ABSTRACT

Title of dissertation: MERGER EFFICIENCIES IN THE U.S. BOTTLED WATER INDUSTRY

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This dissertation contributes to the literature concerning horizontal merger efficiencies and non-price competition in merger analysis. It focuses on the U.S. premium bottled water industry, where manufacturers face both price and non-price competitions. Chapter 1 gives an overview of this dissertation and chapter 2 to chapter 4 are three papers that the dissertation features.

In chapter 2, I study the market power and marginal cost efficiency that was created following the merger of Coca-Cola and Glaceau in the U.S. premium bottled water market by assuming a vertical relationship between upstream manufactures and downstream retailers. In this framework, bottled water manufacturers are assumed to compete solely in prices and product attributes are exogenous. My supply-side model allows for a merger efficiency on Glaceau products by including an indicator for Glaceau products post-merger in the marginal cost function. With counterfactual simulations based on the demand and supply-side estimates, I show

the merger has limited impacts on market power while marginal cost efficiency plays an important role in affecting the equilibrium prices and market shares post-merger.

In chapter 3, I develop a conceptual framework by extending the vertical relation in chapter 2 to incorporate multi-dimension non-price competitions. This conceptual framework can be applied to consumer good industries with both price and non-price competitions. In this chapter, I provide a detailed description of model derivations, estimation strategies, and counterfactual simulations.

In chapter 4, I apply the framework developed in chapter 3 to the merger of Coca-Cola and Glaceau and explore how horizontal merger efficiencies affect the equilibrium market outcomes considering both price and non-price competitions. To understand the underlying mechanisms that rationalize Glaceau's significant boosts in market shares, product varieties, and advertising expenditures post-merger, I estimate a structural demand and supply model where manufacturers choose wholesale prices, product varieties, and advertising, and I allow for several types of efficiencies on Glaceau. With counterfactual simulations, I show how marginal cost, product variety fixed cost, and advertising fixed cost efficiencies affect equilibrium market outcomes and consumer welfares.

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by

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Dedication

To my family, friends, and mentors.

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Chapter 1: Overview

This dissertation features three papers exploring the effects of horizontal merger efficiencies on equilibrium market outcomes and consumer welfares in the U.S. bottled water industry. Horizontal mergers are prevalent economic activities across many industries, which may have significant effects on the market structure, competition, and consumer welfares. Most existing empirical studies in horizontal merger focus exclusively on unilateral effects of differentiated products, and little work has been done examining the effects of horizontal merger on synergies or efficiencies. Without merger efficiencies, the horizontal merger is prone to increase market power and thus increases prices and reduces outputs, which may significantly lessen competition and impair consumer welfares. Considering merger synergies or efficiencies, merging parties can share technology, patents, management, labor, distribution network and business partnership with each other and thus reduced relative marginal cost and fixed costs. In this case, reduced cost via merger efficiencies allows the merging parties to lower prices after the merger, which strengthens competition and is beneficial to the consumer. The co-existence of market power and merger efficiency makes horizontal merger analysis complicated since they affect prices in opposite directions. With non-price competition, market power and merger efficiency affect both price and non-price factors, such as product quality, product variety, innovation, service level, and advertising intensity. In this dissertation, focusing on the merger of Coca-Cola and Glaceau (manufacturer of Vitaminwater and Smartwater) in the U.S. bottled water industry, I investigate how market power, merger efficiencies, and non-price competition play roles in affecting equilibrium market outcomes and consumer welfares.

The paper in chapter 2 investigates how marginal cost efficiency plays a role in affecting equilibrium prices, market shares, and consumer welfares. In this chapter, I focus on the "trade-off" effect between market power and marginal cost efficiency after the merger of Coca-Cola and Glaceau, and assume a Nash-Bertrand competition between premium bottled water manufacturers. I use the standard random coefficient logit model (e.g. Berry et al. (1995), BLP hereafter; Nevo (2000)) to estimate consumer demand, and the estimation results suggest that the premium bottled water products are highly differentiated. My supply-side model follows Villas-Boas (2007)'s approach by incorporating a vertical relationship between upstream manufacturers and downstream retailers. To capture the merger efficiency on Glaceau post-merger, I include an indicator for Glaceau products in the marginal cost function in post-merger periods. My supply-side estimates suggest the merger on average reduced the marginal cost of Vitaminwater products by 4.4%-5.3%. I implement several counterfactual scenarios to identify the effects of merger on market power and marginal cost efficiency. I find the merger has limited impacts on market power while marginal cost efficiency plays an important role in affecting equilibrium prices and market shares. In particular, I find the marginal cost efficiency explains about 20% of the market share boosts in Glaceau products in 2009 compared to the "no merger" baseline.

The second paper in chapter 3 develops a conceptual framework which incorporates consumer demand, retailer's pricing, and manufacturer's price and non-price competitions. This conceptual framework can be applied to industries with the vertical structure between upstream manufacturers and downstream retailers that face both price and no-price competitions. The demand-side model extends the random coefficient logit framework (BLP) by incorporating endogenous product attributes. This setting is similar to Fan (2013)'s framework and I allow endogenous product attributes to affect consumer utility nonlinearly. The supply-side model builds on Villas-Boas (2007)'s framework and I extend the model by allowing manufacturers to choose endogenous product attributes in addition to wholesale prices when maximizing profits. In this chapter, I provide a detailed description of model derivations, estimation strategies, and counterfactual simulations.

The final paper in chapter 4 applies the framework developed in chapter 3 to the U.S. premium bottled water industry. In this paper, I investigate how horizontal merger efficiencies affect equilibrium market outcomes considering both price and non-price competitions. Focusing on a recent merger of Coca-Cola and Glaceau, which is the manufacturer of Vitaminwater and Smartwater in the U.S. premium bottled water market, I quantify efficiencies that were created following the merger between those two manufacturers. To understand the underlying mechanisms that rationalize Glaceau's significant boosts in market shares, product varieties, and advertising expenditures post-merger, I estimate a structural demand and supply model where manufacturers choose wholesale prices, product varieties, and advertising, and I allow for several types of efficiencies. With counterfactual simulations, I show how marginal cost, product variety fixed cost, and advertising fixed cost efficiencies affected equilibrium market outcomes. My results suggest that in a highly differentiated industry with competitions in multiple dimensions, the horizontal merger which appears to be "bad" may turn out to be "good" through efficiency gains, without hurting other competitors and consumers.

Chapter 2: Market Power and Merger Efficiency: A Case in the U.S. Bottled Water Industry

2.1 Introduction

Corporate mergers and acquisitions are important and prevalent phenomena in the modern economy. Mergers may increase market power, but they can also create significant benefits for consumers. There are a number of empirical research papers that focus exclusively on the unilateral effects of the horizontal merger through internalizing sales of differentiated products produced by the merging parties (e.g. Berry and Pakes (1993); Nevo (2000)), or the increased market power post-merger (e.g. Kim and Singal (1993); Nevo (2001); Capps et al. (2003)). However, little work has been done examining the effects of horizontal merger on efficiencies (Whinston (2003)), or to empirically evaluate the trade-offs between market power and merger efficiencies.

This paper studies the economic effects of the horizontal merger of Coca-Cola

Researcher(s) own analyses calculated (or derived) based in part on data from The Nielsen Company (US), LLC and marketing databases provided through the Nielsen Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the Nielsen data are those of the researcher(s) and do not reflect the views of Nielsen. Nielsen is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

and Glaceau in the U.S. premium bottled water industry. In May 2007, Coca-Cola announced its proposed acquisition of Glaceau which is the manufacturer of Vitaminwater and Smartwater for over $4 billion. This proposed merger was quickly approved by the U.S. antitrust agencies without any anticompetitive concerns. By 2011, one of Glaceau's flagship brands, Vitaminwater, increased annual revenues from $350 million to more than $1 billion (INVESTOPEDIA (2015)). [1] With retailer scanner data, I find that after the merger the market shares of Glaceau brands (Vitaminwater and Smartwater) increased significantly in many U.S. regions, while price variations were quite similar to other flavored brands. These observed post-merger market outcomes contrast with the existing literature that suggests horizontal mergers tend to be "bad" by increasing market power, thus hurting consumers. In addition, I find the retail prices of Vitaminwater decreased slightly in the post-merger period, suggesting plausible merger synergies or efficiencies on Glaceau products.

To evaluate the market power and synergies or efficiencies that were created after the merger, I develop a structural model of demand and supply that allows for post-merger efficiency change in marginal cost for Glaceau products. My research focus is on premium bottled water products which include top-sale spring water, purified water, and enhanced water in the U.S. market. For the consumer demand estimation, following the existing literature such as Nevo (2000), Villas-Boas (2007), and Bonnet and Dubois (2010), I use a discrete choice random coefficient model de-

[1] `https://www.investopedia.com/articles/markets/081315/vitaminwater-has-been-cocacolas-best-purchase.asp`.

veloped by Berry et al. (1995), henceforth BLP, to estimate consumer substitution patterns with heterogeneous tastes for each product. Consistent with the related literature in the bottled water industry, the demand estimates imply small substitution effects between bottled water products within the choice set (e.g. Bonnet and Dubois (2010)). In addition, I find bottled water consumers are more likely to switch to cheap outside choices when facing a price increase, suggesting that premium products are highly differentiated, and Glaceau's increases in market shares after the merger were largely from cheap outside products.

The supply model involves the vertical relationship between upstream manufacturers and downstream retailers. The pricing games between manufacturers and retailers yield two-stages. In the first stage, I assume that bottled water manufacturers choose wholesale prices in each market knowing that retailers will respond based on their choices. In the second stage, a monopolist retailer chooses corresponding retail prices given manufacturers' optimal choices for wholesale prices. Following Ellickson et al. (2017), I assume retailers incur no marginal cost or fixed cost of retailing. To back-out manufacturers' price-cost margins with limited data, I apply Villas-Boas (2007)'s approach which recovers manufacturers' price-cost margins from retailer's optimal pricing given consumers' substitution patterns from the demand estimates. To capture the merger synergies or efficiencies on Glaceau products post-merger, I include an indicator for Glaceau products in the marginal cost function in the post-merger period. The supply-side estimates suggest the merger created efficiencies for Glaceau in reducing the marginal cost post-merger. In particular, I find that the merger reduced Glaceau's marginal cost by 6.04 cents per liter on average comparing to its pre-merger marginal cost on average, controlling for time and region fixed effects.

With both demand and supply estimates, I conduct several counterfactual simulations to separately identify the effects of market power and efficiency on market outcomes: (i) the merger of Coca-Cola and Glaceau does not occur; (ii) the merger occurs with only unilateral effect; (iii) the merger occurs with both unilateral effect and marginal cost efficiency (real data). I find a limited increase in market power post-merger comparing to the "no merger" baseline, while marginal cost efficiency plays a significant role in reducing prices. In particular, for the year 2009, I find compared to the "no merger" baseline, the merger with observed data (1) reduces Glaceau's retail prices by about 3.8%-5.3%, and (2) boosts Glaceau's market shares by 17.9%-15.7%. Additionally, the merger increases consumer surplus by 13.5% compared to the "no merger" baseline. Without marginal cost efficiency, my counterfactual simulations suggest the merger would not only increase prices for the merging party but also decrease consumer surplus.

This paper contributes to several aspects of the literature on horizontal merger analysis. First, it contributes to the literature on market power and price competition. For example, focusing on the airline industry, Kim and Singal (1993) study the effect of merger on airline fares and find that merging airlines raised fares significantly on routes they serve compared to other routes. Nevo (2001) measures the market power in the ready-to-eat cereal industry. This paper concentrates on the premium bottled water industry and empirically measures the market power changes after a merger.

Second, this study relates to literature on horizontal merger efficiency. Dating back to the 1960s, Williamson (1968) proposes a framework to evaluate the welfare trade-off between efficiency gains and prices increases when conducting merger analysis. Ashenfelter et al. (2015) study the Miller-Coors joint venture in the U.S. beer industry and assess the effects of increased market concentration and efficiencies on pricing. Considering the ready-mix concrete industry, Kulick (2017) investigates cost efficiencies of horizontal mergers among concrete plants in the U.S. Building on these studies, this paper quantifies the marginal cost efficiency and market power of a horizontal merger between two bottled water manufacturers.

At last, this study relates to the strand of literature that considers vertical relationships between upstream manufacturers and downstream retailers. Villas-Boas (2007) develops a feasible framework to recover yogurt manufacturers' price-cost margins when data of wholesale prices are not available. Gayle (2013) extends this vertical framework to the airline fare market and explores the efficiency of code-share contracts between airlines. Ellickson et al. (2017) apply the vertical framework to the single-serve-brew coffee market and study how bilateral bargaining between manufacturers and retails would affect retail profitability on private labels. In terms of industry, the closest study to this paper is Bonnet and Dubois (2010), which focuses on the double marginalization of manufacturers and retailers in the French bottled water market.

2.2 Industrial Background

As is the case for most consumer product industries, bottled water manufacturers compete primarily in prices. There exists a vertical structure between upstream bottled water manufacturers and downstream retailers in which manufacturers decide wholesale prices and retailers choose corresponding retail prices. The bottled water sector in the U.S. is highly concentrated. Nestle, Pepsi, Coca-Coca, and retailers' own brands account for the more than 80% of the total market shares. Bottled water products are further classified as purified, spring, imported, and flavored water products based on water sources and ingredients. In terms of unit price, bottled water brands can be categorized as "premium" brand and "cheap brand". Bottled water of premium brand is normally sold as a single-bottle or small packs with much higher per-unit prices compared to other products. The premium brands include imported and enhanced water brands. Bottled water of cheap brand is sold either as big packs or in large containers, and constitutes the majority of bottled water market shares.

2.3 Data Sources

My primary data source is the Nielsen Retailer Scanner Data which covers the sample period from January 2006 to December 2009. The data include retail prices and unit sales by UPC code on a weekly basis for a sample of grocery stores, convenience stores, drug stores, large merchandisers and liquor stores. Focusing on

10 top-sale premium bottled water brands, I restrict the estimation samples to 52 grocery retailer chains in 92 distinct geographic regions. According to the Nielsen Company, a geographic region is defined as the Designated Market Area (DMA), which includes one or more metropolitan areas within a certain distance. To reduce estimation bias, my estimation samples only include DMA regions with at least two grocery chains in the Nielsen data. Grocery chains in a given DMA region often operate a few hundred individual stores respectively and many of them also operate business in adjacent regions. For the retail industry, pricing and promotion decisions are normally made at the region-chain level, which allows me to define the market as a region-retailer pair. This market definition is the same as Ellickson et al. (2017) who study the U.S. single-serve-brew coffee industry.

The bottled water brands of this paper come from the Nielsen classification of "Water-Bottled", which excludes carbonated and energy beverages. I collect top-sale bottled water brands within this Nielsen category and further classify these brands into premium and cheap brands based on their per-unit prices. On average, in a region-retailer pair market, each retailer's own water brand takes up to one third of the total market shares. For national brands, Nestle accounts for about 30% of the market shares and focuses on cheap products with either big-packs or large containers. Pepsi and Coca-Cola have both flavored and non-flavored water brands, and their products account for about 9% and 10% of the total bottled water market shares respectively.

The basic unit of study is the brand-package level and I aggregate all UPC code level data to the brand-package level. Moreover, I classify products of the same brand into 2 groups: single-pack and multi-pack. So for each brand, I have two "products" as the basic unit of study. The focus of this study is on the premium water brands so I include 10 top-sale premium bottled water brands in the choice set and treat other brands as outside options. [2] Aggregating week-level data to month-level yields 146,107 sample observations at the region-chain-product-month-year level over 2006-2009.[3] To capture consumer heterogeneity and improve demand estimation, I include household demographics from the Nielsen Household Panel as supplementary data source. In particular, for each year and DMA region, I randomly select 50 households and record their household income for later use.

2.3.1 Retail Prices and Market Shares

Figure 1 presents the average retail prices of 3 flavored water brands, Vitaminwater, Propel, and Fruit2O over 2006 to 2009. The trends in the figure are calculated at the region-retailer level, which measure the average prices of these 3 brands in a representative regional retailer. The vertical red line at July 2007 signifies the time when the merger of Coca-Cola and Glaceau is completed. As suggested in the figure, all 3 flavored brands have similar small downward sloping time trends in retail prices over time, suggesting prices of flavored water are declining steadily over time. I find the price of Vitaminwater fluctuates more than other brands.

Figure 2 plots the average market shares of Vitaminwater, Propel, and Fruit2O

[2] I find Dasani's unit prices differ significantly across package and container sizes. For single bottle products with container size less than 1 liter, the unit price of Dasani is almost 3 times higher than products with larger container or multi-packs. Thus I exclude multi-pack and big-container Dasani from the premium bottled water category. In the rest of this paper, "Dasani" means single bottle Dasani products which belong to the premium water category based on unit price.

[3] Product and brand-package pair are used interchangeably.

over 2006 to 2009. It is obvious that the market share of Vitaminwater increases significantly in the post-merger period. However, the market shares of Propel and Fruit2O don't increase even though these 2 brands have similar declining price trends with Vitaminwater. In particular, the market share of Fruit2O reduces in the post-merger period. It seems the increase in Vitaminwater shares after the merger is due to price effect, but for flavored brands, Fruit2O and Propel, price effects are not significant in affecting shares. It is possible that consumers of Vitaminwater are more price elastic than consumers of other flavored brands, and consumer substitution patterns play roles in affecting equilibrium market shares when facing price drops in several brands.

2.4 Consumer Demand

2.4.1 Demand Model

For the demand estimation, I use the random coefficient logit model developed by BLP. Suppose in a given market r and time period t, each individual consumer i can purchase product j from a set of consumer products G_J or choose an outside option. The utility that consumer i receives from purchasing product j (brand-package) in market r at time t is given by:

$$u_{ijrt} = \alpha_i p_{jrt} + \beta_i X_{jrt} + \xi_{jrt} + \epsilon_{ijrt} \tag{2.1}$$

where X_{jrt} includes a set of observable product attributes and region and time fixed effects, and p_{jrt} denotes the observable retail price. ξ_{jrt} is the unobserved product attributes or quality valuations specific to market r at time t, and ϵ_{ijrt} is a consumer specific stochastic term.

Most bottled water products contain no obvious attributes but "water", which makes it difficult to include specific product attributes in the model. To address this issue, I use the same approach of Nevo (2000) and Bonnet and Dubois (2010) who use product fixed effects to capture the time-invariant product attributes. In order to capture each consumer's heterogeneous tastes for different products, I allow coefficients of some variables to be varying across the local population by interacting them with household income draws

$$[\alpha_i, \beta_i] = [\bar{\alpha}, \bar{\beta}] + \Pi I_i^{\text{inc}} \tag{2.2}$$

where I_i^{inc} denotes per-capita household income of household or consumer i, $\bar{\alpha}$ and $\bar{\beta}$ are the mean effects across population.[4] The indirect utility function defined above can be further decomposed into a constant part $\delta_{jrt}(p_{jrt}, X_{jrt}, \xi_{jrt}; \bar{\alpha}, \bar{\beta})$, plus a random part $\mu_{ijrt}(p_{jrt}, X_{jrt}, I_i^{\text{inc}}; \Pi)$ such that

$$u_{ijrt} = \delta_{jrt} + \mu_{ijrt} + \epsilon_{ijrt}. \tag{2.3}$$

The first term, $\delta_{jrt} = \bar{\alpha}p_{jrt} + \bar{\beta}X_{jrt} + \xi_{jrt}$ represents the mean utility of purchasing

[4]For each DMA region, I take 50 draws of household income, and allow these income draws to be correlated with the price coefficient.

product j in market r at time t across all consumers, and the second term, μ_{ijrt} represents the consumer-specific taste deviations from the mean.

For simplicity, I normalize the mean utility of purchasing outside good to zero. The idiosyncratic error terms ϵ_{ijrt} are assumed to be *iid* draws from the Type I extreme value distribution. For a given market r with J products in the choice set G_J, the market share of product j at time t can be calculated analytically as follows:

$$S_{jrt} = \int \frac{\exp(\delta_{jrt} + \mu_{ijrt})}{1 + \sum_{c=1}^{J} \exp(\delta_{crt} + \mu_{icrt})} dF(I^{\text{inc}}), \tag{2.4}$$

where $F(.)$ is a cumulative distribution function of consumer income.

2.4.2 Demand Estimation

The random coefficient demand model is estimated by the fixed point algorithm developed proposed by BLP via the generalized method of moments (GMM). As suggested by existing literature, it is necessary to use appropriate instrumental variables to reduce estimation bias since retail prices may be correlated with unobserved product attributes and demand shocks. BLP suggest a set of instruments which are measures of isolation in product space and include the summation of (i) product attributes of other products by the same manufacturer in the same market, and (ii) product attributes of other products produced by other manufacturers in the same market. Hausman (1996) and Nevo (2000) use the so-called Hausman type of instruments which are prices in other markets. Cost shifters such as input prices and wage rates are also widely used in related empirical studies. In this paper, in addition to the BLP type instruments, I include instrumental variables that share features of both Hausman type and cost shifter type instruments. Particularly, for each given market, I use the retail prices in the 3 geographically nearest markets of other states as instrumental variables.

Table 1 presents partial results of demand estimation for logit and random coefficient logit models. The logit demand model is a simplified version of random coefficient model which restricts all nonlinear demand parameters to be zeros. It can be estimated easily with a two stage least square approach (2SLS) with appropriate instrumental variables. For the random coefficient model, I allow per-capita household income to be correlated with consumer's preference for price, the constant term, and package size (multi-pack dummy). To better identify nonlinear parameters, I create additional instrumental variables by interacting the average income across individuals with the mean price of the three geographically nearest regions, the constant, and package size. Regression observations are at the brand-package-region-month-year level and both models contain product, region, and time fixed effects. The mean price coefficient is -2.140 and -2.408 for the logit model and random coefficient model respectively, suggesting a downward sloping demand function under both specifications. [5] The mean own-price elasticities from both models are close in magnitude and random coefficient logit model yields a more elastic demand function.

[5]The mean price coefficient (-2.408) of RCL is calculated as $\frac{1}{NM}\sum_{r=1}^{M}\sum_{i=1}^{N}(\alpha+\Pi_{\text{price}}I_{ir}^{\text{inc}}p_{jr})$, where subscripts i,j, and r denote individual draw, product, and market. N and M represents the number of draws of each market and the total number of markets in the estimation sample. I also find all consumer-specific price coefficients α_i are negative for all sample observations and individual consumer draws.

Table 2 and table 3 present the mean own-price and cross-price elasticities across 16 premium bottled water products. On average, consumers are less price elastic to cheaper products, such as Aquafina Splash and Fruit2O, and more price elastic to more expensive products, such as Vitaminwater. For example, a 1% decrease in the price of multi-pack Fruit2O will increase its demand by about 2.6%, but the same proportion of price reduction in Vitaminwater will boost Vitaminwater's demand by more than 4%. The demand-side estimates are consistent with Miller and Weinberg (2017) who suggest own-price elasticities tend to be higher for more expensive products in their analysis of price substitution patterns among beers. I show that cross-price elasticities of bottled water products are relative small in magnitude, which are consistent with findings of Bonnet and Dubois (2010), who estimate bottled water demand in French market.

Tables 4 and 5 show the diversion ratios of inside and outside bottled water products. The diversion ratio measures the fraction of consumers that substitute from one product to the other after a price increase. For differentiated products with Bertrand competition, any two of them are highly differentiated or substitutable if the diversion ratio between them is low. Following Conlon and Mortimer (2018), I define the diagonal elements as the diversion to the outside good rather than -1. According to the definition, if all products are substitutes and consumers make discrete choices, each row of the diversion matrix must sum to one. Each row j in table 4 represents the diversion ratios of product j's lost shares to different products when product j increases price. For example, single-bottle Evian's diversion to the outside good and single-bottle Dasani are 95.98% and 0.28% respectively, which means when Evian increases its price by 1%, about 96% of Evian's lost shares go to outside products and only about 0.3% of Evian's lost shares go to single-bottle Dasani. I find the diversion ratios to the outside good are very large in magnitude, which echoes the cross-price elasticities reported in tables 2 and 3 that inside premium bottled water products are highly differentiated.

2.5 Supply

2.5.1 Retailers' Pricing

Following Villas-Boas (2007) and Ellickson et al. (2017), I assume the supply model yields two stages where upstream manufacturers choose wholesale prices in the first stage and downstream retailers choose corresponding retail prices in the second stage given manufacturers' choices. [6] This two-stage game can be solved backward starting from retailer's pricing decisions. Similar to Ellickson et al. (2017), I assume that retailers carry no marginal cost of retailing and are monopolists in each market (region-chain pair). Thus a monopolist retailer's profit in market r at time t is

$$\Pi_{rt}^{R} = \sum_{c \in G_{rt}} M_{rt}(p_{rct}^{R} - p_{rct}^{W})S_{rct}, \tag{2.5}$$

where G_{rt} is the set of products that retailer R sells in market r at time t, M_{rt} denotes the market size, S_{rct} is the market share of product c in market r at time t, p_{rct}^{R} is retail price of product c set by retailer R, and p_{rct}^{W} denotes the wholesale

[6] Villas-Boas (2007) assumes Nash-Betrand competition among oligopolist retailers while Ellickson et al. (2017) retailers are monopolists

price of product c set by the manufacturer. [7] Taking first-order derivatives of the retailer's profit function with respect to product j's retail price yields J first order conditions:

$$S_{jrt} + \sum_{c \in G_{rt}} [p^R_{crt} - p^W_{crt}] \frac{\partial S_{crt}}{\partial p_{jrt}} = 0. \tag{2.6}$$

Following Villas-Boas (2007), define $\boldsymbol{\Omega}^R_{rt}$ as retailer R's response matrix, which contains the first order derivatives of product shares with respect to all retail prices in market r at time t

$$\boldsymbol{\Omega}^R_{rt} = \begin{pmatrix} \frac{\partial S_{1rt}}{\partial p^R_{1rt}} & \frac{\partial S_{2rt}}{\partial p^R_{1rt}} & \dots & \frac{\partial S_{Jrt}}{\partial p^R_{1rt}} \\ \frac{\partial S_{1rt}}{\partial p^R_{2rt}} & \frac{\partial S_{2rt}}{\partial p^R_{2rt}} & \dots & \frac{\partial S_{Jrt}}{\partial p^R_{2rt}} \\ \vdots & & \ddots & \vdots \\ \frac{\partial S_{1rt}}{\partial p^R_{Jrt}} & \frac{\partial S_{2rt}}{\partial p^R_{Jrt}} & \dots & \frac{\partial S_{Jrt}}{\partial p^R_{Jrt}} \end{pmatrix}. \tag{2.7}$$

Stacking the first order conditions above and rearranging them yields a $J \times 1$ vector of monopolist retailer's price-cost margins [8]

$$\boldsymbol{p}^R_{rt} - \boldsymbol{p}^W_{rt} = -\boldsymbol{\Omega}^R_{rt}(\boldsymbol{p}_{rt})^{-1}\boldsymbol{S}_{rt}. \tag{2.8}$$

Using the monopolist retailer's pricing equation in (2.8), manufacturers' wholesale prices $\boldsymbol{p}^W_{rt}$ can be computed from demand estimates, observed market shares, and retail prices.

[7] I assume market size M_{rt} of market r is constant in a given year, and it is 10% greater than the maximum observed sales among bottled water category within each market. This definition of market size is similar to Miller and Weinberg (2017) who look at the U.S. beer industry.

[8] Vectors and matrices are denoted as bold symbols in the remaining of this paper.

2.5.2 Manufacturers' Pricing

In the first stage of game, each manufacturer chooses wholesale prices with full information about how these decisions would affect the optimal behaviors of rival manufacturers and the downstream retailer. In particular, the first order conditions in equation (2.8) implicitly define equilibrium retail prices as a function of wholesale prices

$$\boldsymbol{p}_{rt}^{R^*} = p^{R^*}(\boldsymbol{p}_{rt}^{W}). \tag{2.9}$$

Similarly, the equilibrium market shares can be written as a function of manufacturers' wholesale prices

$$\boldsymbol{S}_{rt}^{*} = S^{*}(p^{R^*}(\boldsymbol{p}_{rt}^{W})). \tag{2.10}$$

Equation (2.10) suggests that manufacturers' wholesale prices affect equilibrium market shares indirectly through retailer's best responses.

Suppose manufacturer m offers a bundle of products G_{rm}, which contains N_m products in a market r to a monopolist retailer at time t. Then manufacturer m's profit function is defined as

$$\Pi_{rt}^{m} = \sum_{j \in G_{rm}} M_{rt}(p_{jrt}^{W} - c_{jrt}^{W}) S_{jrt}(\boldsymbol{p}_{rt}), \tag{2.11}$$

where c_{jrt}^{W} represents the marginal cost of producing, shipping and distributing product j to market r at time t. I assume that the marginal cost is different across products. Following Grennan (2013) and Miller and Weinberg (2017), I parameterize marginal cost as linear function of explanatory variables:

$$c_{jrt}^{w} = \Psi_j + \gamma_r + \eta_t + \omega_{jrt}, \tag{2.12}$$

where Ψ_j denotes the fixed effect of producing product j, γ_r and η_t are sets of region-specific and period-specific fixed effects, and ω_{jrt} is unobservable cost shifters.

To capture the merger efficiency or synergy on Glaceau products post-merger, I include an indicator $\mathbb{1}\{\text{Glaceau Post-Merger}\}$ for Glaceau products n the marginal cost function in the post-merger period, thus the fixed effect of producing product j can be re-written as

$$\Psi_j = \Psi_j^0 + \Psi_{\text{Glaceau}}^{\text{post}} \times \mathbb{1}\{\text{Glaceau Post-Merger}\}. \tag{2.13}$$

where Ψ_j^0 measures the average baseline production and distribution cost for product j, and $\Psi_{\text{Glaceau}}^{\text{post}}$ measures Glaceau's cost changes post-merger.

The manufacturer's profit can be derived as a function of its wholesale prices $\boldsymbol{p}_{rt}^{W}$ by replacing market share with the right-hand side of equation (2.10)

$$\Pi_{rt}^{m} = \sum_{j \in G_{rm}} M_{rt}(p_{jrt}^{W} - c_{jrt}^{W}) S_{jrt}^{*}(p^{R^*}(\boldsymbol{p}_{rt}^{W})). \tag{2.14}$$

With manufacturer's profit function specified above and knowing that retailers behave according to equation (2.8), the manufacturer's optimal pricing decisions will be acquired by taking the first order derivatives with respect to wholesale prices. By assuming Bertrand competition and a pure-strategy Nash equilibrium, the J

first-order conditions are:

$$\sum_{c \in G_{rm}} [p^W_{crt} - c^W_{crt}] \frac{\partial S^*_{crt}}{\partial p^W_{jrt}} + S_{jrt} = 0, \quad \forall j \in G_{rm}. \tag{2.15}$$

The supply model incorporates the vertical relationship between upstream manufacturers and downstream retailers, and each manufacturer anticipates how changes in wholesale prices would affect retail price and therefore change consumer demand. Thus for market r at time t, the effect of wholesale price of product j on the market share of product c can be expressed as

$$\frac{\partial S^*_{crt}}{\partial p^W_{jrt}} = \left[\frac{\partial S_{crt}}{\partial p^R_{1rt}} \frac{\partial p^R_{1rt}}{\partial p^W_{jrt}} + \frac{\partial S_{crt}}{\partial p^R_{2rt}} \frac{\partial p^R_{2rt}}{\partial p^W_{jrt}} + ... + \frac{\partial S_{crt}}{\partial p^R_{Jrt}} \frac{\partial p^R_{Jrt}}{\partial p^W_{jrt}} \right]. \tag{2.16}$$

where $\frac{\partial p^R_{crt}}{\partial p^W_{jrt}}$ denotes product j's wholesale price pass-though to product c's retail price. This formula suggests that a change in product j's wholesale price affects product c's demand indirectly through the impact on the equilibrium retail prices for all products in the game. Define $\mathbf{\Delta}^W_{rt}$ as the manufacturer's response matrix in market r at time t whose general elements equal to the left-hand side of equation (2.16)

$$\mathbf{\Delta}^W_{rt} = \begin{pmatrix} \frac{\partial S^*_{1rt}}{\partial p^W_{1rt}} & \frac{\partial S^*_{2rt}}{\partial p^W_{1rt}} & \cdots & \frac{\partial S^*_{Jrt}}{\partial p^W_{1rt}} \\ \frac{\partial S^*_{1rt}}{\partial p^W_{2rt}} & \frac{\partial S^*_{2rt}}{\partial p^W_{2rt}} & \cdots & \frac{\partial S^*_{Jrt}}{\partial p^W_{2rt}} \\ \vdots & & \ddots & \vdots \\ \frac{\partial S^*_{1rt}}{\partial p^W_{Jrt}} & \frac{\partial S^*_{2rt}}{\partial p^W_{Jrt}} & \cdots & \frac{\partial S^*_{Jrt}}{\partial p^W_{Jrt}} \end{pmatrix}. \tag{2.17}$$

The system of J by 1 first order conditions can be expressed in matrix form as

$$\boldsymbol{p}_{rt}^{W} - \boldsymbol{c}_{rt}^{W} = -(\boldsymbol{T}_{rt} * \boldsymbol{\Delta}_{rt}^{W})^{-1}\boldsymbol{S}_{rt}, \tag{2.18}$$

where $\boldsymbol{T}_{rt}$ is a J by J matrix which describes manufacturers' ownership for J products in market r at time t. Specifically, $\boldsymbol{T}_{rt}(j,c) = 1$ if products j and c are produced by the same manufacturer, $\boldsymbol{T}_{rt}(j,c) = 0$, otherwise. "$*$" represents the element by element multiplication of two matrices. In practice, to reduce computation complexity, manufacturer's response matrix $\boldsymbol{\Delta}_{rt}^{W}$ can be decomposed as the multiplication of two matrices

$$\boldsymbol{\Delta}_{rt}^{W} = \boldsymbol{\Delta}_{rt}^{p^{T}}\boldsymbol{\Omega}_{rt}^{R}. \tag{2.19}$$

Matrix $\boldsymbol{\Delta}_{rt}^{p}$ describes each product's wholesale price pass-though to retail prices of all products, whose general elements are $\boldsymbol{\Delta}_{rt}^{p}(j,c) = \frac{\partial p_{crt}^{R}}{\partial p_{jrt}^{W}}$. $\boldsymbol{\Delta}_{rt}^{p}$ can be computed analytically and detailed derivations are presented in the appendix.

To derive the supply-side estimation equation, let's first add equation (2.8) to equation (2.18) to obtain the equation as follows

$$\boldsymbol{p}_{rt}^{R} - \boldsymbol{c}_{rt}^{W} = -(\boldsymbol{T}_{rt} * \boldsymbol{\Delta}_{rt}^{W})^{-1}\boldsymbol{S}_{rt} - (\boldsymbol{\Omega}_{rt}^{R})^{-1}\boldsymbol{S}_{rt}. \tag{2.20}$$

Replacing marginal cost in equation (2.20) with the right-hand side of equation (2.12), and rearranging terms yields the supply-side estimation equation

$$\boldsymbol{p}_{rt}^{R} - \boldsymbol{\Psi}_{rt} - \boldsymbol{\gamma}_{r} - \boldsymbol{\eta}_{t} = -(\boldsymbol{T}_{rt} * \boldsymbol{\Delta}_{rt}^{W})^{-1}\boldsymbol{S}_{rt} - (\boldsymbol{\Omega}_{rt}^{R})^{-1}\boldsymbol{S}_{rt} + \boldsymbol{\omega}_{rt}. \tag{2.21}$$

2.5.3 Supply Estimation

Given demand estimates, observed retail prices, and market shares, manufacturer's response matrices $\mathbf{\Delta}_{rt}^{W}$ and $\mathbf{\Omega}_{rt}^{R}$ can be pre-calculated, thus the supply-side estimation equation in (2.20) reduces to a simple linear regression of cost shifters. One can use ordinary least square approach to estimate cost-side parameters.

Table 6 presents the mean retailer and manufacturer's price-cost margins (markups), and recovered marginal costs based on equations (2.8), (2.18), and (2.20). As shown in the table, the total channel profits are almost evenly distributed between manufacturers and monopolist retailers. For example, Propel's markup is about \$0.37 per liter and its relative retailer's markup is about \$0.41 per liter. In general, cheaper brands have lower markups and marginal costs while more expensive brands have higher counterparts. On average, Fruit2O is the cheapest premium water brand which yields the lowest manufacturer markup, retailer markup, and marginal cost, which are \$0.34, \$0.38, and \$0.24 per liter respectively.

Table 7 presents the key parameter estimates of the supply-side model. As expected, the merger generates efficiency on Glaceau by reducing corresponding marginal cost. As shown, in the post-merger period, the average marginal cost of Glaceau products has been reduced by 6.04 cents per liter controlling for time-specific and region-specific fixed effects. In particular, for single-bottle and multi-pack Vitaminwater products, the merger decreases their marginal costs by about 5.3% and 4.4% respectively.

2.6 Counterfactual Analysis

With both demand and supply-side estimates, I use counterfactual simulations to investigate how the merger of Coca-Cola and Glaceau would affect the market outcomes. Specifically, I perform 2 counterfactual scenarios:

(i) The merger of Coca-Cola and Glaceau does not occur.

(ii) The merger occurs with only a unilateral effect.[9]

For each market (region-chain-time pair), I resolve retailers and manufacturers' new equilibrium choices under different market structures by assuming no efficiency on Glaceau. Manufacturers are assumed to move first, and the new equilibria are solved by using a two-step procedure. First, with a guess for manufacturers' wholesale prices $\boldsymbol{p}_0^W$, a monopolist retailer solves for the corresponding retail prices $\boldsymbol{p}_0^{R^*} = p^{R^*}(\boldsymbol{p}_0^W)$ that maximizes its profits. Second, with given market and cost structures and manufacturers' market shares $\boldsymbol{S}_0^* = S^*(p^{R^*}(\boldsymbol{p}_0^W))$, response matrices $\boldsymbol{\Delta}_0^W$ and $\boldsymbol{\Omega}_0^R$ are calculated. The two-step procedure continues until the system of equations in (2.20) is satisfied under reasonable tolerances. Due to the large sample size and computational burden, the counterfactual analyses in this paper will focus on the top 20 retail chains which cover the most DMA regions.[10]

[9] In this case, competition between the products of the merging firms is eliminated, allowing the merged "new" firm to unilaterally exercise market power.

[10] These top 20 retailer chains operate business in several DMA regions, and I rank them based on the number of DMA regions they cover. Out of 91 DMA regions in the estimation sample, the top 1 retailer covers 71 DMA regions and the 20th retailer covers 8. The selected retailers account for 10,011 markets (75.24% of the sample markets).

2.6.1 The Predicted Trends of Vitaminwater

In figures 3 to 5 I predict the brand-level retail price, market share, and per-unit net profit of Vitaminwater under different counterfactual scenarios starting from January 2006 to December 2009. The "merger-scenario 1" describes the counterfactual scenario that the merger of Coca-Cola and Glaceau occurs with only unilateral effects but without efficiencies. Figures 3 to 5 show that the time trends under "merger-scenario 1" and "no merger" are overlapping and most identical for Vitaminwater's retail price, market share, and per-unit net profit. These counterfactual outcomes suggest that the merger has a very small and insignificant impact on the market power of Glaceau through unilateral effect. For the pre-merger period, all predicted time trends under different scenarios are overlapping and identical to the corresponding observed data, justifying the model's performance.

Figure 3 plots the time trend of Vitaminwater's average brand level retail price, which is weighted by product volumes. As discussed earlier, the unilateral effect of merger plays a very limited role in affecting the merging party (Glaceau)'s market power. However, the merge creates efficiency by reducing Glaceau's marginal cost and thus decreases Vitaminwater's retail price compared to the "no merger" scenario. These two findings suggest that (1) the merging party has very small market power, and (2) marginal cost efficiency plays a vital role in explaining Vitaminwater's price reduction after the merger.

Figure 4 presents the average market share of Vitaminwater across sample regions and retailer chains over 2006-2009. It is obvious that the market share of

Vitaminwater increases significantly after the merger. Again, the unilateral effect of merger plays trivial roles in affecting equilibrium market share. Comparing to the "no merger" baseline, the realized merger increases Vitaminwater's market share by more than 10% in each month.

Figure 5 plots the time trend of Vitaminwater's per-unit net profit. The per-unit net profit is a measure for firm's profitability in a given market, which is computed as the multiplication of the manufacturer's price-cost margin and the corresponding market share of each product. The overall time trend of per-unit net profit is quite similar to that of the market share, which exhibits a significant boost in the post-merger period. Compared to the "no merger" baseline, I find the merger with marginal cost efficiency increases Vitaminwater's per-unit net profit by about 16% on average.

2.6.2 Mean Effects Under Different Merger Scenarios

Table 8 provides the average equilibrium wholesale and retail prices across 20 large retailer chains under different counterfactual scenarios in 2009. The values in column (i) denote the equilibrium market outcomes from the "no merger" baseline. The numbers in columns (ii) and (iii) are calculated based on the counterfactual outcomes from scenario (ii) and the real data respectively, which denote the percentage changes relative to the corresponding values of column (i). The numbers in table 8 suggest that the merger has trivial effects on the equilibrium prices of competing brands, which can be explained by the small inside good share and weak consumer substitution patterns across premium bottled water brands. Comparing columns (i) and (ii) I find the merger with only unilateral effect generated very limited market power which increases the wholesale and retail prices of all brands by less than 1%. As expected, compared to the "no merger" scenario, the percentage changes in wholesale prices are larger in magnitude than the percentage changes in corresponding retail prices under both scenario (ii) and (iii), which is due to the wholesale to retail price pass-through effect. For example, under scenario (ii), the merger increases Smartwater's wholesale price by 0.27% but only increases its retail price by 0.2% comparing to the "no merger" scenario. It is evident that the marginal cost efficiency yields much larger effects on prices than the unilateral effect of merger. A comparison between columns (i) and (iii) reveals that the merger with marginal cost efficiency reduces Smartwater and Vitaminwater's wholesale prices by 6.91% and 4.58%, and decreases their retail prices by 5.26% and 3.80% respectively.

Analogous to table 8, table 9 provides equilibrium market shares, per-unit net profits, and changes of consumer surplus under different counterfactual scenarios. All numbers presented in the table are for the year of 2009. A comparison between columns (i) and (ii) of tables 8 and 9 reveals that the merger with only unilateral effect reduces market shares of the merging party's brands. This is due to the price increases. In particular, compared to the "no merger" baseline, the merger with only unilateral effect decreases market shares of Smartwater, Vitaminwater, and Dasani by 0.82%, 0.64%, and 3.19% respectively. More importantly, I find the marginal cost efficiency explains about 20% of the market share boosts in Glaceau products in the post-merger period. Relative to the "no merger" baseline in 2009, the realized merger with marginal cost efficiency increases markets shares of Smartwater and Vitaminwater by 19.44% and 17.50% respectively. The unilateral effect (scenario (ii)) has a very limited impact on per-unit net profit, relative to the marginal cost efficiency (scenario (iii)). Despite small profit loses in Dasani and competing brands, I find the merger with marginal cost efficiency increases the per-unit net profits of Smartwater and Vitaminwater by 17.91% and 15.66% respectively compared to the "no merger" scenario in 2009.

For consumer welfare, column (ii) reveals the merger with only unilateral effect decreases consumer surplus by 0.96% relative to the "no merger" baseline. This result is consistent with the existing antitrust literature focusing on unilateral effect of horizontal merger. Scenario (ii) is profitable for the merging party but harmful to consumers, which is unlikely to be approved by antitrust agencies. However, if considering efficiency in marginal cost, the merger would not only significantly improve the merging party's profits but also increase consumer surplus. The realized merger in column (iii) is predicted to have increased consumer surplus by 13.51% relative to the "no merger" baseline.

2.7 Conclusion

This study focuses on the merger of Coca-Cola and Glaceau in the U.S. premium bottled water industry and investigates how merger efficiency plays roles in affecting prices, market outcomes, and consumer welfares. To understand the effect of merger on Glaceau products, I develop a structural demand and supply model which incorporates the vertical relationship between manufacturers and retailers and allows for marginal cost efficiency on Glaceau products post-merger. The demand-side estimates suggest that premium bottled water products are highly differentiated which yield low consumer substitution patterns. My supply estimates suggest the merger generates efficiency on Glaceau through marginal cost reduction. On average, the merger decreases the marginal cost of Vitaminwater products by 4.4%-5.3%.

With both demand and supply estimates, I implement several counterfactual scenarios to identify the effects of merger on market power and marginal cost efficiency. I find the merger has limited impacts on the market power of premium bottled water products since they are highly differentiated, and marginal cost efficiency plays an important role in affecting equilibrium prices and market shares. In particular, for the year 2009, I find compared to the "no merger" scenario, the realized merger (1) reduces Glaceau's wholesale prices by 4.6%-6.9%; (2) decreases Glaceau's retail prices by 3.8%-5.3%; (3) raises Glaceau's market shares by 17.5%-19.4%; and (4) increases Glaceau's per-unit net profits by 15.7%-17.1%. In addition, the merger increases consumer surplus by 13.5% compared to the "no merger" baseline in 2009.

Chapter 3: A Structural Demand and Supply Framework with Endogenous Product Attributes and Non-price Competition

3.1 Introduction

In this paper, I develop a conceptual framework which incorporates consumer demand, retailer's pricing, and manufacturer's strategic choices for wholesale prices and endogenous product attributes considering both price and non-price competitions. In addition to price competition, manufacturers may compete in non-price aspects as well, such as product quality, product variety, innovation, service level, and advertising intensity. The conceptual framework in this paper can be applied to industries with the vertical structure between upstream manufacturers and downstream retailers that face both price and no-price competitions.

My demand-side model builds on the standard random coefficient logit model developed by Berry et al. (1995), henceforth BLP. To capture the impacts of endogenous product attributes on consumer demand, similar to Fan (2013), I include the observable endogenous product attributes in the consumer utility function. To deal with consumer heterogeneity, I allow coefficients of price and product attributes to vary across local population by interacting them with household demographics. In addition, I allow consumer utility to affect endogenous product attributes nonlinearly. The demand model can be estimated with the fixed point algorithm developed BLP by generalized method of moments (GMM). Since retail price product attributes are potentially endogenous, appropriate instrumental variables are needed to reduce estimation bias. In addition to the BLP type instruments, I propose to use instrumental variables that share features of both Hausman type and cost shifter type to instrument endogenous prices and product attributes, such as price and attributes of the same product in other markets.

The supply-side model incorporates the vertical structure between upstream manufacturers and downstream retailers and is assumed to be a two-stage static game. In the first stage, manufacturers simultaneously choose wholesale price and endogenous product attributes in each market. In the second stage, given manufacturers' choices, retailers decide corresponding retail prices. The two-stage game is solved backward and one can back-out the monopolist retailer's price-cost margin with Villas-Boas (2007)'s approach, given demand estimates, retail prices and shares. To relax the monopolist retailer assumption and capture the degree of competition among downstream retailers, I follow Miller and Weinberg (2017)'s approach by adjusting the monopolist retailer's markup with a retail scaling parameter. Manufacturers' profit in each market is defined as a function of variable profit and fixed costs of endogenous product attributes. Following Fan (2013)'s model setting, I assume the derivatives of fixed cost functions with respect to each endogenous product attribute are linear functions of endogenous product attributes. Manufacturers' optimal choices can be found by taking the first order derivatives with respect to wholesale price and endogenous product attributes, and these first order conditions form the supply side estimation equations. Given demand estimates and pre-calculated response matrices, marginal cost and fixed cost parameters can be estimated with GMM. I also provide a detailed procedure to conduct counterfactual analysis with demand and supply-side estimates.

3.2 Consumer Demand

3.2.1 Demand Model

Following the existing literature, I assume a consumer derives utility from some characteristics of a product and that this utility is also influenced by region-specific and time-specific factors and individual-specific preferences. The indirect utility that consumer i receives from purchasing product j in market r at time t is given by:

$$u_{ijrt} = \alpha_i p_{jrt} + \boldsymbol{\beta}_i \boldsymbol{x}_{jrt} + \sum_{k=1}^{K} g_k(y_{jrtk}, \boldsymbol{\theta}_{ik}) + \xi_{jrt} + \epsilon_{ijrt}, \tag{3.1}$$

where p_{jrt} is the observed retail price in market r at time t, $\boldsymbol{x}_{jrt}$ contains the observable product characteristics that are assumed to be exogenous and a set of region and time fixed effects, y_{jrtk} denotes the k-th endogenous characteristic of product j in market r at time t. ξ_{jrt} is the unobserved product characteristics or quality valuations specific to market r t, and ϵ_{ijrt} is a consumer specific stochastic term. This model specification supplements BLP and echoes Fan (2013) by considering endogenous product characteristics. In particular, I allow the consumer's utility from each endogenous characteristic to be a flexible function of that characteristic. For example, the consumer i's utility from the k-th endogenous characteristics y_{jk} of product j can be defined either as a quadratic function

$$g_k(y_{jk}, \boldsymbol{\theta}_{ik}) = \theta^1_{ik} y_{jk} + \theta^2_{ik} y^2_{jk}, \tag{3.2}$$

or a simple linear function

$$g_k(y_{jk}, \theta_{ik}) = \theta_{ik} y_{jk}. \tag{3.3}$$

Consumers' heterogeneous preferences are captured by consumer-specific parameters α_i, $\boldsymbol{\beta}_i$, and $\boldsymbol{\theta}_{ik}$, where α_i is a scalar, and $\boldsymbol{\beta}_i$ and $\boldsymbol{\theta}_{ik}$ are vectors. Similar to Nevo (2000), I assume these consumer taste-specific parameters depend on both consumer demographics $\boldsymbol{D}_i$ and unobservable consumer characteristics $\boldsymbol{v}_i$, and they are assumed to be multivariate normally distributed as the following

$$\begin{pmatrix} \alpha_i \\ \boldsymbol{\beta}_i \\ \boldsymbol{\theta}_i \end{pmatrix} = \begin{pmatrix} \bar{\alpha} \\ \bar{\boldsymbol{\beta}} \\ \bar{\boldsymbol{\theta}} \end{pmatrix} + \boldsymbol{\Pi} \boldsymbol{D}_i + \boldsymbol{\Sigma} \boldsymbol{v}_i, \qquad \boldsymbol{D}_i \sim \mathcal{P}_D(\boldsymbol{D}), \qquad \boldsymbol{v}_i \sim \mathcal{P}_v(\boldsymbol{v}), \tag{3.4}$$

where $\boldsymbol{D}_i$ is a $d \times 1$ vector of demographics that follow the distribution $\mathcal{P}_D$. Suppose K_1 is the dimension of observed exogenous characteristics vector, K_2 is the dimension of vector $\bar{\boldsymbol{\theta}}$, then $\boldsymbol{v}_i$ is a $(K_1 + K_2 + 1) \times 1$ vector which is normally distributed with distribution $\mathcal{P}_v$. $\boldsymbol{\Pi}$ is a $(K_1{+}K_2{+}1) \times d$ matrix of coefficients that measure how tastes vary with consumer demographics, and $\boldsymbol{\Sigma}$ is a $(K_1 + K_2 + 1) \times (K_1 + K_2 + 1)$ matrix of parameters whose off-diagonal elements are zeros. This parametric specification allows individual's taste or valuation for price and product characteristics to be varying across consumers.

The indirect utility function in equation (3.1) can be decomposed into a constant part $\delta_{jrt}(p_{jrt}, \boldsymbol{x}_{jrt}, \boldsymbol{y}_{jrt}, \xi_{jrt}; \bar{\alpha}, \bar{\boldsymbol{\beta}}, \bar{\boldsymbol{\theta}})$, plus a random part $\mu_{ijrt}(p_{jrt}, \boldsymbol{x}_{jrt}, \boldsymbol{y}_{jrt}, \boldsymbol{D}_i, \boldsymbol{v}_i; \boldsymbol{\Pi}, \boldsymbol{\Sigma})$ such that

$$u_{ijrt} = \delta_{jrt} + \mu_{ijrt} + \epsilon_{ijrt}, \tag{3.5}$$

where δ_{jrt} is a function of product characteristics given linear parameters

$$\delta_{jrt} = \bar{\alpha} p_{jrt} + \bar{\boldsymbol{\beta}} \boldsymbol{x}_{jrt} + \sum_{k=1}^{K} g_k(y_{jrtk}, \bar{\boldsymbol{\theta}}_k) + \xi_{jrt}, \tag{3.6}$$

and represents the mean utility of purchasing product j in market r at time t across all consumers. μ_{ijrt} is a function of consumer characteristics given nonlinear parameters

$$\mu_{ijrt} = [p_{jrt}, \boldsymbol{x}_{jrt}, \boldsymbol{y}_{jrt}]' * (\boldsymbol{\Pi} \boldsymbol{D}_i + \boldsymbol{\Sigma} \boldsymbol{v}_i), \tag{3.7}$$

which denotes the consumer-specific deviations from the mean.

It is very likely that consumers may prefer products which are not included in the given product choice set. Most of the existing literature normalizes consumer's utility from the outside option to be fixed (e.g. normalize to zero). By assuming that consumers choose the product that gives them the highest utility, the market share of product j in market r at time t can be calculated analytically or numerically according to the distributional assumptions on $\boldsymbol{D}$, $\boldsymbol{v}$, and $\boldsymbol{\epsilon}$

$$S_{jrt}(p_{jrt}, \boldsymbol{x}_{jrt}, \boldsymbol{y}_{jrt}; \bar{\alpha}, \bar{\boldsymbol{\beta}}, \bar{\boldsymbol{\theta}}, \boldsymbol{\Pi}, \boldsymbol{\Sigma}) = \int d\mathcal{P}_{\epsilon}(\boldsymbol{\epsilon}) d\mathcal{P}_D(\boldsymbol{D}) d\mathcal{P}_v(\boldsymbol{v}). \tag{3.8}$$

In particular, if we assume the idiosyncratic error terms $\boldsymbol{\epsilon}$ are *iid* draws from the Type I extreme value distribution, and normalize the utility from outside good to zero, the market share of product j in market r at time t can be calculated analytically with the following formula

$$S_{jrt}(p_{jrt}, \boldsymbol{x}_{jrt}, \boldsymbol{y}_{jrt}; \bar{\alpha}, \bar{\boldsymbol{\beta}}, \bar{\boldsymbol{\theta}}, \boldsymbol{\Pi}, \boldsymbol{\Sigma}) = \int \frac{\exp(\delta_{jrt} + \mu_{ijrt})}{1 + \sum_{c=1}^{J} \exp(\delta_{krt} + \mu_{ikrt})} d\mathcal{P}_D(\boldsymbol{D}) d\mathcal{P}_v(\boldsymbol{v}), \tag{3.9}$$

where J denotes the number of products available in the choice set.

3.2.2 Demand Estimation

For the random coefficient logit demand model with only endogenous price, BLP develops a algorithm to estimate parameters via the generalized method of moments (GMM). Following the same spirit of BLP algorithm, the demand model with endogenous price and product characteristics can be estimated with appropriate instrumental variables for corresponding product characteristics. Assume $Z = [Z_1, Z_2, ..., Z_L]$ is a set of instruments for endogenous price and product characteristics, parameters $\boldsymbol{\Gamma} = [\bar{\alpha}, \bar{\boldsymbol{\beta}}, \bar{\boldsymbol{\theta}}, \boldsymbol{\Pi}, \boldsymbol{\Sigma}]$ can be estimated using the following moment conditions

$$E[Z_l G(\boldsymbol{\Gamma}^*)] = 0, \qquad l = 1, ..., L \tag{3.10}$$

where G denotes the structural errors or residuals and $\mathbf{\Gamma^*}$ is the set of true parameters. Parameter estimates can be found such that

$$\hat{\mathbf{\Gamma}} = \arg\min_{\mathbf{\Gamma}} \quad G(\mathbf{\Gamma})^{'} Z W^{-1} Z^{'} G(\mathbf{\Gamma}) \tag{3.11}$$

where W is the weighting matrix which can be calculated from the first stage estimates whose weighting matrix is an identity matrix. To calculate structural error G, I assume the observed market share of product j in market r at time t equals to its expression in equation (3.9)

$$S_{jrt} = s_{jrt}(\delta_{jrt}; \mathbf{\Pi}, \mathbf{\Sigma}). \tag{3.12}$$

In particular, the mean utility δ_{jrt} can be solved numerically by inverting market share equations with the BLP contraction mapping algorithm

$$\delta_{jrt}^{(h+1)} = \delta_{jrt}^{(h)} + \ln S_{jrt} - \ln \hat{s_{jrt}}(\delta_{jrt}^{(h)}; \mathbf{\Pi}, \mathbf{\Sigma}), \tag{3.13}$$

where h denotes the fixed-point iteration index, $\hat{s_{jrt}}$ is the predicted market share given $\delta_{jrt}^{(h)}$ and a guess of nonlinear parameters. The mean utility δ_{jrt} is found as long as equation (3.13) holds under acceptable tolerance. Once δ_{jrt} is computed, the structural error term G can be expressed as

$$G_{jrt} = \delta_{jrt}(S_{jrt}; \mathbf{\Pi}, \mathbf{\Sigma}) - \bar{\alpha} p_{jrt} - \bar{\boldsymbol{\beta}} \boldsymbol{x}_{jrt} - \sum_{k=1}^{K} g_k(y_{jrtk}, \bar{\boldsymbol{\theta}}_k), \tag{3.14}$$

and the linear parameters $[\bar{\alpha}, \bar{\boldsymbol{\beta}}, \bar{\boldsymbol{\theta}}]$ can be estimated with appropriate instruments by GMM in equation (3.10). In practice, the linear and nonlinear parameters are estimated simultaneously by the following steps:

(1) Give a initial guess for nonlinear parameters $[\mathbf{\Pi}_0, \mathbf{\Sigma}_0]$ and solve for the mean utility δ_{jrt}.

(2) Solve linear parameters $[\bar{\alpha}, \bar{\boldsymbol{\beta}}, \bar{\boldsymbol{\theta}}]$ given δ_{jrt} and $[\mathbf{\Pi}_0, \mathbf{\Sigma}_0]$ from step 1, by using an instrumental variable approach.

(3) Repeat steps 1 and 2 such that the objective function in equation (3.11) is satisfied.

With demand side estimates, the partial derivatives of market share with respect to prices and endogenous product characteristics in each market can be calculated as

$$\frac{\partial S_{crt}(p, y)}{\partial p_{jrt}} = \begin{cases} \sum_{i=1}^{n} \alpha_i S_{icrt}(1 - S_{icrt}) & \text{if} \quad j = c \\ -\sum_{i=1}^{n} \alpha_i S_{ijrt} S_{icrt} & \text{otherwise,} \end{cases} \tag{3.15}$$

$$\frac{\partial S_{crt}(p, y)}{\partial y_{jrtk}} = \begin{cases} \sum_{i=1}^{n} S_{icrt}(1 - S_{icrt}) \frac{\partial g_k(y_{jrtk}, \boldsymbol{\theta}_{ik})}{\partial y_{jrtk}} & \text{if} \quad j = c \\ -\sum_{i=1}^{n} S_{ijrt} S_{icrt} \frac{\partial g_k(y_{jrtk}, \boldsymbol{\theta}_{ik})}{\partial y_{jrtk}} & \text{otherwise.} \end{cases} \tag{3.16}$$

Here i indexes individual draws and y_{jrtk} represents the k-th endogenous product characteristics of product j in market r at time t. Price elasticities between product

j and product c in each market and time period can be expressed as

$$\frac{\partial S_{crt}(p,y)}{\partial p_{jrt}}\frac{p_{jrt}}{S_{crt}} = \begin{cases} \frac{p_{crt}}{S_{crt}}\sum_{i=1}^{n}\alpha_i S_{icrt}(1-S_{icrt}) & \text{if} \quad j=c \\ -\frac{p_{jrt}}{S_{crt}}\sum_{i=1}^{n}\alpha_i S_{ijrt}S_{icrt} & \text{otherwise.} \end{cases} \tag{3.17}$$

3.2.3 Identification and Instruments

Since prices and some product characteristics are potentially endogenous, appropriate instrumental variables are needed to help reduce estimation bias. Traditional instrumental variables of the BLP model fall into 3 types. The first type of instruments are the BLP instruments proposed by Berry (1994) and BLP. BLP type instruments are measures of isolation in product space which include the summation of (i) product characteristics of other products by the same manufacturer in the same market, and (ii) product characteristics of other products produced by other manufacturers in the same market. The advantages of the BLP type instruments are that they are normally available in the data and tend to be highly correlated with prices. However, the are several weaknesses associated with the BLP type instruments as well. First, they have limited variations over time. For example, product characteristics of automobiles are fixed in a relative long time period. Second, they assume the unobservable product attributes are uncorrelated with observed attributes.

The second type of instruments are Hausman type, which use prices in other markets as a proxy for cost shifters (e.g. Hausman (1996); Nevo (2000)). The intuition behind the Hausman type instrument is that prices in other markets may share common cost shocks. For example, if the manufacturer faces a cost increase, it will increase corresponding prices in all markets. However, Hausman type instruments are invalid if products in other markets are facing common demand shocks.

The third type of instruments include data from the cost side, or observed cost shifters that may affect supply. For example, Berry et al. (1999) use cost shifters such as wage and exchange rates to approximate marginal cost of automobile production. More and more, the empirical literature has recognized the importance of combining several types of instruments to reduce estimation bias. For example, the importance of having both BLP type and cost shifter type instruments has been supported by Reynaert and Verboven (2014) with simulations, and Berry and Haile (2015) explain that both types of instruments are essential, especially without additional data or model structure.

In the traditional BLP model, firms only consider pricing decisions and all product characteristics are assumed to be exogenous. In my conceptual model, in additional to pricing decisions, firms also strategically choose certain product characteristics periodically, thus these product characteristics are considered endogenous. With endogenous product characteristics, one possible instrument choice shares the same spirit as that in BLP, which uses the attributes of competing products as instruments. For example, focusing on the newspaper industry, Fan (2013) uses the demographics in the non-overlapping markets of a newspaper's competitors to instrument three endogenous newspaper characteristics. The second plausible instrument choice follows the same logic of Hausman type instrument, by using the product characteristics of the same product in other market as instruments.

3.3 Supply

In this section, I develop a framework for the vertical structure between manufacturers and retailers where manufacturers face both price and non-price competitions. This framework builds on Villas-Boas (2007)'s setting and extends to non-price competition. The stylized model can be applied to any consumer good industry which incorporates both upstream firms and downstream retailers. Following the existing literature, I assume the supply side model yields two stages. In the first stage, upstream firms choose prices and product attributes in each market. In the second stage, given upstream firms' choices, downstream retailers choose corresponding retail prices in each market. By observing consumer demand, downstream retailers and upstream firms solve optimal choices by maximizing their profits respectively.

3.3.1 Retailer Pricing Decisions

The vertical structure between manufacturers and retailers makes the two-stage game complicated since two parties are both involved in choices of multiple dimensions. Villas-Boas (2007) argued that vertical relationships are especially hard to estimate due to infra-marginal components, transaction costs, and imperfect information issues. However, for most fast-moving consumer goods, the nature of direct-to-store delivery simplifies the game significantly. With direct-to-store distributors, downstream retailers are not responsible for shipping, stocking, and managing inventories. Instead, these costs are transferred to the upstream firms. Ellickson et al. (2017) made a similar assumption by assuming downstream retailers face no marginal costs in the ready-to-drink coffee industry.

Let's first suppose a monopolist retailer R sells differentiated products for several manufacturers in market r, thus the retailer's profit of selling these products is given by

$$\Pi_r^R = \sum_{j \in G_r} M_r (p_{jr}^R - p_{jr}^W) S_{jr}, \tag{3.18}$$

where G_r is the set of products available in market r, M_r is the market size of market r, S_{jr} denotes the market share for product j in retailer R, p_{jr}^R is the retail price of product j set by retailer R in market r, and p_{jr}^W denotes the wholesale price set by corresponding manufacturers. Due to the nature of direct-to-store delivery in fast-consuming good industries, the marginal cost of retailing largely transfers to the manufacturer side and thus can be simplified to zero. Maximizing the retailer's profit function by taking first order derivative with respect to product j's retail price yields the following first order condition:

$$S_{jr} + \sum_{c \in G_r} [p_{cr}^R - p_{cr}^W] \frac{\partial S_{cr}}{\partial p_{jr}} = 0. \tag{3.19}$$

Following Villas-Boas (2007), define $\mathbf{\Omega}_r^R$ as retailer R's response matrix, which contains the first order derivatives of market shares with respect to all retail prices in market r. Stacking the first order conditions above and rearranging them yields a vector of monopolist retailer's price-cost margins for all products it sells in a given time period:

$$\boldsymbol{m}_r^{R,\text{monopoly}} = \boldsymbol{p}_r^R - \boldsymbol{p}_r^W = -\boldsymbol{\Omega}_r^R(\boldsymbol{p}_r)^{-1}\boldsymbol{S}_r, \tag{3.20}$$

where $\boldsymbol{m}_{rt}^{R,\text{monopoly}}$ is the markup of monopolist retailer R in market r.[1] With demand-side estimates, the retailer's response matrix $\boldsymbol{\Omega}_r^R$ can be calculated numerically, thus the retailer's marginal cost (wholesale price) can be calculated together with observed market shares and retail prices under the monopoly pricing assumption according to equation (3.20). In reality, the monopolist retailer assumption rarely holds for consumer products and the representative retailer doesn't have much monopoly power over differentiated products except its own brand. To relax the monopolist retailer assumption and capture the degree of competition among downstream retailers, I follow Miller and Weinberg (2017)'s approach by adjusting the monopolist retailer's markup with a retail scaling parameter. This retail scaling parameter reflects the average degree of competition among retailers in the industry. For a high degree of competition among retailers, the retail scaling parameter would be close to zero, suggesting low profit margins for retailers. However, for a low degree of competition, such as monopolist or oligopolist retailers, the retail scaling parameter would be close to one which suggests high profit margins for retailers. Given any competition structure, the retailer R's pricing equation can be

[1] Vectors and matrices are denoted as bold symbols in the remaining of this chapter.

approximated as the following

$$\boldsymbol{p}_r^R = \boldsymbol{p}_r^W + \boldsymbol{\lambda} \boldsymbol{m}_r^{R,\text{monopoly}}, \tag{3.21}$$

where $\boldsymbol{\lambda}$ is a retail scaling parameter vector with each element $\lambda_j \in [0, 1]$. Replacing equation (3.20) in equation (3.21) yields

$$\boldsymbol{p}_r^R = \boldsymbol{p}_r^W - \boldsymbol{\lambda} \boldsymbol{\Omega}_r^R(\boldsymbol{p}_r)^{-1} \boldsymbol{S}_r. \tag{3.22}$$

If $\lambda_j = 1$, the representative retailer plays as a monopolist and has full monopoly power over product j; if $\lambda_j = 0$, the representative retailer competes in a perfect competitive market and uses marginal cost pricing with product j; If $0 < \lambda_j < 1$, the retailer as intermediate levels of market power over product j, which is more realistic for consumer products. In empirical research, the parameter vector $\boldsymbol{\lambda}$ can be either treated as a known parameter vector based on appropriate assumptions of retailer competition, or taken as an unknown parameter vector which needs to be estimated.

3.3.2 Manufacturer Decisions

In modling choices of the upstream firms, most of the existing literature focuses exclusively on pricing decisions. For example, Villas-Boas (2007) assumes upstream manufacturers are oligopolists playing Nash-Bertrand games in the wholesale market. Fan (2013) extends the Nash-Bertrand competition model by allowing firms to choose some product attributes endogenously. My supply side framework builds on Fan (2013)'s model and incorporates the vertical structure between upstream manufacturers and downstream retailers.

In the first stage of game, each upstream manufacturer simultaneously chooses wholesale prices and corresponding product attributes for their products in each market, with full information about how these choices change the optimal behaviors of rival manufacturers and the downstream retailers. The two-stage game can be solved backward, and retailer R's optimal pricing defined in equation (3.22) can be expressed as

$$\boldsymbol{p}_r^R = \boldsymbol{p}_r^W - \boldsymbol{\lambda}\boldsymbol{\Omega}_r^R(\boldsymbol{p}_r)^{-1}\boldsymbol{S}_r(\boldsymbol{p}_r^R, \boldsymbol{y}_r), \tag{3.23}$$

which implicitly defines retailer R's equilibrium prices $p^{R*}(\boldsymbol{p}_r^W, \boldsymbol{y}_r)$ given manufacturers' choices of wholesale price $\boldsymbol{p}_r^W$ and endogenous product attributes $\boldsymbol{y}_r$ in market r. Similarly, the equilibrium product shares can also be written as a function of manufacturers' choices

$$\boldsymbol{S}_r^* = S^*(p^{R*}(\boldsymbol{p}_r^W, \boldsymbol{y}_r), \boldsymbol{y}_r). \tag{3.24}$$

Equation (3.24) suggests that endogenous product attributes $\boldsymbol{y}_r$ affect market shares both directly through consumer utility and indirectly through retailer's best responses. Wholesale prices affect market shares indirectly via retailer's best responses.

Suppose a upstream consumer good manufacturer m offers a bundle of differentiated products G_{rm}, which contains N_m products in a market r to a monopolist retailer in a given time period. Similar to Fan (2013)'s setting, I assume the manufacturer's profit is given by

$$\Pi_r^m = \sum_{j \in G_{rm}} M_r (p_{jr}^W - c_{jr}^W) S_{jr}(\boldsymbol{p}_r^R, \boldsymbol{y}_r) - \sum_{j \in G_{rm}} \sum_{k=1}^{K} F_{jkr}(y_{jkr}), \tag{3.25}$$

where the first term denotes variable profit and the second term denotes fixed cost of choosing endogenous product attributes. Specifically, $F_{jkr}(.)$ measures manufacturer's fixed cost of choosing endogenous attribute k for product j in market r, which is a function of corresponding product attributes y_{jkr}, such as product quality, variety, and advertising intensity. This functional form of $F_{jkr}(.)$ can either be linear or quadratic depending on the nature of attributes. For example, Sullivan (2016) defines the fixed cost that a ice cream manufacturer has to pay to the retailer as a linear function of the number of flavors that manufacturer offers in that market. Murry (2017) assumes the fixed cost of an automobile manufacturer's advertisement is a quadratic function of the advertising intensity in each market. Fan (2013) also makes quadratic functionoal form assumptions on the fixed cost of choosing a certain combination of newspaper attributes. Following Fan (2013), I assume the slope of the fixed cost function $F_{jkr}(y_{jkr})$ with respect to the k-th endogenous product attribute y_{jkr} is

$$F'_{jkr} = (\Theta_{jk} y_{jkr} + \nu_{jkr}^f) M_r, \tag{3.26}$$

where ν_{jkr}^f is unobservable, Θ_{jk} denotes the parameter of product j for the k-th attribute.[2] Equation (3.26) implicitly determines the quadratic functional form for the fixed cost function of offering each product attribute. c^W_{jr} represents the marginal costs of production, shipping and distribution of product j to market r. The existing literature often approximates marginal cost using input prices, local wage rates, distances, and product characteristics, and parameterizes it as a linear function of these factors (e.g. Petrin (2002); Villas-Boas (2007); Miller and Weinberg (2017)). Following the existing literature, I parameterize manufacturer's marginal cost as a linear function of the observed cost components

$$c^w_{jr} = \boldsymbol{\eta} W_{jr} + \omega_{jrt}, \tag{3.27}$$

where $\boldsymbol{\eta}$ is the vector of cost parameters, W_{jr} represents the observed cost component which may include input prices, transportation distances, and dummy variables for product j and market r. ω_{jr} is unobservable cost shifter.

The manufacturer's profit can be derived as a function of its own strategic decisions by replacing market share with equation (3.24)

$$\Pi^m_r = \sum_{j \in G_{rm}} M_r (p^W_{jr} - c^W_{jr}) S^*_{jr}(p^{R*}(\boldsymbol{p}^W_r, \boldsymbol{y}_r), \boldsymbol{y}_r) - \sum_{j \in G_{rm}} \sum_{k=1}^{K} F_{jkr}(y_{jkr}). \tag{3.28}$$

Given the manufacturer's profit function in equation (3.28), and knowing that the retailer behaves according to equation (3.23), the manufacturer's optimal pricing and endogenous attributes choices can be found by taking the first order derivatives

[2] My fixed cost function differs from Fan (2013)'s specification by omitting the intercept term in the slope and assuming fixed cost is proportional to the market size.

with respect to p_{jr}^W and y_{jkr} respectively for each product j and attribute k. Suppose each product has the number of K endogenous product attributes and there are J products available in market r at a given time period, by assuming a pure-strategy Nash equilibrium, the J first order conditions for manufacturers' price competition are

$$\sum_{c \in G_r} [p_{cr}^W - c_{cr}^W] \frac{\partial S_{cr}^*}{\partial p_{jr}^W} + S_{jr} = 0, \tag{3.29}$$

for $j = 1, ..., J$. Similarly, the $J \times K$ first order conditions for manufacturers' non-price competitions are

$$\begin{aligned}
\sum_{c \in G_r} [p_{cr}^W - c_{cr}^W] \frac{\partial S_{cr}^*}{\partial y_{j1r}} =& \Theta_{j1} y_{j1r} + \nu_{j1r}^f \\
\sum_{c \in G_r} [p_{cr}^W - c_{cr}^W] \frac{\partial S_{cr}^*}{\partial y_{j2r}} =& \Theta_{j2} y_{j2r} + \nu_{j2r}^f \qquad \forall j \in G_r \\
&\vdots \\
\sum_{c \in G_r} [p_{cr}^W - c_{cr}^W] \frac{\partial S_{cr}^*}{\partial y_{jKr}} =& \Theta_{jK} y_{jKr} + \nu_{jKr}^f
\end{aligned} \tag{3.30}$$

Where $S_{cr}^* = S_{cr}^*(p^{R*}(\boldsymbol{p}_r^W, \boldsymbol{y}_r), \boldsymbol{y}_r)$ represents the market share of product c in market r which is a function of wholesale prices $\boldsymbol{p}_r^W$ and endogenous product attributes $\boldsymbol{y}_r$.

3.3.3 Vertical Structure and Pass-through

The supply side model considers the vertical structure between upstream manufacturers and downstream retailers, and each manufacturer anticipates how changes in wholesale prices and corresponding endogenous product attributes would affect retail price and therefore change consumer demand. For example, a change in wholesale price of one product will directly affect retail prices of all products and further influence their shares in a given market and time period. Thus the effect of the wholesale price of product j on the demand of product c can be expressed as

$$\frac{\partial S_c^*}{\partial p_j^W} = \left[\frac{\partial S_c}{\partial p_1^R}\frac{\partial p_1^R}{\partial p_j^W} + \frac{\partial S_c}{\partial p_2^R}\frac{\partial p_2^R}{\partial p_j^W} + ... + \frac{\partial S_c}{\partial p_J^R}\frac{\partial p_J^R}{\partial p_j^W}\right], \tag{3.31}$$

where vector $[\frac{\partial p_1^R}{\partial p_j^W}, \frac{\partial p_2^R}{\partial p_j^W}, ..., \frac{\partial p_J^R}{\partial p_j^W}]$ is product j's wholesale price pass-though to retail prices. This formula suggests that a change in product j's wholesale price affects product c's demand indirectly through the impact on the equilibrium retail prices for all products in the game. Similarly, considering retail pass-through, the impact of non-price competition in the k-th endogenous product attribute of product j on the demand of product c is

$$\frac{\partial S_c^*}{\partial y_{jk}} = \frac{\partial S_c}{\partial y_{jk}} + \sum_{i=1}^{J}\left[\frac{\partial S_c}{\partial p_i^R}\frac{\partial p_i^R}{\partial y_{jk}}\right], \tag{3.32}$$

where $\frac{\partial p_i^R}{\partial y_{jk}}$ is the pass-through of the k-th endogenous product attribute of product j to product i's retail price. The first term on the left-hand side is the direct impact of increasing or decreasing the k-th attribute of product j on the demand of product c in the same market. Additionally, a change in y_{jk} has a indirect effect on the demand of product c through an impact on the equilibrium retail prices for all products in the game, which is captured by the second term of equation (3.32). The difficulties of the vertical structure lie in computing or recovering the pass-through of manufacturers' choices to retail prices.

To recover the pass-through of wholesale price to retail price, Sudhir (2001), Villas-Boas (2007), and Miller and Weinberg (2017) apply the implicit function theorem to the retail pricing first order conditions. More recently, Murry (2017) extends the implicit function theorem to recover the pass-through of wholesale price to retailer advertising. Similar to Sudhir (2001), Villas-Boas (2007), Miller and Weinberg (2017), and Murry (2017), I compute the pass-through of wholesale price to retail price $\frac{\partial \boldsymbol{p}^R}{\partial \boldsymbol{p}^W}$ by applying the implicit function theorem, and also extend this approach to calculate the retail price pass-through of each endogenous product attribute $\frac{\partial \boldsymbol{p}^R}{\partial \boldsymbol{y}_k}$, for $k = 1, ..., K$.

To compute the pass-through with the implicit function theorem, let's first rewrite the retailer first-order conditions in equation (3.19) as follows:

$$Q(j) = S_{jr} + \sum_{c \in G_r} [p^R_{cr} - p^W_{cr}] \frac{\partial S_{cr}}{\partial p_{jr}} = 0, \tag{3.33}$$

where Q contains J equations of retailer r's optimal pricing for each product, and $Q(j)$ denotes the j-th first-order condition of retailer r's pricing. I simplify the notation by dropping the retailer subscript r. With this system of equations, I define some matrices of derivatives of Q with general elements as follows: $\boldsymbol{Q}_p(c, j) = \frac{\partial Q(j)}{\partial p^R_c}$, $\boldsymbol{Q}_w(c, j) = \frac{\partial Q(j)}{\partial p^W_c}$, and $\boldsymbol{Q}^k_y(c, j) = \frac{\partial Q(j)}{\partial y_{ck}}$, for $k = 1, ..., K$. Define the matrix $\boldsymbol{\Delta}^p_w$ as the wholesale to retail price pass-through whose general elements are $\boldsymbol{\Delta}^p_w(c, j) = \frac{\partial p^R_j}{\partial p^W_c}$. Similarly, for the k-th endogenous product attribute, its product attribute to retail price pass-through is defined as the matrix $\boldsymbol{\Delta}^p_{y_k}$, with general elements $\boldsymbol{\Delta}^p_{y_k}(c, j) = \frac{\partial p^R_j}{\partial y_{ck}}$.

According to the implicit function theorem, the matrix of wholesale to retail price pass-through $\mathbf{\Delta}_w^p$ is the solution to the following system of equations:

$$\boldsymbol{Q}_p \mathbf{\Delta}_w^p = \boldsymbol{Q}_w, \tag{3.34}$$

and $\mathbf{\Delta}_w^p$ is obtained as:

$$\mathbf{\Delta}_w^p = \boldsymbol{Q}_p^{-1} \boldsymbol{Q}_w. \tag{3.35}$$

Following the same approach, the matrix of the k-th endogenous product attribute to retail price pass-through $\mathbf{\Delta}_{y_k}^p$ can be computed as:

$$\mathbf{\Delta}_{y_k}^p = \boldsymbol{Q}_p^{-1} \boldsymbol{Q}_y^k, \tag{3.36}$$

for $k = 1, ..., K$. Expressions for matrices $\boldsymbol{Q}_p$ and $\boldsymbol{Q}_y^k$ are very complicated which incorporate the calculation of 3-dimension Hessian matrices. With matrix form, $\boldsymbol{Q}_p$ is expressed as

$$\boldsymbol{Q}_p = \frac{\partial \boldsymbol{S}}{\partial \boldsymbol{p}^R} + \frac{\partial^2 \boldsymbol{S}}{\partial \boldsymbol{p}^R \partial \boldsymbol{p}^{R^T}} \circledcirc (\boldsymbol{p}^R - \boldsymbol{p}^W) + \left(\frac{\partial \boldsymbol{S}}{\partial \boldsymbol{p}^R} \right)^T, \tag{3.37}$$

where $\circledcirc$ denotes the multiplication of 3-dimension to 2-dimension matrices.[3] The first term $\frac{\partial \boldsymbol{S}}{\partial \boldsymbol{p}^R}$ is $\mathbf{\Omega}^R$ defined in equation (3.20). Let's define the second order derivatives of market shares with respect to all retail prices $\frac{\partial^2 \boldsymbol{S}}{\partial \boldsymbol{p}^R \partial \boldsymbol{p}^{R^T}}$, as $\mathbf{\Delta}_{pp}^{ss}$, a 3-dimension

[3]In this chapter, $\circledcirc$ denotes the following rule of matrix multiplication: for a 3-dimension matrix A (J by J by J) and a 2-dimension matrix B (J by 1), $A \circledcirc B = C$, where C is a 2-dimension matrix (J by J) with general element $C(c, j) = A(c, :, j)B$.

matrix with general element $\boldsymbol{\Delta}_{pp}^{ss}(c,j,h) = \frac{\partial^2 S_h}{\partial p_j^R \partial p_c^R}$. Replacing retailer's equilibrium markup $(\boldsymbol{p}^R - \boldsymbol{p}^W)$ with $-\boldsymbol{\lambda}\boldsymbol{\Omega}^{R^{-1}}\boldsymbol{S}$, and treating retail scaling parameters the same across all products, $\boldsymbol{Q}_p$ can be expressed in the matrix notation as follows

$$\boldsymbol{Q}_p = \boldsymbol{\Omega}^R - \lambda \boldsymbol{\Delta}_{pp}^{ss} \circledcirc \boldsymbol{\Omega}^{R^{-1}}\boldsymbol{S} + \boldsymbol{\Omega}^{R^T}, \tag{3.38}$$

where parameter λ denotes the retail scaling parameter. Similarly, $\boldsymbol{Q}_y^k$ is expressed as

$$\boldsymbol{Q}_y^k = \frac{\partial \boldsymbol{S}}{\partial \boldsymbol{y}_k} + \frac{\partial^2 \boldsymbol{S}}{\partial \boldsymbol{p}^R \partial \boldsymbol{y}_k^T} \circledcirc (\boldsymbol{p}^R - \boldsymbol{p}^W), \tag{3.39}$$

for $k = 1, ..., K$. Define $\boldsymbol{\Omega}^{y_k}$ as manufacturer's response matrix in terms of the k-th endogenous product attribute with general elements $\boldsymbol{\Omega}^{y_k}(c,j) = \frac{\partial S_j}{\partial y_{ck}}$, and $\boldsymbol{\Delta}_{py_k}^{ss}$ as a 3-dimension matrix of second order derivatives of market shares with respect to retail prices and the k-th endogenous product attribute, whose general elements are $\boldsymbol{\Delta}_{py_k}^{ss}(c,j,h) = \frac{\partial^2 S_h}{\partial p_j^R \partial y_{ck}}$. In matrix notation, $\boldsymbol{Q}_y^k$ is defined as

$$\boldsymbol{Q}_y^k = \boldsymbol{\Omega}^{y_k} - \lambda \boldsymbol{\Delta}_{py_k}^{ss} \circledcirc \boldsymbol{\Omega}^{R^{-1}}\boldsymbol{S}. \tag{3.40}$$

At last, knowing $\boldsymbol{Q}_w = -\boldsymbol{\Omega}^{R^T}$, and expressions of $\boldsymbol{Q}_p$ and $\boldsymbol{Q}_y^k$, pass-through matrices $\boldsymbol{\Delta}_w^p$ and $\boldsymbol{\Delta}_{y_k}^p$ can be computed accordingly with pre-calculated response matrices $\boldsymbol{\Omega}^R$, $\boldsymbol{\Omega}^{y_k}$, $\boldsymbol{\Delta}_{pp}^{ss}$, and $\boldsymbol{\Delta}_{py_k}^{ss}$, and retail scaling parameter λ. [4]

[4]The retail scaling parameter λ can be treated as a known or unknown parameter. For example, one can make a monopolist retailer assumption by setting $\lambda = 1$, or assume a high degree of retail competition by setting λ to small numbers less than 1. My model setting also allows for a flexible degree of price competition among retailers when λ is treated as a unknown parameter which needs to be estimated empirically with appropriate instrumental variables.

3.3.4 Supply Estimation

Given manufacturers' first order conditions for pricing in equation (3.29), I can simply recover manufacturers' price-cost margins as

$$\boldsymbol{p}^W - \boldsymbol{c}^W = -(\boldsymbol{T} * \boldsymbol{\Delta}_w^s(\lambda))^{-1}\boldsymbol{S}, \tag{3.41}$$

where $\boldsymbol{T}$ is a J by J matrix which describes manufacturers' ownership for J products in a given market and time period. Specifically, $\boldsymbol{T}(c,j) = 1$ if products c and j are produced by the same manufacturer, $\boldsymbol{T}(c,j) = 0$, otherwise. The symbol '$*$' represents element by element matrix multiplication. $\boldsymbol{\Delta}_w^s(\lambda)$ denotes the manufacturer's response matrix of wholesale price to market share which depends on the retail scaling parameter λ. Its general elements are $\boldsymbol{\Delta}_w^s(\lambda)(c,j) = \frac{\partial S_j^*}{\partial p_c^W}$. Mathematically, $\boldsymbol{\Delta}_w^s(\lambda) = \boldsymbol{\Delta}_w^{p^T}(\lambda)\boldsymbol{\Omega}^R$.

With matrix notation, the $J \times K$ first order conditions for manufacturers' non-price competitions listed in equation (3.30) are

$$(\boldsymbol{T} * \boldsymbol{\Delta}_{y_k}^s(\lambda))(\boldsymbol{p}^W - \boldsymbol{c}^W) = \boldsymbol{\Theta}_k \boldsymbol{y}_k + \boldsymbol{\nu}_k^f, \quad k = 1, ..., K, \tag{3.42}$$

where $\boldsymbol{\Delta}_{y_k}^s(\lambda)$ is the manufacturer's response matrix of the k-th endogenous product attribute to market share which depends on retail scaling parameter λ. The general elements of this matrix are $\boldsymbol{\Delta}_{y_k}^s(\lambda)(c,j) = \frac{\partial S_j^*}{\partial y_{ck}}$, and it can be computed as $\boldsymbol{\Delta}_{y_k}^s(\lambda) = \boldsymbol{\Delta}_{y_k}^{p^T}(\lambda)\boldsymbol{\Omega}^R$. Replacing the manufacturer price-cost margins on the left-hand side of equation (3.42) with the right-hand side of equation (3.41) yields K systems of supply-side estimation equations:

$$-[\boldsymbol{T} * \boldsymbol{\Delta}^s_{y_k}(\lambda)][(\boldsymbol{T} * \boldsymbol{\Delta}^s_w(\lambda))^{-1}\boldsymbol{S}] = \boldsymbol{\Theta}_k \boldsymbol{y}_k + \boldsymbol{\nu}^f_k, \quad k = 1, ..., K, \tag{3.43}$$

which involve both linear parameter vectors $\boldsymbol{\Theta}_k$, and a scalar nonlinear parameter λ. To estimate the marginal cost parameter vector $\boldsymbol{\eta}$, I add the retailer's pricing equation (3.22) to manufacturer's pricing equation (3.41), and replace marginal cost with its parameterized form in equation (3.27). This procedure yields the supply-side estimation equation for marginal cost parameters:

$$\boldsymbol{p}^R = -(\boldsymbol{T} * \boldsymbol{\Delta}^s_w(\lambda))^{-1}\boldsymbol{S} - \lambda \boldsymbol{\Omega}^{R^{-1}}\boldsymbol{S} + \boldsymbol{\eta} W + \boldsymbol{\omega}. \tag{3.44}$$

Systems of equations of (3.43) and (3.44) together form the supply-side estimation equations for the set of parameter $\boldsymbol{\Gamma}^S = [\lambda, \boldsymbol{\eta}, \boldsymbol{\Theta}_1, ..., \boldsymbol{\Theta}_K]$, where λ is nonlinear parameter scalar and $\boldsymbol{\eta}, \boldsymbol{\Theta}_1, ..., \boldsymbol{\Theta}_K$ are linear parameter vectors.

Similar to demand-side estimation, the supply-side parameter $\boldsymbol{\Gamma}^S$ is estimated by GMM with appropriate instrumental variables for endogenous product attributes $\boldsymbol{y}_k$ and the retail scaling parameter λ. The set of instruments for $\boldsymbol{y}_k$ in supply estimation can be the same as what is used in demand estimation. Additional instruments are required if the retail scaling parameter λ is to be estimated, which is due to the fact that unobserved costs $\boldsymbol{\omega}$ may affect retail markups (Miller and Weinberg (2017)). Instruments for λ may include demand variables and variables that affect retail competition but not retail costs.

Assume $Z^S = [Z_1^S, Z_2^S, ..., Z_I^S]$ is a set of instruments for retail scaling parameter and endogenous product attributes, parameters $\mathbf{\Gamma}^S$ can be estimated using the following moment conditions

$$E[Z_i^S G^S(\mathbf{\Gamma}^{S^*})] = 0, \qquad i = 1, ..., I \tag{3.45}$$

where G^S denotes the structural errors or residuals and $\mathbf{\Gamma}^{S^*}$ is the set of true parameters. The GMM parameter estimates are obtained when the objective function is minimized:

$$\hat{\mathbf{\Gamma}}^S = \arg\min_{\mathbf{\Gamma}^S} \quad G^S(\mathbf{\Gamma}^S)' Z^S W^{S^{-1}} Z^{S'} G^S(\mathbf{\Gamma}^S). \tag{3.46}$$

W^S is the weighting matrix for supply estimation. Given a guess for λ, the structural error term G^S can be decomposed into several components and expressed as $G^S = [G_{1k}^S, ..., G_{1K}^S, G_2^S]$, where

$$G_{1k}^S = -[\boldsymbol{T} * \mathbf{\Delta}_{y_k}^s(\lambda)][(\boldsymbol{T} * \mathbf{\Delta}_w^s(\lambda))^{-1}\boldsymbol{S}] - \mathbf{\Theta}_k \boldsymbol{y}_k, \quad k = 1, ..., K \tag{3.47}$$

and

$$G_2^S = \boldsymbol{p}^R + (\boldsymbol{T} * \mathbf{\Delta}_w^s(\lambda))^{-1}\boldsymbol{S} + \lambda \mathbf{\Omega}^{R^{-1}}\boldsymbol{S} - \boldsymbol{\eta} W. \tag{3.48}$$

With pre-calculated response matrices $\mathbf{\Omega}^R$, $\mathbf{\Omega}^{y_k}$, $\mathbf{\Delta}_{pp}^{ss}$, and $\mathbf{\Delta}_{py_k}^{ss}$ based on demand estimates $\hat{\mathbf{\Gamma}}$, supply-side parameter $\mathbf{\Gamma}^S$ can be estimated by GMM as defined in equation (3.46). If the retail scaling parameter λ is given, we can use a simple instrumental variable approach to estimate linear parameters. Otherwise, the linear and nonlinear parameters are estimated as follows:

(1) Given demand-side estimates, pre-compute response matrices $\boldsymbol{\Omega}^R$, $\boldsymbol{\Delta}^{ss}_{pp}$, $\boldsymbol{\Omega}^{y_k}$, and $\boldsymbol{\Delta}^{ss}_{py_k}$, for $k = 1, ..., K$.

(2) Give a initial guess for nonlinear parameter λ_0, compute $\boldsymbol{\Delta}^s_w(\lambda_0)$ and $\boldsymbol{\Delta}^s_{y_k}(\lambda_0)$, for $k = 1, ..., K$.

(3) Estimate linear parameters $\boldsymbol{\eta}_0, \boldsymbol{\Theta}_{10}, ..., \boldsymbol{\Theta}_{K0}$ by using instrumental variable approach, then compute structural errors $G^S(\boldsymbol{\Gamma}^S_0)$.

(4) Repeat step 2 and 3 until the objective function defined in (3.46) is minimized.

3.4 Counterfactual Analysis

One important advantage of the structural model is it allows researchers to do counterfactual simulations of policy changes, collusions, and mergers. Considering the case of a proposed horizontal merger of manufacturer A and manufacturer B, researchers have both demand and supply-side estimates $[\hat{\boldsymbol{\Gamma}}_{\text{pre}}, \hat{\boldsymbol{\Gamma}}^S_{\text{pre}}]$ based on the data in the pre-merger period and can use this to predict the equilibrium market outcomes and consumer welfares if the merger happens with efficiencies. In this case, suppose the supply-side estimates change from $\hat{\boldsymbol{\Gamma}}^S_{\text{pre}}$ to $\hat{\boldsymbol{\Gamma}}^S_{\text{post}}$ if the merger occurs with synergies or efficiencies, the counterfactual equilibrium market outcomes can be predicted by solving the structural demand and supply models derived above with parameters $[\hat{\boldsymbol{\Gamma}}_{\text{pre}}, \hat{\boldsymbol{\Gamma}}^S_{\text{post}}]$ and ownership matrix $\boldsymbol{T}_{\text{post}}$. To be more specific, one can do the following steps to calculate the counterfactual market outcomes:

(1) With pre-merger demand and supply-side estimates $[\hat{\boldsymbol{\Gamma}}_{\text{pre}}, \hat{\boldsymbol{\Gamma}}^S_{\text{pre}}]$, recover demand-side unobservables $\hat{\boldsymbol{\xi}}$ and $\hat{\boldsymbol{\epsilon}}$, and supply-side unobservables $\hat{\boldsymbol{\omega}}$ and $\hat{\boldsymbol{v}^f}$.

(2) Given a initial guess for manufacturers' choices for wholesale prices $\boldsymbol{p}_0^W$ and endogenous product attributes $\boldsymbol{y}_0$, solve for retailer's optimal retail prices $\boldsymbol{p}_0^R$ with given parameters $\hat{\boldsymbol{\Gamma}}_{\text{pre}}$ and demand-side unobservables $[\hat{\boldsymbol{\xi}}, \hat{\boldsymbol{\epsilon}}]$ according to equation (3.22).

(3) Based on $\boldsymbol{p}_0^W$, $\boldsymbol{y}_0$, $\boldsymbol{p}_0^R$, $\hat{\boldsymbol{\Gamma}}_{\text{pre}}$ and demand-side unobservables $[\hat{\boldsymbol{\xi}}, \hat{\boldsymbol{\epsilon}}]$, recompute response matrices $\boldsymbol{\Omega}^R$, $\boldsymbol{\Delta}^{ss}_{pp}$, $\boldsymbol{\Omega}^{y_k}$, $\boldsymbol{\Delta}^{ss}_{py_k}$, $\boldsymbol{\Delta}^{s}_{w}$, and $\boldsymbol{\Delta}^{s}_{y_k}$, for $k = 1, ..., K$.

(4) Compute the right-hand side of equations (3.43) and (3.44), and left-hand side of equation (3.43) based on $\boldsymbol{T}_{\text{post}}$, supply-side unobservables $[\hat{\boldsymbol{\omega}}, \hat{\boldsymbol{v}^f}]$, and response matrices computed in step 3.

(5) Repeat steps 2 to 4 until the equations in (3.43) and (3.44) hold under reasonable tolerances.

By following the steps above, one can find the counterfactual equilibrium market outcomes post-merger $[\hat{\boldsymbol{p}}^W_{\text{post}}, \hat{\boldsymbol{y}}_{\text{post}}]$ and conduct analyses by comparing them with observed pre-merger counterparts.

3.5 Concluding Remarks

I develop a conceptual framework which incorporates vertical relationships between upstream firms and downstream retailers to estimate demand and supply when considering both price and non-price competition. In addition to the classic price competition game, my framework allows firms to compete in endogenous product attributes. My demand-side model builds on BLP (1995) and Fan (2013) which allows for endogenous prices and product attributes and consumer heterogeneity. The supply-side model can be applied to industries with differentiated products and vertical relationships between upstream manufacturers and downstream retailers, where manufacturers simultaneously choose wholesale prices and endogenous product attributes in the first stage, retailers choose retail prices in the second stage given manufacturers' optimal behaviors. My model also relaxes the monopolist retailer assumption (e.g. Ellickson et al. (2017)) by incorporating a retail scaling parameter to flexibly capture the degree of competition among retailers. In this paper, I provide detailed identification and estimation strategies, and ways to implement counterfactual simulations when conducting policy analyses, such as merger and tax simulations. Considering the model application, researchers can apply it to a wide range of industries that have vertical relations with downstream retailers and non-price competition among their differentiated products. Fast moving consumer goods such as beverages, milk, ice cream, and yogurt may fall in this category. For the ice cream industry, Sullivan (2016) provides evidence that premium ice cream manufacturers collude not only in price but also in product space, e.g. choice of flavors. Future studies may apply the framework developed in this paper to understand research questions in relevant industries, such as how price and non-price competitions affect the equilibrium market outcomes, channel profits between manufacturers and retailers, and merger analysis.

Chapter 4: What Makes A Good Merger? An Analysis of Merger Efficiencies in the U.S. Bottled Water Industry

4.1 Introduction

Horizontal mergers are prevalent economic activities in the modern economy, which may have significant effects on the market structure, competition, and consumer welfares. Most existing empirical studies in horizontal merger find exclusively "bad" effects of merger via market power increase (e.g. Kim and Singal (1993); Nevo (2001); Capps et al. (2003)), and little work has been done examining the effects of horizontal merger on synergies or efficiencies (Whinston (2003)). In addition, it is unclear how important the underlying merger efficiencies are in affecting the equilibrium market outcomes.

Another gap of knowledge lies in the non-price dimensions of competition in horizontal merger analysis. The 2010 Merger Guidelines of the United States Department of Justice (DOJ) places more weights on non-price considerations in

Researcher(s) own analyses calculated (or derived) based in part on data from The Nielsen Company (US), LLC and marketing databases provided through the Nielsen Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the Nielsen data are those of the researcher(s) and do not reflect the views of Nielsen. Nielsen is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

merger analysis, and recent enforcement actions reveal an increased focus on non-price effects of merger (Gundlach and Moss (2018)), yet most empirical research relies solely on price effects by assuming Nash-Bertrand pricing equilibria when conducting merger analyses. Non-price effects are critically important in antitrust analysis because price may not be the key strategic variable in all industries, and the effect of a merger on these non-price dimensions of competition do not necessarily correspond to their price effects (Kwoka and Kilpatrick (2018)).

In this paper, I explore the economic effects of Coca-Cola's acquisition of Glaceau, a major enhanced water manufacturer in the U.S. bottled water market. In May 2007, Coca-Cola announced its proposed acquisition of Glaceau for $4.2 billions, which was quickly approved by the U.S. regulators one month later. After the merger, I find that compared to other enhanced water brands, the market shares of Glaceau brands (Vitaminwater and Smartwater) increased significantly in many U.S. regions, while price trends were similar to other flavored brands post-merger. In addition, I find that the product varieties (measured in number of UPCs) and per-capita advertising expenditures of Glaceau increased significantly in the post-merger period. Classic models that incorporate only price effects cannot rationalize the observed changes in varieties and advertising post-merger. The dramatic changes in product varieties and advertising of Glaceau after the merger explicitly suggest that the merger affects Glaceau's choices for variety and advertising through not only efficiency changes but also non-price competition.

To quantify the market power and efficiencies from the merger, I estimate a structural model of demand and supply that incorporates both price and non-price competitions, and I allows for post-merger efficiency changes for Glaceau in marginal cost, product variety fixed cost, and advertising fixed cost. I focus on premium bottled water products. In addition to the standard Nash-Bertrand pricing competition, I assume manufacturers strategically choose product varieties and advertising in each market. For the demand side, sharing the same spirit with Fan (2013) and Murry (2017), I use a discrete choice random coefficient model that incorporates endogenous price and product characteristics for the estimation of consumer substitution patterns. In particular, I assume product variety and advertising affect consumer purchase decisions. My demand estimates imply small substitution effects between bottled water products within the choice set, consistent with the findings of Bonnet and Dubois (2010). Moreover, consumers are more likely to switch to cheaper outside choices rather than substituting between premium water products when facing a price increase, suggesting that premium water products are highly differentiated and the share increase of Glaceau post-merger mostly came from outside products rather other premium products.

The supply side of the model involves choices of varieties and advertising by manufacturers, and prices by manufacturers and retailers. I assume that in each market manufacturers choose wholesale prices, product varieties, and advertising in the first stage, and a monopolist retailer chooses corresponding retail prices in the second stage. Due to the direct store delivery (DSD) business approach of bottled water products, the retailer part of the supply model can be heavily simplified by transferring all shipping, inventory, and stock management costs to manufacturers. Thus I assume there is no marginal cost or fixed cost associated with retailers.

Since wholesale price data are unobservable, I use Villas-Boas (2007)'s approach to recover wholesale prices from retailer's optimal pricing given consumers' substitution patterns from the demand estimates. The same approach to recover wholesale prices has been applied to a wide range of industries by Gayle (2013), Ellickson et al. (2017), and Murry (2017). To rationalize the observed data of Glaceau and capture possible merger efficiencies through marginal cost and fixed cost variations, the supply model incorporates indicators for Glaceau products in post-merger periods in corresponding marginal cost and fixed cost functions. For horizontal merger efficiencies or synergies, most previous studies only focus on one type of efficiency by assuming efficiency gains are the same for all merging parties after the merger. However, Coca-Cola is significantly "larger" than Glaceau in terms of both total revenues and sales, it is reasonable to believe that the merger efficiencies for Coca-Cola are trivial, and I am comfortable to ignore efficiencies on Coca-Cola bottled water products (Dasani) post-merger.

The model suggests the merger generated efficiencies for Glaceau in all three aspects by reducing the corresponding cost parameters post-merger. Specifically, I estimate that the merger reduced Glaceau average marginal cost by 8.36 cents per liter controlling for fixed effects, and the merger decreased Vitaminwater product variety and advertising fixed cost parameters by about 20% and 80% respectively. The results of implied merger efficiencies rationalize the observed increases in Glaceau product variety and advertising post-merger.

To separately quantify the effects of different merger efficiencies on equilibrium market outcomes, I conduct 5 counterfactual merger scenarios that impose different efficiency structures to the merging party. I compare observed prices, product varieties, advertising, and market shares to the corresponding predictions from the different counterfactual merger scenarios. Product variety and advertising efficiencies are found to play primary roles in affecting manufacturers' equilibrium choices for product variety and advertising respectively, while marginal cost efficiency is found to play a dominant role in affecting equilibrium prices. In particular, the observed post-merger retail prices of Glaceau in 2009 are 4.72%-6.98% lower than they would have been under the "no merger" scenario, and product varieties, advertising, and shares are 25.44%-44.52%, 144.06%-322.43%, and 40.1%-60.7% higher respectively. These results suggest efficiencies that are created through merger have substantial impacts on the "weaker" merging party's market outcomes. I quantify net profits of all competing brands and calculate welfare measures under different merger scenarios and show that the merger increased the average net profit of competing brands and consumer surplus by 0.68%-3.13% and 30.12% respectively, compared to the "no merger" baseline in year 2009. These results imply limited market power effects on prices, and justify regulators' quick approval. More importantly, my results suggest that, with efficiencies and non-price dimensions of competition, the merger which appears to have had negative consequences may yield benefits.

This study relates to several strands of literature in both economics and marketing. First, it relates to research concerning market power and price effects (e.g. Kim and Singal (1993); Nevo (2001)). Kim and Singal (1993) show that compared to other routes, merging airlines raised fares significantly on routes they serve. Nevo (2001) proposes a framework to measure changes in market power post-merger, by calculating price-cost margins via robust demand estimates of the random coefficient model. Second, it relates to literature about horizontal merger efficiencies. Though the literature about the relationship between market power and merger efficiencies can date back to at least 1960s (e.g. Williamson (1968)), limited empirical work has done in this area. For instance, Williamson (1968) suggests a framework to evaluate the tradeoff between the welfare effects of efficiency gains and prices increases. Ashenfelter et al. (2015) examine the effects of increased concentration and efficiencies on pricing, by focusing on the Miller-Coors joint venture in the U.S. beer industry. Kulick (2017) estimates the price effects and cost efficiencies of horizontal mergers in the ready-mix concrete industry. My study considers merger efficiencies in multiple dimensions and incorporate non-price competition.

The third strand of related literature is about the non-price competition of differentiated products. My study includes manufacturers' strategic choices for product varieties and adverting, and their corresponding impacts on consumer demand. In terms of competition in product space, Sullivan (2016) develops a model to study competition in the market for super-premium ice cream by allowing two parties to collude in both price and product space. The results suggest that firms collude not only in price but also in the choice of flavors they offer. My study shares some similarities with Sullivan (2016) to the extent that the coordination/merger affects both prices and product varieties. Considering competition in advertising, Murry (2017) develops and estimates a model of pricing and advertising decisions of new car manufacturers and local retailers. Similar to Murry (2017), my supply side model involves manufacturers' strategic advertising decisions which affect consumer demand. [1]

Fourth, my study considers the vertical relationships between upstream manufacturers and downstream retailers. One pioneering work of this stream of literature is Villas-Boas (2007), who develops a feasible model which incorporates retailer pass-through to calculate manufacturers' markups when wholesale prices are not available. Gayle (2013) and Ellickson et al. (2017) extend the vertical framework to the airline markets, and the coffee market respectively. My supply side framework draws upon the literature on vertical structure between upstream and downstream firms, and the double marginalization of manufacturers and retailers (e.g. Bonnet and Dubois (2010)).

Finally, this paper relates to literature that examines post-merger effects. These studies compare the changes to the predictions before and after merger, typically by assuming a Nash-Bertrand competition among firms. Nevo (2000) empirically models the post-merger effects of the ready-to-eat cereal industry by recovering marginal costs and simulating post-merger price equilibria accordingly. For the U.S. airline market, Ciliberto et al. (2016) explore the post-merger effects between American Airlines and U.S. Air by allowing the market entry decisions to be endogenous, and also assuming Nash-Bertrand competition pre and post-merger. A recent study of Miller and Weinberg (2017) relaxes the unilateral effects of merger with consideration of the potential post-merger coordination effects. I provide a novel approach by accounting for both price and non-price competitions and by considering merger efficiencies in several dimensions.

[1] Unlike Murry (2017), I am not modeling the retailer advertising decisions.

The contribution of this study goes well beyond the application to the bottled water industry. My comprehensive setting that involves both price and non-price effects, and allows for merger efficiencies in several aspects can be generalized to many other industries and consumption goods that share similar features with premium bottled water. With antitrust agencies' increasing concerns for non-price effects in merger, understanding and evaluating the harms and benefits of non-price aspects of merger is a important policy and practical issue in the analysis of mergers. However, as noted by Kwoka and Kilpatrick (2018), there remains a gap between the price effects and non-price effects in terms of economic analytics and antitrust implications. In addition to contributions in merger efficiencies, my study contributes to the literature on non-price effects by showing how merger efficiencies affect non-price outcomes.

The rest of the paper is organized as follows. Section 2 provides background information on the U.S. bottled water industry, discusses datasets used in the analysis, and describes market outcomes before and after the merger, with an emphasis on the premium bottled water brands. Section 3 develops the demand model and discusses identification strategies and estimation results. Section 4 develops the supply model and discusses relevant estimation results. Section 5 implements counterfactual simulations under several merger scenarios and discusses the corresponding roles that different merger efficiencies played in affecting equilibrium market outcomes. Section 6 concludes the paper.

4.2 Industrial Background

The U.S. bottled water industry is a typical consumer product industry which incorporates the vertical relation between upstream manufacturers and downstream retailers. Bottled water manufacturers compete in prices, product varieties, and advertising intensity at local markets. As bottled water products belong to the fast-moving consumer goods, they are normally distributed by the direct store delivery (DSD) business approach, which means that manufacturers are responsible of distributing goods directly to the point of sale, and retailers carry no transportation and related service costs. The U.S. bottled water sector is highly concentrated where Nestle, Pepsi, Coca-Coca, and retailers' own brands account for 80% of the total market share in 2008. Bottled water products include purified water, spring water, imported water, and flavored water, and are sold in different containers and package sizes. In general, imported and flavored water brands are much more expensive than other categories, and the unit price of "big pack" products are significantly lower than single bottle counterparts.

4.2.1 Data

The primary data for this paper are drawn from the Nielsen Retailer Scanner Data from period of January 2006 to December 2009. The data include weekly information of retail prices and quantities sold by UPC code for a sample of grocery stores, convenience stores, drug stores, large merchandisers and liquor stores. I restrict the estimation samples to grocery stores within 92 distinct geographic regions and 10 top sale premium bottled water brands. [2] The Nielsen Company defines a geographic region as the Designated Market Area (DMA), which includes one or more metropolitan areas within a certain distance. In each DMA region, there are several grocery store chains competing with each other. A representative local grocery store chain normally operates a few hundred individual stores in each DMA region or regions nearby. Some large chains operate in dozens of DMAs across the nation. Pricing, stocking, and promotion decisions are made at the region-chain level, so I define the market as a region-retailer pair. By aggregating region-store level data to region-chain level data, the computational burden can be reduced significantly. My final data contain 52 grocery store chains across 92 DMA regions, which make up to 4,784 region-retailer pair markets (RRM).

I concentrate the samples on the Nielsen classification of "Water-Bottled", which excludes carbonated and energy drinks. Within this category, I observe various types of water with very different package sizes. The bottled water can be further classified as pure water, spring water, enhanced water, and imported water. Pure water is purified municipal water, e.g. Aquafina; spring water is water transported from certain spring resources, e.g. Deer Park; enhanced water is purified municipal water with additional nutrition or flavor facts, e.g. Vitaminwater; imported water is spring water which is imported from abroad, e.g. Fiji. Generally speaking, imported water is the most expensive, and pure water is the cheapest. Table 10 presents market shares of 14 flagship brands with top sales and popularity nationwide according to retail scanner data. Retailers' own brand is the highest and

[2] I exclude DMAs which contain only one grocery chain in the Nielsen sample.

accounts for one third of the total market share. Nestle accounts for about 31% of market share, and Pepsi and Coca-Cola account for about 9% and 10% respectively. Among manufacturers with top shares, Nestle concentrates on big-pack purified and spring water products with much lower unit prices while Pepsi and Coca-Cola have both flavored and non-flavored water brands. Except Crystal Geyser, brands of other manufacturers are marketed as much more expensive "premium" brands which cover imported and flavored water products.

Since bottled water is sold in different package sizes, it is natural to treat the brand-size pair as the baseline unit of study. Unfortunately, the heterogeneous package sizes across brands make this brand-size combination infeasible. Instead, I categorize different package sizes into 2 groups, namely, single-pack and multi-pack. With this simple classification, I am able to aggregate all UPC level data to brand-package level data, which form my basic product unit of study. For each brand, I define two "products", e.g. single-pack Vitaminwater and multi-pack Vitaminwater. The product variety is defined as the number of unique UPC codes that belong to each "product" category in each market. For example, for the "product" of single-pack Vitaminwater, it may include 8 unique UPC codes representing products of different flavors and package sizes in a given market, in this case, the product variety (number of UPCs) of single-pack Vitaminwater is defined as 8. I restrict my choice set to 10 top sale premium bottled water brands and I further aggregate the week-level data to month-level for estimation purpose.[3] Thus the samples used for

[3] I find Dasani's unit prices differ significantly across package and container sizes. For single bottle products with container size less than 1 liter, the unit price of Dasani is almost 3 times higher than products with larger container or multi-packs. Thus I exclude multi-pack and big-container Dasani from the premium bottled water category. In the rest of this paper, "Dasani" means single

consumer demand estimation consist of 146,107 observations at the region-chain-product-month-year level, over the time period from 2006-2009.[4] In additional to the Nielsen Retailer Scanner Data, I use household demographics from the Nielsen Household Panel to improve demand estimation. For each DMA region, I take 50 draws of household income, and allow these income draws to be correlated with the price coefficient.

To understand manufacturers' strategic decisions on advertising and to capture the effect of advertising on bottled water demand, I incorporate advertising information in both demand and supply models. The advertising data come from the Kantar TNS company, which collects information of firms' advertising expenditures on cable TV, radio, magazines, newspapers, and outdoor display. The TNS advertising data contain monthly advertising expenditures for each brand at the national level, and regional specific advertising expenditures for more than 100 DMA regions. I divide the monthly national advertising expenditure of each brand by the total U.S. population to form the national level per-capita advertising expenditure of each brand which measures the advertising intensity at the national level. For regions with local advertising expenditures, I divide the monthly regional advertising expenditure of each brand by the total population of the corresponding region to form the regional level per-capita advertising expenditure of each brand that measures the advertising intensity at the regional level.

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bottle Dasani products which belong to the premium water category based on unit price.

[4]Product and brand-package pair are used interchangeably.

4.2.2 Price Effects of Coca-Cola and Glaceau Merger

I observe significant differences for Glaceau products in terms of market shares, product varieties, and advertising before and after the merger with Coca-Cola. On the national level, after merging with Cocoa-Cola, the market shares of Glaceau's flagship brands, Vitaminwater and Smartwater have almost doubled on average. In addition, the product variety (number of UPCs) and per-capita advertising expenditure of Vitaminwater are much larger in the post-merger period than before. However, the average monthly prices of both brands seem to be fairly robust in the pre and post-merger periods. To identify the mechanisms behind these economic phenomena, I compare retail price, share, product variety, and advertising patterns with those of other premium brands, which have similar national market shares.

Figure 6 and 7 present trends of average retail prices and market shares of 5 premium bottled water brands between January 2006 and December 2009 respectively. The trends in the figures are calculated at the region-retailer level, which measure the average changes in prices and shares in a representative regional retailer. The vertical red long-dash line at July 2007 signifies the time when the merger of Coca-Cola and Glaceau is approved. The vertical blue line at February 2007 and red short-dash line at November 2007 respectively signify the time that 4 months before and after the merger was approved. The eight-month time window between February 2007 and November 2007 roughly includes the time for pre-merger negotiation, merger consummation, and realization of synergies or efficiencies post-merger. Among these 5 premium water brands, Dasani and Fiji are non-flavored brands while Vitaminwater, Fruit2O, and Propel are flavored brands. Considering prices, non-flavored brands Fiji and Dasani yield relative stable trends before and after merger, and prices are quite flat along the time trend. Flavored brands Vitaminwater, Propel, and Fruit2O all yield consistent small downward time trends which suggest prices of flavored water continue to decline with time. In addition, prices of Vitaminwater fluctuate more than other brands.

Figure 7 shows the trends of average market shares of selected premium brands. In the post-merger period, I observe a significant increase in Vitaminwater share while market shares of non-flavored brands are relatively stable over time. One may attribute the increase of Vitaminwater share to its corresponding price effects, but for flavored brands, Fruit2O and Propel, which share similar downward time trends in prices, their corresponding market shares don't increase in the post-merger periods. On the contrary, Fruit2O share reduces consistently in the post-merger period. These findings suggest that the boost of Vitaminwater shares in the post-merger period cannot be solely explained by price effects, other non-price factors are likely to play roles in affecting competition as well. Besides, the decreasing average prices and increasing average shares of the merging party are contradictory to previous findings that the horizontal merger with Betrand competition tends to increase market power, if the merger occurs without efficiencies.

At the regional (DMA) level, I find retail prices and market shares yield similar time trends with what presented in figure 6 and figure 7 at the national level. To illustrate the price and share trends at the regional level, I choose four large DMA regions of Atlanta, Houston, San Francisco, and Philadelphia as examples.

Figures 8-11 present the price trends of selected premium bottled water products in these four DMA regions. I find the price trends of these four DMA regions are very similar to the national level price trend that the price of flavored brands are declining slightly over time. However, regional level trends have more variations across time and regions. Figures 12-15 show the market share trends in these four DMA regions. As expected, I find the regional level share trends also echo with the national level share trend that Vitaminwater's market share increases significantly in the post-merger period.

4.2.3 Non-price Effects of the Merger

Figure 16 presents the trend of total number of UPCs of 5 premium bottled water brands from January 2006 to December 2009. Similar to figure 7, the time window between February 2007 and November 2007 approximates the period that the merger is under negotiation, waiting for approval, and realization with synergies. In the pre-merger period, especially before February 2007, Vitaminwater's total number of UPCs in the U.S. market is around 30. However, in the post-merger period, Vitaminwater's total number of UPCs is about 40 and relative stable between November 2007 to January 2008. The trend of Propel is quite similar to that of Vitaminwater and Propel increases its total number of UPCs in the post-merger period, suggesting plausible competition in product varieties among these two brands. For non-flavored brands, Fiji and Dasani, the trends in total number of UPCs don't change that much before and after the merger. In addition, figure 16 indicates that

Fruit2O's total number of UPCs declines consistently after the merger, which can be explained by the cost savings of offering less varieties.

Figure 17 reveals the trend of average product varieties (number of UPCs) sold in a local market (region-chain pair). For a representative local retailer, flavored brands consistently have much higher product varieties than non-flavored brands. That's because flavored products offer flavor choices for the same container and package size. On average, product varieties of non-flavored brands, Fiji and Dasani, don't vary much with time, but variations of flavored brands, Vitaminwater and Propel, increase significantly in the post-merger period. Though there exists an increasing trend in Vitaminwater varieties pre-merger, the post-merger average values are much larger. In particular, the average product varieties that Propel offers at a representative retailer increases abruptly in November 2007 after a quite stable trend before the merger, suggesting Propel offers more varieties as a strategic responses to its rivals' non-price competition.

Referring to specific regions, figures 18-21 depict how average product varieties change across time in Atlanta, Houston, San Francisco, and Philadelphia. Comparing to the national average trend in figure 17, the regional trends of product variety seem to be more heterogeneous. For example, for Atlanta and Houston regions, I observe abrupt increases in Vitaminwater's number of UPCs around November 2007, and for the Philadelphia region, I find Vitaminwater's number of UPCs begins to boost significantly at February 2007. In addition, similar to Propel's national level trend in product variety, I find Propel starts to offer a greater number of UPCs in these four regions at November 2007. The time window between February 2007 and

November 2007 coincides with the time when the Coca-Cola and Glaceau merger was under negotiation, waiting for approval, and realized with synergies and efficiencies.

Figure 22 presents the trend of per-capita advertising expenditure of the same premium bottled water brands discussed above. I find the advertising expenditure is quite seasonal and that manufacturers tend to advertise in spring and summer. Among these brands, Propel's advertising expenditure is significantly higher than other brands before July 2007. After the merger, especially after November 2007, Vitaminwater advertises aggressively and its corresponding advertising expenditures are much higher than its counterparts before the merger. The increasing trend of Vitaminwater's advertising after the merger coincides with its market share boots in the post-merger period, thus I have reason to believe that Vitaminwater's advertising intensity contributed to its market share rise post-merger.

Trends in figures 16-22 imply that non-price effects of product variety and advertising may affect demand positively. Moreover, price and non-price effects interrelate with one another and simultaneously determine demand and market outcomes. For example, more product variety and higher advertising would stimulate consumer demand but also increase total costs which drives price up, the rise in price inevitably reduces consumption along the demand curve. If the increased costs of offering more varieties and advertising cannot be compensated by the gains from a boost in demand, firms will not choose to do so. However, the increasing trends of Vitaminwater's product varieties, advertising, and shares suggest that the merger generates efficiencies for Glaceau brands by lowering costs of varieties and advertising. The 2008 annual report of Coca-Cola Company states that "In 2007, the Company transferred the majority of the distribution of Glaceau branded products to its existing bottling system with the exception of certain regional Glaceau distributors and certain channels." [5] This statement provides evidence that Coca-Cola company is in charge of the distribution of Glaceau branded products after the merger in 2007, suggesting merger efficiencies on Glaceau through a reduction in distribution costs. The purpose of this paper is to explore how merger affects equilibrium market outcomes through efficiencies by considering both price and non-price effects.

4.3 Consumer Demand

4.3.1 Demand Model

For the demand model, I use the standard random coefficient model developed by Berry et al. (1995), hereafter BLP. To capture the impacts of product variety and advertising on demand, I include the number of UPCs for each product (brand-package size) and the per-capita advertising expenditure of each brand in the consumer utility function. [6] Suppose consumers $i = 1, ..., N_{rt}$ purchase bottled water in market r, where r denotes the region-retailer pair (market), over $t = 1, ..., T$ time periods. Each consumer can purchase one of the observed products among the inside good set ($j = 1, ..., J$) or choose other products which are defined as the outside good. The utility that consumer i receives from purchasing product j

[5] See Coca-Cola Company's 2008 Annual Report Pursuant to Section 13 or 15(d) of the Securities Exchange Act 1934 (page 48), `http://www.annualreports.com/HostedData/AnnualReportArchive/c/NYSE_KO_2008.pdf`.

[6] The word of "product" and "brand-package size" means the same thing and is used interchangeably in the remaining paper.

(brand-package) in market r at time t is given by:

$$u_{ijrt} = \alpha_i p_{jrt} + \beta_i X_{jrt} + f(N^{upc}_{jrt}, D_j; \theta^d) + \theta^a A_{B_jrt} + \xi_{jrt} + \epsilon_{ijrt} \tag{4.1}$$

where X_{jrt} contains the observable product characteristics and a set of region and time fixed effects, p_{jrt} is the observed retail price charged by region-retailer pair r in time t. ξ_{jrt} is the unobserved product characteristics or quality valuations specific to market r in period t, and ϵ_{ijrt} is a consumer specific stochastic term. In addition to many classic demand specifications (e.g. BLP; Nevo (2000); Nevo (2001); Ellickson et al. (2017)), which use exogenous product characteristics as explanatory variables, I include product variety (number of UPCs) N^{upc}_{jrt} and per-capita advertising A_{B_jrt} in the consumer indirect utility function. The utility that consumers gain from product variety is defined as

$$f(N^{upc}_{jrt}, D_j; \theta^d) = \theta^d_f log(N^{upc}_{jrt}) D_j + \theta^d_{nf} log(N^{upc}_{jrt})(1 - D_j), \tag{4.2}$$

where D_j is an indicator that equals to 1 if product j is flavored water. This functional form allows marginal utility of product variety to be different for flavored and non-flavored water products, and the logarithm of N^{upc}_{jrt} ensures that product variety increases utility at a decreasing rate given positive parameters θ^d_f and θ^d_{nf}.

I assume advertising enters directly in the utility function defined above. In particular, the per-capita advertising $A_{B_{j}rt}$ is defined as

$$A_{B_{j}rt} = \bar{A_{Bt}} + A_{Brt}, \qquad \forall j \in B, \tag{4.3}$$

where $\bar{A_{Bt}}$ is the national level per-capita advertising expenditure of brand B at time t, which is assumed to have the same effects across all markets. A_{Brt} is the corresponding DMA regional level per-capita advertising expenditure. Consistent with Murry (2017)), I assume the brand advertising has the same effects on all products of that brand in the same market.

The product characteristics included in X_{jrt} are hard to observe for bottled water. Even though nutrition facts can be observed from the label of enhanced water, many other products contain nothing but "water", which suggests many products share exactly the same attributes. To deal with this problem, I follow Nevo (2000) and Bonnet and Dubois (2010) by using product fixed effects instead of attributes to capture the time-invariant product characteristics. I specify the consumer-specific coefficient as $[\alpha_i, \beta_i] = [\bar{\alpha}, \bar{\beta}] + \Pi I_i^{\text{inc}}$, where I_i^{inc} denotes per-capita household income of consumer i, $\bar{\alpha}$ and $\bar{\beta}$ are the mean effects across population. Noticing that the indirect utility function can be decomposed into a constant part $\delta_{jrt}(p_{jrt}, X_{jrt}, N_{jrt}^{upc}, D_j, A_{B_{j}rt}, \xi_{jrt}; \bar{\alpha}, \bar{\beta}, \theta^d, \theta^a)$, plus a random part $\mu_{ijrt}(p_{jrt}, X_{jrt}, I_i^{\text{inc}}; \Pi)$ such that

$$u_{ijrt} = \delta_{jrt} + \mu_{ijrt} + \epsilon_{ijrt} \tag{4.4}$$

where the first term, $\delta_{jrt} = \bar{\alpha} p_{jrt} + \bar{\beta} X_{jrt} + f(N_{jrt}^{upc}, D_j; \theta^d) + \theta^a A_{B_j rt} + \xi_{jrt}$ represents the mean utility of purchasing product j in market r at time t across all consumers, the second term, μ_{ijrt} denotes the consumer-specific deviations from the mean.

Following standard assumptions in the literature, I assume the mean utility of purchasing the outside option is zero, and the idiosyncratic error terms ϵ_{ijrt} are *iid* draws from the Type I extreme value distribution. Under these assumptions, if there are J products in the choice set, the market share of product j, in market r, at time t is:

$$S_{jrt} = \int \frac{\exp(\delta_{jrt} + \mu_{ijrt})}{1 + \sum_{k=1}^{J} I_{krt} \exp(\delta_{krt} + \mu_{ikrt})} dF(I^{\text{inc}}) \tag{4.5}$$

where I_{krt} ia an indicator for whether product k is offered to market r in time t, $F(.)$ is a cumulative distribution function of consumer income.

Without the random part μ_{ijrt}, the random coefficient logit model will reduce to the logit model, which yields the following reduced-form specification:

$$\log(S_{jrt}) - \log(S_{0rt}) = \alpha p_{jrt} + \beta X_{jrt} + f(N_{jrt}^{upc}, D_j; \theta^d) + \theta^a A_{B_j rt} + \xi_{jrt}. \tag{4.6}$$

Berry (1994) suggests a simple two stage least square (2SLS) method to estimate the above model with appropriate instruments for the endogenous variables.

4.3.2 Demand Estimation

The demand model is estimated with the fixed point algorithm developed by BLP via the generalized method of moments (GMM). Since retail prices are very likely to be correlated with unobserved product characteristics and demand shocks, appropriate instrumental variables are needed to help reduce estimation bias. Traditional instrumental variables of the BLP model fall into 3 types. The first type of instruments are the BLP instruments proposed by BLP. BLP type instruments include the summation of (i) product characteristics of other products by the same manufacturer in the same market, and (ii) product characteristics of other products produced by other manufacturers in the same market. The second type of instruments are Hausman type, which use observed retailer prices in other markets as a proxy for cost shifters (e.g. Nevo (2000)). The third type of instruments include data from the cost side, or observed cost shifters that may affect supply. In this study, I use instruments that share features of both Hausman type and cost shifter type instruments. Specifically, for each given market (region-retailer pair) at time period t, I use the retail prices in the 3 geographically nearest markets in other states as instruments. Intuitively, these instruments are Hausman type because they are prices in other markets. However, the markets I choose are close to each other and in other states, which can be regarded as a proxy for cost shifters, since the markets close to each other yield very similar production and shipping costs. I avoid unobserved state effects by using the nearest markets which are out of the local state. In addition to price, the number of UPCs and the market level advertising are potentially endogenous as well, since manufacturers make strategic decisions on product variety and advertising in each period. Following the same logic of Hausman type instruments, in the same time period, I use the average number of UPCs of the same retailer in other regions as instruments for product variety. In terms of market level advertising, I follow Murry (2017) by using the national level advertising as instrument.

Table 11 presents partial results of demand estimation for logit and random coefficient logit models. The logit model specification is estimated with the 2SLS by instrumenting endogenous price, product variety, and advertising. For the random coefficient model, I allow per-capita household income to affect preferences for price, the constant, and package size (multi-pack dummy). In addition to the set of instruments discussed above, I use interaction terms as IVs by interacting the average income across individuals with the mean price of 3 geographically nearest regions, the constant, and package size to identify nonlinear parameters. Observations are at the brand-package-region-month-year level and both regressions include product, region, and time fixed effects. The mean price coefficient of logit and random coefficient model are -2.095 and -2.439 respectively, suggesting downward sloping demand functions under both specifications. [7] All other coefficients have expected signs, and specifically, product variety and advertising affect demand positively under both specifications. The mean own-price elasticities of both models are close in magnitude but the random coefficient logit model yields more elastic demand.

Tables 12-13 show the mean own-price and cross-price elasticities across 16 products (brand-package pairs). On average, consumers are less price elastic to relative cheaper products, such as Aquafina Splash and Fruit2O. For instance, a

[7] The mean price coefficient (-2.439) of RCL is calculated as $\frac{1}{NM}\sum_{r=1}^{M}\sum_{i=1}^{N}(\alpha + \Pi_{\text{price}} I_{ir}^{\text{inc}} p_{jr})$, where subscripts i,j, and r denote individual draw, product, and market. N and M represents the number of draws of each market and the total number of markets in the estimation sample. I also find all consumer-specific price coefficients α_i are negative for all sample observations and individual consumer draws.

1% increase in the price of single-bottle Fiji will decrease its demand by roughly 4.1%. The findings that own-price elasticities tend to be higher for more expensive products are consistent with Miller and Weinberg (2017), who look at the price substitution patterns among beers. The cross-price elasticities are relative small in magnitude, which are consistent with the findings of Bonnet and Dubois (2010), who estimate bottled water demand in the French market.

To better understand the price competition between bottled water manufacturers, I also calculate the diversion ratio which measures the fraction of consumers that substitute from one product to the other after a price increase. In a market of Bertrand competition where manufacturers offer differentiated products, any two products face lower diversion ratio if they are highly differentiated or substitutable, which suggests a lower degree of price competition. Tables 14-15 present the diversion ratios of inside goods and the outside good. Following Conlon and Mortimer (2018), I define the diagonal elements as the diversion to the outside good rather than -1. According to the definition, if all products are substitutes and consumers make discrete choices, each row of the diversion matrix must sum to one. Each row j in table 13 represents the diversion ratios of product j's lost shares to different products when product j increases price. For example, Aquafina single-bottle's diversion to the outside good and Dasani single-bottle are 96.56% and 0.30% respectively, when Aquafina increases its price by 1%, suggesting consumers are more likely to switch to cheaper products rather than substituting between premium water products when facing a price increase. In general, I find the diversion ratios to the outside good are very high for all inside goods, which reflects the cross-price elasticities reported in table 12 that premium bottled water products are highly differentiated and less substitutable.

Tables 16 and 17 present the average advertising elasticities of 16 products across all sample markets. For premium bottled water products, I find advertising plays a small role in affecting demand, which is consistent with Zheng and Kaiser (2008), who estimate the own-advertising elasticity of bottled water of 0.083. In addition to bottled water, Zheng and Kaiser (2008) estimate the advertising elasticities of milk, juice, soft drinks, and coffee, and find they are similar to bottled water's advertising elasticity in terms of magnitude. My estimates for bottled water advertising elasticity are similar to Zheng and Kaiser (2008) in terms of magnitude. For example, consider the single-bottle Vitaminwater, its mean own-advertising elasticity is 0.0516, which suggests a 1% increase in Vitaminwater's advertising will only increase its demand by about 0.05%. If the advertising elasticity is constant along the demand curve, a 200% increase in Vitaminwater's advertising may would increase its demand by roughly 10%.

4.4 Supply

The supply model incorporates two stages. In the first stage, each manufacturer m chooses a subset of products J_{rt} to offer in market r at time t, the wholesale price p_j^w and product variety N_{jrt}^{upc} for each brand-package pair j, and the per-capita brand level advertising A_{B_jrt}.[8] I assume that each manufacturer makes decisions simultaneously and repeatedly in each market and time period. In the second stage,

[8] I allow A_{B_jrt} to be zero but not negative.

the retailer sets retail prices given manufacturers' wholesale prices, product varieties, and advertising. Consistent with related literature (e.g. Ellickson et al. (2017); Sullivan (2016)), I assume this game is played on a monthly basis in each market r, and firms make decisions each month with respect to their choices for wholesale prices, product variesties, and advertising expenditures.

4.4.1 Retailer Pricing Decisions

The vertical structure between manufacturers and retailers makes the two-stage game complicated since two parties are both involved in choices of multiple dimensions. However, the nature of direct-to-store delivery for bottled water products simplifies the game significantly. With direct-to-store distributors, retailers are not responsible for shipping, stocking, and managing inventories. Instead, these costs are borne by the manufacturers. Thus I can make two reasonable assumptions based on the stylized facts of direct-to-store delivery: (1) retailers incur no marginal cost for delivering bottled water products; (2) retailers do not choose products and product varieties.

Consider a market r with the monopolist retailer R which sells differentiated products (bottled water) for several manufacturers, the retailer's profit of selling these products is given by

$$\Pi_{rt}^{R} = \sum_{k \in G_{rt}} M_{rt}(p_{rkt}^{R} - p_{rkt}^{W})S_{rkt}, \tag{4.7}$$

where G_{rt} is the set of products available in market r at time t, M_{rt} is the market size of market r in time t, S_{rkt} is the market share for product k in retailer R at time t, p^R_{rkt} is the retail price of product k set by the retailer, and p^W_{rkt} denotes the wholesale price set by corresponding manufacturers. [9] Remember, I assume there is no marginal cost for retailers due to direct-to-store delivery. The marginal cost of retailing transfers to the manufacturer side. Maximizing the profit function with respect to product j's retail prices yields the following first order conditions:

$$S_{jrt} + \sum_{k \in G_{rt}} [p^R_{krt} - p^W_{krt}] \frac{\partial S_{krt}}{\partial p_{jrt}} = 0. \tag{4.8}$$

Following Villas-Boas (2007), define $\boldsymbol{\Omega}^R_t$ as retailer R's response matrix, which contains the first order derivatives of product shares with respect to all retail prices in market r at time t. Stacking the first order conditions above and rearranging them yields a vector of monopolist retailer's price-cost margins for all products it sells:

$$\boldsymbol{m}^{R,\text{monopoly}}_{rt} = \boldsymbol{p}^R_{rt} - \boldsymbol{p}^W_{rt} = -\boldsymbol{\Omega}^R_t(\boldsymbol{p}_{rt})^{-1}\boldsymbol{S}_{rt}, \tag{4.9}$$

where $\boldsymbol{m}^{R,\text{monopoly}}_{rt}$ is the markup for a monopolist retailer in market r.[10] Given demand estimates, observed market shares, and retail prices, I can back out the retailer's marginal cost (wholesale price) under the monopoly pricing assumption according to equation (4.9).

[9] I assume market size M_{rt} of market r is constant in a given year, and it is 10% greater than the maximum observed sales among bottled water category within each market. This definition of market size is similar to Miller and Weinberg (2017) who look at the U.S. beer industry.

[10] Vectors and matrices are denoted as bold symbols in the remaining of this paper.

4.4.2 Manufacturer Decisions

In the first stage of the game, each manufacturer chooses wholesale prices, brand level advertising, and corresponding product varieties (number of UPCs) with full information about how these decisions change the optimal behaviors of rival manufacturers and the downstream retailer. In particular, the first order conditions in equation (4.8) implicitly define equilibrium retail prices $p^{R*}(\boldsymbol{p}^W, \boldsymbol{N}^{\text{upc}}, \boldsymbol{A})$, and product shares $S^*(p^{R*}(\boldsymbol{p}^W, \boldsymbol{N}^{\text{upc}}, \boldsymbol{A}), \boldsymbol{N}^{\text{upc}}, \boldsymbol{A})$, given the choices of manufacturers. Notice that both product variety $\boldsymbol{N}^{\text{upc}}$ and brand advertising $\boldsymbol{A}$ affect market shares directly because consumer utility is a function of them, as well as indirectly through retailer pricing decisions. Wholesale prices affect market shares through retailer pricing decisions indirectly.

Suppose manufacturer m offers a bundle of products G_{rm}, which contains N_m products in a market r to a monopolist retailer at time t, the corresponding profit function is given as

$$\Pi_{rt}^m = \sum_{j \in G_{rm}} M_{rt}(p_{jrt}^W - c_{jrt}^W) S_{jrt}^*(\boldsymbol{p}_{rt}^{R*}, \boldsymbol{N}_{rt}^{\text{upc}}, \boldsymbol{A}_{rt}) - \sum_{j \in G_{rm}} F_{jm}(N_{jrt}^{\text{upc}}) - \sum_{B_j \in G_{rm}} H_{B_j m}(A_{B_j rt}), \tag{4.10}$$

where $F_{jm}(.)$ is manufacturer m's fixed cost of offering brand-package pair j in each market, $H_{B_j m}(.)$ is manufacturer m's fixed cost of advertising for brand B_j ($j \in B_j$). Since N_{jrt}^{upc} and $A_{B_j rt}$ both affect consumer utilities in the demand side, I can view product variety and advertising analogously to endogenous product characteristics. Similar to Fan (2013), I assume the slope of fixed cost function $F_{jm}(N_{jrt}^{\text{upc}}, \nu_{jrt}^f; \Theta_m)$

with respect to product variety N^{upc}_{jrt} is

$$F'_{jm} = (\Theta_m N^{\text{upc}}_{jrt} + \nu^f_{jrt}) M_{rt}, \tag{4.11}$$

and the slope of fixed cost function $H_{B_j m}(A_{B_j rt}, \nu^h_{jrt}; \Gamma_m)$ with respect to advertising $A_{B_j rt}$ is

$$H'_{B_j m} = (\Gamma_m A_{B_j rt} + \nu^h_{jrt}) M_{rt}. \tag{4.12}$$

Where ν^f_{jrt} and ν^h_{jrt} are unobservables, Θ_m and Γ_m are parameters. [11] Equation (4.11) and (4.12) implicitly determine the quadratic functional forms for product variety and advertising fixed costs. In terms of the direct-to-store delivery, it is natural to think that the shelf space in a supermarket or grocery store is limited and fixed for each manufacturer, so manufacturers encounter some sort of fixed opportunity costs of stocking an additional UPC. Considering advertising fixed cost, Murry (2017) assumes manufacturers face convex fixed advertising cost, which nests my quadratic functional form assumption. c^W_{jrt} represents the marginal costs of production, shipping and distribution. I assume that the marginal cost is different across products. The marginal cost of product j in market r of time r is then parameterized as

$$c^w_{jrt} = \Psi_j + \gamma_r + \eta_t + \omega_{jrt}, \tag{4.13}$$

where Ψ_j is a product fixed effect which reflects the mean marginal cost of each product. γ_r and η_t are sets of region-specific and period-specific effects, and ω_{jrt} is

[11] My fixed cost funciton differs from Fan (2013)'s specification by omitting the intercept term in the slope and assuming fixed cost is proportional to the market size.

unobservable cost shifters.

To accommodate the production cost change post-merger, I allow the marginal cost of Glaceau brands to differ pre and post-merger:

$$\Psi_j = \Psi_j^{\text{pre}} + \Psi_{\text{Glaceau}}^{\text{post}} \times \mathbb{1}\{\text{ Post-Merger}\}, \quad j \in G_{\text{Glaceau}}. \tag{4.14}$$

where Ψ_j^{pre} measures Glaceau's baseline production and distribution cost for product j pre-merger, and $\Psi_{\text{Glaceau}}^{\text{post}}$ measures the corresponding changes post-merger. Similarly, Glaceau's fixed cost coefficient Θ_{Glaceau} is also allowed to vary pre and post-merger

$$\Theta_{\text{Glaceau}} = \Theta_{\text{Glaceau}}^{\text{pre}} + \Theta_{\text{Glaceau}}^{\text{post}} \times \mathbb{1}\{\text{ Post-Merger}\}. \tag{4.15}$$

To rationalize the significant rise of Glaceau's advertising expenditures in the post-merger period, I allow Glaceau's advertising coefficient to vary pre and post-merger as well:

$$\Gamma_{\text{Glaceau}} = \Gamma_{\text{Glaceau}}^{\text{pre}} + \Gamma_{\text{Glaceau}}^{\text{post}} \times \mathbb{1}\{\text{ Post-Merger}\}. \tag{4.16}$$

With the profit function specified in equation (4.10), and knowing that retailers behave according to equation (4.9), a manufacturer's optimal pricing, choice of product varieties, and advertising can be found by taking the first order derivatives with respect to p_{jrt}^W, N_{jrt}^{upc}, and $A_{B_j rt}$ respectively.[12] By assuming a pure-strategy

[12]In reality, the measure for product variety (number of UPCs) N_{jrt}^{upc} is a integer. Previous studies such as Sullivan (2016), use moment inequalities to simulate the upper and lower bound for the fixed cost parameter. To simplify the analysis, I treat N_{jrt}^{upc} as a continuous variable. Considering the advertising first order condition, it does not hold with equality when advertising expenditure is zero in the data. Since I estimate demand without supply restrictions, zero advertising expenditures are not an issue here. As discussed by Murry (2017), the zero advertising expenditure is an issue when one needs to back out manufacturers' advertising costs and simulate counterfactuals.

Nash equilibrium, the first-order conditions are:

$$\sum_{k \in G_{rm}} [p^W_{krt} - c^W_{krt}] \frac{\partial S^*_{krt}}{\partial p^W_{jrt}} = -S_{jrt}, \qquad \forall j \in G_{rm} \tag{4.17}$$

$$\sum_{k \in G_{rm}} [p^W_{krt} - c^W_{krt}] \frac{\partial S^*_{krt}}{\partial N^{\text{upc}}_{jrt}} = \Theta_m N^{\text{upc}}_{jrt} + \nu^f_{jrt}, \qquad \forall j \in G_{rm}. \tag{4.18}$$

$$\sum_{k \in G_{rm}} [p^W_{krt} - c^W_{krt}] \frac{\partial S^*_{krt}}{\partial A_{B_j rt}} = \Gamma_m A_{B_j rt} + \nu^h_{jrt}, \qquad \forall j \in G_{rm}. \tag{4.19}$$

Where market share $S^*_{krt}(p^{R*}(\boldsymbol{p}^W_{rt}, \boldsymbol{N}^{\text{upc}}_{rt}, \boldsymbol{A}_{rt}), \boldsymbol{N}^{\text{upc}}_{rt}, \boldsymbol{A}_{rt})$ of product k in market r at time t is a implicit function of wholesale prices, product varieties, and brand level advertising. Focusing on FOCs of wholesale prices, a change in wholesale price of a single product directly affects retail prices and further influence shares of all products in the market. Thus for market r at time t I have

$$\frac{\partial S^*_k}{\partial p^W_j} = \left[\frac{\partial S_k}{\partial p^R_1} \frac{\partial p^R_1}{\partial p^W_j} + \frac{\partial S_k}{\partial p^R_2} \frac{\partial p^R_2}{\partial p^W_j} + ... + \frac{\partial S_k}{\partial p^R_{J_{rt}}} \frac{\partial p^R_{J_{rt}}}{\partial p^W_j} \right]. \tag{4.20}$$

In addition to the pass-through effects on retail prices, product variety and advertising affect market shares directly as well:

$$\frac{\partial S^*_k}{\partial N^{\text{upc}}_j} = \sum_{i=1}^{J_{rt}} \left[\frac{\partial S_k}{\partial p^R_i} \frac{\partial p^R_i}{\partial N^{\text{upc}}_j} \right] + \frac{\partial S_k}{\partial N^{\text{upc}}_j}, \tag{4.21}$$

$$\frac{\partial S^*_k}{\partial A_{B_j}} = \sum_{i=1}^{J_{rt}} \left[\frac{\partial S_k}{\partial p^R_i} \frac{\partial p^R_i}{\partial A_{B_j}} \right] + \frac{\partial S_k}{\partial A_{B_j}}. \tag{4.22}$$

Following Murry (2017), I do not back out advertising for manufacturers who do not advertise, and keep their advertising expenditures at zeros in counterfactuals.

Following Villas-Boas (2007), let $\boldsymbol{T}_{rt}$ be a J by J matrix which describes manufacturers' ownership for J_{rt} products in market r at time t. Specifically, $\boldsymbol{T}_{rt}(j,k) = 1$ if products j and k are produced by the same manufacturer, $\boldsymbol{T}_{rt}(j,k) = 0$, otherwise. Define $\boldsymbol{\Delta}_{rt}^{W}$, $\boldsymbol{\Delta}_{rt}^{\text{upc}}$, and $\boldsymbol{\Delta}_{rt}^{A}$ as manufacturer's response matrices in terms of wholesale price, product varieties, and advertising, whose general elements are $\boldsymbol{\Delta}_{rt}^{W}(j,k) = \frac{\partial S_{krt}^{*}}{\partial p_{jrt}^{W}}$, $\boldsymbol{\Delta}_{rt}^{\text{upc}}(j,k) = \frac{\partial S_{krt}^{*}}{\partial N_{jrt}^{\text{upc}}}$, and $\boldsymbol{\Delta}_{rt}^{A}(j,k) = \frac{\partial S_{krt}^{*}}{\partial A_{B_j rt}}$ respectively. Then the systems of three J_{rt} by 1 FOCs can be expressed in matrix forms as

$$\boldsymbol{p}_{rt}^{W} - \boldsymbol{c}_{rt}^{W} = -(\boldsymbol{T}_{rt} * \boldsymbol{\Delta}_{rt}^{W})^{-1}\boldsymbol{S}_{rt}, \tag{4.23}$$

$$(\boldsymbol{p}_{rt}^{W} - \boldsymbol{c}_{rt}^{W})(\boldsymbol{T}_{rt} * \boldsymbol{\Delta}_{rt}^{\text{upc}}) = \boldsymbol{\Theta}_{rt} * \boldsymbol{N}_{rt}^{\text{upc}} + \boldsymbol{\nu}_{rt}^{f}, \tag{4.24}$$

$$(\boldsymbol{p}_{rt}^{W} - \boldsymbol{c}_{rt}^{W})(\boldsymbol{T}_{rt} * \boldsymbol{\Delta}_{rt}^{A}) = \boldsymbol{\Gamma}_{rt} * \boldsymbol{A}_{rt} + \boldsymbol{\nu}_{rt}^{h}, \tag{4.25}$$

where $\boldsymbol{\Theta}_{rt}$ and $\boldsymbol{\Gamma}_{rt}$ are J_{rt} by 1 vectors with element $\boldsymbol{\Theta}_{rt}(j) = \Theta_k$ and $\boldsymbol{\Gamma}_{rt}(j) = \Gamma_k$, if product j belongs to brand k. Adding the retailer's pricing equation (4.9) to manufacturer's pricing equation (4.23), and replacing marginal cost with its parameterized form in equation (4.13) I get the supply side estimation equation for marginal cost parameters:

$$\boldsymbol{p}_{rt}^{R} - \boldsymbol{\Psi}_{rt} - \boldsymbol{\gamma}_{r} - \boldsymbol{\eta}_{t} = -(\boldsymbol{T}_{rt} * \boldsymbol{\Delta}_{rt}^{W})^{-1}\boldsymbol{S}_{rt} - (\boldsymbol{\Omega}_{rt}^{R})^{-1}\boldsymbol{S}_{rt} + \boldsymbol{\omega}_{rt}. \tag{4.26}$$

Replacing manufacturer markups in equations (4.24) and (4.25) with the right-hand side of equation (4.23), yields estimation equations for product variety and advertising fixed cost parameters.

4.4.3 Supply Estimation

Given the demand estimates and supply side specification, marginal cost and fixed cost parameters $\boldsymbol{\Xi} = (\boldsymbol{\Psi}, \boldsymbol{\Theta}, \boldsymbol{\Gamma})$ can be estimated with instrumental variable approaches if response matrices $\boldsymbol{\Omega}_{rt}^{R}$, $\boldsymbol{\Delta}_{rt}^{W}$, $\boldsymbol{\Delta}_{rt}^{\text{upc}}$ and $\boldsymbol{\Delta}_{rt}^{A}$ are pre-calculated. Recall that the matrix of $\boldsymbol{\Delta}_{rt}^{W}$ can be decomposed as $\boldsymbol{\Delta}_{rt}^{P'}\boldsymbol{\Omega}_{rt}^{R}$, where $\boldsymbol{\Delta}_{rt}^{P'}$ is a J_{rt} by J_{rt} matrix which denotes the transpose of the retail pass-through matrix with element $\boldsymbol{\Delta}_{rt}^{P}(j,k) = \frac{\partial p_{krt}^{R}}{\partial p_{jrt}^{W}}$. Villas-Boas (2007) showed that $\boldsymbol{\Delta}_{rt}^{P}$ can be expressed as $\boldsymbol{\Delta}_{rt}^{P} = \boldsymbol{G}_{rt}^{-1}\boldsymbol{\Omega}_{rt}^{R}$, where $\boldsymbol{G}_{rt}$ is a complicated matrix that involves calculation of the second-order derivatives of shares with respect to retail prices.[13] Similarly, I can pre-calculate $\boldsymbol{\Delta}_{rt}^{\text{upc}}$ and $\boldsymbol{\Delta}_{rt}^{A}$ this way given demand estimates.[14]

With pre-calculated markup terms, equation (4.26) is simply a linear equation of marginal cost variables, which can be estimated with ordinary least square approach. For equations (4.24) and (4.25), manufacturers' endogenous choices for product varieties and advertising are very likely to be correlated with unobserved cost $\boldsymbol{\nu}_{rt}^{f}$ and $\boldsymbol{\nu}_{rt}^{h}$ respectively. I instrument product variety with the average product variety of other regions within the same chain and its interaction with an indicator that equals one for Coca-Cola and Glaceau in the post-merger period. Considering endogenous advertising, I instrument it with the nationwide per-capital advertising

[13] Refer to Villas-Boas (2007)'s equation (4.9) for details. My specification differs from Villas-Boas (2007) by defining a market as a region-retailer pair, so the retailer ownership matrix can be dropped.

[14] Derivations of $\boldsymbol{\Delta}_{rt}^{\text{upc}}$ and $\boldsymbol{\Delta}_{rt}^{A}$ are similar to $\boldsymbol{\Delta}_{rt}^{W}$, which requires the computation of the second order derivatives of the demand function, see Villas-Boas (2007) and Gayle (2013) for details.

expenditure and its interaction with an indicator defined above. These instruments are valid if unobserved costs $\boldsymbol{\nu}_{rt}^{f}$ and $\boldsymbol{\nu}_{rt}^{h}$ are orthogonal to their corresponding instruments.

Table 18 provides the average retailer markups, manufacturer markups, and recovered marginal costs based on equations (4.9), (4.23), and (4.26) with demand estimates and observed data from January 2006 to December 2009. As shown in the table, under monopolist retailer assumption the total channel variable profit is almost evenly distributed between manufacturers and retailers. For example, Aquafina's markup is about \$0.41 per liter and its relative retailer markup is about \$0.44 per liter. In general, cheaper brands have lower markups and marginal costs while more expensive brands have higher counterparts. On average, Vitaminwater is the most expensive brand and also yields the highest manufacturer markup, retailer markup, and marginal cost, which are \$0.43, \$0.47, and \$1.15 per liter respectively.

Table 19 presents the supply-side estimation results. For the supply-side estimation, consistent with earlier discussion, I discard the data between February 2007 and November 2007 to exclude the noises when the merger was under negotiation, and allow for the realization of efficiencies. Columns (i)-(iii) provide key parameter estimates for marginal cost, product variety and advertising fixed cost estimation equations. As expected, the merger indeed raises Glaceau's marginal cost, product variety and advertising efficiencies by reducing corresponding cost parameters. As shown, the average marginal cost of Glaceau products reduces by 8.36 cents per liter post-merger controlling for other fixed effects. In particular, for single-pack Vitaminwater, the merger decreases the marginal cost by about 7.2%. The merger has a significant impact on Vitaminwater's product variety efficiency, which decreases its relevant fixed cost parameter by 19.4%. This result may partly explain the observed data trend in which product variety of Vitaminwater increases in the post-merger period. Turning to the advertising efficiency, I find the merger reduces the advertising fixed cost parameter for Vitaminwater largely by 79.2% on average, which is likely to explain Glaceau's advertising spikes in the post-merger period.

4.5 Counterfactual Analysis

With both demand and supply side estimates, I can now use counterfactual analysis to study how the merger of Coca-Cola and Glaceau would affect the market outcomes. I perform 5 counterfactual scenarios under different merger efficiency and synergy assumptions:

(1) The merger of Coca-Cola and Glaceau does not occur.

(2) The merger occurs with only a unilateral effect.

(3) The merger occurs with both unilateral effect and marginal cost efficiency.

(4) The merger occurs with both unilateral effect and product variety fixed cost efficiency.

(5) The merger occurs with both unilateral effect and advertising fixed cost efficiency.

To calculate post-merger outcomes under different merger assumptions I resolve retailers and manufacturers' optimal decisions under vertical relationships for each market. To be consistent with my supply model I assume manufacturers move first, and the equilibria are solved by using a two-step procedure. First, given a guess of wholesale prices, product varieties, and advertising intensities the monopolist retailer solves for the corresponding optimal retail prices that maximizes its total profits. Second, manufacturers take retailer's optimal pricing decisions into consideration and solve for their optimal wholesale prices, product varieties, and advertising intensities respectively.[15] The two-step procedure continues until the manufacturers' optimal choices converge to the guess of equilibria in the first step. Due to the large sample size and computational burden to solve the equilibria, the counterfactual analyses in the rest of this paper will focus on the top 20 retail chains which cover the most DMA regions.[16]

4.5.1 The Predicted Trends of Vitaminwater

In figures 23-26 I predict the brand-level retail price, product variety, advertising intensity, and market share of Vitaminwater under 4 scenarios starting from January 2006 to December 2009. The vertical solid blue line indicates the time at February 2007 and the dash red line signifies the time at November 2007. Consistent with supply-side estimation, I drop data between February 2007 to November 2007 to allow for the merger negotiation, consummation, and realization of efficiencies on Glaceau. I exclude scenario (2) from the figures because the unilateral effects

[15]Similar to Murry (2017), I only solve advertising intensity when it is positive in the real data. For brands with zero advertising expenditures in a given market, I assume their advertising expenditures are zero and do not solve their advertising first order conditions.

[16]These top 20 retailer chains operate business in several DMA regions, and I rank them based on the number of DMA regions they cover. Out of 91 DMA regions in the estimation sample, the top 1 retailer covers 71 DMA regions and the 20th retailer covers 8. The selected retailers account for 8243 markets (75.31% of the sample markets).

are very small in this merger case. The results show that the predicted equilibrium outcomes under all 4 counterfactual scenarios are almost identical to the observed real data in the pre-merger period, which justifies the model performance. The reported retail price in figure 23 is the average brand level retail price weighted by product volumes. I find prices in scenario (3) are nearly the same as the real prices, and prices in scenarios (4) and (5) are almost the same as prices in the "no merger" scenario. These two findings suggest marginal cost reduction plays a dominant role in affecting Vitaminwater's equilibrium prices post-merger. However, the magnitudes of the marginal cost efficiency in prices are small, which implies limited market power of the merger.

Figure 24 shows the average product variety (number of UPCs) of Vitaminwater across sample regions and retailer chains. As shown, product varieties yield stable upward time trends and the observed product varieties in the post-merger periods are higher than the predicted product varieties of all other counterfactual scenarios. Compared to the "no merger" scenario, both marginal cost and product variety efficiency scenarios generate significant higher product varieties, but the magnitude of the product variety efficiency scenario is closer to the observed data. On average, the merger increases product varieties by about 16.7% and 22.7% under marginal cost and product variety efficiency scenarios respectively, relative to the "no merger" baseline.

Figure 25 plots the average per-capita advertising expenditure across sample regions. It shows that Vitaminwater's advertising decisions are quite seasonal and usually spike between spring and summer. In the post-merger periods, advertising expenditures are much lower under the “no merger” scenario than their counterparts in the real data, which suggests merger actually increases advertising of Vitaminwater. However, except advertising efficiency, other efficiencies do not have significant effects on firm’s advertising expenditures. During November 2007 to December 2009, relative to the “no merger” baseline, the merger with only advertising efficiency raises advertising by 173.7%.

Figure 26 presents the market shares of Vitaminwater under 4 counterfactual scenarios. In the post-merger period, market shares in the “no merger” scenario are substantially lower than in the real data and appear to track the pre-merger trend. Among all merger efficiencies, the marginal cost efficiency plays the biggest role in raising market shares and product variety efficiency yields a slightly lower magnitude than marginal cost efficiency in increasing market shares. Advertising efficiency has limited impacts on market shares of Vitaminwater.

4.5.2 Mean Effects Under Different Merger Scenarios

Table 20 provides the mean equilibrium wholesale prices, product varieties, and per-capita advertising across 20 retailer chains under different merger scenarios. All numbers in the table are for year 2009, which is the final year of the sample. Column (i) presents the equilibrium outcome values of the “no merger” baseline. The numbers in columns (ii) to (vi) are calculated based on the counterfactual outcomes of scenarios (2)-(5) and the real data respectively, and denote the percentage changes relative to corresponding values in column (i). In general, I find the merger has small effects on the equilibrium outcomes of other brands, which is due to small inside good share and weak substitution effects across brands. Comparing columns (i) and (ii) I find the merger with only unilateral effects yields very limited market power which increases the wholesale prices of all brands by less than 1%, while it has significant effects on Dasani product varieties and advertising by decreasing them by 3.74% and 18.85% respectively. This suggests the merging party re-maximizes its total profits by strategically shifting resources from the lower markup brands to the higher markup brands. A comparison of columns (i) and (iii) reveals that the merger with marginal cost efficiency decreases wholesale prices of Smartwater and Vitaminwater by 9.54% and 6.01%, while it simultaneously raises their corresponding product varieties by 22.10% and 15.52% respectively. In addition, the merger reduces Smartwater advertising by 38.02% to offset its increased fixed cost of product variety, and increases other brands' average product varieties and advertising. On the contrary to scenario (iii), scenario (iv) reduces both product varieties and advertising of other brands relative to the "no merger" scenario. However, the merger with product variety efficiency increases Vitaminwater product variety significantly, by 22.89% relative to the "no merger" baseline. The comparison between columns (i) and (v) reveals that advertising efficiency plays trivial roles in affecting wholesale prices and product varieties but significant roles in affecting advertising.

Numbers in column (vi) are calculated based on the observed data, which reflect the merger with all three efficiency effects. It is evidenced that the merger reduces wholesale prices of Glaceau brands primarily through marginal cost efficiency and raises product varieties of Glaceau brands through both marginal cost and product variety efficiencies. On average, I find the merger decreases Smartwater and Vitaminwater wholesale prices by 9.35% and 5.86%, and increases their corresponding product varieties by 25.44% and 44.52% respectively relative to the "no merger" scenario in 2009. Additionally, I also identify a strong boost in Vitaminwater advertising through merger which raises per-capita advertising expenditure by 322.43% comparing to the "no merger" baseline. To maximize total profits of the merging party, the merger internalizes competitions by increasing Dasani wholesale prices and reducing its product variety and advertising. However, the merger has insignificant effects on the equilibrium outcomes of non-flavored brands. Considering flavored brands, the effects of merger on wholesale prices are trivial, but the merger plays positive roles in affecting product varieties and advertising.

Analogous to table 20, table 21 provides equilibrium retail prices, market shares, per-unit net profits, and changes of consumer surplus under different counterfactual scenarios. Since retailers determine retail prices by responding to manufacturers' optimal behaviors, retail prices are simultaneously affected by manufacturers' wholesale prices, product varieties, and advertising. In general, results suggest that under different merger scenarios, retail prices of Smartwater, Vitaminwater, and Dasani change in the same direction as changes in wholesale prices relative to the "no merger" scenario. A comparison of columns (i) and (ii) reveals that the merger with only unilateral effect yields higher market power and thus increases prices. Together with product variety and advertising changes reported in column (ii) of table 20, increased retail prices result in market share drops in Smartwater, Vitaminwater, and Dasani relative to the numbers in column (i). However, the merger under scenario (ii) is not profitable for the merging party since it reduces Dasani's per-unit net profit significantly by 8.42% relative to the "no merger" scenario, which contradicts the outcome of horizontal merger with Bertrand competition. Notice that manufacturers compete not only in prices but also product varieties, it is straightforward to associate competition in product varieties with Cournot competition, since product varieties affect outputs (shares) positively and directly. It is known that horizontal merger with Cournot competition yields a "merger paradox" that the merger tends to reduce output which is not profitable for the merging party unless it forms a monopoly post-merger. In my case, Dasani's gains from increased price with Bertrand competition are heavily offset by the corresponding losses from reduced product varieties with Cournot competition. Focusing on column (iii) I find the merger with marginal cost efficiency raises the market shares of Smartwater and Vitaminwater by 69.13% and 51.75% compared to the "no merger" baseline, which are primarily attributed to the price reduction and product variety increment of these brands. Unlike merger under scenario (ii), the merger is profitable for Glaceau and the entire merging party because the net gain from Glaceau brands is much larger than the loss from Dasani. As expected, the merger with product variety efficiency affects Vitaminwater market share and profit most significantly, but yields limited effects on other brands. Even though the merger under scenario (iv) reduces the profit of Dasani relative to the "no merger" baseline, the merger is still profitable since the lost profit from Dasani is compensated by the much larger profit gains from Vitaminwater. The comparison between columns (ii) and (v) suggests relatively small effects of advertising efficiency on shares and profits. Specially, the merger with advertising efficiency raises Smartwater and Vitaminwater profit by 3.81% and 10.44% relative to the "no merger" baseline.

Column (vi) presents the scenario where the merger occurs with all three efficiencies. Compared to the "no merger" scenario, the merger decreases Smartwater and Vitaminwater retail prices by 6.98% and 4.72%, and increases retail prices of Dasani, non-flavored, and flavored brands by 0.87%, 0.18%, and 0.27% respectively. The shares of Smartwater and Vitaminwater boost strikingly, which can be attributed to price reductions, product variety increases, and advertising increments. In particular, the merger increases market shares of Smartwater and Vitaminwater by 59.91% and 89.73% relative to the "no merger" baseline. Compared to other scenarios, the merger with all three efficiencies generates the highest total profit for the merging party, it also increases profits of both non-flavored and flavored brands on average. Unlike most of the existing antitrust literature that find exclusively "bad" effects of merger, my results suggest the merger can be "good" for both the merging party and rivals with efficiencies and non-price dimensions of competitions.

For consumer welfare, column (ii) shows the merger with only unilateral effects decreases consumer surplus by 1.06% relative to the "no merger" baseline. This finding is consistent with other antitrust literature focusing on unilateral effects of merger. Scenario (i) is neither profitable for the merging party nor harmless to consumers, which is unlikely to occur. I find consumer surplus varies substantially under different efficiency effects. For instance, columns (ii) and (iii) reveal that the marginal cost efficiency raises consumer surplus by 25.25%, and columns (ii) and (v) suggest that the advertising efficiency raises consumer surplus by 0.89%. Finally, the observed merger in column (vi) is predicted to increase consumer surplus by 30.12% relative to the "no merger" baseline, which suggests the merger of Coco-Cola and Glaceau is beneficial to consumers and justifies DOJ's quick decision to approve the merger.

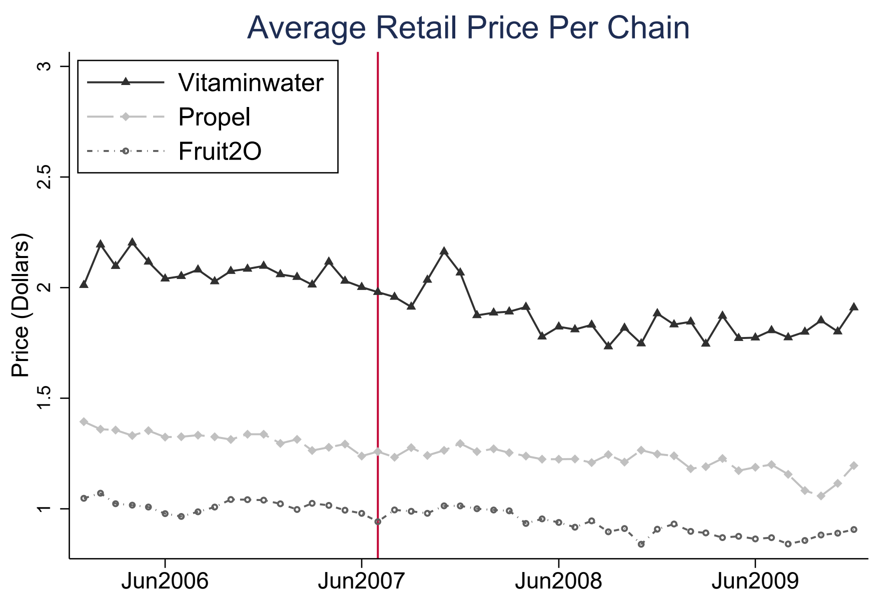
4.6 Conclusion

I empirically investigate how merger efficiencies affect equilibrium market outcomes considering both price and non-price competitions. This study focuses on the merger of Coca-Cola and Glaceau in the U.S. premium bottled water industry and explores the underlying mechanism that rationalizes Glaceau's increases in market shares, product varieties, and advertising expenditures post-merger. Without obvious systematic price reductions post-merger, the dramatic increasing share of Glaceau products is difficult to explain by the traditional model of Nash-Bertrand competition. The plausible interpretation of this phenomenon is that premium bottled water manufacturers compete in both price and non-price dimensions.

To understand the merger effects on the "weaker" merging party, Glaceau, I develop a structural model of differentiated products which incorporates both price and non-price competition effects and consider the post-merger efficiency variations of Glaceau in marginal cost, product variety fixed cost, and advertising fixed cost. My supply estimates suggest the merger indeed increases Glaceau's efficiencies across all three aspects by reducing corresponding cost parameters post-merger. With both demand and supply estimates, I implement several counterfactual scenarios to separately identify the effects of merger under different efficiencies. I find product variety and advertising fixed efficiency play primary roles in affecting manufacturers' equilibrium choices for product variety and advertising respectively, while marginal cost efficiency plays not only the dominant role in affecting equilibrium prices but also an important role in affecting equilibrium product variety. In particular, for the year 2009, I find comparing to the "no merger" scenario, the merger with observed data (1) reduces Glaceau's retail prices by 4.72%-6.98%, which is primarily attributed to marginal cost efficiency; (2) increases Glaceau's product varieties by 25.44%-44.52% through both marginal cost and product variety fixed cost efficiencies; (3) raises Glaceau's advertising by 144.06% to 322.43% through advertising fixed cost efficiency; and (4) boosts Glaceau's market shares by 59.91%-89.73%. My findings also suggest the merger increases consumer surplus by 30.12% compared to the "no merger" baseline.

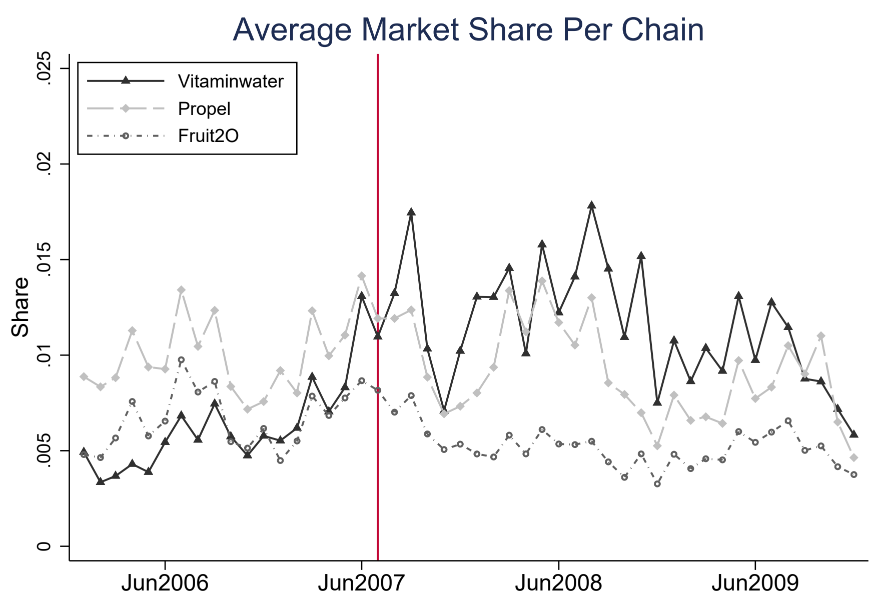
In an industry with multi-dimension competitions, price effects and market power may not be the only aspects that an antitrust agency should focus on. In fact, non-price effects, such as product variety, quality, and advertising, and their relevant efficiency gains through merger may increase a merging party's market share significantly with little price variations. Thus the mergers that seem to have had negative consequences may actually yield benefits to the consumers when efficiencies exist. Unlike the case in this paper, if goods or services of an industry are highly substitutable, a merger with non-price effects and efficiencies would gain market shares from competing goods rather than creating new demand, thus hurt competing firms. My study provides a novel approach of evaluating merger from a more comprehensive perspective by considering both price and non-price competitions and their related efficiency effects of merger. Future studies may extend the framework to other industries which share similar features with premium bottled water.

Figure 1: National Average Retail Prices of Selected Premium Water Brands



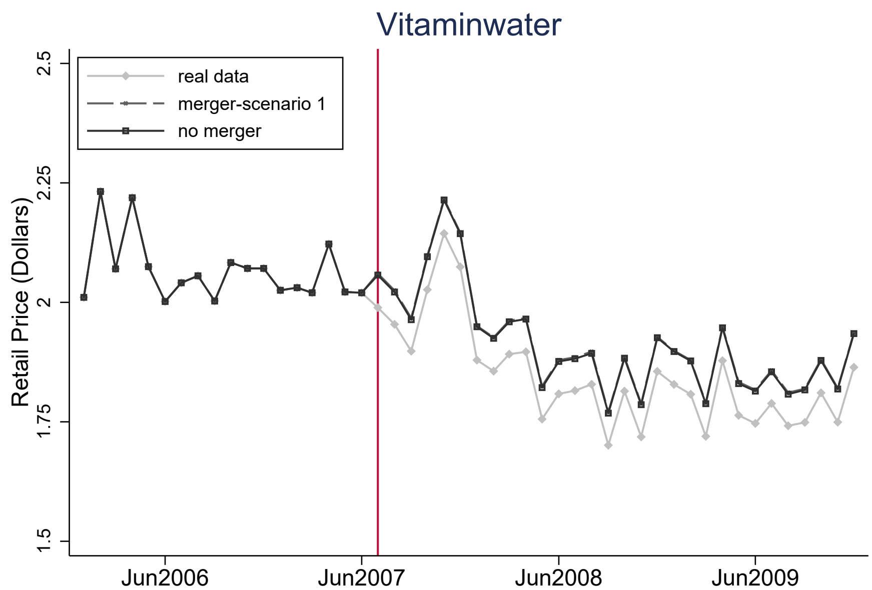
Note: The month index starts from January 2006 and ends in December 2009. Prices are measured in 2006 U.S. dollars per liter, which is adjusted by monthly non-alcoholic beverage CPI (year 2006=100). Each dot in the figure represents the average value across 52 retailer chains and 92 DMA regions in a given month.

Figure 2: National Average Market Share of Selected Premium Water Brands



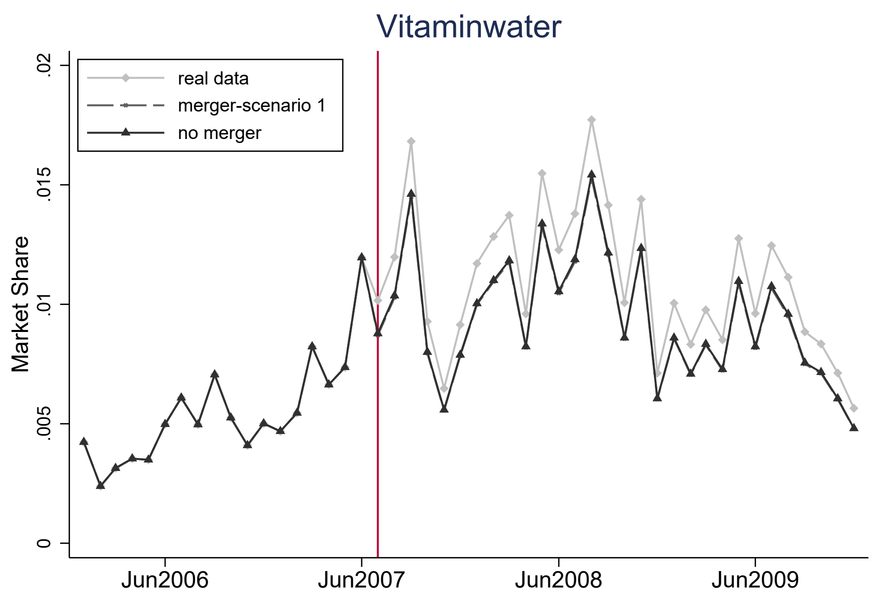
Note: Each dot in the figure represents the average value across 52 retailer chains and 92 DMA regions in a given month. To calculate market shares, I restrict water products to the Nielsen "Water Bottled" category, and calculate the total quantities of "Water Bottled" sold in each market (region-retailer pair) each month. The market size of each market is defined as 1.1 times the corresponding maximum monthly total quantities of "Water Bottled" in a given year.

Figure 3: Counterfactual Retail Prices of Vitaminwater



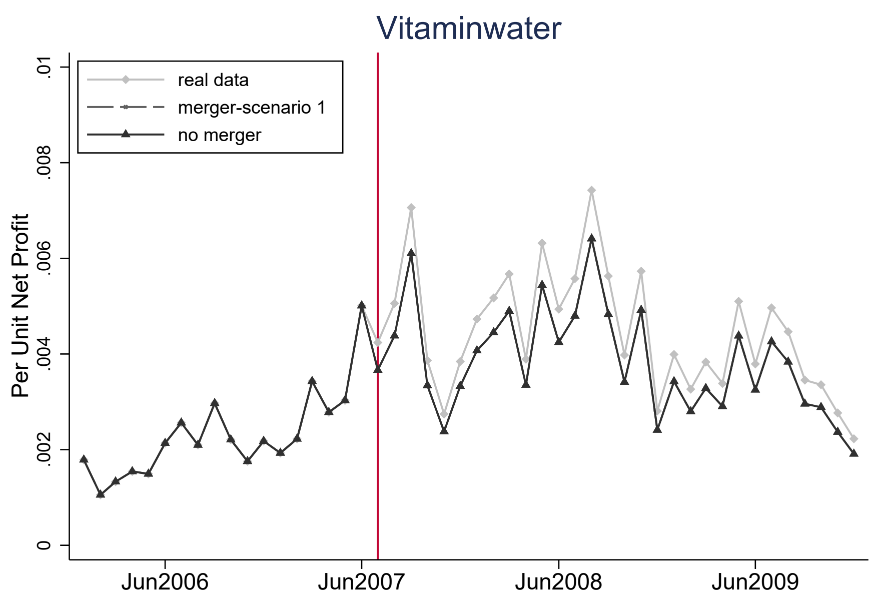
Note: This figure plots the brand level average retail prices of Vitaminwater products. Brand-level retail price is the average price of each product weighted by their corresponding market shares. "merger-scenario 1" denotes merger occurs with only unilateral effect. Each dot in the figure represents its average value across top 20 retailer chains and their relevant DMA regions in a given month. In the pre-merger period, equilibrium outcomes of all scenarios are overlapping.

Figure 4: Counterfactual Market Shares of Vitaminwater



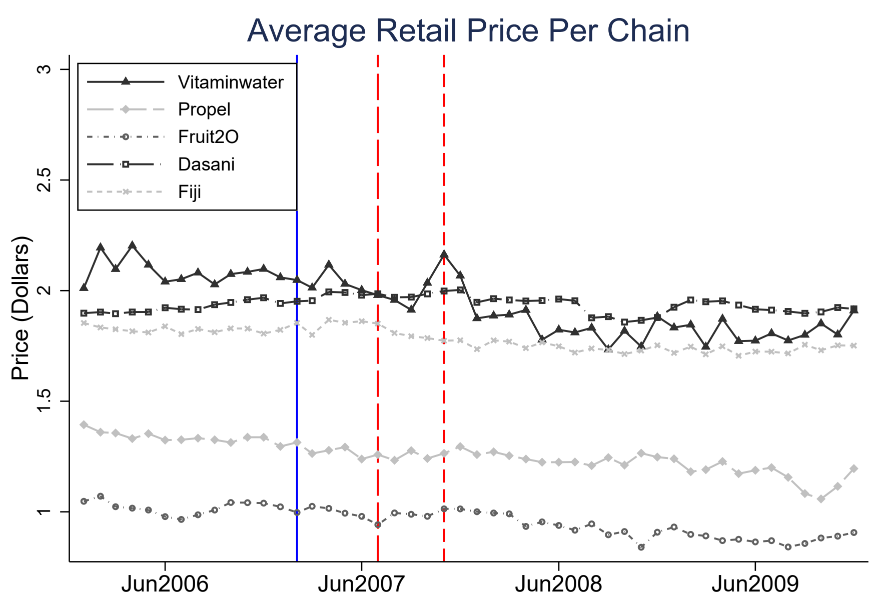
Note: This figure plots the brand level average market share of Vitaminwater products. Market shares are the summations of their product level counterparts. “merger-scenario 1” denotes merger occurs with only unilateral effect. Each dot in the figure represents its average value across top 20 retailer chains and their relevant DMA regions in a given month. In the pre-merger period, equilibrium outcomes of all scenarios are overlapping.

Figure 5: Counterfactual Per-Unit Profit of Vitaminwater



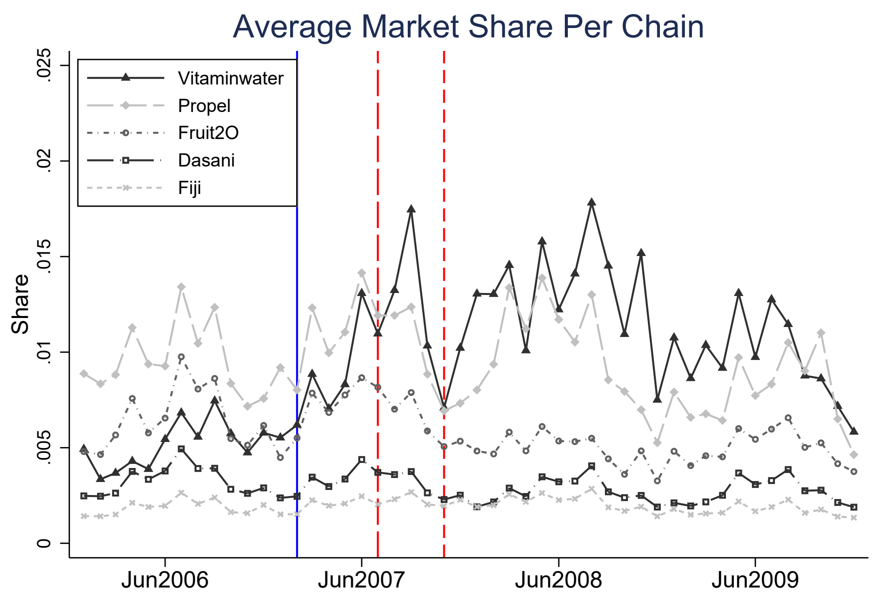
Note: This figure plots the brand level average per-unit profit of Vitaminwater products, which is computed as the multiplication of markups and market shares. The "real" profits are not observable in the data, and "real data" in the figure are calculated based on the observed market shares and recovered manufacturer's price-cost margins. "merger-scenario 1" denotes merger occurs with only unilateral effect. Each dot in the figure represents its average value across top 20 retailer chains and their relevant DMA regions in a given month. In the pre-merger period, equilibrium outcomes of all scenarios are overlapping.

Figure 6: National Average Retail Prices of Selected Premium Water Brands



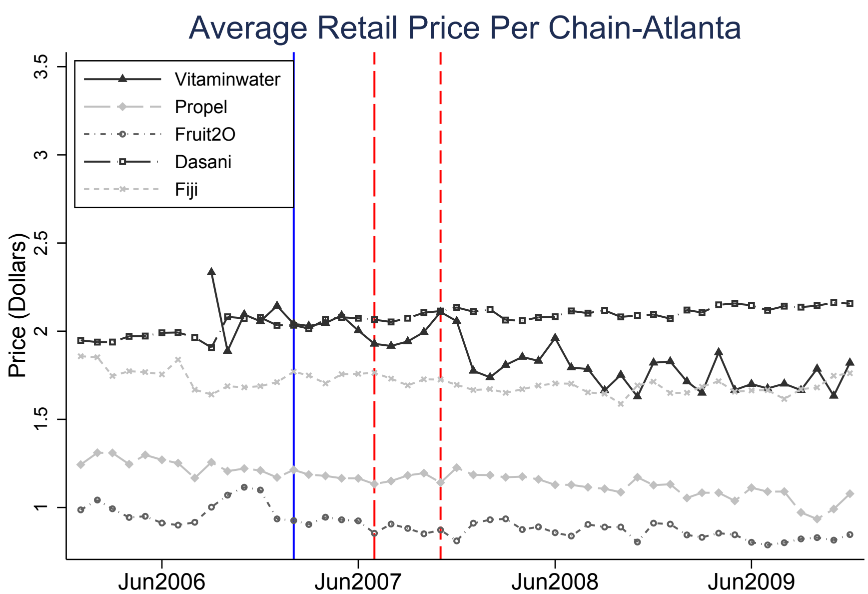
Note: The month index starts from January 2006 and ends in December 2009. Prices are measured in 2006 U.S. dollars per liter, which is adjusted by monthly non-alcoholic beverage CPI (year 2006=100). Each dot in the figure represents the average value across 52 retailer chains and 92 DMA regions in a given month.

Figure 7: National Average Market Share of Selected Premium Water Brands



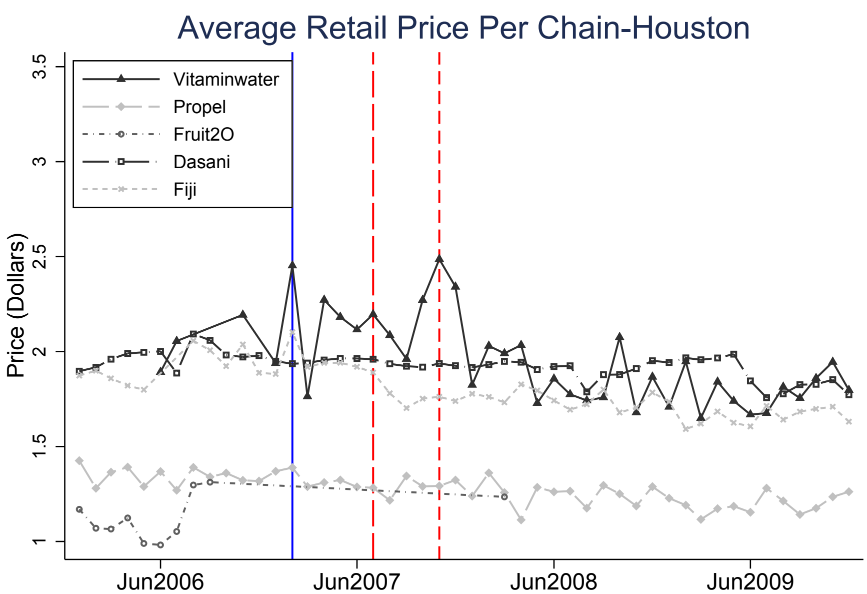
Note: Each dot in the figure represents the average value across 52 retailer chains and 92 DMA regions in a given month. To calculate market shares, I restrict water products to the Nielsen "Water Bottled" category, and calculate the total quantities of "Water Bottled" sold in each market (region-retailer pair) each month. The market size of each market is defined as 1.1 times the corresponding maximum monthly total quantities of "Water Bottled" in a given year.

Figure 8: Average Retail Price of Selected Premium Water Brands in Atlanta



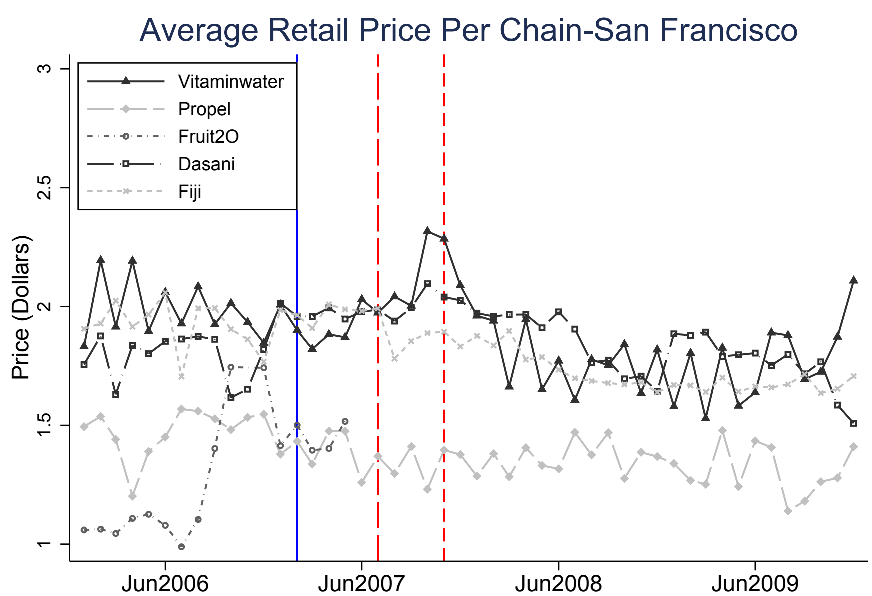
Note: Each dot in the figure represents the average value across retailers in the local DMA region in a given month.

Figure 9: Average Retail Price of Selected Premium Water Brands in Houston



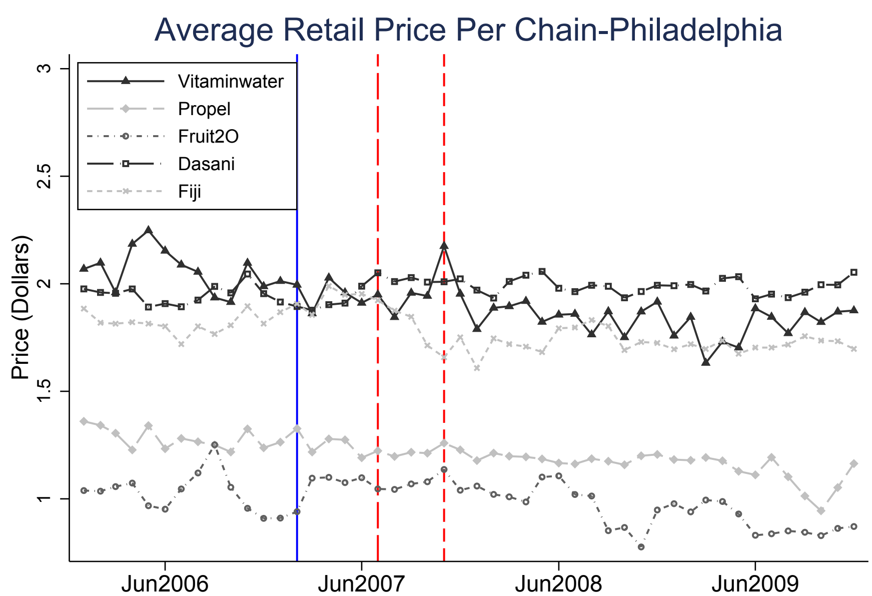
Note: Each dot in the figure represents the average value across retailers in the local DMA region in a given month.

Figure 10: Average Retail Price of Selected Premium Water Brands in San Francisco



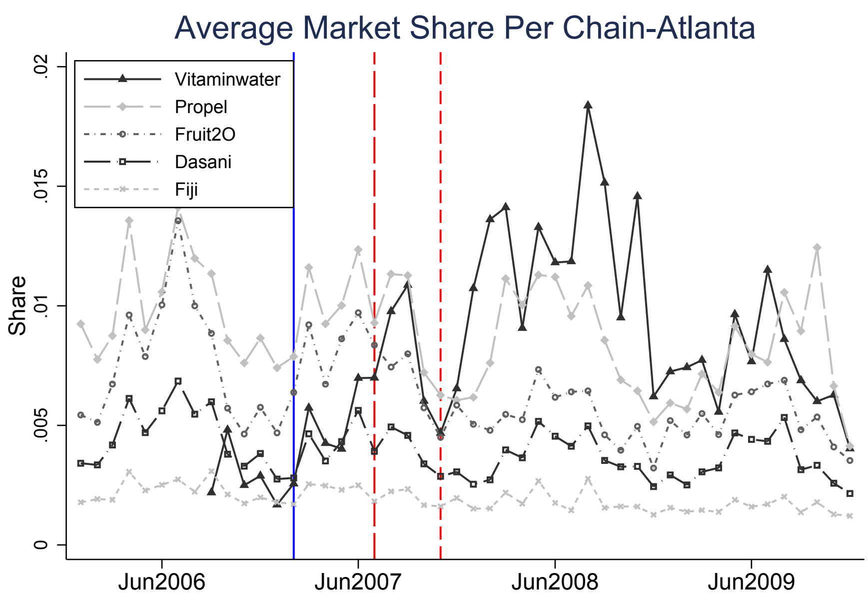
Note: Each dot in the figure represents the average value across retailers in the local DMA region in a given month.

Figure 11: Average Retail Price of Selected Premium Water Brands in Philadelphia



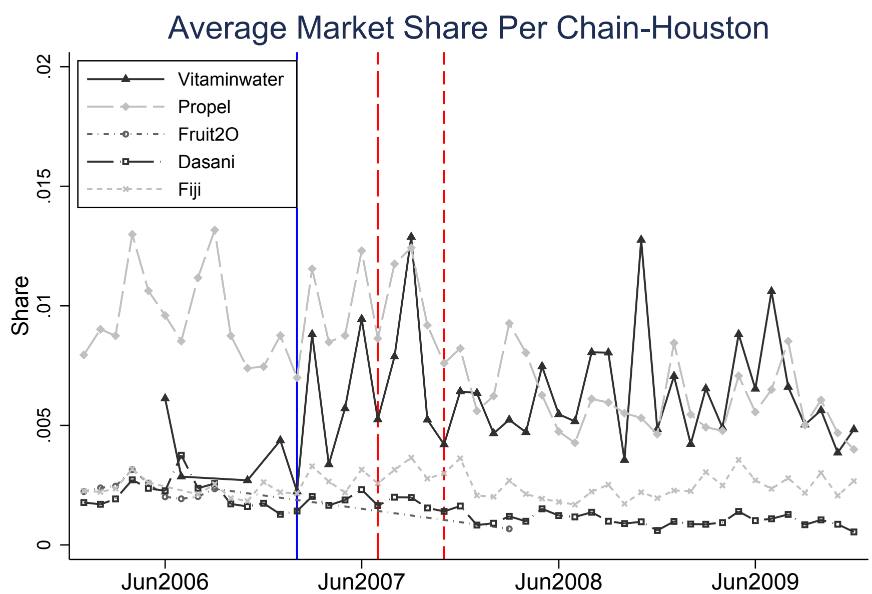
Note: Each dot in the figure represents the average value across retailers in the local DMA region in a given month.

Figure 12: Average Market Share of Selected Premium Water Brands in Atlanta



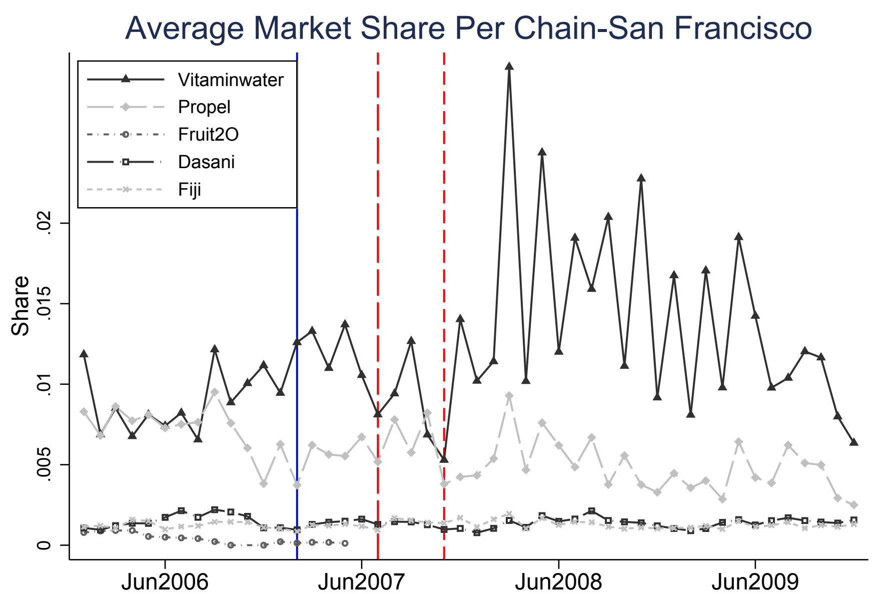
Note: Each dot in the figure represents the average value across retailers in the local DMA region in a given month.

Figure 13: Average Market Share of Selected Premium Water Brands in Houston



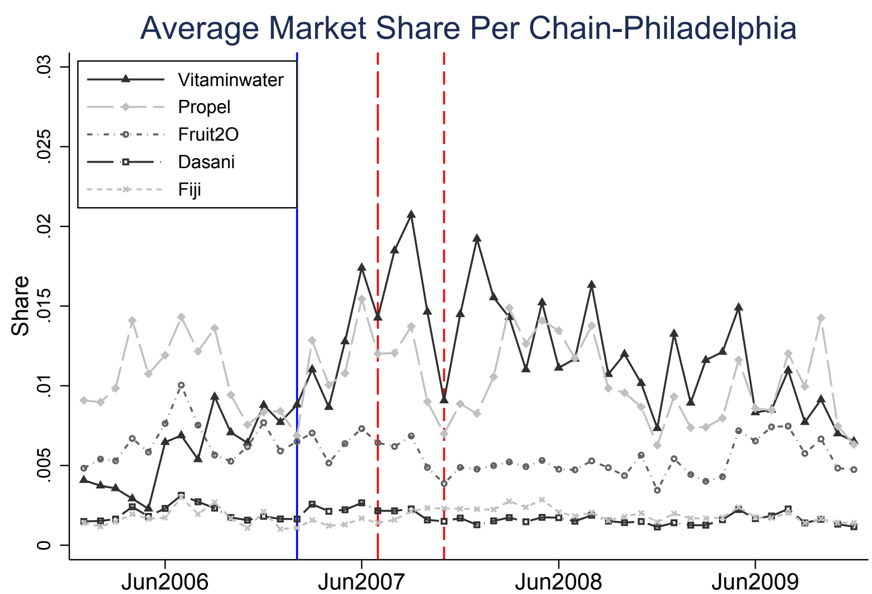
Note: Each dot in the figure represents the average value across retailers in the local DMA region in a given month.

Figure 14: Average Market Share of Selected Premium Water Brands in San Francisco



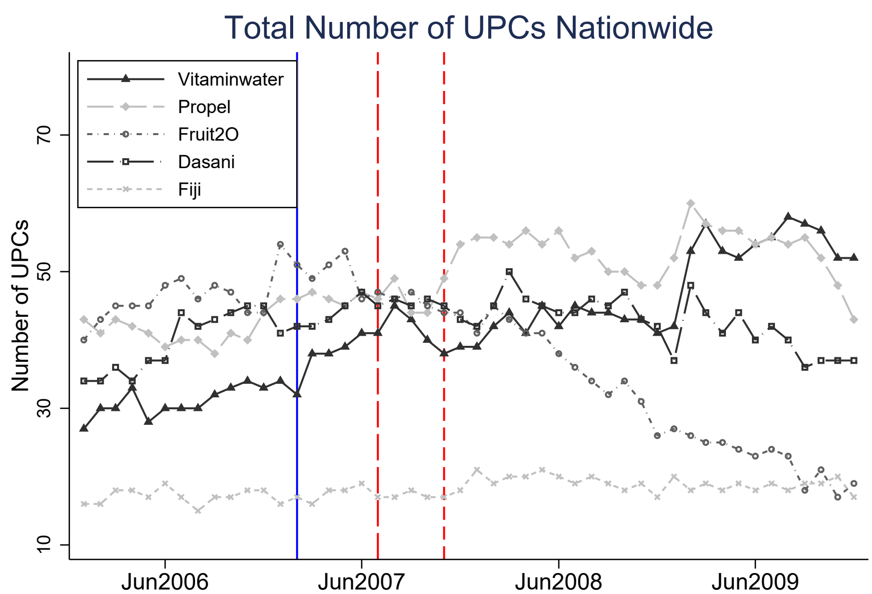
Note: Each dot in the figure represents the average value across retailers in the local DMA region in a given month.

Figure 15: Average Market Share of Selected Premium Water Brands in Philadelphia



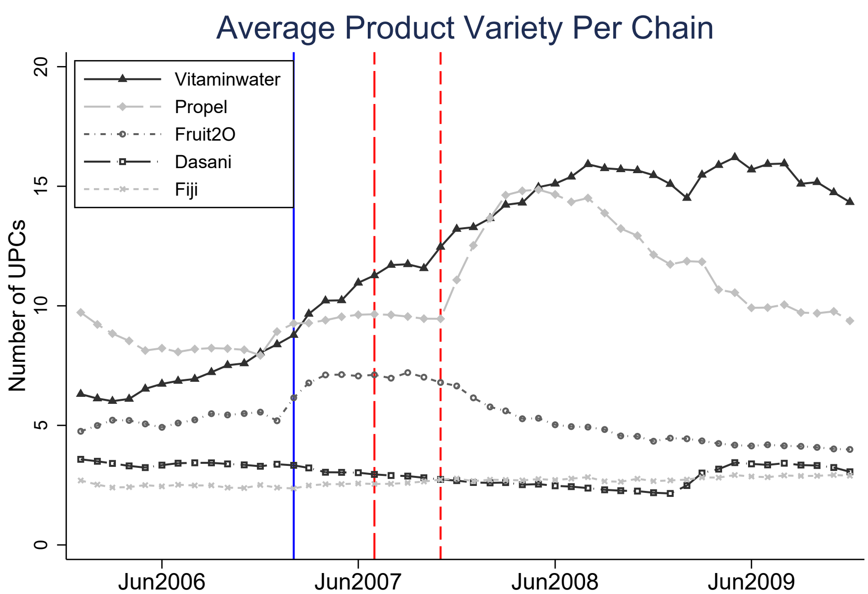
Note: Each dot in the figure represents the average value across retailers in the local DMA region in a given month.

Figure 16: Total Number of UPCs of Selected Premium Water Brands



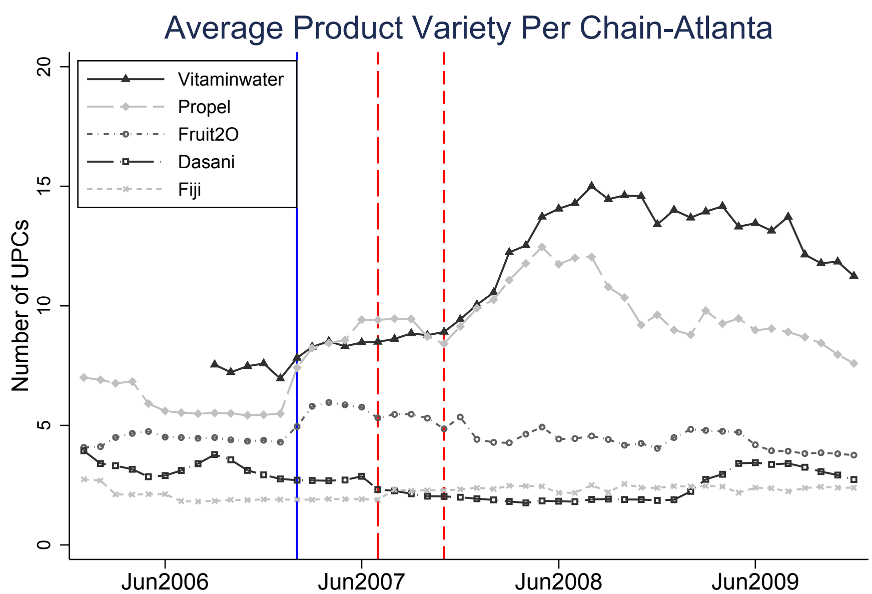
Note: Each dot in the figure represents the total number of UPCs of each brand sold in a given month nationwide.

Figure 17: Average Product Varieties of Selected Premium Water Brands



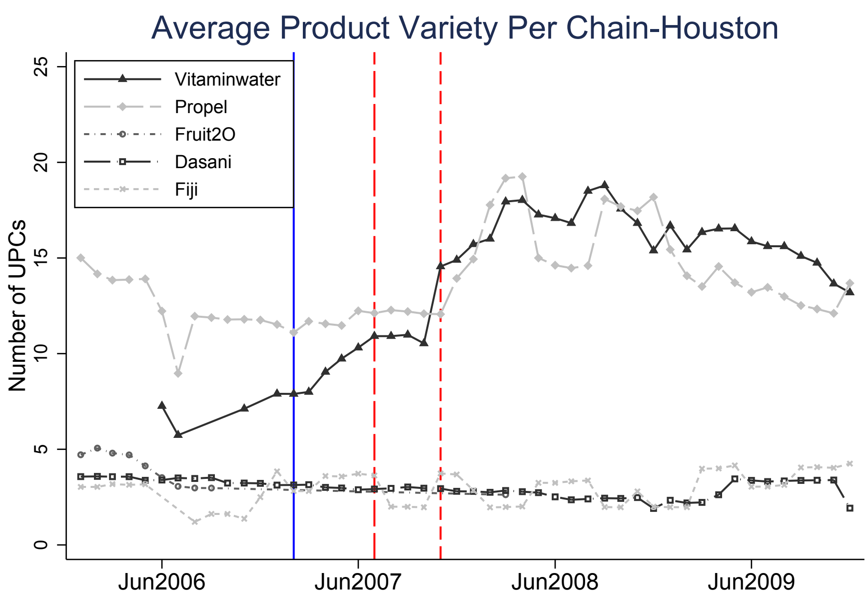
Note: Each dot in the figure represents the average value across 52 retailer chains and 92 DMA regions in a given month.

Figure 18: Average Product Variety of Selected Premium Water Brands in Atlanta



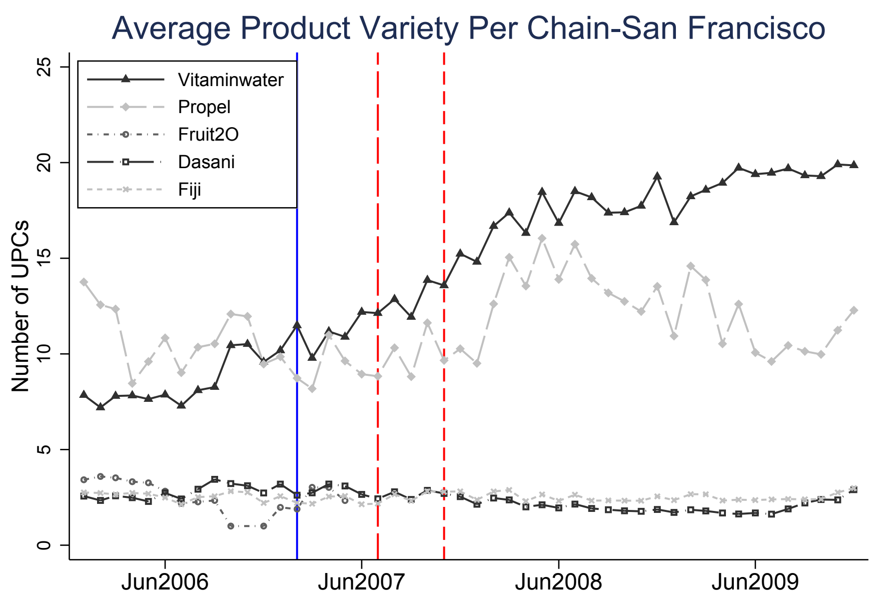
Note: Each dot in the figure represents the average value across retailers in the local DMA region in a given month.

Figure 19: Average Product Variety of Selected Premium Water Brands in Houston



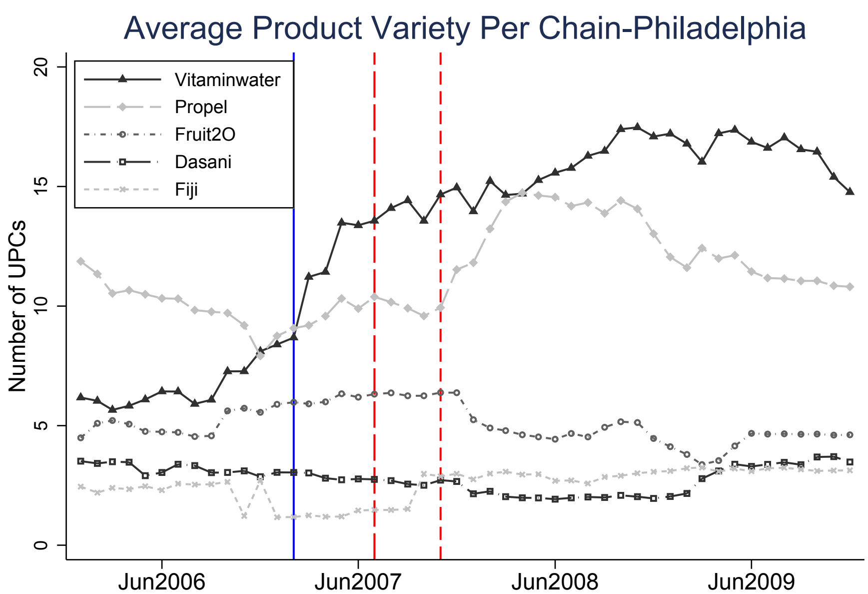
Note: Each dot in the figure represents the average value across retailers in the local DMA region in a given month.

Figure 20: Average Product Variety of Selected Premium Water Brands in San Francisco



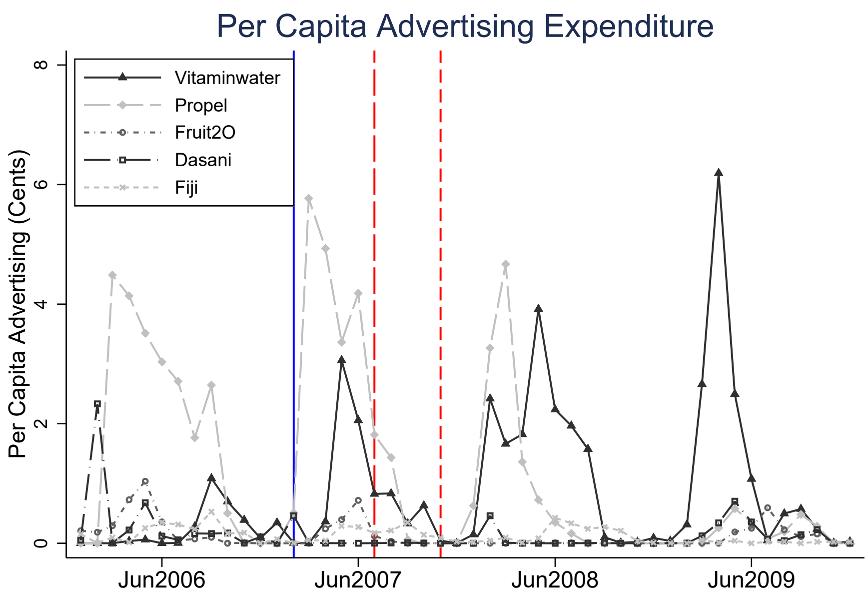
Note: Each dot in the figure represents the average value across retailers in the local DMA region in a given month.

Figure 21: Average Product Variety of Selected Premium Water Brands in Philadelphia



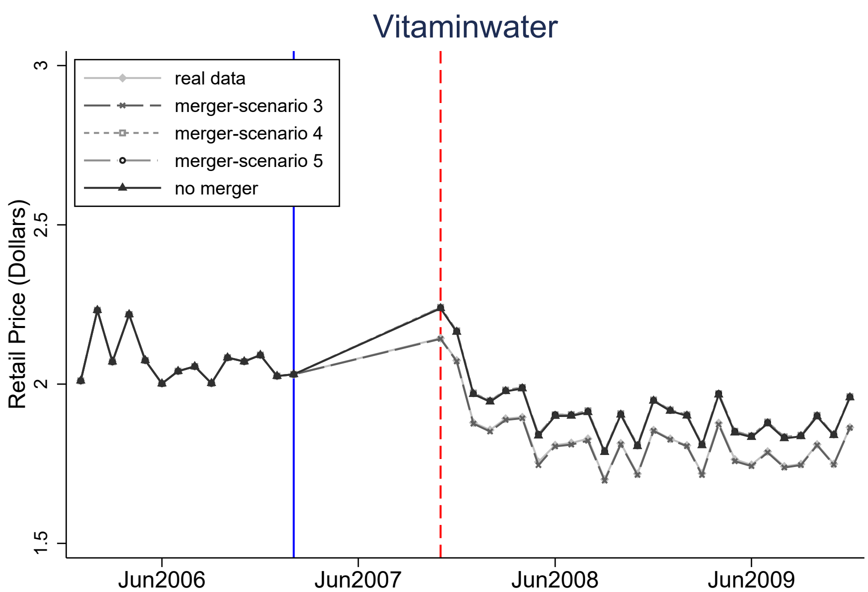
Note: Each dot in the figure represents the average value across retailers in the local DMA region in a given month.

Figure 22: National Per-capita Advertising Expenditure of Selected Premium Water Brands



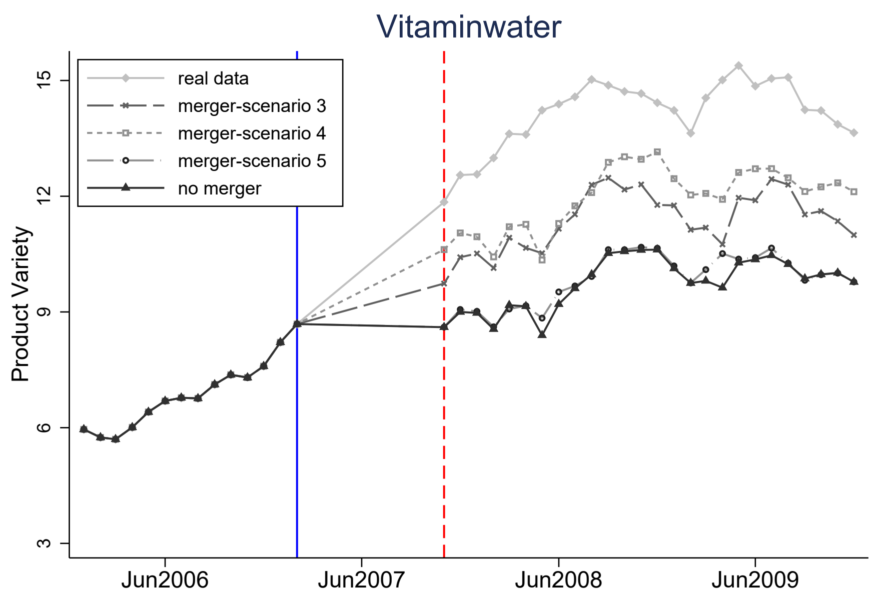
Note: Each dot in the figure represents the per-capita advertising expenditure in a given month, which is calculated by dividing the total national advertising expenditure by the U.S. population.

Figure 23: Counterfactual Retail Prices of Vitaminwater



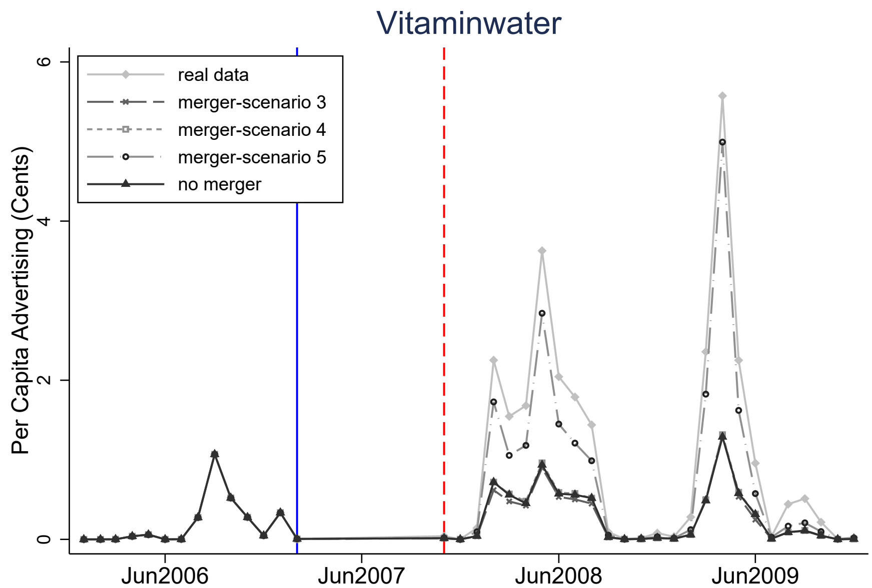
Note: This figure plots the brand level average retail prices of Vitaminwater products. Brand-level retail price is the average price of each product weighted by their corresponding market shares. "Scenario 3" denotes merger occurs with both unilateral effect and marginal cost efficiency; "Scenario 4" denotes merger occurs with both unilateral effect and product variety fixed cost efficiency; "Scenario 5" denotes merger occurs with both unilateral effect and advertising fixed cost efficiency. Each dot in the figure represents its average value across top 20 retailer chains and their relevant DMA regions in a given month. In the pre-merger period, equilibrium outcomes of all scenarios are overlapping.

Figure 24: Counterfactual Product Varieties of Vitaminwater



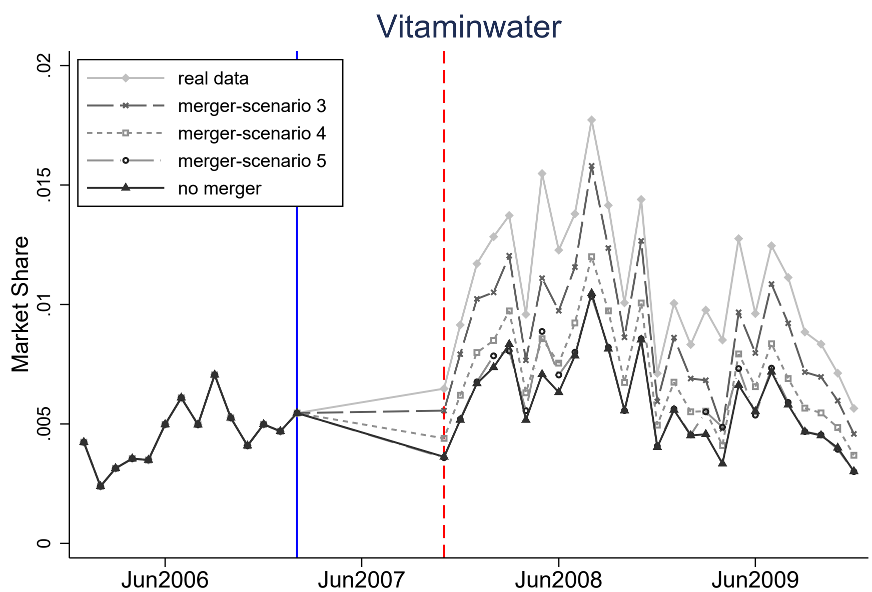
Note: This figure plots the brand level average number of UPCs of Vitaminwater products. The number of UPCs are the summations of their product level counterparts. "Scenario 3" denotes merger occurs with both unilateral effect and marginal cost efficiency; "Scenario 4" denotes merger occurs with both unilateral effect and product variety fixed cost efficiency; "Scenario 5" denotes merger occurs with both unilateral effect and advertising fixed cost efficiency. Each dot in the figure represents its average value across top 20 retailer chains and their relevant DMA regions in a given month. In the pre-merger period, equilibrium outcomes of all scenarios are overlapping.

Figure 25: Counterfactual Per-Capita Advertising Expenditure of Vitaminwater



Note: This figure plots the national level per-capital advertising expenditures of Vitaminwater products. "Scenario 3" denotes merger occurs with both unilateral effect and marginal cost efficiency; "Scenario 4" denotes merger occurs with both unilateral effect and product variety fixed cost efficiency; "Scenario 5" denotes merger occurs with both unilateral effect and advertising fixed cost efficiency. Each dot in the figure represents its average value across top 20 retailer chains and their relevant DMA regions in a given month. In the pre-merger period, equilibrium outcomes of all scenarios are overlapping.

Figure 26: Counterfactual Market Shares of Vitaminwater



Note: This figure plots the average market share of Vitaminwater products. Market shares are the summations of their product level counterparts. “Scenario 3” denotes merger occurs with both unilateral effect and marginal cost efficiency; “Scenario 4” denotes merger occurs with both unilateral effect and product variety fixed cost efficiency; “Scenario 5” denotes merger occurs with both unilateral effect and advertising fixed cost efficiency. Each dot in the figure represents its average value across top 20 retailer chains and their relevant DMA regions in a given month. In the pre-merger period, equilibrium outcomes of all scenarios are overlapping.

Table 1: Demand Estimates for Logit and Random Coefficient Logit Model

Variable	parameter	Model	
		Logit	RCL
Price	α	-2.140 (0.043)	-5.536 (0.158)
Demographic Interactions			
Income $\times$ Price			1.024 (0.049)
Income $\times$ Constant			-1.727 (0.085)
Income $\times$ Multi-pack			0.176 (0.034)
Mean Own-price Elasticity		-3.42	-3.79

Note: There are 146,107 observations at the brand-package-region-retailer-month-year level. Both regressions include product (brand-package pair), region, and time fixed effects. For the RCL specification, 100% of the estimated individual price coefficients are negative.

Table 2: Mean Own-Price and Cross-Price Elasticities for 16 Products (Brand-Package Pairs)

Brand-package	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Aquafina s	-4.310	0.006	0.013	0.002	0.004	0.003	0.005	0.010
(2) Aquafina Splash m	0.013	-2.649	0.013	0.003	0.005	0.003	0.005	0.019
(3) Dasani s	0.013	0.006	-4.389	0.002	0.004	0.003	0.005	0.010
(4) Evian s	0.014	0.007	0.013	-3.961	0.005	0.003	0.005	0.012
(5) Evian m	0.014	0.007	0.013	0.002	-3.661	0.003	0.005	0.011
(6) Fiji s	0.014	0.007	0.013	0.002	0.004	-4.043	0.005	0.011
(7) Fiji m	0.013	0.005	0.012	0.002	0.004	0.003	-4.080	0.011
(8) Fruit2O m	0.012	0.012	0.013	0.003	0.005	0.003	0.006	-2.609
(9) Smartwater s	0.015	0.010	0.013	0.003	0.005	0.004	0.005	0.015
(10) Smartwater m	0.013	0.007	0.013	0.002	0.004	0.003	0.005	0.011
(11) Vitaminwater s	0.013	0.006	0.012	0.002	0.004	0.003	0.005	0.010
(12) Vitaminwater m	0.011	0.005	0.011	0.002	0.004	0.003	0.005	0.010
(13) Propel s	0.014	0.008	0.013	0.002	0.005	0.004	0.005	0.011
(14) Propel m	0.014	0.009	0.013	0.003	0.005	0.004	0.006	0.019
(15) Sobe Life s	0.013	0.007	0.012	0.002	0.004	0.003	0.005	0.010
(16) Sobe Life m	0.012	0.007	0.011	0.002	0.004	0.002	0.005	0.013

Note: "s" denotes single-bottle product and "m" denotes multi-pack product.These price elasticities are calculated based on the random coefficient model, formulas are given by Nevo (2000). All prices are deflated by nonalcoholic beverage consumer index (year 2006=100), and are measured as U.S. dollars per liter.

Table 3: Mean Own-Price and Cross-Price Elasticities for 16 Products (Continued)

Brand-package	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Aquafina s	0.009	0.002	0.040	0.005	0.014	0.018	0.011	0.001
(2) Aquafina Splash m	0.013	0.002	0.042	0.005	0.015	0.025	0.011	0.001
(3) Dasani s	0.008	0.002	0.040	0.005	0.014	0.017	0.011	0.001
(4) Evian s	0.010	0.002	0.043	0.006	0.016	0.019	0.011	0.001
(5) Evian m	0.010	0.002	0.043	0.005	0.016	0.019	0.011	0.001
(6) Fiji s	0.010	0.002	0.045	0.006	0.016	0.017	0.012	0.001
(7) Fiji m	0.008	0.002	0.042	0.009	0.014	0.017	0.011	0.002
(8) Fruit2O m	0.010	0.002	0.036	0.011	0.013	0.030	0.011	0.002
(9) Smartwater s	-3.318	0.002	0.048	0.005	0.019	0.023	0.014	0.001
(10) Smartwater m	0.010	-3.743	0.046	0.005	0.013	0.017	0.013	0.001
(11) Vitaminwater s	0.009	0.002	-4.325	0.005	0.014	0.017	0.012	0.001
(12) Vitaminwater m	0.007	0.002	0.041	-4.505	0.010	0.014	0.011	0.002
(13) Propel s	0.012	0.002	0.045	0.005	-3.707	0.021	0.013	0.001
(14) Propel m	0.012	0.002	0.043	0.008	0.018	-3.060	0.013	0.002
(15) Sobe Life s	0.009	0.002	0.041	0.005	0.013	0.017	-4.234	0.001
(16) Sobe Life m	0.007	0.002	0.043	0.010	0.009	0.018	0.009	-3.994

Note: "s" denotes single-bottle product and "m" denotes multi-pack product.These price elasticities are calculated based on the random coefficient model, formulas are given by Nevo (2000). All prices are deflated by nonalcoholic beverage consumer index (year 2006=100), and are measured as U.S. dollars per liter.

Table 4: Mean Diversion Ratios of Inside Products and Outside Good

Brand-package	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Aquafina s	96.55	0.28	0.29	0.06	0.13	0.08	0.12	0.49
(2) Aquafina Splash m	0.28	96.21	0.24	0.07	0.14	0.08	0.11	0.72
(3) Dasani s	0.33	0.28	96.52	0.06	0.13	0.08	0.13	0.49
(4) Evian s	0.33	0.29	0.28	95.98	0.13	0.09	0.12	0.52
(5) Evian m	0.33	0.28	0.28	0.06	96.03	0.08	0.12	0.49
(6) Fiji s	0.34	0.30	0.28	0.06	0.13	95.81	0.12	0.48
(7) Fiji m	0.33	0.26	0.29	0.06	0.13	0.09	96.00	0.62
(8) Fruit2O m	0.25	0.46	0.25	0.07	0.14	0.07	0.13	96.73
(9) Smartwater s	0.31	0.40	0.27	0.06	0.13	0.08	0.11	0.62
(10) Smartwater m	0.31	0.33	0.28	0.06	0.13	0.08	0.13	0.49
(11) Vitaminwater s	0.32	0.29	0.29	0.07	0.13	0.08	0.13	0.47
(12) Vitaminwater m	0.30	0.25	0.28	0.06	0.12	0.08	0.15	0.58
(13) Propel s	0.33	0.34	0.27	0.06	0.13	0.08	0.12	0.49
(14) Propel m	0.31	0.38	0.27	0.07	0.13	0.09	0.13	0.89
(15) Sobe Life s	0.30	0.31	0.27	0.06	0.12	0.08	0.12	0.46
(16) Sobe Life m	0.28	0.33	0.26	0.05	0.11	0.07	0.14	0.69

Note: "s" denotes single-bottle product and "m" denotes multi-pack product. The diagonal elements denote the diversion to the outside good. Numbers represent percentage values and elements in each row should sum to 100 in theory. Since the values in table 4 are calculated from the mean of each market, the summation of row elements cannot be exactly equal to 100.

Table 5: Mean Diversion Ratios of Inside Products and Outside Good (Continued)

Brand-package	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Aquafina s	0.32	0.05	0.95	0.12	0.44	0.65	0.28	0.03
(2) Aquafina Splash m	0.42	0.05	0.86	0.09	0.42	0.80	0.25	0.03
(3) Dasani s	0.31	0.05	0.95	0.12	0.44	0.65	0.28	0.03
(4) Evian s	0.36	0.05	0.98	0.11	0.48	0.65	0.28	0.03
(5) Evian m	0.36	0.06	0.99	0.10	0.47	0.66	0.28	0.02
(6) Fiji s	0.37	0.05	1.06	0.11	0.50	0.62	0.30	0.03
(7) Fiji m	0.32	0.05	1.05	0.21	0.46	0.66	0.29	0.05
(8) Fruit2O m	0.30	0.05	0.73	0.23	0.36	0.98	0.24	0.05
(9) Smartwater s	95.89	0.05	0.99	0.09	0.52	0.74	0.30	0.03
(10) Smartwater m	0.38	95.64	1.08	0.10	0.42	0.64	0.32	0.03
(11) Vitaminwater s	0.33	0.05	96.95	0.12	0.44	0.64	0.29	0.03
(12) Vitaminwater m	0.29	0.06	1.11	96.17	0.36	0.61	0.31	0.05
(13) Propel s	0.40	0.05	1.00	0.10	96.24	0.69	0.31	0.03
(14) Propel m	0.40	0.05	0.93	0.18	0.51	96.53	0.29	0.04
(15) Sobe Life s	0.34	0.05	0.98	0.11	0.41	0.63	96.29	0.03
(16) Sobe Life m	0.30	0.05	1.10	0.25	0.29	0.73	0.24	95.85

Note: "s" denotes single-bottle product and "m" denotes multi-pack product. The diagonal elements denote the diversion to the outside good. Numbers represent percentage values and elements in each row should sum to 100 in theory. Since the values in table 5 are calculated from the mean of each market, the summation of row elements cannot be exactly equal to 100.

Table 6: Average Markups and Recovered Marginal Cost

Brand	Manufacturer Markup	Retailer Markup	Marginal Cost	Retail Price
Aquafina	0.408	0.453	1.022	1.883
Aquafina Splash	0.354	0.388	0.240	0.982
Dasani	0.409	0.457	1.070	1.936
Evian	0.378	0.434	0.779	1.592
Fiji	0.398	0.458	0.923	1.779
Fruit2O	0.342	0.384	0.239	0.965
Smartwater	0.374	0.415	0.599	1.389
Vitaminwater	0.428	0.479	1.136	2.043
Propel	0.371	0.409	0.536	1.317
Sobe	0.410	0.457	0.970	1.837

Note: All numbers here are measured in 2006 U.S. dollars per liter.

Table 7: Supply-Side Estimates

Variable	Cost-side Estimates
Dummy Smart. Single	0.6040
	0.0124)
Dummy Smart. Multi	0.8607
	(0.0127)
Dummy Vitamin. Single	1.1486
	(0.0125)
Dummy Vitamin. Multi	1.3778
	(0.0125)
Glaceau × PostMerger	-0.0604
	(0.0040)

Note: There are 146,107 observations at the brand-package-chain-region-month-year level, which covers 13,304 markets (chain-region-year-month). In addition to variables presented in the table, the regression includes fixed effects of other products, region-specific and time-specific fixed effects.

Table 8: Counterfactual Results Under Different Scenarios

Uni. Eff.	N	Y	Y
Marg. Eff.	N	N	Y
	Value	% Changes to Scenario (i)	
Merger Scenarios	(i)	(ii)	(iii)
		Wholesale Prices	
Smartwater	0.926	0.27%	-6.91%
Vitaminwater	1.412	0.16%	-4.58%
Dasani	1.461	0.72%	0.15%
Non-flavored	1.328	0.00%	0.02%
Flavored	0.776	0.00%	0.02%
		Retail Prices	
Smartwater	1.318	0.20%	-5.26%
Vitaminwater	1.855	0.13%	-3.80%
Dasani	1.904	0.60%	0.18%
Non-flavored	1.767	-0.01%	0.08%
Flavored	1.164	-0.01%	0.11%

Note: This table provides average wholesale and retail prices at the brand-chain-region level of 20 retailer chains which cover most DMA regions. The numbers in column (i) are calculated assuming the merger never happened. The numbers in column (ii) are calculated assuming the merger occurs with only unilateral effects. Column (iii) denotes the real data and relevant predictions.

Table 9: Counterfactual Results Under Different Scenarios (Continued)

Uni. Eff.	N	Y	Y
Marg. Eff.	N	N	Y
	Value	% Changes to Scenario (i)	
Merger Scenarios	(i)	(ii)	(iii)
		Market Shares	
Smartwater	0.37%	-0.82%	19.44%
Vitaminwater	0.81%	-0.64%	17.50%
Dasani	0.29%	-3.19%	-1.23%
Non-flavored	0.18%	0.06%	-0.61%
Flavored	0.56%	0.05%	-0.60%
		Profits	
Smartwater	1.552	0.03%	17.91%
Vitaminwater	4.196	0.02%	15.66%
Dasani	1.065	-0.04%	-0.56%
Non-flavored	0.901	0.04%	-0.53%
Flavored	2.073	0.04%	-0.56%
		Consumer Surplus	
		-0.96%	13.51%

Note: This table provides average market shares and per-unit net profit at the brand-chain-region level of 20 retailer chains which cover most DMA regions. The numbers in column (i) are calculated assuming the merger never happened. The numbers in column (ii) are calculated assuming the merger occurs with only unilateral effects. Column (iii) denotes the real data and relevant predictions. The "profit" values reported in column (i) denote the per-unit net profit of each brand. The total net profit of each brand can be obtained by multiplying it by the market size of a given market (the unit of market size is 1,000 liters).

Table 10: Market Shares of Top Flagship Brands

Brand	Manufacturer	Market Share
Aquafina	Pepsi	0.0724
Auafina Splash	Pepsi	0.0023
Nestle Spring	Nestle	0.2860
Crystal Geyser	CG Roxane LLC	0.0560
Retailer Own Brand		0.3275
Dasani	Coca-Cola	0.0735
Evian	Danone	0.0037
Fiji	Fiji Water LCC	0.0042
Fruit2O	Sunny Delight Beverages Co	0.0040
Smartwater	Glaceau (Coca-Cola)	0.0053
Vitaminwater	Glaceau (Coca-Cola)	0.0239
Nestle Pure Life	Nestle	0.0209
Propel	Pepsi	0.0142
Sobe Life	Pepsi	0.0033

Note: The shares listed in the table are national market shares calculated based on the Nielsen Retailer Scanner Data in 2008. With the full samples in the Nielsen Retailer Scanner Data of year 2008, I aggregate all the observed quantities sold to brand-year level (within the "Water-Bottled" category), and divide each brand's aggregated annual quantities by the summation over all brands. Arrowhead, Deer Park, Ice Mountain, Ozarka, Poland Spring, and Zephyrhills are all brands of Nestle spring water, that are marketed in different regions of U.S. Since it is rare to find these brands in the same market (region-retailer pair), I treat them as the same brand across regions and assign a common name "Nestle Spring".

Table 11: Demand Estimates for Logit and Random Coefficient Logit Model

Variable	parameter	Model	
		Logit	RCL
Price	α	-2.095 (0.039)	-5.355 (0.141)
Product variety (flavored)	θ^d_f	1.055 (0.029)	1.014 (0.028)
Product variety (non-flavored)	θ^d_{nf}	1.323 (0.082)	1.409 (0.083)
Advertising	θ^a	0.048 (0.003)	0.052 (0.003)
Demographic Interactions			
Income $\times$ Price			0.956 (0.044)
Income $\times$ Constant			-1.613 (0.077)
Income $\times$ Multi-pack			0.213 (0.031)
Mean Own-price Elasticity		-3.34	-3.82

Note: There are 146,107 observations at the brand-package-region-retailer-month-year level. Both regressions include product (brand-package pair), region, and time fixed effects. For the RCL specification, 100% of the estimated individual price coefficients are negative.

Table 12: Mean Own-Price and Cross-Price Elasticities for 16 Products (Brand-Package Pairs)

Brand-package	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Aquafina s	-4.388	0.006	0.013	0.002	0.004	0.003	0.005	0.011
(2) Aquafina Splash m	0.013	-2.604	0.013	0.002	0.005	0.003	0.005	0.016
(3) Dasani s	0.014	0.006	-4.474	0.002	0.004	0.003	0.005	0.011
(4) Evian s	0.014	0.006	0.013	-4.003	0.005	0.003	0.005	0.011
(5) Evian m	0.014	0.006	0.013	0.002	-3.670	0.003	0.005	0.011
(6) Fiji s	0.014	0.006	0.013	0.002	0.004	-4.095	0.005	0.010
(7) Fiji m	0.013	0.005	0.012	0.002	0.004	0.003	-4.133	0.011
(8) Fruit2O m	0.013	0.010	0.013	0.003	0.005	0.003	0.006	-2.566
(9) Smartwater s	0.015	0.009	0.014	0.003	0.005	0.004	0.005	0.014
(10) Smartwater m	0.013	0.007	0.013	0.002	0.004	0.003	0.006	0.010
(11) Vitaminwater s	0.013	0.006	0.013	0.002	0.004	0.003	0.005	0.010
(12) Vitaminwater m	0.012	0.005	0.011	0.002	0.004	0.003	0.006	0.010
(13) Propel s	0.014	0.008	0.013	0.002	0.005	0.004	0.005	0.011
(14) Propel m	0.014	0.008	0.014	0.003	0.005	0.004	0.006	0.017
(15) Sobe Life s	0.013	0.007	0.012	0.002	0.004	0.003	0.005	0.010
(16) Sobe Life m	0.012	0.007	0.012	0.002	0.004	0.002	0.005	0.012

Note: "s" denotes single-bottle product and "m" denotes multi-pack product.These price elasticities are calculated based on the random coefficient model, formulas are given by Nevo (2000). All prices are deflated by nonalcoholic beverage consumer index (year 2006=100), and are measured as U.S. dollars per liter.

Table 13: Mean Own-Price and Cross-Price Elasticities for 16 Products (Continued)

Brand-package	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Aquafina s	0.009	0.002	0.041	0.006	0.015	0.018	0.011	0.001
(2) Aquafina Splash m	0.012	0.002	0.042	0.005	0.014	0.023	0.011	0.001
(3) Dasani s	0.008	0.002	0.041	0.006	0.014	0.018	0.011	0.001
(4) Evian s	0.010	0.002	0.044	0.006	0.016	0.018	0.011	0.001
(5) Evian m	0.009	0.002	0.043	0.005	0.016	0.018	0.011	0.001
(6) Fiji s	0.010	0.002	0.046	0.006	0.016	0.017	0.012	0.001
(7) Fiji m	0.008	0.002	0.043	0.009	0.014	0.017	0.011	0.002
(8) Fruit2O m	0.009	0.002	0.036	0.010	0.013	0.027	0.011	0.002
(9) Smartwater s	-3.309	0.002	0.048	0.005	0.018	0.022	0.014	0.001
(10) Smartwater m	0.010	-3.758	0.046	0.005	0.013	0.017	0.013	0.001
(11) Vitaminwater s	0.009	0.002	-4.408	0.006	0.014	0.017	0.012	0.001
(12) Vitaminwater m	0.007	0.002	0.042	-4.619	0.010	0.014	0.011	0.002
(13) Propel s	0.011	0.002	0.046	0.005	-3.728	0.020	0.013	0.001
(14) Propel m	0.011	0.002	0.043	0.008	0.017	-3.031	0.013	0.002
(15) Sobe Life s	0.009	0.002	0.042	0.005	0.013	0.017	-4.308	0.001
(16) Sobe Life m	0.007	0.002	0.044	0.010	0.009	0.018	0.009	-4.045

Note: "s" denotes single-bottle product and "m" denotes multi-pack product.These price elasticities are calculated based on the random coefficient model, formulas are given by Nevo (2000). All prices are deflated by nonalcoholic beverage consumer index (year 2006=100), and are measured as U.S. dollars per liter.

Table 14: Mean Diversion Ratios of Inside Products and Outside Good

Brand-package	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Aquafina s	96.56	0.28	0.30	0.06	0.13	0.08	0.12	0.49
(2) Aquafina Splash m	0.28	96.35	0.25	0.06	0.13	0.08	0.11	0.65
(3) Dasani s	0.33	0.28	96.53	0.06	0.13	0.08	0.13	0.48
(4) Evian s	0.33	0.28	0.29	96.02	0.13	0.08	0.12	0.50
(5) Evian m	0.33	0.27	0.28	0.06	96.08	0.08	0.13	0.47
(6) Fiji s	0.34	0.29	0.28	0.06	0.12	95.84	0.12	0.46
(7) Fiji m	0.33	0.26	0.29	0.06	0.13	0.09	96.03	0.60
(8) Fruit2O m	0.25	0.41	0.26	0.07	0.13	0.07	0.13	96.86
(9) Smartwater s	0.31	0.37	0.27	0.06	0.12	0.08	0.11	0.58
(10) Smartwater m	0.31	0.31	0.28	0.06	0.12	0.08	0.13	0.47
(11) Vitaminwater s	0.32	0.29	0.29	0.07	0.13	0.08	0.13	0.46
(12) Vitaminwater m	0.30	0.25	0.29	0.06	0.12	0.08	0.15	0.56
(13) Propel s	0.33	0.32	0.27	0.06	0.13	0.08	0.12	0.46
(14) Propel m	0.31	0.35	0.28	0.07	0.13	0.09	0.13	0.80
(15) Sobe Life s	0.30	0.30	0.27	0.06	0.12	0.08	0.12	0.45
(16) Sobe Life m	0.28	0.33	0.26	0.05	0.11	0.07	0.14	0.66

Note: "s" denotes single-bottle product and "m" denotes multi-pack product. The diagonal elements denote the diversion to the outside good. Numbers represent percentage values and elements in each row should sum to 100 in theory. Since the values in table 14 are calculated from the mean of each market, the summation of row elements cannot be exactly equal to 100.

Table 15: Mean Diversion Ratios of Inside Products and Outside Good (Continued)

Brand-package	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Aquafina s	0.32	0.05	0.95	0.12	0.44	0.64	0.28	0.03
(2) Aquafina Splash m	0.38	0.05	0.87	0.10	0.40	0.74	0.25	0.03
(3) Dasani s	0.31	0.05	0.95	0.12	0.44	0.64	0.28	0.03
(4) Evian s	0.35	0.05	0.99	0.11	0.47	0.64	0.28	0.03
(5) Evian m	0.35	0.05	1.00	0.10	0.46	0.64	0.28	0.02
(6) Fiji s	0.36	0.05	1.06	0.11	0.50	0.61	0.30	0.03
(7) Fiji m	0.32	0.05	1.06	0.21	0.46	0.65	0.29	0.05
(8) Fruit2O m	0.28	0.05	0.74	0.22	0.34	0.89	0.23	0.05
(9) Smartwater s	95.99	0.05	1.00	0.09	0.50	0.70	0.30	0.03
(10) Smartwater m	0.36	95.70	1.09	0.11	0.41	0.62	0.32	0.03
(11) Vitaminwater s	0.33	0.05	96.97	0.12	0.44	0.63	0.29	0.03
(12) Vitaminwater m	0.29	0.06	1.11	96.17	0.35	0.61	0.31	0.05
(13) Propel s	0.39	0.05	1.00	0.10	96.30	0.67	0.31	0.03
(14) Propel m	0.37	0.05	0.94	0.18	0.49	96.64	0.29	0.04
(15) Sobe Life s	0.34	0.05	0.99	0.11	0.40	0.62	96.32	0.03
(16) Sobe Life m	0.29	0.05	1.11	0.25	0.29	0.72	0.24	95.89

Note: "s" denotes single-bottle product and "m" denotes multi-pack product. The diagonal elements denote the diversion to the outside good. Numbers represent percentage values and elements in each row should sum to 100 in theory. Since the values in table 15 are calculated from the mean of each market, the summation of row elements cannot be exactly equal to 100.

Table 16: Mean Advertising Elasticities for 16 Products (Brand-Package Pairs)

Brand-package	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Aquafina s	0.0207	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001
(2) Aquafina Splash m	-0.0001	0.0075	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001
(3) Dasani s	-0.0001	0.0000	0.0095	0.0000	0.0000	0.0000	0.0000	-0.0001
(4) Evian s	-0.0001	0.0000	0.0000	0.0051	0.0000	0.0000	0.0000	-0.0001
(5) Evian m	-0.0001	0.0000	0.0000	0.0000	0.0053	0.0000	0.0000	-0.0001
(6) Fiji s	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0065	0.0000	-0.0001
(7) Fiji m	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0066	-0.0001
(8) Fruit2O m	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0151
(9) Smartwater s	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001
(10) Smartwater m	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001
(11) Vitaminwater s	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001
(12) Vitaminwater m	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001
(13) Propel s	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001
(14) Propel m	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001
(15) Sobe Life s	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001
(16) Sobe Life m	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0002

Note: "s" denotes single-bottle product and "m" denotes multi-pack product. These advertising elasticities are calculated based on the logit model. The advertising expenditures are deflated by the consumer index (year 2006=100), and are measured as U.S. cents per-capita.

Table 17: Mean Advertising Elasticities for 16 Products (Continued)

Brand-package	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Aquafina s	-0.0001	0.0000	-0.0006	-0.0001	-0.0004	-0.0007	-0.0001	0.0000
(2) Aquafina Splash m	-0.0001	0.0000	-0.0005	-0.0001	-0.0004	-0.0007	-0.0001	0.0000
(3) Dasani s	-0.0001	0.0000	-0.0006	-0.0001	-0.0004	-0.0007	-0.0001	0.0000
(4) Evian s	-0.0001	0.0000	-0.0006	-0.0001	-0.0005	-0.0006	-0.0001	0.0000
(5) Evian m	-0.0001	0.0000	-0.0006	-0.0001	-0.0005	-0.0006	-0.0001	0.0000
(6) Fiji s	-0.0001	0.0000	-0.0007	-0.0001	-0.0005	-0.0005	-0.0001	0.0000
(7) Fiji m	-0.0001	0.0000	-0.0006	-0.0001	-0.0005	-0.0006	-0.0001	0.0000
(8) Fruit2O m	-0.0001	0.0000	-0.0005	-0.0002	-0.0004	-0.0008	-0.0001	0.0000
(9) Smartwater s	0.0250	0.0000	-0.0006	-0.0001	-0.0004	-0.0005	-0.0001	0.0000
(10) Smartwater m	-0.0001	0.0251	-0.0007	-0.0001	-0.0004	-0.0004	-0.0001	0.0000
(11) Vitaminwater s	-0.0001	0.0000	0.0516	-0.0001	-0.0004	-0.0006	-0.0001	0.0000
(12) Vitaminwater m	-0.0001	0.0000	-0.0007	0.0563	-0.0004	-0.0005	-0.0001	0.0000
(13) Propel s	-0.0001	0.0000	-0.0006	-0.0001	0.0759	-0.0005	-0.0001	0.0000
(14) Propel m	-0.0001	0.0000	-0.0006	-0.0001	-0.0005	0.0871	-0.0001	0.0000
(15) Sobe Life s	-0.0001	0.0000	-0.0006	-0.0001	-0.0003	-0.0005	0.0304	0.0000
(16) Sobe Life m	-0.0001	0.0000	-0.0008	-0.0002	-0.0002	-0.0006	-0.0001	0.0345

Note: "s" denotes single-bottle product and "m" denotes multi-pack product. These advertising elasticities are calculated based on the logit model. The advertising expenditures are deflated by the consumer index (year 2006=100), and are measured as U.S. cents per-capita.

Table 18: Average Markups and Recovered Marginal Cost

Brand	Manufacturer Markup	Retailer Markup	Marginal Cost	Retail Price
Aquafina	0.407	0.444	1.032	1.883
Aquafina Splash	0.362	0.394	0.226	0.982
Dasani	0.408	0.448	1.080	1.936
Evian	0.381	0.431	0.780	1.592
Fiji	0.399	0.452	0.928	1.779
Fruit2O	0.350	0.389	0.225	0.965
Smartwater	0.379	0.414	0.596	1.389
Vitaminwater	0.426	0.468	1.148	2.043
Propel	0.377	0.410	0.531	1.317
Sobe Life	0.410	0.449	0.977	1.837

Note: All numbers here are measured in 2006 U.S. dollars per liter.

Table 19: Supply-Side Estimates

Variable	Estimation Equation		
	Marginal Cost (i)	Product Variety (ii)	Advertising (iii)
Dummy Smart. Single	0.6103		
	(0.0088)		
Dummy Smart. Multi	0.8753		
	(0.0092)		
Dummy Vitamin. Single	1.1561		
	(0.0090)		
Dummy Vitamin. Multi	1.3984		
	(0.0100)		
Dummy Smart.		0.4201	0.1832
		(0.0050)	(0.0224)
Dummy Vitamin.		0.0391	0.1850
		(0.0013)	(0.0198)
Glaceau $\times$ Post Merger	-0.0836	-0.0076	-0.1349
	(0.0049)	(0.0013)	(0.0199)

Note: Estimates in product variety and advertising equations are relative small in magnitudes, numbers presented in columns (ii) and (iii) are multiplied by 1000. There are 121,408 observations at the brand-package-chain-region-month-year level, which covers 10,945 markets (chain-region-year-month). In addition to variables presented in the table, all regressions include fixed effect of other products/brands. Regression in column (i) also includes region and time fixed effects.

Table 20: Counterfactual Results Under Different Scenarios

Uni. Eff.	N	Y	Y	Y	Y	Y
Marg. Eff.	N	N	Y	N	N	Y
Vari. Eff.	N	N	N	Y	N	Y
Ad. Eff.	N	N	N	N	Y	Y
	Value	% Changes Relative to No Merger Scenario (i)				
Merger Scenarios	(i)	(ii)	(iii)	(iv)	(v)	(vi)
			Wholesale Prices			
Smartwater	0.952	0.26%	-9.54%	0.36%	0.25%	-9.35%
Vitaminwater	1.439	0.14%	-6.01%	0.21%	0.16%	-5.86%
Dasani	1.468	0.44%	0.72%	0.51%	0.46%	0.86%
Non-flavored	1.334	0.00%	0.01%	0.00%	0.00%	0.00%
Flavored	0.773	0.00%	0.03%	-0.01%	0.00%	0.03%
			No.UPCs			
Smartwater	2.276	-0.52%	22.10%	1.32%	0.43%	25.44%
Vitaminwater	10.027	0.28%	15.52%	22.89%	1.29%	44.52%
Dasani	3.081	-3.74%	-1.22%	-4.08%	-3.39%	-1.46%
Non-flavored	2.310	-0.04%	0.81%	-0.20%	0.23%	0.64%
Flavored	6.760	0.05%	0.69%	-0.01%	0.25%	0.66%
			Advertising			
Smartwater	0.111	1.86%	-38.02%	2.62%	203.21%	144.06%
Vitaminwater	0.254	-0.10%	-2.47%	1.95%	222.05%	322.43%
Dasani	0.177	-18.85%	-13.18%	-21.10%	-17.52%	-13.25%
Non-flavored	0.006	0.66%	1.26%	-2.95%	3.83%	-0.92%
Flavored	0.139	0.38%	7.29%	-0.82%	1.86%	14.27%

Note: This table provides average wholesale prices, number of UPCs, and per-capita advertising expenditure at the brand-chain-region level of 20 retailer chains which cover most DMA regions. The numbers in column (i) are calculated assuming the merger never happened. The numbers in column (ii) are calculated assuming the merger occurs with only unilateral effects. Columns (iii)-(iv) represent merger scenarios under different efficiency or synergy effects. Column (vi) denotes the real data and relevant predictions. I don't observe wholesale prices in the data, the numbers reported in above are obtained by equation (4.9) with demand estimates.

Table 21: Counterfactual Results Under Different Scenarios (Continued)

Uni. Eff.	N	Y	Y	Y	Y	Y
Marg. Eff.	N	N	Y	N	N	Y
Vari. Eff.	N	N	N	Y	N	Y
Ad. Eff.	N	N	N	N	Y	Y
	Value	% Changes Relative to No Merger Scenario (i)				
Merger Scenarios	(i)	(ii)	(iii)	(iv)	(v)	(vi)
			Retail Prices			
Smartwater	1.345	0.19%	-7.20%	0.30%	0.19%	-6.98%
Vitaminwater	1.875	0.11%	-4.90%	0.20%	0.14%	-4.72%
Dasani	1.902	0.37%	0.70%	0.44%	0.38%	0.87%
Non-flavored	1.766	-0.01%	0.12%	0.02%	0.00%	0.18%
Flavored	1.162	-0.01%	0.19%	0.02%	0.01%	0.27%
			Market Share			
Smartwater	0.27%	-0.74%	53.83%	0.95%	1.40%	59.91%
Vitaminwater	0.50%	0.01%	50.87%	20.13%	5.59%	89.73%
Dasani	0.29%	-8.27%	-4.42%	-9.08%	-7.62%	-4.74%
Non-flavored	0.17%	-0.20%	2.37%	-0.54%	0.65%	2.38%
Flavored	0.55%	0.12%	-0.16%	-0.23%	0.13%	-0.20%
			Profit			
Smartwater	1.030	-0.33%	69.13%	1.69%	3.81%	80.08%
Vitaminwater	2.540	0.60%	51.75%	21.22%	10.44%	91.23%
Dasani	1.117	-8.42%	-4.59%	-9.38%	-7.99%	-5.53%
Non-flavored	0.872	0.06%	3.64%	-0.39%	1.65%	3.13%
Flavored	2.082	0.13%	0.12%	-0.27%	0.19%	0.68%
			Consumer Surplus			
		-1.06%	24.19%	0.95%	-0.17%	30.12%

Note: This table provides average retail prices, market shares, and per-unit net profit at the brand-chain-region level of 20 retailer chains which cover most DMA regions. The numbers in column (i) are calculated assuming the merger never happened. The numbers in column (ii) are calculated assuming the merger occurs with only unilateral effects. Columns (iii)-(iv) represent merger scenarios under different efficiency or synergy effects. Column (vi) denotes the real data and relevant predictions. The “profit” values reported in column (i) denote the per-unit net profit of each brand. The total net profit of each brand can be obtained by multiplying it by the market size of a given market (the unit of market size is 1,000 liters).

Appendix A: Derivation of Δ^p matrix

Recall the monopolist retailer's first order condition in region r at time t: [1]

$$S_j + \sum_{c \in G_{rt}} [p_c^R - p_c^W] \frac{\partial S_c}{\partial p_j} = 0. \tag{A1}$$

Following Villas-Boas (2007), totally differentiating equation (A1) with respect to all retail prices p_c^R and wholesale prices p_c^W yields:

$$\sum_{c=1}^{J} \left\{ \frac{\partial S_j}{\partial p_c^R} + \sum_{m=1}^{J} \left[\frac{\partial^2 S_m}{\partial p_j^R \partial p_k^R} (p_m^R - p_m^W) \right] + \frac{\partial S_c}{\partial p_j^R} \right\} \boldsymbol{d} p_c^R - \frac{\partial S_n}{\partial p_j^R} \boldsymbol{d} p_n^W = 0 \tag{A2}$$

where c, j, m, n are products indexes. Define $\boldsymbol{G}$ as a J by J matrix with elements $g(j,c)$, where

$$g(j,c) = \sum_{c=1}^{J} \left\{ \frac{\partial S_j}{\partial p_c^R} + \sum_{m=1}^{J} \left[\frac{\partial^2 S_m}{\partial p_j^R \partial p_c^R} (p_m^R - p_m^W) \right] + \frac{\partial S_c}{\partial p_j^R} \right\}. \tag{A3}$$

[1] Drop region and time subscripts for convenience.

Since the retailer's price-cost margin $(\boldsymbol{p}^R - \boldsymbol{p}^W)$ can be expressed as $\Omega^R(\boldsymbol{p})^{-1}S(\boldsymbol{p})$, the matrix $\boldsymbol{G}$ can be decomposed into two part to increase the speed of calculation:

$$\boldsymbol{G} = \boldsymbol{G}_1 + \boldsymbol{G}_2, \tag{A4}$$

where the general element of $\boldsymbol{G}_1$ is

$$g_1(j,c) = \sum_{c=1}^{J}\left[\frac{\partial S_j}{\partial p_c^R} + \frac{\partial S_c}{\partial p_j^R}\right], \tag{A5}$$

and the general element of $\boldsymbol{G}_2$ is

$$g_2(j,c) = \sum_{c=1}^{J}\sum_{m=1}^{J}\left[\frac{\partial^2 S_m}{\partial p_j^R \partial p_c^R}(p_m^R - p_m^W)\right]. \tag{A6}$$

Let $\boldsymbol{\Omega}_n^R$ be a J by 1 vector with element $\boldsymbol{\Omega}_n^R(j,n) = \frac{\partial S_n}{\partial p_j^R}$. For a given wholesale price p_n^W, equation (A2) is computed for all J products. Thus these J equations in (A2) can be expressed as

$$G\boldsymbol{d}p^R - \Omega_n^R \boldsymbol{d}p_n^W = \boldsymbol{0}. \tag{A7}$$

Then the n-th column of $\boldsymbol{\Delta}^p$ is

$$\frac{\boldsymbol{d}p^R}{\boldsymbol{d}p_n^W} = \boldsymbol{G}^{-1}\boldsymbol{\Omega}_n^R. \tag{A8}$$

Stacking all J vectors we have matrix $\boldsymbol{\Delta}^p$

$$\boldsymbol{\Delta}^p = (\boldsymbol{G}_1 + \boldsymbol{G}_2)^{-1}\boldsymbol{\Omega}^R. \tag{A9}$$

Bibliography

Steven Berry, James Levinsohn, and Ariel Pakes. Automobile prices in market equilibrium. *Econometrica*, 63 (4):847–890, 1995.

Aviv Nevo. Mergers with differentiated products: The case of the ready-to-eat cereal industry. *The RAND Journal of Economics*, 31 (3):395–421, 2000.

Sofia Berto Villas-Boas. Vertical relationships between manufacturers and retailers: Inference with limited data. *The Review of Economic Studies*, 74 (2):625–652, 2007.

Ying Fan. Ownership consolidation and product characteristics: A study of the us daily newspaper market. *The American Economic Review*, 103 (5):1598–1628, 2013.

Steven Berry and Ariel Pakes. Some applications and limitations of recent advances in empirical industrial organization: Merger analysis. *The American Economic Review*, 82 (2):247–252, 1993.

E. Han Kim and Vijay Singal. Mergers and market power: Evidence from the airline industry. *The American Economic Review*, 83 (3):549–569, 1993.

Aviv Nevo. Measuring market power in the ready-to-eat cereal industry. *Econometrica*, 69 (2):307–342, 2001.

Cory Capps, David Dranove, and Mark Satterthwaite. Competition and market power in option demand markets. *Rand Journal of Economics*, 34 (4):737–763, 2003.

Michael D. Whinston. Lectures on antitrust economics, chapter 3: Horizontal mergers. 2003.

Céline Bonnet and Pierre Dubois. Inference on vertical contracts between manufacturers and retailers allowing for rnonlinear pricing and resale price maintenance. *The Rand Journal Economics*, 41 (1):139–164, 2010.

Paul B. Ellickson, Pianpian Kong, and Mitchell J. Lovett. Private labels and retailer profitability: Bilateral bargaining in the grocery channel. September 2017.

Oliver E. Williamson. Economies as an antitrust defense: The welfare tradeoffs. *The American Economic Review*, 58 (1):18–36, 1968.

Orley C. Ashenfelter, Daniel S. Hosken, and Matthew C. Weinberg. Efficiencies brewed: Pricing and consolidation in the us beer industry. *The Rand Journal Economics*, 46 (2):328–361, 2015.

Robert Kulick. Horizontal mergers, prices, and productivity. November 2017.

Philip G. Gayle. On the efficiency of codeshare contracts between airlines: Is double marginalization eliminated? *The American Economic Journal: Microeconomics*, 5 (4):244–273, 2013.

Jerry Hausman. Valuation of new goods under perfect and imperfect competition. In *The Economics of New Goods*, pages 207–248. National Bureau of Economic Research, Inc, 1996. URL `https://EconPapers.repec.org/RePEc:nbr:nberch:6068`.

Nathan H. Miller and Matthew C. Weinberg. Understanding the price effects of the millercoors joint venture. *Econometrica*, 85 (6):1763–1791, 2017.

Christopher T. Conlon and Julie Holland Mortimer. Empirical properties of diversion ratios. July 2018.

Matthew Grennan. Price discrimination and bargaining: Empirical evidence from medical devices. *American Economic Review*, 103 (1):145–177, 2013.

Steven Berry. Estimating discrete-choice models of product differentiation. *The RAND Journal of Economics*, 25 (2):242–262, 1994.

Steven Berry, James Levinsohn, and Ariel Pakes. Voluntary export restraints on automobiles: Evaluating a trade policy. *American Economic Review*, 89 (3):400–430, 1999.

Mathias Reynaert and Frank Verboven. Improving the performance of random coefficients demand models: The role of optimal instruments. *Journal of Econometrics*, 179 (1):83–98, 2014.

Steven T Berry and Philip Haile. Identification in differentiated products markets. Working Paper 21500, National Bureau of Economic Research, 2015. URL `http://www.nber.org/papers/w21500`.

Christopher J. Sullivan. The ice cream split: Empirically distinguishing price and product space collusion. November 2016.

Charles Murry. Advertising in vertical relationships: An equilibrium model of the automobile industry. January 2017.

Amil Petrin. Quantifying the benefits of new products: The case of the minivan. *Journal of Political Economy*, 110 (4):705–729, 2002.

K. Sudhir. Structural analysis of manufacturer pricing in the presence of a strategic retailer. *Marketing Science*, 20(3):244–264, 2001.

Gregory T. Gundlach and Diana L. Moss. Non-price effects of mergers: Introduction and overview. *The Antitrust Bulletin*, 63 (2):155–168, 2018.

John Kwoka and Shawn Kilpatrick. Nonprice effects of mergers: Issues and evidence. *The Antitrust Bulletin*, 63 (2):169–182, 2018.

Federico Ciliberto, Charles Murry, and Elie Tamer. Market structure and competition in airline markets. May 2016.

Yuqing Zheng and Harry M. Kaiser. Estimating asymmetric advertising response: An application to u.s. nonalcoholic beverage demand. *Journal of Agricultural and Applied Economics*, 40(3):837–849, 2008.