Pricing the Razor: Evidence on two-part tariffs

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October 26, 2018

Abstract

This paper finds evidence from men's razor market for the hypothesis that tie-in sale can be used to implement a two-part tariff pricing strategy. I estimate a demand system of the razor by random coefficient logit model with market level sales data from Nielsen Store Scanner dataset and individual demographics data from March CPS. The estimated parameters are used to construct price-cost markup. By comparing the markups of different products, I find the evidence that Gillette is using two-part tariff strategy. This conclusion can be generalized as that a monopolist can set the prices of tie-in products in line with two-part tariff.

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1 Introduction

In this paper, the hypothesis that tie-in sale can be used as two-part tariff method is confirmed by evidence from men's razor market. I estimate a random coefficient logit model with the market level razor sales data in the United States between 2015 to 2016. The estimated parameters are used to compute the price-cost markup of each product. Then I compare the markups of different products. The result shows that Gillette charged high markups to its disposable razors and low markups to its cartridges. Further, the markup difference contributes to most of the price difference. Last, the markup difference of Gillette's brands is more significant than that of a fringe competitor. This result is explained as that Gillette intentionally lowers down cartridge price to promote sales when it can use the handle to extract consumers surplus from shave services. In other words, the tie-in nature of men's non-disposable razor system is used to implement a two-part tariff pricing strategy.

When a service is provided jointly by a durable foremarket good and a non-durable aftermarket good, a firm can force the foremarket good buyers to buy its aftermarket good by tie-in arrangement or compatibility. This business strategy is called tie-in sale.[1] Examples of tie-in sales include printer and inks, video game console and games, and razor handle and cartridges. An interesting problem regarding to tie-in sale is what is the best pricing schedule of foremarket good and aftermarket good.

A common view, usually referred as "razor-and-blades" business model, says that a firm should set a low price on foremarket good or even give it away and set a high price on aftermarket good. Due to the low foremarket price, more consumers buy that foremarket product and are locked with this firm. Then the firm can set a high price on aftermarket good. The "razor-and-blades" model reveals the coordination between pricing on two products. However, it is doubtful that the "razor-and-blades" pricing strategy applies to all tie-in products, especially to razors.

[1] 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, as Burnstein 1960 says, tie-in products are not necessarily complementary. In this paper, I use a narrow definition of "tie-in sale".

Picker (2011) raises a critical view regarding the "razor-and-blades" story. He traces back the razor prices in the early 20^{th} century with some historical evidence, such as the 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 cartridges when it monopolized this market with the patents from 1904 to 1921. After its patents expired, Gillette lowered the price of the original handle set to \$ one but offered a new, luxury, but compatible handle set at \$5. On the contrary, the price of cartridges did not change over time. Picker concludes that Gillette was not playing "razor-and-blades" strategy during its monopoly time until it was being challenged by entrants.

The strategy Gillette played might be two-part tariff. This pricing strategy, which is firstly analyzed by Oi (1971), involves setting a low marginal price for a service and extracting the consumer surplus by charging a high lump-sum fee. Schmalensee (1981, 2015) says that the two-part tariff can take the form of a tie-in sale; that is, a cartridge provides unit shave service while the handle price can be viewed as a lump-sum fee.

According to this theory, a monopolistic razor company sells 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 increase, his willingness to pay for the razor handle also go up. Thus, the consumer can readily accept a high handle price. For the firm, a high handle price can 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 market structure. There are two separated but interdependent market: the handle market and the cartridge market. The "razor-and-blades" story implicitly assumes that the handle market is a competitive market. Thus, each razor company would like to lower its razor price to compete with each other. However, if a consumer has bought a handle, he is locked to the cartridges of the same brand. Thus, each company is a local monopolist in the cartridge market and can set a high cartridge price. On the contrary, the "two-part tariff" theory assumes 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 two-part tariff strategy during its monopoly period. But, when its patent was expired, Gillette had to lower down the handle price to compete with other firms. However, when the price of a handle was not high enough, a consumer may not care about the switching cost; that is, purchasing a new handle from other company. Thus, the handle could not lock the consumers. In other words, giving handles away could not help the companies raise the prices in the cartridge market.

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

To my knowledge, this is the first paper to examine tie-in sales as a two-part tariff. There is a growing body of literature regarding pricing on tie-in products. Li (2015) studies the optimal intertemporal price discrimination schedule in the e-reader and e-books industry. She finds the optimal pricing schedule depends on use intensity. For avid consumers, a firm should harvest (price-cutting over time) on e-readers and investing (price-raising over time) in e-books. For general consumers, a firm should invest in e-readers and harvest on e-books. Chintagunta, Qin, and Vitorino (2018) investigate single-serve coffee system industry, where coffee machine manufacturer licenses other firms to produce coffee pods. They find licensing agreement is associated with less price dispersion in the afermarket and lower prices of primary good. Gil and Hartman (2009) and Hartmann and Nair (2010)'s findings are more close to this paper. Gil and Hartman study the concession sales at movie theaters. They find the demand condition for movie tickets and concession supports metering strategy (setting a low price for movie tickets and high price for concession). They also find high-priced concessions do extract more surplus from customers with a greater willingness to pay for the tickets. Hartmann and Nair (2010) find the demand condition in men's razor market is feasible for the two-tariff strategy (setting a high price for handles and low price for cartridges). However, these papers only show that when pricing tie-in products what the firms should do, rather than what they did.

According to identifying which pricing strategy is actually used by firms, Shepard (1991) reveal evidence that gas stations use a quality scale to discriminating 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) is driven by price discrimination. Verboven (1996, 2002) and Cohen (2008) find that the price difference across consumer groups can be explained by markup difference, which is evidence of price discrimination. Lakdawalla and Sood (2013) compare the difference in drug consumptions of insured and uninsured patients across markets. They find the health insurance works as a two-part tariff arrangement. Bonnet and Dubois (2010) study the bottled water wholesale market and find evidence that there exists a two-part arrangement between manufacturers and retailers.

This paper contributes the existing literature in two aspects. First, it provides evidence to correct a common misunderstanding regarding the pricing strategy upon razors. More generally, this paper confirms that tie-in sale can be used to play a two-part tariff strategy. Moreover, this paper enriches the empirical literature of pricing on tie-in sales, price discrimination, and application of random coefficient logit model on pricing.

The rest of this paper proceeds as follows. Section II presents a brief description of the men's shaving razor market. Section III presents the theoretical model of firm pricing behavior. Section IV discusses the empirical strategy. Section V introduces the data and the variables. Section VI presents the empirical results. And section VII presents the conclusion.

2 Men's shaving razor market

This section presents a brief introduction of men's razor market. Section 2.1 will introduce the product differentiation and heterogeneous consumers. The nature of the products and consumer preference calls for using random coefficient logit model when estimating demand system. Section 2.2 will introduce the market structure. We will find that Gillette dominates the high-end segment of this market and other firms are fringe competitors. Thus, Gillette can implement two-part pricing in this market segment while other firms may not be able to do that. Section 2.3 presents some stylized facts regarding pricing strategy in the high-end segment.

2.1 Products and Demand

There are over two hundred highly differentiated brands in the 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 the researchers. For example, some brands have finer blades than the others. However, it is hard to measure the sharpness of a blade. Also, the perceived quality is affected by advertising. For example, by advertising, Gillette successfully sets its products apart from the other brands. However, it is hard to find a valid measurement for the advertisement.

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. It is likely that the main differences are the name and packaging design.

Another horizontal difference which this paper concerns about is the category; that is, disposable or non-disposable. A disposable razor is a razor head attached with a handle. The handle is not durable and would be discarded with the razor head. A non-disposable system consists of a well-made handle with the replaceable cartridges. 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, offers both disposable razor and 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.

The consumers have a variety of preference according to those product characteristics. Further, ethnicity, age, and income affect the preference profoundly. For example, Mintel's research[2] says that the low-income group is partial to the disposable razors and a Hispanic is more likely to buy a high-quality razor. Since demographics make-ups vary across areas and change over time, we can witness distinctive preferences in markets.

2.2 Market Structure

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 dominator, attained 39.0% of the total sales volume, while Schick and BiC acquired 10.7% and 14.4% respectively. As it has been mentioned above, the count of blades is the main quality factor. Thus, the market can be split into two segments by quality. The high-end segment consists of the razors with five or six blades, while the low-end segment contains the razors with no more than four blades.

The low-end segment is more competitive. Gillette only attained 34.5% sales vol-

[2] Mintel is a privately owned market search firm whose databases and analysis are accessible to university students.

ume. Schick's market share shrank to 10.1%. And BiC acquired 16.1% of this market. A non-negligible force in this market segment are the private-label brands[3], which as a whole seized 35.9% of the low-quality segment. The private-label brands are often priced lower than a main-stream brand. In other words, they are price-taker rather than price-maker. 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.

In contrast, the high-end market is monopolized by Gillette. Gillette made up to 58.1% of the advanced razors; that is almost four times its largest opponent's market share.

Table 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

The competition also comes from outside. The established companies face increasing challenge from online subscription service.[4] 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 more of a ritual. Moreover, some consumers prefer electric shavers. However, those competitors are not likely to affect the market power of Gillette.

Table 2: Unit Price and Package Size

	Disposable		Cartridge	
	Price ($)	Size (ct.)	Price ($)	Size (ct.)
Gillette Mach 3	2.88	2.90	2.62	7.31
Gillette Fusion	5.04	2.00	4.07	5.44
Schick Quattro	2.41	3.00	2.72	5.38
Schick Hydro 5	2.82	3.52	3.29	4.86

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 head.
c. The package size indicates the weighted average package size of each brands.

2.3 Pricing

There are four brands which provides both disposable razors and non-disposable systems in all sample markets. We can compare their price to find some stylized facts on pricing strategy. As Table (??) shows, for all of the Gillette's brands, the disposable razor price is higher than cartridge price. In contrast, Schick set lower prices on disposables razor than on cartridges. We can also figure out that, the average package size of cartridge is always larger than disposable razor. The stylized facts may imply that Gillette applies two-part tariff strategy while Schick does not. However, we cannot rule out the possibility that the price difference is driven by package size difference.

3 Data and Variables

This section introduces data and variables used for estimation. Section (3.1) will introduce two main data sources, Nielsen Store Scanner dataset and March CPS. Section (3.2) will discuss how do I define product and market. Section (3.3) will show how the variables used for estimation are constructed. Section (3.4) will describe how to construct Hausman instrumental variables.

[3] 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.

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

3.1 Data

The sales volume, price, and product characteristics data is from the Nilsen Retail Scanner dataset and the consumer demographics data is from the CPS Annual Social and Economics Supplement (March CPS hereafter).

3.1.1 Nielsen Retail Scanner Data

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

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

This dataset documents the product categories, brand, package size, and additional characteristics of 2.6 million UPCs. For the 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 counts of the razor heads contained in a package. Other characteristics include the manufacturer's name, the counts of blades built in a razor head, designed for men or women.

For each UPC, the participating retailers report weekly average price and sales volume. 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 is from more than 35,000 participating stores, including grocery, drug, mass merchandiser, convenience, liquor, and other stores. It covers more than half of the total sales volume of all the U.S. grocery and drug stores, more than 30 percent of the mass merchandiser sales volume, and almost 1% of the convenience and liquor stores. Also, the coverage varies across the geographic markets. It ranges from 1% to 86% for the grocery stores and from 28% to 92% for the drug stores. The data is started with 2006 and 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 locates.

3.1.2 March CPS

The March CPS is an annual survey conducted by the United States Census Bureau for the Bureau of Labor Statistics. This 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 for producing 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 10086 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 should 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. [5]

3.2 Products and markets

The definitions of the product and market should be clarified to adapt the data to the BLP model.

[5] 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 category variable which causes many problems in estimation.

3.2.1 Products

A product is defined by brand in conjunction with category (i.e., disposable or cartridge). The packages of different size 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 cartridge 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 attains large market fraction, each of them is only sold in certain outlets.[6] All the singe-blade and twin-blade brands are dropped for the reason that none of them offer both the disposable and cartridge. And the quality difference between these disposables and cartridges is significant. Also, local brands which do not cover all the geographic markets are excluded for simplicity.

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 for what this treatment is acceptable. First, the handle-cartridge bundles only attain 4.43% of the volume sales. Thus, dropping it 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 the consumers purchase handle-cartridge bundles mainly for the handles and the handle-cartridge bundles are not competing with the cartridges or disposable razors.

Under this context, the consumer choice set consists of 18 inside products (listed in Table ??), which are manufactured by three companies (Gillette, Schick, and BiC), and an outside product. The outside product can be a dropped product or a distant

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

substitute such as an electric shaver or professional service in a salon. In other words, the outside product represents the consumption of the potential consumers who did not buy any inside products.

Table 3: 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.

3.2.2 Markets

The market is defined by a geographic area in conjunction with a quarter. 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 March CPS are dropped. Then, 77 geographic areas left in the sample. Since the number of geographic areas is not 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.

Figure: CBSAs in sample

There are 616 markets in total. And, in each of these markets, there are 18 products. Then the sample consists of 11088 observations.

3.3 Variables

The variables used to estimate the BLP model consist of market share, price, package size, handle price (for cartridge), cartridge dummy, and brand dummies.

The market share of each inside product is as the ratio of sales volume to market size.

The sales volume data of Nielsen Retail Scanner is UPC-store-weekly level. It is aggregated to product-area-quarterly level for estimation.

As it has been mentioned above, the products of the same brand and category but different package sizes (then different UPC) are treated as the same product in this paper. Also, the manufacturers have been known to use more than one UPC for the same product.[7] Thus, it is reasonable to aggregate 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 BLP model.

BLP model simulates the market share with the consumer demographics. It is hard to know the consumer demographics of each store. But the consumer demographics in an area is accessible. Thus, the store-level data is 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 the promotion or other occurrences. Aggregating the weely-level data to quarterly-level reduces the effect of the random disturbances.

The market size of each area is measured by the maximum total sales volume of all inside and outside products from 2013 through 2016. Thus, the market size differs in the area but keeps constant over time.[8]

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

[8] 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 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 the razor heads instead of the package. In other words, the price variable represents the average price of each razor head rather than the package. The package size variable is the weighted average package size. It is the ratio of total razor-head sold to total sales volume. It has been known that a handle is sold with at least one cartridge, which means there is no price data for the handles. The handle price is estimated by the price of the handle-cartridge bundle with only one cartridge minus the unit price of the cartridge of the same brand.

The product characteristics are captured by cartridge dummy, blade-count dummies, and maker 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 maker 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 characteristics product characteristics which affect the consumers' choice but cannot be observed or measured by economists. There are four brands (Mach 3, Fusion, Quattro Titanium, Hydro 5) which offer both the disposable and cartridge. 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 the seasonal fix effect and the trend.

Demographics data is from sample individuals of the March CPS. 40 male individuals were randomly drawn from each area in each year. To exclude the outliers, the individuals of top 1% and bottom 1% income are dropped. 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

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 paper.

Latino.

Summary statistics of those variables are displayed in Table ??.

Table 4: 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 Dataset.

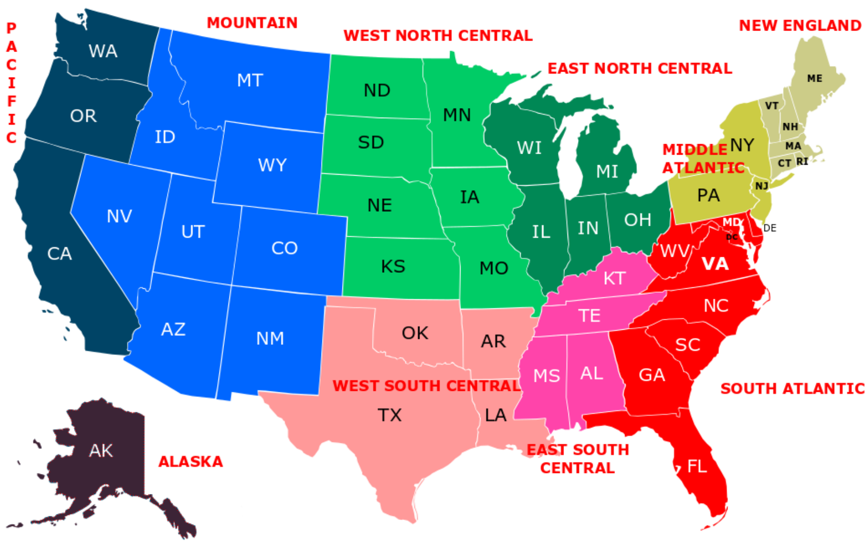
3.4 Instruments

As it has been mentioned above, the price variable is instrumented by the quarterly regional average prices (Hausman, 1996). The 74 geographic areas are divided into 10 regions (listed in Table ??). A regional average price, z_{jc}, is calculated as

$$z_{jc} = \frac{\sum\limits_{\gamma\in\Gamma} (p_{j\gamma} q_{j\gamma}) - p_{jc} q_{jc}}{\sum\limits_{\gamma\in\Gamma} q_{j\gamma} - q_{jc}} \tag{1}$$

, where c stands for the geographic market, Γ stands for the area, q stands for the sales volume. Some areas are dropped due to lacking of 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 1: Regions



Resources: www.wikimedia.org

4 Model

This section shows that, facing the same consumer demand, the optimal cartridge price under two-part tariff is below that under linear pricing. And the latter one is numerically equals to the price of a disposable razor. Also, if the disposable razors are sold to low-demand consumers while cartridges are sold to high-demand consumers, the cartridge price is below the disposable razor price.

4.1 A continuum model

Consider a market in which each consumer has a linear demand function for 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 cartridges. Otherwise, he will not purchase anything. In other words, the individual rationality condition is

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

, 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 handle is $N = 1 - \hat{\lambda}$, where $\hat{\lambda}$ stands for the marginal consumer.

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

$$\begin{aligned} \max_{p_c, R} \quad & \int_{\hat{\lambda}}^{1} (\lambda - p_c) p_c d\lambda + (1 - \hat{\lambda}) R \\ \text{s.t.} \quad & \frac{1}{2}(\lambda - p_c)^2 - R \geq 0 \qquad \text{for any } \lambda \in [\hat{\lambda}, 1] \end{aligned} \tag{3}$$

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

$$\hat{\lambda} = p_c + \sqrt{2R} \tag{4}$$

Solving equation (??) and use of (??) yield

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

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

$$\max_{p_c} \quad \int_{\hat{\lambda}}^{1} (\lambda - p_c) p_c d\lambda \tag{6}$$

and

$$\begin{aligned} \max_{R} \quad & (1-\hat{\lambda})R \\ \text{s.t.} \quad & \frac{1}{2}(\lambda - p_c)^2 \geq R \qquad \text{for any } \lambda \in [\hat{\lambda}, 1] \end{aligned} \tag{7}$$

Solving for this problem yields the optimal price schedule

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

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

$$\begin{aligned} \max_{p_d, R} \quad & \int_{\hat{\lambda}}^{1} (\lambda - p_d) p_d d\lambda \\ \text{s.t.} \quad & \frac{1}{2}(\lambda - p_d)^2 \geq 0 \qquad \text{for any } \lambda \in [\hat{\lambda}, 1] \end{aligned} \tag{9}$$

, where p_d stansd for price of a disposable razor. Solving for this problem yields

$$p_d^* = \frac{1}{3} \tag{10}$$

Equation (4), (7), and (10) establish that

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

$$p_c^{2PT} < p_c^{LP} = p_d \tag{11}$$

The reason for what a 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 earn profits from not only the cartridges but also the handle. Further, if the monopolist lowers down 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 handle.

4.2 A two-type model

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

$$\begin{aligned} \frac{1}{2}(\lambda_L - p_d)^2 &\geq \frac{1}{2}(\lambda_L - p_c)^2 - R \\ \frac{1}{2}(\lambda_H - p_c)^2 - R &\geq \frac{1}{2}(\lambda_H - p_d)^2 \end{aligned} \tag{12}$$

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

Now, the firm's problem is

$$\begin{aligned} \max_{p_d, p_c, R} \quad & n(p_d - c_d)(\lambda_L - p_d) + (1-n)(p_c - c_c)(\lambda_H - p_c) + (1-n)R \\ \text{s.t.} \quad & \frac{1}{2}(\lambda_L - p_d)^2 \geq 0 \\ & \frac{1}{2}(\lambda_H - p_c)^2 - R \geq 0 \\ & \frac{1}{2}(\lambda_L - p_d)^2 \geq \frac{1}{2}(\lambda_L - p_c)^2 - R \\ & \frac{1}{2}(\lambda_H - p_c)^2 - R \geq \frac{1}{2}(\lambda_H - p_d)^2 \end{aligned} \tag{13}$$

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

$$\begin{aligned}
p_d &= \frac{n}{1+n}\lambda_L + \frac{1-n}{1+n}\lambda_H + \frac{n}{1+n}c_d \\
p_c &= c_c \\
R &= (\lambda_H - c_c)^2 - (\frac{n}{1+n})^2(2\lambda_H - \lambda_L - c_d)^2
\end{aligned} \tag{14}$$

. The result establishes that

Proposition 2: *When a firm sets prices of cartridge and handle as two-part tariff and sells disposable razors to sort low-demand consumers from high-demand, then the price of cartridge is below that of disposable under regular case.*[9]

$$p_c < p_d \tag{15}$$

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 the accounting data but also strong assumptions on the supply equation. Thus, it is not feasible for this paper. 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

[9]That is, $\lambda_L > c_d$ and $\lambda_H > c_d$. The condition means both type of consumers are potential buyers of the disposable razor.

group. Thus, the disposable razor price can be used as a benchmark to examine the pricing on cartridge. If a firm sets cartridge price quite lower than 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 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 then they have less willingness to pay. The quality of disposable razors might be superior to cartridges. In this paper, I will only compare disposable razors and cartridges of same brands. Thus I can control for quality difference. 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 linear pricing strategy on cartridge. The markup difference of disposable razor and cartridges offered by Schick can be viewed as being driven by demand difference. So if Gillette is using 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 can be mostly explained by markup difference.
- 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 paper concerned with is the price-cost markup, which is calculated as:

$$markup = p - mc \tag{16}$$

But, it has been known that the price data is accessible while the marginal cost data is not. A straightforward way to measure the marginal cost in equation (??) is using accounting cost. However, this measurement is not valid in most of the case. First, accounting data is 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.[10] Besides that, packaging costs, transportation costs, and marketing costs could not be captured by input prices. Furthermore, even if appropriate accounting data is available, it is still challenging to convert accounting cost into the economic cost and converting average cost into the marginal cost.

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

$$\max_{p_j} \sum_{j \in \mathcal{F}_f} (p_j - mc_j) M_t s_j, \tag{17}$$

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.[11] Solving this problem, the price-cost markup of brand j is

$$p_j - mc_j = [\Omega^{-1} s]_{(j,1)}, \tag{18}$$

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, $\partial s_r / \partial p_j$.

[10] 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.

[11] This equation is not consistent with theoretical model. I will derive a consistent specification in the future.

5.3 OLS Logit

5.3.1 Discrete Choice Model

Generally, $\partial s_r / \partial p_j$ can be estimated by regressing s_r on p_j. However, since demands for all 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 paper is estimating the demand sensitivity with the discrete choice demand model which is introduced by McFadden (1978). This model assumes that a consumer has the indirect utility function:

$$u_{ijt} = \alpha(y_i - p_{jt}) + X_j\beta + \xi_{jt} + \epsilon_{ijt}, \qquad \text{for } j = 1, 2, ..., J, \tag{19}$$

where y_i stands for income of individual i, p_{jt} stands for price of product j in market t, X_j stands for observed characteristics of product j, ξ_{jt} stands for unobserved valuation of product j which is common to all consumers in market t, and ϵ_{ijt} is a mean-zero stochastic term. For simplicity, equation (9) can be transformed into

$$u_{ijt} = \alpha y_i - \delta_{jt} + \epsilon_{ijt}, \tag{20}$$

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

Income effect is introduced in a linear form, αy_i. Thus, different income level would not make any difference to choice and the income term will be canceled out in following steps.[12] Also, the terms which do not vary by 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

[12]If income effect is important, it can be modelled by a indirect utility which is concave to income, such as BLP (1995) in which

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

to all consumers. The last term, ϵ_{ijt}, captures individual deviation from mean utility.

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

$$\begin{aligned} u_{i0t} &= \alpha y_i - \alpha p_{0t} + X_{0t}\beta + \xi_{0t} + \epsilon_{i0t} \\ &= \alpha y_i + \epsilon_{i0t}. \end{aligned} \tag{21}$$

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

Product j would be selected if and only if

$$u_{ijt} > u_{irt}, \qquad \text{for } r = 0, 1, ..., J, \text{and } r \neq j. \tag{22}$$

In the real world, consumers' choices are diverse; no brand can acquire the whole market. Since all consumers sort the mean utilities in the same order, the diversity can only be accounted by ϵ_{ijt}.[13] The implication of this assumption will be discussed later.

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

$$s_{ijt} = \frac{\exp\left(X_{jt}\beta - \alpha p_{jt} + \xi_{jt}\right)}{\sum_{r=0}^{J} \exp\left(X_{rt}\beta - \alpha p_{rt} + \xi_{rt}\right)}. \tag{23}$$

The coefficients can be estimated by matching predicted choice probability to observed consumer purchase history.[14]

Generally, however, individual purchase history data is not readily accessible. An alternative method is using predicted market share, instead of predicted choice proba-

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

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

bility, to match the data.[15] As equation (14) shows,

$$
\begin{aligned}
s_{jt} &= \frac{1}{ns}\sum_{i=1}^{ns}\frac{\exp\left(X_{jt}\beta-\alpha p_{jt}+\xi_{jt}\right)}{\sum_{r=0}^{J}\exp\left(X_{rt}\beta-\alpha p_{rt}+\xi_{rt}\right)} \\
&= \frac{\exp\left(X_{jt}\beta-\alpha p_{jt}+\xi_{jt}\right)}{\sum_{r=0}^{J}\exp\left(X_{rt}\beta-\alpha p_{rt}+\xi_{rt}\right)},
\end{aligned}
\tag{24}
$$

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

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

$$
\min_{\alpha,\beta}||S-s(X,p,\xi;\alpha,\beta)||. \tag{25}
$$

The objective function in equation (??) is non-linear to the coefficients. Solving non-linear minimization problem by 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 (??), it is convenient to apply log-linearization: taking log on both sides of equation (??) yields

$$
\begin{aligned}
\ln(s_{jt}) &= -\alpha p_{jt}+X_{jt}\beta+\xi_{jt}-\ln(\sum_{r=0}^{J}e^{X_{rt}\beta-\alpha p_{rt}+\xi_{rt}}) \\
\ln(s_{0t}) &= -\ln(\sum_{r=0}^{J}e^{X_{rt}\beta-\alpha p_{rt}+\xi_{rt}})
\end{aligned}
\tag{26}
$$

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

$$
\ln(s_{jt})-\ln(s_{0t})=\delta_{jt}\equiv X_{jt}\beta-\alpha p_{jt}+\xi_{jt} \tag{27}
$$

[15]Some dataset, such as Nielsen Household Scanner Dataset, provide data about each shopping trip of sample household. For the products which consumers do not purchase frequently, however, the shopping trip data cannot be used directly. Consumers buy razors by 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 discrete choice model treats it as that this consumer prefers outside option. So using individual shopping trip data may significantly underestimate mean utility of inside products.

Since S_{jt} and S_{0t} are observed, equation (17) can be consistently estimated with the ordinary least square regression when the structural residual term, ξ_{jt}, is stochastic and uncorrelated with regressors.

5.3.2 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: unobserved product characteristics and simultaneity.

Some of the product characteristics are observable to the consumers but unobservable to the researchers. When the unobserved product characteristics are correlated with price, the price variable can be endogenous. For example, in the razor market, the sharpness of the blade cannot be observed by the researchers. But the consumers can perceive the sharpness when they use it. And they would like to pay more for a sharper razors. Also, since it is costly to product 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

$$\xi_{jt} = \xi_j + \Delta\xi_{jt} \tag{28}$$

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

$$\ln(s_{jt}) - \ln(s_{0t}) = -\alpha p_{jt} + \xi_j + \Delta\xi_{jt}. \tag{29}$$

Another source of the price endogeneity is the simultaneity problem; that is, the price is endogenously determined by 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

$$p_{jt} = c_{jt} + f(\Delta\xi_{jt}), \tag{30}$$

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

This paper applies the Hausman instruments, the average prices in adjacent areas, to solve this problem. Due to common cost shifter, prices in adjacent areas are correlated. Also, if $\Delta\xi_{jt}$ is independent across areas, $p_{j,-t}$ would be uncorrelated with $\Delta\xi_{jt}$. Thus, the prices of the brand in other areas are valid IVs.

5.3.3 Demand Elasticities

With Hausman instrumental variables, equation (??) 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,

$$\frac{\partial \hat{s}_{jt}}{\partial p_{rt}} = \begin{cases} -\alpha \hat{s}_{jt}(1-\hat{s}_{jt}) & if \quad j = r, \\ \alpha \hat{s}_{jt}\hat{s}_{rt} & if \quad j \neq r, \end{cases} \tag{31}$$

and the demand elasticities,

$$\hat{\eta}_{jrt} = \frac{\partial \hat{s}_{jt}}{\partial p_{rt}} \cdot \frac{p_{rt}}{\hat{s}_{jt}} \begin{cases} -\alpha p_{jt}(1-\hat{s}_{jt}) & if \quad j = r, \\ \alpha p_{rt}\hat{s}_{rt} & if \quad j \neq r. \end{cases} \tag{32}$$

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

5.4 Random Coefficient Logit

5.4.1 Independence of Irrelevant Alternatives

In conditional logit model, the random disturbance term, ϵ_{ijt}, is assumed to be independent by 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 (??) shows, the cross elasticities depend only on market share and price of product j. As it shows in Table (22), if Gillette reduces Fusion cartridge price, all other products, such as Private Label disposable razors and Schick Hydro 5 cartridge which is Fusion's close substitute, lose the same size of market share. 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 low price brand is inelastic, and then the price-cost markup of low-price brand is high. Those implications are opposite to common sense.

5.4.2 Individual-Specific Coefficients

One way to relax 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 choose among three-blade, four-blade, or five-bladed, and at last choose among 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 individuals. That is,

$$\begin{bmatrix} \alpha_i \\ \beta_i \end{bmatrix} = \begin{bmatrix} \alpha \\ \beta \end{bmatrix} + \Pi D_i, \tag{33}$$

where

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

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

$$u_{ijt} = \alpha_i y_i + \delta_{jt} + \mu_{ijt} + \epsilon_{ijt}, \tag{34}$$

where

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

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

$$s_{ijt} = \frac{\exp(\delta_{jt} + \mu_{ijt})}{\sum_{r=0}^{J} \exp(\delta_{rt} + \mu_{irt})}. \tag{35}$$

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

$$s_{jt} = \frac{1}{ns} \frac{\exp(\delta_{jt} + \mu_{ijt})}{\sum_{r=0}^{J} \exp(\delta_{rt} + \mu_{irt})}. \tag{36}$$

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

$$\min_{\alpha,\beta} ||S - s(p, X, D; \theta_1, \theta_2)|| \ ^{16} \tag{37}$$

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

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

5.4.3 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 mean utility, $\delta_{\cdot t}^{H}$, can be solved by computing the series

$$\delta_{\cdot t}^{h+1} = \delta_{\cdot t}^{h} + \ln S_{\cdot t} - \ln\left(s(\delta_{\cdot t}^{h};\theta_2)\right), \qquad h = 0, 1, ..., H, \tag{38}$$

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 the observed market share,$S_{\cdot t}$, and unknown coefficients, θ_2. Then the mean utility function is

$$\delta_{jt}(S_{\cdot t};\theta_2) = -\alpha p_{jt} + X_j\beta + \xi_{jt} \tag{39}$$

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

$$w_{jt} = \Delta\xi_{jt} \equiv \delta_{jt}(S_{\cdot t};\theta_2) - (-\alpha p_{jt} + x_{jt}\beta), \tag{40}$$

Then the moment condition is

$$E[Z'w(\theta)] = 0, \tag{41}$$

where Z consist of the exogenous regressors and Hausman instrumental variable. Then the GMM estimate is

$$\hat{\theta} = \operatorname*{argmin}_{\theta} w(\theta)'Z\Phi^{-1}Z'w(\theta), \tag{42}$$

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

Equation (??) 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,

$$\theta_1 = (X_L'Z\Phi^{-1}Z'X_L)^{-1}X_L'Z\Phi^{-1}Z'\delta(\theta_2). \tag{43}$$

Then equation (32) 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 (??). The starting point of θ_2 can be an arbitrary value.
- Perform the contraction mapping in equation (??) 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 (??) 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.
- Using search algorithm to find a new value for θ_2 in equation (??) 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 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 GMM objective function in step 5 is close enough to zero.

5.4.4 Demand Elasticities

Due to the function form of the market share equation (??), 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

$$\frac{\partial \hat{s}_{jt}}{\partial p_{rt}} = \begin{cases} -\frac{1}{ns}\sum_{i=1}^{ns}(\hat{\alpha}_i \hat{s}_{ijt}(1-\hat{s}_{ijt})) & if \quad j = r, \\ \frac{1}{ns}\sum_{i=1}^{ns}(\hat{\alpha}_i \hat{s}_{ijt}\hat{s}_{irk}) & if \quad j \neq r, \end{cases} \tag{44}$$

where

$$\hat{s}_{ijt} = \frac{\exp\left(\hat{\delta}_{jt} + \sum_k \sum_D \hat{\pi}_{kd} x_{jtk} D_{itd}\right)}{\sum_{r=0}^{J} \exp\left(\hat{\delta}_{rt} + \sum_k \sum_D \hat{\pi}_{kd} x_{rtk} D_{itd}\right)}. \tag{45}$$

Also, the demand elasticity is

$$\hat{\eta}_{irt} \equiv \frac{\partial \hat{s}_{jt}}{\partial p_{rt}} \cdot \frac{p_{rt}}{\hat{s}_{jt}} = \begin{cases} -\frac{p_{jt}}{\hat{s}_{jt}} \frac{1}{ns} \sum_{i=1}^{ns} (\hat{\alpha}_i \hat{s}_{ijt}(1 - \hat{s}_{ijt})) & if \quad j = r \\ \frac{p_{rt}}{\hat{s}_{jt}} \frac{1}{ns} \sum_{i=1}^{ns} (\hat{\alpha}_i \hat{s}_{ijt} \hat{s}_{irk}) & if \quad j \neq r \end{cases} \tag{46}$$

6 Results

6.1 Conditional Logit Results

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 5: Results from the Conditional Logit Model

	(1)	(2)	(3)	(4)	(5)	(6)
Price	-0.494	-0.527	-0.572	-0.822	-0.922	-1.448
	(0.018)	(0.018)	(0.021)	(0.018)	(0.018)	(0.031)
Package Size	0.457	0.460	0.450	-0.052	-0.060	-0.175
	(0.01)	(0.009)	(0.009)	(0.007)	(0.007)	(0.009)
Handle Price	0.096	-0.093	-0.096	-0.026	-0.022	-0.017
	(0.008)	(0.008)	(0.008)	(0.005)	(0.005)	(0.005)
Cartridge	0.276	0.153	0.318	1.704	1.680	1.907
	(0.063)	(0.027)	(0.064)	(0.040)	(0.038)	(0.041)
Blades = 4	0.117	0.153	0.178	—	—	—
	(0.027)	(0.027)	(0.028)	—	—	—
Blades = 5	1.608	1.670	1.737	—	—	—
	(0.035)	(0.034)	(0.038)	—	—	—
Schick	-1.488	-1.522	-1.560	—	—	—
	(0.025)	(0.025)	(0.026)	—	—	—
BiC	-0.724	-0.765	-0.813	—	—	—
	(0.030)	(0.030)	(0.032)	—	—	—
Dummies:						
Brand				✓	✓	✓
Time		✓	✓		✓	✓
Instruments			✓			✓
1st stage R^2	—	—	0.97	—	—	0.97
1st stage F-test	—	—	2920.53	—	—	489.11
Observations	11088	11088	11088	11088	11088	11088
R^2	0.60	0.61	0.61	0.86	0.87	0.99

Table (??) displays the results of the conditional logit model. Column (1) to (3) are according to specification (??), in which the independent variables consist of the observed product characteristics. The unobserved product characteristics are embedded in the structural error term. Column (2) introduces a time fixed effect to control for the trend and quarterly change of preference. Column (3) use the Hausman instrumental variables in a two-stage least squares regression. From column (1) to (3), the price coefficient increases from -0.494 to -0.572 as expected, which implies that the Hausman instruments alleviate the endogeneity caused by simultaneity problem.

Columns (4) to (6) are according to specification (??), in which a brand fixed effect is introduced to control for the unobserved product characteristics and all no market-invariant product characteristics are dropped. Comparing the price coefficients in column (1) to (3) with those in column (4) to (6), we find the effect of including brand dummies is significant, which implies that the brand fixed effect works well on controlling for the endogeneity caused by unobserved characteristics.

In column (6), all the coefficients have desirable signs. Thus, it is an appropriate benchmark to develop the BLP model.

6.2 BLP Results

6.2.1 Estimation

The specification of the BLP model is based on equation (??) which includes a brand fixed effect to control for the unobserved characteristics and interactions between product characteristics and individual demographics to allow for individual specific coefficients. The individual demographics are sampled from the March CPS. The price variable is instrumented by Hausman IV to control for the simultaneity problem.[17] The coefficient estimates are computed by the procedure discussed in Section (??).

Table (??) shows the estimates of the preference parameters of the BLP model. The preference means, denoted as α and β in equation (??), are presented in column

[17] The product characteristics variables and individual demographics variables have been discussed in section 5.3. The instrumental variables have been discussed in section 5.4.

Table 6: Results from the Full Model

Variable	Means	Individual deviations	
		Income	Hispanic
Price	-1.932	-0.464	—
	(0.272)	(0.070)	—
Package Size	-0.611	0.416	—
	(0.116)	(0.064)	—
Handle Price	-0.077	—	—
	(0.011)	—	—
Cartridge	3.055	—	—
	(0.253)	—	—
Blades = 4	—	0.249	0.983
	—	(0.127)	(0.292)
Blades = 5	—	1.753	3.640
	—	(0.206)	(0.386)

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

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

6.2.2 Elasticities

The market-specific demand elasticities are computed with the estimated coefficients and mean utilities by equation (??). Table (??) presents the median of these estimated elasticities over 616 markets for selected products. The cells in the diagonal of the first 8 rows indicate the own-elasticities of the selected brands, and other cells are 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.

Table 7: 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

6.2.3 Markups

The market-specific price-cost markups are computed with the estimated coefficients and mean utilities by equation (??). Table (??) presents the medians over 616 markets for the brands which have both disposable razor and non-disposable system. We find, for all of these four brands, the markups of disposable razors are higher than the markups of cartridges. Gillette earned 59% more profit from a "Mach 3" disposable razor than from a cartridge of the same brand. It increases to 115% for "Fusion". However, the differences of Gillette's brands are much larger than those of Schick's brands. The average markup difference of Gillette's brands is 0.48, while it is 0.08 for Schick.

Table 8: Median Markups

		Disposable	Cartridge	Diff.
Gillette's				
	Mach 3	0.81	0.51	0.30
	Fusion	1.16	0.54	0.62
Schick's				
	Quattro	0.55	0.43	0.12
	Hydro 5	0.43	0.38	0.05

6.2.4 Measure of Price Discrimination

As discussed above, the price of a disposable razor can be viewed as the price when a firm sells shave service by linear pricing strategy. Thus, if a firm also prices a cartridge by linear pricing strategy, the prices of disposable razor and cartridge should be close with each other. Moreover, as Table (??) shows, the coefficient estimate of cartridge dummy is 3.055, which means a firm can ask higher price for a cartridge than a disposable razor of the same brand. In other words, if the firm does not implement two-part tariff, 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 intentionally lowers down its cartridge price on the purpose of implementing two-part tariff.

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

$$\text{Ratio} = \frac{\text{Markup}_{\text{disposable}} - \text{Markup}_{\text{cartridge}}}{\text{Price}_{\text{disposable}} - \text{Price}_{\text{cartridge}}} \tag{47}$$

This ratio evaluates the extent to which price difference is drove by markup difference. The result shows, on average, over 90% of price difference of Gillette's brands can be explained by markup difference.

This conclusion can be strengthened by comparing the ratio of Gillette's brands and Schick's brands. As discussed, a firm can implement two-part tariff only if it has market power. Since the razor market is dominated by Gillette, other firms should not use two-part tariff strategy. Thus, for any brand made by the rest firms in this market, the ratio calculated with equation (??) 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 two-part tariff pricing strategy in men's shaving razor market.

7 Conclusion

This paper uses a random-coefficient logit model to estimate the demand system of men's razors with market level sales data in the United States between 2015 to 2016. The estimates are used to calculate the price-cost markups of each products. The result shows that: First, the markup of cartridges are lower than the disposable razors of the same brands. Second, the markup difference can contribute a large fraction of price difference of Gillette's brands. Last, the ratio of markup difference to price difference of Gillette's brands is much higher than that of Schick's brands. This evidence is consistent with the prediction of two-part tariff theory. In other words, it comes to a conclusion that Gillette is using two-part tariff strategy in this market.

This conclusion can be generalized as that a tie-in sale can be used to implementing two-part tariff, or inversely, the two-part tariff can take the form of tie-in sale.

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