products in a market, J^2 price coefficients need to be estimated, which is often too much.

The dimensionality problem calls for an alternative estimation strategy. This dissertation estimates the demand sensitivity with the discrete choice demand model which was introduced by McFadden (1978). This model assumes that a consumer has the indirect utility function:

$$u_{ijt} = \alpha(y_i - p_{jt}) + X_j\beta + \xi_{jt} + \epsilon_{ijt}, \qquad \text{for } j = 1, 2, ..., J, \tag{5.4}$$

where y_i stands for the income of individual i, p_{jt} stands for the price of product j in market t, X_j stands for the observed characteristics of product j, ξ_{jt} stands for the unobserved valuation of product j which is common to all the consumers in market t, and ϵ_{ijt} is a mean-zero stochastic term. For simplicity, equation (5.4) can be transformed into

$$u_{ijt} = \alpha y_i - \delta_{jt} + \epsilon_{ijt}, \tag{5.5}$$

where $\delta_{jt} = p_{jt} + X_j\beta + \xi_{jt}$.

The income effect is introduced in a linear form, αy_i. Thus, different income levels would not make any difference to the choice and the income term will be canceled out in the following steps.[2] Also, the terms which do not vary by the individuals, that is $-\alpha p_{jt} + X_j\beta + \xi_{jt}$, are denoted as δ_{jt}. Then δ_{jt} captures the mean utility of product j which is common to all the consumers. The last term, ϵ_{ijt}, captures the individual deviation from the mean utility.

An outside product is introduced to complete the consumers' choice set. The indirect utility function of the outside option is:

$$\begin{aligned} u_{i0t} &= \alpha y_i - \alpha p_{0t} + X_{0t}\beta + \xi_{0t} + \epsilon_{i0t} \\ &= \alpha y_i + \epsilon_{i0t}. \end{aligned} \tag{5.6}$$

Note that the mean utility of the outside option is normalized to be zero.

[2] If the income effect is important, it can be modelled by an indirect utility function which is concave to the income, such as Berry, Levinsohn, and Pakes (1995) in which

$$u_{ijt} = \ln(\alpha(y_i - p_{jt})) + X_j\beta + \xi_{jt} + \epsilon_{ijt}.$$

Product j would be selected if and only if

$$u_{ijt} > u_{irt}, \qquad \text{for } r = 0, 1, ..., J, \text{and } r \neq j. \tag{5.7}$$

In the real world, the consumers' choices are diverse; no brand can acquire the whole market. Since all the consumers sort the mean utilities in the same order, the diversity can only be accounted by ϵ_{ijt}.[3] The implication of this assumption will be discussed later.

When ϵ_{ijt} follows a Type I Extreme Value Distribution, the probability that an individual i chooses product j is

$$s_{ijt} = \frac{\exp\left(X_{jt}\beta - \alpha p_{jt} + \xi_{jt}\right)}{\sum_{r=0}^{J} \exp\left(X_{rt}\beta - \alpha p_{rt} + \xi_{rt}\right)}. \tag{5.8}$$

The coefficients can be estimated by matching the predicted choice probability to the observed consumer purchase history.[4]

Generally, however, the individual purchase history data are not readily accessible. An alternative method is using the predicted market share, instead of predicted choice probability, to match the data.[5] As equation (5.9) shows,

$$\begin{aligned} s_{jt} &= \frac{1}{ns} \sum_{i=1}^{ns} \frac{\exp\left(X_{jt}\beta - \alpha p_{jt} + \xi_{jt}\right)}{\sum_{r=0}^{J} \exp\left(X_{rt}\beta - \alpha p_{rt} + \xi_{rt}\right)} \\ &= \frac{\exp\left(X_{jt}\beta - \alpha p_{jt} + \xi_{jt}\right)}{\sum_{r=0}^{J} \exp\left(X_{rt}\beta - \alpha p_{rt} + \xi_{rt}\right)}, \end{aligned} \tag{5.9}$$

the predicted market share is assumed to be equal to the average choice probability of individuals, which is numerically equal to the choice probability.

[3] In this context, if the mean utility of product r is not the highest, then it is purchased by the individual i^* only when ϵ_{i^*jt} is high enough.

[4] That is, using MLE to estimate the coefficients which have the highest probability to make the observed purchase history happen.

[5] Some datasets, such as the Nielsen Household Scanner Dataset, provide data about the shopping trips of sample households. For the products which the consumers do not purchase frequently, however, the shopping trip data cannot be used directly. Consumers buy razors every several months. So in many of the trip observations, consumers did not purchase any of the razors. This does not mean they do not prefer any of the inside choices. But the discrete choice model treats it as if this consumer prefers the outside option. So using the individual shopping trip data may significantly underestimate the mean utility of inside products.

Given the predicted and the observed market shares, the coefficients can be estimated by solving

$$\min_{\alpha,\beta} ||S - s(X, p, \xi; \alpha, \beta)||. \tag{5.10}$$

The objective function in equation (5.10) is non-linear in the coefficients. Solving the non-linear minimization problem by a search procedure is costly. Also, the method of instrumental variables, in its most commonly used 2SLS form, cannot be applied to a non-linear model. Therefore, the objective function of estimation problem should be linearized. When the market share takes the form of equation (5.9), it is convenient to apply a log-linearization: taking log on both sides of equation (5.9) yields

$$\begin{aligned} \ln(s_{jt}) &= -\alpha p_{jt} + X_{jt}\beta + \xi_{jt} - \ln\left(\sum_{r=0}^{J} e^{X_{rt}\beta - \alpha p_{rt} + \xi_{rt}}\right), \\ \ln(s_{0t}) &= -\ln\left(\sum_{r=0}^{J} e^{X_{rt}\beta - \alpha p_{rt} + \xi_{rt}}\right). \end{aligned} \tag{5.11}$$

Then taking difference between $\ln(s_{jt})$ and $\ln(s_{0t})$ yields

$$\ln(s_{jt}) - \ln(s_{0t}) = \delta_{jt} \equiv X_{jt}\beta - \alpha p_{jt} + \xi_{jt}. \tag{5.12}$$

Since S_{jt} and S_{0t} are observed, equation (5.12) can be consistently estimated with the ordinary least square regression when the structural residual term, ξ_{jt}, is stochastic and uncorrelated with the regressors.

Endogeneity

It is common that the price variable is correlated with the structural error term, ξ_{jt}; that is, the price variable is endogenous. The endogeneity is usually from two sources: the unobserved product characteristics and the simultaneity.

Some of the product characteristics are observable to the consumers but unobservable to the researchers. When the unobserved product characteristics are correlated with the price, the price variable can be endogenous. For example, in the razor market, the sharpness and durability of the blade cannot be observed by the researchers.

But the consumers can perceive sharpness when they use it. And they are willing to pay more for the sharper razors. Also, since it is costly to produce the sharper blades, the sharpness is correlated with the price. As a result, the price coefficient would be overestimated if the unobserved quality is ignored.

As Nevo (2000, 2001) suggested, a brand fixed effect can be used to control for the unobserved product characteristics. The brand fixed effect captures the product characteristics that do not vary by market. Then the structural error term can be decomposed as

$$\xi_{jt} = \xi_b + \Delta\xi_{jt}, \tag{5.13}$$

where ξ_j stands for the brand fixed effect of brand b, and $\Delta\xi_{jt}$ is the market specific deviation from the mean utility. Since the brand fixed effect captures all the product characteristics information, X_{jt} can be dropped out. Then equation (5.12) is transformed into

$$\ln(s_{jt}) - \ln(s_{0t}) = -\alpha p_{jt} + \xi_b + \Delta\xi_{jt}. \tag{5.14}$$

Another source of the price endogeneity is the simultaneity problem; that is, the price is endogenously determined by the firms' pricing conduct. Since the razor market is highly concentrated, a firm is a price maker. In other words, the firm is able to react to the consumers' taste, $\Delta\xi_{jt}$. Then a pricing function should be

$$p_{jt} = c_{jt} + f(\Delta\xi_{jt}), \tag{5.15}$$

where c_{jt} stands for the marginal cost, and $f(\cdot)$ is a markup function. In this case, the OLS estimation of equation (5.14) is biased.

To solve this problem, this dissertation applies the Hausman (1996) instruments, the average prices in adjacent areas. Due to the common cost shifter, the prices in the adjacent areas are correlated. Also, if $\Delta\xi_{jt}$ is independent across the areas, $p_{j,-t}$

would be uncorrelated with $\Delta\xi_{jt}$. Thus, the prices of the brand in other areas are valid IVs.

Demand Elasticities

With Hausman instrumental variables, equation (5.14) can be consistently estimated by a two-stage least squares regression. Furthermore, the estimated price coefficient and the predicted market share can be used to calculate the price sensitivities,

$$\frac{\partial \hat{s}_{jt}}{\partial p_{rt}} = \begin{cases} -\alpha \hat{s}_{jt}(1 - \hat{s}_{jt}) & if \quad j = r, \\ \alpha \hat{s}_{jt}\hat{s}_{rt} & if \quad j \neq r, \end{cases} \tag{5.16}$$

and the demand elasticities,

$$\hat{\eta}_{jrt} = \frac{\partial \hat{s}_{jt}}{\partial p_{rt}} \cdot \frac{p_{rt}}{\hat{s}_{jt}} \begin{cases} -\alpha p_{jt}(1 - \hat{s}_{jt}) & if \quad j = r, \\ \alpha p_{rt}\hat{s}_{rt} & if \quad j \neq r. \end{cases} \tag{5.17}$$

Then, the price-cost markup can be derived by substituting the price sensitivity into equation (5.3).

5.4 Random Coefficient Logit Model

Independence of Irrelevant Alternatives

In the conditional logit model, the random disturbance term, ϵ_{ijt}, is assumed to be independent by the observations, which means that a consumer's taste on one brand has nothing to do with his taste on another brand. This assumption, named as Independence of Irrelevant Alternatives (IIA), implies several unrealistic conclusions.

As equation (5.17) shows, the cross elasticities depend only on the market share and the price of product j. Then, if Gillette reduces the Fusion cartridge price, all other products would lose the same size of market share, no matter if it is a close substitute or a distant substitute. On the other hand, the own elasticity is close to

$-\alpha p_{jt}$ when the market share of each brand is small. It implies that the demand for the low-price brand is inelastic, and then the price-cost markup of low-price brand is high. These implications are opposite to common sense.

Individual-Specific Coefficients

One way to relax the IIA assumption is to use the nested logit model. This model assumes that, for example, a consumer makes a choice between the disposable razor and non-disposable razor at first, then chooses among the three-blade, the four-blade, or the five-bladed cartridges, and finally chooses among the specific brands. A problem with the nested logit model is that the estimated substitution pattern heavily depends on the nesting which is determined a priori.

A more complicated way is to let the coefficients of price and other product characteristics vary across the individuals. That is,

$$\begin{bmatrix} \alpha_i \\ \beta_i \end{bmatrix} = \begin{bmatrix} \alpha \\ \beta \end{bmatrix} + \Pi D_i, \tag{5.18}$$

where

$$D_i \sim \hat{P}^*_D(D),$$

D_i stands for the demographics of individual i. Then equation (5.5) becomes

$$u_{ijt} = \alpha_i y_i + \delta_{jt} + \mu_{ijt} + \epsilon_{ijt}, \tag{5.19}$$

where

$$\delta_{jt} = -\alpha p_{jt} + X_j\beta + \xi_{jt},$$
$$\mu_{ijt} = \sum_k \sum_D \pi_{kd} x_{jtk} D_{itd}.$$

The individual probability to purchase product j is similar with the conditional logit model:

$$s_{ijt} = \frac{\exp(\delta_{jt} + \mu_{ijt})}{\sum_{r=0}^{J} \exp(\delta_{rt} + \mu_{irt})}. \tag{5.20}$$

Then the predicted market share equals to the mean of individual probabilities

$$s_{jt} = \frac{1}{ns} \frac{\exp\left(\delta_{jt} + \mu_{ijt}\right)}{\sum_{r=0}^{J} \exp\left(\delta_{rt} + \mu_{irt}\right)}. \tag{5.21}$$

The coefficients can be estimated by matching the predicted market share with the observed market share data. But, as the conditional Logit model, the objective function of

$$\min_{\alpha,\beta} ||S - s(p, X, D; \theta_1, \theta_2)|| \ ^6 \tag{5.22}$$

is non-linear to the coefficients. Since equation (5.21) cannot be log-linearized, a more complicated estimation algorithm is required.

Estimation Algorithm

The contraction mapping approach, introduced by Berry (1994), can be applied to solve the estimation problem. This approach suggests that an approximation of the mean utility, $\delta_{\cdot t}^{H}$, can be solved by computing the series

$$\delta_{\cdot t}^{h+1} = \delta_{\cdot t}^{h} + \ln S_{\cdot t} - \ln\left(s(\delta_{\cdot t}^{h}; \theta_2)\right), \qquad h = 0, 1, ..., H, \tag{5.23}$$

where H is the smallest integer such that $||\delta_{\cdot t}^{H} - \delta_{\cdot t}^{H-1}||$ is smaller than some tolerance level. The approximation of mean utility, $\delta_{\cdot t}^{H}$, is a function of observed market share,$S_{\cdot t}$, and unknown coefficients, θ_2. Then the mean utility function is

$$\delta_{jt}(S_{\cdot t}; \theta_2) = -\alpha p_{jt} + X_j \beta + \xi_{jt}. \tag{5.24}$$

Unlike the conditional logit model, a generalized method of moments is applied to estimate θ. The GMM error term is defined as

$$w_{jt} = \Delta\xi_{jt} \equiv \delta_{jt}(S_{\cdot t}; \theta_2) - (-\alpha p_{jt} + x_{jt}\beta). \tag{5.25}$$

Then the moment condition is

$$E[Z' w(\theta)] = 0, \tag{5.26}$$

[6] For simplicity, this dissertation denotes $[\alpha, \beta]$ as θ_1 and $[\sigma_k, \pi_{kd}]$ as θ_2.

where Z consists of the exogenous regressors and the Hausman instrumental variables. Then the GMM estimate is

$$\hat{\theta} = \underset{\theta}{\operatorname{argmin}}\, w(\theta)' Z \Phi^{-1} Z' w(\theta), \tag{5.27}$$

where Φ is a consistent estimate of $E[Z'ww'Z]$.

Equation (5.27) can be solved by a non-linear search over θ. To make the search procedure more efficient, θ_1 can be expressed as a function of θ_2,

$$\theta_1 = (X_L' Z \Phi^{-1} Z' X_L)^{-1} X_L' Z \Phi^{-1} Z' \delta(\theta_2). \tag{5.28}$$

Then equation (5.27) can be solved by searching over θ_2 only.

The estimation takes the following steps:

- Select starting points for δ and θ_2. The starting point of δ can be set as the predicted value of equation (5.24). The starting point of θ_2 can be an arbitrary value.
- Perform the contraction mapping in equation (5.23) with the observed market share $S_{\cdot t}$ and the starting points of δ and θ_2. Keeping θ_2 fixed at its starting point, iterate the value of δ until $||\ln S - \ln(s(\delta; \theta_2))||$ is small enough. Then we get an updated δ as a function of θ_2.
- Calculate the GMM error term in equation (5.25) with the starting point of θ_2 we got from step 1 and the value of δ we got from step 2. Then we have ω as a function of θ_2.
- Estimate the weighting matrix $\Phi = Z'\omega\omega' Z$ with ω we got from step 3.
- Use a search algorithm to find a new value for θ_2 in equation (5.27) with the error term we got from step 3 and the weighting matrix we got from step 4. Then we have a new value of θ_2 and a value of the GMM objective function according to this θ_2.

- Return to step 2 and update θ_2 with the value we got from step 5. Then repeat step 2 to step 5, until the value of the GMM objective function in step 5 is close enough to zero.

Demand Elasticities

Due to the functional form of market share equation (5.21), predicting $\partial \hat{s}_{jt}/\partial p_{rt}$ and η_{jt} is quite complicated in the random coefficient Logit model. Given $\hat{\delta}$ and $\hat{\theta}$, the price sensitivity can be calculated as

$$\frac{\partial \hat{s}_{jt}}{\partial p_{rt}} = \begin{cases} -\frac{1}{ns}\sum_{i=1}^{ns}(\hat{\alpha}_i \hat{s}_{ijt}(1-\hat{s}_{ijt})) & if \quad j = r, \\ \frac{1}{ns}\sum_{i=1}^{ns}(\hat{\alpha}_i \hat{s}_{ijt}\hat{s}_{irk}) & if \quad j \neq r, \end{cases} \tag{5.29}$$

where

$$\hat{s}_{ijt} = \frac{\exp(\hat{\delta}_{jt} + \sum_k \sum_D \hat{\pi}_{kd} x_{jtk} D_{itd})}{\sum_{r=0}^{J} \exp(\hat{\delta}_{rt} + \sum_k \sum_D \hat{\pi}_{kd} x_{rtk} D_{itd})}. \tag{5.30}$$

Also, the demand elasticity is

$$\hat{\eta}_{irt} \equiv \frac{\partial \hat{s}_{jt}}{\partial p_{rt}} \cdot \frac{p_{rt}}{\hat{s}_{jt}} = \begin{cases} -\frac{p_{jt}}{\hat{s}_{jt}}\frac{1}{ns}\sum_{i=1}^{ns}(\hat{\alpha}_i \hat{s}_{ijt}(1-\hat{s}_{ijt})) & if \quad j = r, \\ \frac{p_{rt}}{\hat{s}_{jt}}\frac{1}{ns}\sum_{i=1}^{ns}(\hat{\alpha}_i \hat{s}_{ijt}\hat{s}_{irk}) & if \quad j \neq r. \end{cases} \tag{5.31}$$

Chapter 6 Data and Variables

This chapter introduces the data and the variables used for estimation. Section 6.1 introduces two main data sources: the Nielsen Store Scanner dataset and the March CPS. Section 6.2 discusses how to define the product and the market. Section 6.3 shows how the variables used for estimation are constructed. Section 6.4 describes how to construct Hausman instrumental variables.

6.1 Data

The sales volume, the price, and the product characteristics data are from the Nielsen Retail Scanner dataset. On the other hand, the consumer demographics data are from the CPS Annual Social and Economics Supplement (March CPS hereafter). The sample used in this dissertation consists of 8 quarters, ranging from the first quarter of 2015 to the last quarter of 2016, and covers 75 geographic areas.

Nielsen Retail Scanner Data

The Nielsen datasets at the Kilt's Center for Marketing comprise the Consumer Panel Data, the Retail Scanner Data, and the Ad Intel Data. The Retail Scanner Data consist of the UPC-level product characteristics, the weekly pricing, the sales volume, the promotion, and the store demographics data.

UPC (Universal Product Code) is a widely used barcode symbology for tracking the trade items. Each item sold in the U.S. is uniquely assigned a 12 numeric digits code. Thus, I can track the sales of a specific product no matter if it was sold in a Walmart in New York City or a Safeway in Honolulu.

This dataset documents the information regarding product category, brand, package size, and additional characteristics of 2.6 million UPCs. For razors, the product category indicates if it is a disposable razor, cartridge package, or handle-cartridge bundle. A brand is a product's particular name (e.g., Mach 3, Fusion, or Hydro 5) instead of its manufacturer's name. The package size is the count of the razor heads contained in a package. Other characteristics include the manufacturer's name and the counts of blades built in a razor head.

For each UPC, the retailers report weekly average prices and sales volumes. The price variable is the transaction price rather than the list price. Thus, it reflects both sale and non-sale prices. The Sales volume is sell-through instead of sell-in; that is, it is the volume sold, not purchased, by the retailers.

The data are from more than 35,000 participating stores, including groceries, drug stores, mass merchandisers, and other stores. It covers more than half of the total sales volume of all U.S. grocery and drug stores and more than 30 percent of the mass merchandiser sales volume. Also, the coverage varies across geographic markets. It ranges from 1% to 86% for grocery stores and from 28% to 92% for drug stores. The data started with 2006 and are updated annually. The updates lag by two years (e.g., 2016 Retail Scanner data was released in 2018).

The store demographics include store chain code, channel type, and area location. The area location is indicated by FIPS code, which uniquely identifies in which county or state a store is located.

March CPS

The March CPS is an annual survey conducted by the United States Census Bureau for the Bureau of Labor Statistics. The data report the income received in the previous calendar year, gender, race, age, and other demographics of each surveyed household or individual. Over 90,000 households and 185,000 individuals are selected in order to produce accurate estimates for the entire nation.

Also, the households and individuals are from 278 selected core-based statistical areas (CBSA hereafter), 30 selected combined statistical areas, and 217 selected counties. The number of surveyed individuals varies across areas. For example, there are 10,086 individuals from Los Angeles–Long Beach–Glendale of California, but only 100 individuals from Vineland–Bridgeton of New Jersey. The samples for the smaller areas may be not wholly representative. Thus, the estimates for the smaller areas might be invalid while the estimates for the larger areas should be more convincing. [1]

6.2 Products and Markets

The definitions of the product and market should be clarified to adapt the data to the random coefficient logit model.

Products

A product is defined by brand in conjunction with category (i.e., disposable or cartridge). Packages of different sizes are treated as one product. Regarding this definition, for example, Gillette's Fusion disposable razor and cartridge are different products. But a four-count package of Fusion cartridges is the same product as an eight-count package. Store-owned brands and Generic brands are dropped. The generic brands are excluded since none of them has more than 1% market share. On the contrary, although the store-owned brands as a whole attain large market share, each of them is only sold in certain outlets.[2] All the single-blade and twin-blade brands are dropped for the reason that none of them offer both the disposable and the cartridge. Also the quality difference between these disposables and cartridges is

[1] An alternative data source is the Nielsen Consumer Panel. The Nielsen household samples are more representative of the local demographics. However, the income variable of Nielsen is a categorical variable which causes problems in estimation.

[2] Another reason why private label brands are excluded is that, since the costs of the private label brands of the different retailers are different, it is hard to find an instrumental variable for their prices to control for the simultaneity. A possible way to include private label is to define private label brands sold by different retail chains as different brands.

significant. Thus, I only investigate the high-end segment of this market. Also, the local brands which do not cover all the geographic markets are excluded for simplicity.

The handle-cartridge bundles are dropped to make the data compatible with the demand model. In the discrete choice model, each consumer is assumed to select one product among numerous options. However, a consumer of the non-disposable system is likely to buy both the cartridge package and the handle-cartridge bundle. Dropping all non-disposable bundles is questionable. However, there are two reasons why this treatment is acceptable. First, the handle-cartridge bundles only attain 4.43% of the volume sales. Thus, dropping them would not severely affect the empirical results. In addition, the vast majority of the handle-cartridge bundles contain only one cartridge. Thus, it is reasonable to assume that consumers purchase handle-cartridge bundles mainly for the handles and the handle-cartridge bundles are not competing with the cartridges or the disposable razors.

Under this context, the consumer choice set consists of 18 inside products (listed in Table (6.1)), which are manufactured by three companies (Gillette, Schick, and BiC), and an outside product. The outside product indicates the dropped products and the distant substitutes such as electric shavers and professional services in a salon. In other words, the outside product represents the consumption of potential consumers who did not buy any inside products.

Markets

The market is defined by a geographic area in conjunction with a quarter. In this dissertation, a geographic area is a core-based statistical area (CBSA) which consists of an urban center and adjacent counties that are socioeconomically tied to the urban center. Since the small areas do not have representative March CPS samples, the areas which have less than 40 male individuals in the March CPS are dropped. Then, 75 geographic areas are left in the sample. Since the number of geographic areas is not

Table 6.1: Brands Used For Estimating Demand

	3-Blade	4-Blade	5-Blade
Disposable:			
	G Custom Plus 3	S Quattro Titanium	G Fusion
	G Mach 3	B Flex 4	S Hydro 5
	G Sensor 3		
	S Xtreme 3		
	B Comfort 3		
	B Comfort 3 Advance		
	B Flex 3		
Cartridge:			
	G Mach 3	S Quattro Titanium	G Fusion
	G Mach 3 Turbo		G Fusion ProGlide
	S Hydro 3		S Hydro 5

Note: "G" represents Gillette, "S" as Schick, and "B" as BiC.

large enough, observations in different quarters are introduced to expand the sample size. The sample consists of 8 quarters, ranging from the first quarter of 2015 to the last quarter of 2016.

There are 600 markets in total. And, in each of these markets, there are 18 products. Then, the sample consists of 10,800 observations.

6.3 Variables

The variables used to estimate the random coefficient logit model consist of market share, price, package size, handle price (for cartridge), cartridge dummy, maker dummies, and brand dummies. The market share of each inside product is defined as the ratio of the sales volume to the market size. The sales volume data of Nielsen Retail Scanner is UPC-store-weekly level. In this dissertation, it is aggregated to the product-area-quarterly level for estimation.

As noted, the products of different package sizes (then different UPC) are treated as the same product in this dissertation. Also, the manufacturers have been known to use more than one UPC for the same product.[3] Thus, it is reasonable to aggregate the UPC-level data to the product-level. Also, it is necessary to use the aggregated product definition. If there are too many products in the consumers' choice space, each of them should have a smaller market share, which causes more problems due to the nature of the random coefficient logit model. Aggregating the UPCs to the products helps fix this problem.

The random coefficient logit model simulates the market share with the consumer demographics. It is hard to know the consumer demographics for each store. But the consumer demographics in an area are accessible. Thus, the store-level data are aggregated to the area-level. Also, the sales volume data is hugely messy week-to-week. The sales volume can change by more than fifty percent due to promotions or other occurrences. Aggregating the weekly-level data to quarterly-level reduces the effect of these random disturbances.

The market size of each area is measured by the maximum total sales volume of all the inside and outside products from 2013 through 2016. Thus, the market size differs across areas but stays constant over time.[4]

The price variable is the weighted average unit price. It is calculated as the ratio of total dollar sales to total sales count in a market. The denominator is the count of razor heads instead of the count of packages. In other words, the price variable represents the average price of each razor head rather than that of the package. The package size variable is the weighted average package size. It is the ratio of the total sales count to the number of packages sold. It has been known that a handle is sold

[3] They could offer a new package design to attract people who are open to change while keeping the old design for conservative consumers.

[4] Cohen (2008) argues that this measurement may underestimate the real market size. As a result, estimated price elasticities would be smaller than the actual value. An alternative way is to assume that the market size is proportional to the male population size with a constant proportionality factor. However, since the coverage of the Nielsen Retail Scanner data varies from less than 20% to more than 80% across the areas, it is questionable to set a unique proportionality factor. Thus, this measurement is not applied in this dissertation.

with at least one cartridge, which means there is no price data for the handles. Thus, I use the prices of the handles which are sold with one cartridge as a proxy variable.

The product characteristics are captured by cartridge dummy, blade-count dummies, and manufacturer dummies. Instead of a category variable, two blade-count dummies are used to measure the quality difference due to the blade-count difference. Also, the manufacturer dummies are used to identify if a product is produced by Gillette, Shick, or BiC.

According to Nevo (2000, 2001), the brand dummies are introduced to control for those unobserved product characteristics which affect consumers' choices but cannot be observed or measured by economists. There are four brands (Mach 3, Fusion, Quattro Titanium, Hydro 5) which offer both the disposables and the cartridges. Thus, unlike Nevo's paper, the number of brand dummies does not equal the number of products. Also, 7 quarter dummies are used to control for seasonal fixed effects and any time trend.

Demographic data are from the sample individuals of the March CPS. 40 male individuals were randomly drawn from each area in each year. To exclude the outliers, I drop the individuals of top 1% and bottom 1% income. Then the samples are quadruplicated for eight quarters. Two variables are used to estimate consumers' heterogeneous preferences. The income variable is the sum of the earned and unearned income. Also, the Hispanic dummy indicates if an individual is Spanish, Hispanic, or Latino. Summary statistics of those variables are displayed in Table (6.2).

6.4 Instruments

The price variable is instrumented by the quarterly regional average prices (Hausman, 1996). The 75 geographic areas are divided into 10 regions (listed in Figure

Table 6.2: Summary Statistics

Variables	Mean	Median	Std. Dev.	Min	Max
Dependent Variable:					
Market Share(%)	1.54	1.00	1.52	0.01	8.96
Product Characteristics:					
Price	2.54	2.37	1.13	0.62	6.36
Package Size	4.65	4.69	1.52	1.78	12.39
Handle Price	6.34	6.18	1.60	2.28	14.09
Cartridge	0.39	—	—	0	1
Blades = 4	0.17	—	—	0	1
Blades = 5	0.28	—	—	0	1
Demographics:					
Income	65845	45812	42178	1933	391391
Hispanic	0.22	—	—	0	1

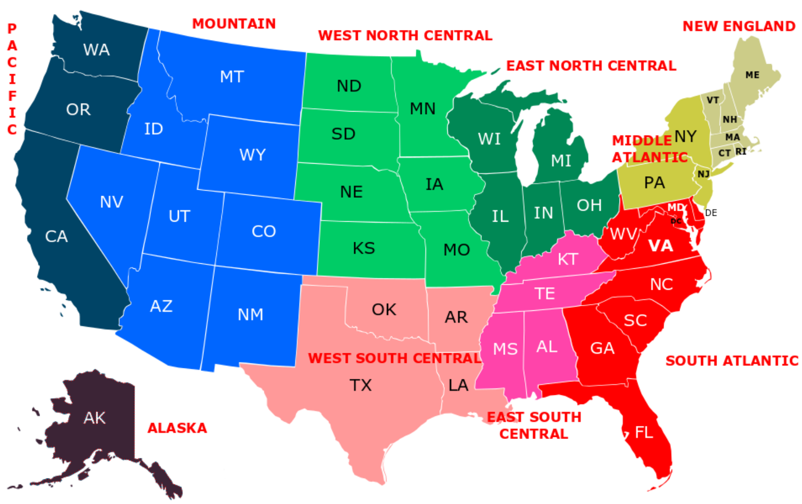
Source: Nielsen Store Scanner Dataset (2015-2016) and March CPS (2015-2016).

6.1). The regional average price, z_{jc}, is calculated as

$$z_{jc} = \frac{\sum_{\gamma \in \Gamma} (p_{j\gamma} q_{j\gamma}) - p_{jc} q_{jc}}{\sum_{\gamma \in \Gamma} q_{j\gamma} - q_{jc}} \tag{6.1}$$

where c stands for the geographic market, Γ stands for the area, and q stands for the sales volume. Some areas are dropped due to lacking the March CPS samples, but their price information can be used to form the instrumental variables. Thus, even though there is only one geographic market in Alaska, it is still possible to construct instrumental variables for that area. The regional average prices of each quarter from 2014 Q1 through 2016 Q4 are used as instruments. Thus, there are 12 instruments for the price variable.

Figure 6.1: Regions



Chapter 7 Empirical Results

7.1 Results from the Conditional Logit Model

As noted in section IV, the logit results cannot yield reliable price-cost markups. However, due to computational simplicity, it is a useful method in evaluating the instrumental variables and comparing the different specifications.

Table (7.1) displays the results of the conditional logit model. Column (1) and (2) are according to specification (5.12), in which the independent variables consist of the observed product characteristics. The unobserved product characteristics are embedded in the structural error term. Column (2) uses the Hausman instrumental variables in a two-stage least squares regression. From column (1) to (2), the price coefficient increases from -0.494 to -0.572 as expected, which implies that the Hausman instruments alleviate the endogeneity caused by the simultaneity problem.

Columns (3) and (4) are according to specification (5.14), in which a brand fixed effect is introduced to control for the unobserved product characteristics, and all market-invariant product characteristics (the blade-count dummies and the maker dummies) are dropped. Comparing the price coefficients in column (1) and (2) with those in column (3) and (4), we find the effect of including the brand dummies is significant, which implies that the brand fixed effect works well in controlling for the endogeneity caused by the unobserved characteristics.

In column (4), all the coefficients have the expected signs. Thus, it is an appropriate benchmark to develop the random coefficient logit model.

Table 7.1: Results from the Conditional Logit Model

	(1)	(2)	(3)	(4)
Price	-0.468	-0.517	-0.838	-1.390
	(0.018)	(0.021)	(0.019)	(0.033)
Package Size	0.502	0.492	-0.016	-0.137
	(0.009)	(0.009)	(0.007)	(0.010)
Handle Price	-0.002	-0.003	-0.014	-0.017
	(0.005)	(0.005)	(0.003)	(0.003)
Cartridge	-0.427	-0.376	1.554	1.858
	(0.062)	(0.063)	(0.041)	(0.047)
Blades = 4	0.195	0.224	—	—
	(0.027)	(0.028)	—	—
Blades = 5	1.586	1.660	—	—
	(0.035)	(0.038)	—	—
Schick	-1.557	-1.601	—	—
	(0.025)	(0.026)	—	—
BiC	-0.764	-0.818	—	—
	(0.030)	(0.032)	—	—
Dummies:				
Brand			✓	✓
Instruments		✓		✓
1st stage R^2	—	0.763	—	0.347
1st stage F-test	—	2895.70	—	476.51
Observations	10800	10800	10800	10800
R^2	0.61	0.61	0.86	0.98

1st stage R^2 stands for the partial R^2 of excluded instruments. All the specifications include the time dummies.

7.2 Results from the Random Coefficient Logit Model

Estimation

The specification of the random coefficient logit model is based on equation (5.19) which includes a brand fixed effect to control for the unobserved characteristics and the interactions between the product characteristics and the individual demographics to allow for the individual specific coefficients. The individual demographics are sampled from the March CPS. The price variable is instrumented by the Hausman IV to control for the simultaneity problem.[1] The coefficient estimates are computed by the procedure discussed in Chapter 5.4.

Table 7.2: Results from the Full Model

Variable	Means	Individual deviations	
		Income	Hispanic
Price	-1.967	-0.461	—
	(0.272)	(0.109)	—
Package Size	-0.632	0.676	—
	(0.116)	(0.122)	—
Handle Price	-0.027	—	—
	(0.011)	—	—
Cartridge	2.625	—	—
	(0.253)	—	—
Blades = 4	—	0.372	1.040
	—	(0.193)	(0.415)
Blades = 5	—	2.760	5.750
	—	(0.483)	(0.808)
GMM Objective		3.302	

Table (7.2) shows the estimates of the preference parameters of the random coefficient logit model. The preference means, denoted as α and β in equation (5.19),

[1]The product characteristics variables and the individual demographics variables have been discussed in section 5.3. The instrumental variables have been discussed in Chapter 6.4

are presented in column 1. All the coefficients are statistically significant and have the expected sign. The results show that a consumer's valuation on a razor is, ceteris paribus, negatively related to its price, package size, and the price of a compatible handle. Also, consumers prefer cartridges to disposable razors.

The last two columns present the individual-specific preference parameters, denoted as π in equation (5.19). With the exception of the term "Blades = 5" interacted with income, all the estimates are significant. The coefficients imply that the wealthier consumers are more sensitive to the price and less sensitive to the size package. Also, the richer and Hispanics are more likely to buy a high-quality razor.

Elasticities

The market-specific demand elasticities are computed with the estimated coefficients and the mean utilities from equation (5.31). Table (7.3) presents the median of these estimated elasticities over 600 markets for the selected products. The cells in the diagonal of the first 8 rows indicate the own-elasticities of the selected brands, and other cells are the cross-elasticities. Cell (m,n) indicates the elasticity of brand in row m with respect to a price change of brand in column n. All the own- and cross-elasticities have desirable signs and magnitudes.[2]

[2]Table 7.3 shows that disposable razors have smaller own-elasticities than cartridges on average, which means that users of disposable razors are less sensitive to the price change than the non-disposable system users. The reason is that the users of the non-disposable system often buy more cartridges at one time than disposable razor users. Thus, they are more likely to buy more cartridges when the price is low and reduce the purchases when the price is high. As a result, the users of non-disposable razors are more sensitive to the price change.

Table 7.3: Median Own and Cross-Elasticities

	Mach 3 (D)	Mach 3	Fusion (D)	Fusion	Quattro (D)	Quattro	Hydro 5	(D) Hydro 5
Gillette Mach 3 (D)	-4.0286	0.1961	0.0133	0.2600	0.0036	0.0139	0.0163	0.0570
Gillette Mach 3	0.0684	-7.0543	0.0129	0.9099	0.0060	0.0374	0.0411	0.1882
Gillette Fusion (D)	0.0164	0.1152	-4.8713	0.6743	0.0027	0.0118	0.0445	0.1530
Gillette Fusion	0.0586	0.6425	0.0494	-11.3863	0.0067	0.0373	0.1087	0.4726
Schick Quattro (D)	0.0601	0.2617	0.0266	0.4580	-4.5368	0.0177	0.0283	0.1034
Schick Quattro	0.0665	0.5157	0.0220	0.7734	0.0060	-6.6520	0.0439	0.1755
Schick Hydro 5 (D)	0.0532	0.3933	0.0540	1.5063	0.0061	0.0288	-7.2710	0.3586
Schick Hydro 5	0.0554	0.5731	0.0497	1.8738	0.0065	0.0346	0.1027	-9.7759
Gillette Custom Plus 3 (D)	0.0680	0.4073	0.0167	0.5106	0.0054	0.0240	0.0277	0.1064
Gillette Sensor 3 (D)	0.0666	0.4399	0.0159	0.5449	0.0054	0.0254	0.0287	0.1143
Gillette Mach 3 Turbo	0.0721	0.6531	0.0146	0.7826	0.0061	0.0339	0.0385	0.1602
Gillette Fusion ProGlide	0.0577	0.5780	0.0519	1.9596	0.0068	0.0352	0.1082	0.4461
Schick Xtreme 3 (D)	0.0611	0.5900	0.0123	0.6932	0.0050	0.0295	0.0328	0.1418
Schick Hydro 3	0.0688	0.4870	0.0155	0.6014	0.0056	0.0273	0.0309	0.1239
BiC Comfort 3 (D)	0.0583	0.4754	0.0135	0.5429	0.0049	0.0256	0.0277	0.1213
BiC Comfort 3 Advance (D)	0.0654	0.4042	0.0153	0.4873	0.0052	0.0239	0.0268	0.1066
BiC Flex 3 (D)	0.0637	0.5042	0.0142	0.6012	0.0053	0.0273	0.0302	0.1294
BiC Flex 4 (D)	0.0636	0.2804	0.0283	0.4899	0.0053	0.0194	0.0304	0.1106

“D” in parentheses stands for disposable razor.

Computed with the results of the full model.

Markups

The market-specific price-cost markups are computed with the estimated coefficients and the mean utilities from equation (5.3). Table (7.4) presents the medians over 600 markets for the brands which have both disposable razor and non-disposable systems. I find, for all of these four brands, the markups on disposable razors are higher than the markups on cartridges. Gillette earned \$0.11 more profit from the "Mach 3" disposable razor than from a cartridge of the same brand. It increases to \$0.51 for the "Fusion". However, the differences in Gillette's brands are much larger than those of Schick's brands. The average markup difference of Gillette's brands is \$0.31, while it is \$0.09 for the Schick.

Table 7.4: Median Markups and Median Prices

		Markups (\$)			Prices (\$)			$\frac{\Delta markup}{\Delta price}$
		Disposable	Cartridge	$\Delta markup$	Disposable	Cartridge	$\Delta price$	
Gillette's								
	Mach 3	0.88	0.77	0.11	2.85	2.58	0.27	40.7%
	Fusion	1.37	0.86	0.51	5.05	4.06	0.99	51.5%
Schick's								
	Quattro	0.58	0.47	0.11	2.40	2.60	-0.20	—
	Hydro 5	0.48	0.41	0.07	2.91	3.30	-0.39	—

Computed with the results of the full model.

Measure of Price Discrimination

As discussed earlier, the price of a disposable razor can be viewed as the price when a firm sells the shaving service using a linear pricing strategy. Thus, if a firm also prices a cartridge using a linear pricing strategy, the prices of disposable razors and cartridges should be close to each other. Moreover, as Table (7.2) shows, the coefficient estimate of the cartridge dummy is 2.625, which means a firm can change a higher price for cartridges than disposable razors of the same brand. In other words, if the firm does not implement the two-part tariff strategy, a cartridge should be more expensive than a disposable razor. Therefore, if we find a cartridge is priced significantly lower than a disposable razor of the same brand, the firm is intentionally lowering down its cartridge price for the purpose of implementing the two-part tariff pricing strategy, whereby it extracts surplus from consumers by charging a higher price for handles.

Since the marginal costs of disposable razor and cartridge might be different, it is necessary to partial out the cost difference from the price difference. Using the markups in Table (7.4) and the average prices in Table (3.2), I form the measure of the two-part tariff which as

$$\frac{\Delta markup}{\Delta price} = \frac{\widehat{markup}_d - \widehat{markup}_c}{price_d - price_c} \tag{7.1}$$

, where subscript c stands for cartridge and d stands for disposable razor. This ratio evaluates the extent to which the price differences are driven by the markup differences. The result shows, on average, over 46% of the price differences of Gillette's brands can be explained by the markup differences.

This conclusion can be strengthened by comparing the ratio of Gillette's brands and Schick's brands. As discussed, a firm can implement the two-part tariff strategy only if it has market power. Since the razor market is dominated by Gillette, other firms may not be able to use the two-part tariff strategy. Thus, for any brand made by other firms in this market, the ratio calculated with equation (47) should be small. Then I calculate the ratios of two brands which sell both disposable razors and cartridges. I find the average ratio of them is 25%, which is much smaller than Gillette's.

To sum up, the empirical evidence is consistent with the explanation that Gillette is implementing the two-part tariff pricing strategy in men's shaving razor market.

Chapter 8 Conclusion

Gillette is one of the most successful companies in the past one hundred years. It has dominated the men's shaving razor market not only because of its constantly innovative products but also because of its marketing strategy. Among those strategies, Gillette's pricing policy for its non-disposable razor system attracts researchers' most attention. The razor-and-blade pricing is used as a textbook example by economists, antitrust scholars, and marketing scientists. However, researchers have different opinions about Gillette's pricing policy. Some researchers claim that Gillette sets a low price for handles and high price for blades. In contrast, others argue that Gillette plays a two-part tariff strategy; that is, Gillette lowers blade price and extracts consumer's surplus by increasing handle price.

This dissertation finds empirical evidence supporting the latter opinion; that is, Gillette's pricing policy for the non-disposable razor system is a practice of two-part tariff. This dissertation uses the random-coefficient logit model to estimate the demand system of men's razors with market-level sales data in the United States between 2015 and 2016. The estimates are used to calculate the price-cost markups of each product. The results show that: First, the markups of cartridges are lower than those of the disposable razors of the same brand. Second, the markup differences can explain a large fraction of the price differences of Gillette's brands. Last, the ratios of the markup differences to the price differences of Gillette's brands are much higher than those of Schick's brands. This evidence is consistent with the prediction of two-part tariff theory. In other words, Gillette is using a two-part tariff strategy in this market.

Moreover, a pair of tie-in products, such as the razor and blade, is a particular type of complementary products. However, the pricing problem of tie-in products is much more complicated than that of regular complementary products. With the evidence from the men's shaving razor market, this dissertation helps us better understand the pricing problem of complementary products; that is, a firm can employ two-part tariff pricing policy for them.

This dissertation can be further extended from two aspects. First, the structural empirical model used in this dissertation is based on a monopolist's pricing problem for simplicity. However, the structure of the razor market is closer to a leader-follower model. Thus, future studies can develop a leader-follower model in which both players use the two-part tariff strategy. It is interesting to examine if the prediction regarding the follower's pricing strategy derived from the theoretical model is consistent with the empirical evidence. On the other hand, it is hard to identify a particular pricing policy without cost side data. Thus, this dissertation uses disposable razor as a benchmark and compares the markups of cartridges with that of disposable razors. However, future studies can develop a thorough hypothesis test approach to make the conclusion more convincing.

Appendix

Appendix A

Table A: First Stage Results

Variable	(2)		(4)	
	Est.	s.e.	Est.	s.e.
avgp141	0.243	0.032	-0.350	0.044
avgp132	0.036	0.022	-0.015	0.023
avgp143	0.158	0.054	0.612	0.058
avgp144	-0.266	0.048	-0.398	0.055
avgp151	0.179	0.051	0.148	0.065
avgp152	-0.123	0.049	-0.144	0.068
avgp153	0.479	0.047	0.430	0.051
avgp154	-0.221	0.039	-0.166	0.040
avgp161	0.207	0.035	0.030	0.037
avgp162	-0.049	0.036	0.435	0.048
avgp163	0.394	0.048	-0.089	0.058
avgp164	-0.060	0.035	0.001	0.056
R^2	0.76		0.35	
F-test	2895.70		476.51	

Column headings are equivalent to those of Table V. All regressions also include the exogenous variables included in the equivalent columns of Table V. The row labeled R^2 displays the partial R^2 of excluded instruments. The row labeled F-test displays the valu of the test statistic for the null hypothesis that coefficients of all variables excluded from the demand are zero.

Appendix B

The specification used in the random coefficient logit model is

$$u_{ijt} = -\alpha p_{jt} + \beta_1 p_{jt}^{hdl} + \beta_2 size_{jt} + \beta_3 cartridge_j + \xi_b + \xi_t + \Delta\xi_{jt}$$

$$+ \pi_1 * p_{jt} * income_{it} + \pi_2 * size_{jt} * income_{it} + \pi_3 * 4BLD_j * income_{it}$$

$$+ \pi_4 * 5BLD_j * income_{it} + \pi_5 * 4BLD_j * Hisp_{it} + \pi_6 * 5BLD_j * Hisp_{it}$$

$$+ \epsilon_{ijt}.$$

p_{jt}: unit price,

p_{jt}^{hdl}: the handle price,

$size_{jt}$: package size,

$cartridge_{jt}$: cartridge dummy,

ξ_b: brand fixed effect,

ξ_t: time fixed effect,

$\Delta\xi_{jt}$: structural error term,

$4BLD_j$: dummy variable, $= 1$ if the razor has 4 blades,

$5BLD_j$: dummy variable, $= 1$ if the razor has 5 blades,

$income_{it}$: individual income,

$Hisp_{it}$: hispanic dummy,

ϵ_{ijt}: type-one extreme value distribution,

j: product,

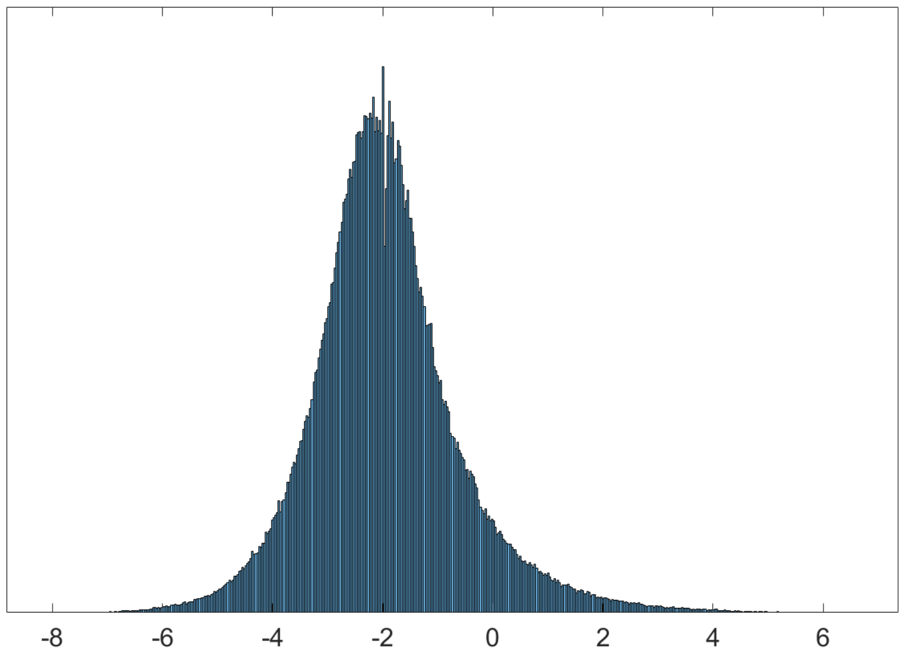
t: market,

b: brand,

i: individual.

Appendix C

Figure C:Frequency Distribution of Price Coefficient (based on Table 7.2)



Appendix D

Table D: Additional Results from the random coefficient logit Model

		(i)		(ii)		(iii)		(iv)	
	Variable	Est.	s.e.	Est.	s.e.	Est.	s.e.	Est.	s.e.
Means	Price	-1.967	0.272	-1.818	0.553	-2.470	0.631	-2.496	1.455
	Package Size	-0.632	0.116	-0.625	0.132	-0.675	0.224	-0.634	0.412
	Handle Price	-0.027	0.011	-0.024	0.008	-0.029	0.021	-0.030	0.044
	Cartridge	2.625	0.253	2.446	0.503	2.956	0.701	2.932	1.498
S.D.	Price	—	—	—	—	-0.439	0.322	-0.568	0.588
	Package Size	—	—	—	—	-0.029	1.563	-0.024	2.486
	4BLD	—	—	—	—	—	—	-4.248	3.629
	5BLD	—	—	—	—	—	—	-0.671	13.008
Interaction	Price	-0.461	0.109	-0.414	0.152	-0.431	0.206	-0.348	0.372
w/ Income	Package Size	0.676	0.122	0.725	0.168	0.667	0.185	0.633	0.309
	4BLD	0.372	0.193	0.401	0.205	0.350	0.194	0.469	0.380
	5BLD	2.760	0.483	2.532	0.616	2.700	0.622	2.874	2.737
Interaction	Price	—	—	-0.038	0.363	—	—	—	—
w/ Hispanic	Package Size	—	—	0.166	0.383	—	—	—	—
	4BLD	1.040	0.415	0.874	0.536	1.553	0.640	3.223	3.063
	5BLD	5.750	0.808	5.380	1.125	6.024	1.285	6.475	3.890
GMM Obj.		3.302		3.034		2.508		1.026	

Specification (iii) includes the results which are presented in Table X.

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