Size Matters – How Consumers' Energy Drink Consumption Is Affected by Package Size Changes

Lai Jiang [*] Ting Zhu [†] Pradeep Chintagunta [‡] Saad Andalib Syed Shah [§]

October 10, 2019

Abstract

This paper is to examine the impact of new product introduction on consumers' demand for energy drinks. In particular, we are interested in how consumers responded to Red Bull's new product with larger package sizes and whether such product innovation strategy helped Red Bull gain higher market share and increased the consumers' total energy drink consumption. We build a demand model of consumers' choices on energy drinks. We find that quantity-discounts (due to larger sizes) and consumers' preferences for larger sizes, helped Red Bull gain higher market share. According to our estimation results, it gained as much as 34.15% and 25.90% market share with introduction of 12 oz and 16 oz cans respectively. However we find that the total consumption of energy drinks by the regular users remained almost the same after the introduction of large size cans by Red Bull. This result suggests that consumers switched from other brands to Red Bull. While introduction of larger package size may be profitable for manufacturers like, Red Bull, it might impose social costs as a large and growing body of scientific evidence demonstrates that energy drinks are harmful to health. As a consequence, policy options such 'soda-tax' or 'cap-rule' have been suggested. We compare the relative efficacy of these options in our counterfactual analysis and find that a 'cap-rule' which limits the size of a can 8 oz is way more effective than a 1 cent per oz soda tax in reducing consumers' energy drink consumptions.

[*] University of California Irvine E-mail: ljiang14@uci.edu
[†] Purdue University E-mail: zhu640@purdue.edu
[‡] University of Chicago E-mail:pradeep.chintagunta@chicagobooth.edu
[§] University of California, Irvine E-mail: ssyedsha@uci.edu

1 Introduction

Today, packaging is more than just the container that holds products. The increasing amount of new package design enables firms to better communicate the benefits of their products, to differentiate from their competitors, and even to adapt to the consumers' changing consumption patterns. For example, in response to the persistent decline of soda consumption, Coca Cola introduced smaller packages to sell less of its product at a higher price. Compared with a regular 12-ounce can of coke that on average sells for 31 cents, a 7.5-ounce can of coke on average sells for 40 cents.[1] This tactic works for Coca Cola since it is beneficial for today's consumers who are more likely to be health-concious than in the past. "Mini-cans" let consumers indulge without consuming as many calories as they would from a regular can of soda. While many firms are using package - downsizing strategies, including examples from yogurt, icecream, tuna and peanut butter, etc, another soft drink company – Red Bull, adopted the opposite strategy in 2007 by introducing a larger package size of its product: energy drinks.

Energy drinks are beverages that contain high caffeine in combination with other ingredients such as taurine, guarana, and B vitamins, and that claims to provide its consumers with extra energy. It began being marketed as a separate beverage category in the United States with the introduction of the Austrian import Red Bull in 1997 (MartinReport). Energy drink consumption and sales have increased dramatically since then. Energy drinks have become a multibillion-dollar business, with steadily increasing sales that rose 16% in 2012 alone, amounting to a US sales market worth more than $12.5 billion.[2] According to the Energy Drinks Markety Report by Modor Intellegience,[3] the energy drinks market is expected to reach USD 83.4 billion worldwide by 2024. Teenagers and young adults are target consumer group for energy drinks. Consumption of energy drinks by children and teens has been a growing trend; a 2012 study of U.S. high school students revealed that energy drinks represented 8.8 % of the sugar-sweetened beverages they consumed. [4]Another U.S. study found that 31% of 12-17 year olds regularly drink energy drinks, in comparison to 22 percent of 25-35 year-olds.[5]

[1]https://www.cbsnews.com/news/for-coke-and-pepsi-smaller-sodas-could-pay-more/

[2]Energy Drinks and Shots: U.S. Market Trends, Packaged Facts, Feb. 11, 2013

[3]https://www.mordorintelligence.com/industry-reports/energy-drinks-market

[4]Park, S., Blanck, H.M., Sherry, B., Brener, N. and O'Toole, T. (2012) Factors associated with sugar-sweetened beverage intake among united states high school students. Journal of Nutrition 142(2): 306–312

[5]Simon, M. and Mosher, J. (2007) Alcohol, Energy Drinks, and Youth: A Dangerous Mix. California: Marin Institute.

The energy drink manufacturers create youth themes and marketing strategies to target the energy drinks' young consumer base. They create their brand image by using dramatic product names (e.g., Cocaine, DareDevil, Bawls, Pimp Juice, Rip It, and Monster Assault), edgy graphics on containers, and sponsorships of extreme sporting events and lifestyles, such as wakeboarding, skateboarding, motocross, and surfing. They associate the energy drink with rebelion, risk taking and adventure seeking. The manufacturers keep introducing new products. For instance, the leading brands Monster and Rockstar releasing new products to the market. They introduce products with new flavors and higher concentrations of caffeine. On the other hand, instead of introducing new flavors, Red Bull increased the product size from 8 oz to 12 oz and 16 oz to encourage consumers to buy a higher volume of the energy drink.

However, energy drinks have been the subject of a lot of controversy recently. From claims of false advertising to disturbing news about deaths that followed energy drink consumption. Although there is debate regarding the overall risks and benefits of energy drink and moderate caffeine consumption, health researchers agree that caffeine consumption can have adverse health consequences, particularly at high doses. Among the most common negative effects are increased anxiety, panic attacks, increased blood pressure, increased gastric acid, bowel irritability, and insomnia. With the rising popularity of energy drinks and with more young people ingesting high levels of caffeine, more serious health problems are now being reported in the nation's poison centers, while reports from other countries suggest potentially serious consequences from caffeine overdose. To response public health concerns, the Federal Government calls for input on regulation of caffeinated energy drinks.[6]

Similar to other soft drinks, increased consumption of sugar-sweetened beverages (SSB) including non-diet sodas, energy drinks, and fruit drinks have been linked with obesity. Some public health researchers suggest that such beverages may be the single largest driver of the obesity epidemic (Finkelstein and Zuckerman, 2008; Ludwig et al., 2001; Malik et al., 2006; Vartanian et al., 2007). So even if the introduction of 12 oz and 16 oz cans by Red Bull helped it gain higher market share, the social cost of such a strategy is not negligible.

With a view to curbing the consumption of SSBs, several public policies have been introduced by the government. One policy option is to regulate the size of the containers. Under such a policy, a cap on size of the SSB containers would be put. Consumers would still have the choice to purchase and consume as much as they want. However, as the drinks would be available in smaller sizes, the proponents of such a 'size-ban'

[6]see from http://www.abc.net.au/news/2013-09-03/government-to-examine-caffienated-energy-drink-regulation/4929964.

believe that such a regulation would lead to lower consumption of the beverage . In fact, the city of New York tried to implement such a rule back in 2013 when it was ultimately struck down by the New York Court of Appeals. If were approved, the Portion Cap Rule, as it was labeled by the New York City Board of Health (Board of Health), would have barred all New York City regulated restaurants, fast-food establishments, delis, movie theaters, sports stadiums and food carts from selling sugar-sweetened drinks in cups larger than 16 ounces (0.5 liters). In California too currently there is a similar bill under consideration for size regulation.

Another policy option is to impose additional tax on the SSB. In the last few years, Boulder, Colorado; Philadelphia, Pennsylvania; Seattle, Washington; and four California cities including Albany, Berkeley, Oakland, and San Francisco have implemented a soda tax. The popularity of this upstream public health policy, designed to reduce consumption of sugar, is exceptional. A soda tax is an excise tax or surcharge on drinks with added sugar. All current soda excise taxes are based on a drinks volume. Tax rates range from 1 cent per ounce in all four California jurisdictions to 2 cents per ounce in Boulder. The rationale for such a tax is simple : a soda-tax would raise the price and thus would lead the consumers to fall back on their consumption. Hence, from an economic point of view, it would be worth exploring which of these two policy options (cap-rule or soda-tax) is a more efficient way to reducing the consumption of sugary drinks.

Our paper examines the demand expansion process of energy drinks for regular users via an important test case: the introduction of large package size energy drink by Red Bull. We build a demand model of consumers' choices of energy drinks. In particular, we are interested in how consumers responded to Red Bull's new product. We focus on two possible complementary mechanisms that may have played a role in the energy drink market. First, comparing the existing products, a new package with a larger volume provides quantity discounts for the same product with smaller sizes. Lower unit price encourages consumers to switch to the new product and switch from other brands. Second, consumption habits could be playing an important role in the market for energy drink. For example, preference for large size could give Red Bull higher market share. This paper tries to quantify these two effects and thus measures relative importance for demand expansion.

While introducing larger package size may help gain a firm higher market share and thus higher profits, it might not be socially optimal if consumption of the product in larger quantities impose significant external costs. This is particularly true for the SSBs. Since energy drinks are considered major SSB products, we also try to compare the relative efficiency of two policy options, soda-tax vis-a-vis cap-rule, targeted to reduce the consumption. While soda-tax works through a price increase a cap-rule regulates the quantity or size in which the product could be served. According to our knowledge, this is the first paper which tries to compare the efficacy of these two policy options.

We use household purchase data and store level data from A.C. Nielsen from 2006 to 2009. We particularly choose these years because Red Bull introduced their larger package sizes in 2007. Our results show that without the introduction of 12 oz Red Bull drinks, the regular users would have decreased their consumption only marginally. However, consumption of Red Bull products would have increased by 34.15%. This result supports consumers' switching to Red Bull from other brands. We also see that price discounts (due to larger package size) have greater contributions than size-preference to Red Bull's higher market share. Finally, we find that a size regulation, where the maximum size of an energy drink is set at 8 oz, reduces the consumption of regular users far more (54%) than 1 cent per oz soda tax (15%). (****WHY IS THAT *** Hetergoeneity of size preferences?)

The rest of the paper is organized as follows. Section 2 discusses related literature and section 3 introduces the energy drink industry background. Section 4 describes the data and provides model free evidence on the relationship between the Red Bull's new product introduction and the consumers' energy drink consumptions. We present the model framework in section 5. We discuss the estimation results and conudct counterfacutal analysis in section 6 and conclude the paper in section 7.

2 Literature

Although package innovation is an important aspect of product innovations, there is limited empirical research on this topic. Experimental research on the effects of package size on consumption generally predicts that larger package size leads to higher food consumption (Wansink (1996), Chandon (2013)). Wansink & Kim (2005) show that people eat more when whey are served with larger portion sizes in their experimental study. Young & Nestle (2002) also shows that the expanding portion size in food has long-term consequences and leads to obesity epidemic. Our paper is able to quantify the effects on energy drink consumption with increasing portion size provided by the energy drink manufacturers. Thus we are able to see how much such a strategy of product innovation helped Red Bull to gain higher market share.

In recent years, there has been an increasing interest in studying the perceived benefits and risks associated with energy drink consumption in public health. For instance, Attila & Çakir (2011) find that the college students who regularly consume energy drinks are more engaged in sports. About 40% of energy drinks users mixed energy drinks with alcoholic beverages. Alsunni & Badar (2011) finds that the commonest reasons for use were company of friends, to keep awake, for more energy and for better performance in driving, sports or exams. Amongst many the commonest benefit reported was the ability to stay awake longer. The students reported a number of adverse effects, including urination and insomnia for males and females respectively. In most studies, the survey data were collected by the researchers. The results are based on consumers' self-reported purchase and consumption patterns. In contrast, our research is based on household scanner panel data that records consumers' purchase behavior accurately.

As mentioned before, while introduction of larger package size may be profitable for SSB manufacturers, it might impose social costs as a large and growing body of scientific evidence demonstrates that sugar drinks are harmful to health. As a consequence, we see the introduction of soda-tax in a number of cities in the US. There is a growing literature on the impact of soda-tax on consumption of sugary drinks. Within the US context, the most well-studied tax is the one implemented in Berkeley in 2014.The first ex-post evaluations suggest soda taxes work in reducing purchases of taxed products. In Berkley, California, sales data indicated a 9% decline in purchases, while self-reported changes in consumption amounted to a 21% reduction of taxed sodas (Falbe et al., 2016, Silver et al., 2017). In Mexico, the demand for sugary drinks fell by 69% in the first two years after implementation of a tax that increased price on average by 10% (Colchero et al., 2017, Colchero et al., 2015). To understand whether policy intervention is effective in changing consumers' soft drink consumption, and calorie and sugar intake, a growing body of research evaluates the effects of soda taxes on consumption decisions. For instance, (Bollinger & Sexton 2018) use retailer scanner panel data to estimate the impact of the Berkeley soda tax on prices and quantities. They find limited impact on consumers' soda demand either because of the low pass-through to retail prices or the substitions from purchases in neighoring markets. (Seiler et al. 2019) also find cross-shopping playing an important role in consumers' reactions to the soda tax. They find the total demand reduction is equal to only 22% after taking into the cross-shopping in Philidephia. Our paper is different from these study in that we use household panel data rather than retailer aggregate sales. We are able to estimate the individual preference for different product chacteristics, inclduing brands and product pakcages and prices. More importantly, we can explore the consumers' heterogeneous response to the price changes and product changes.

While there have been quite a number of studies evaluating the impact of soda-tax on consumption, we do not find any empirical study on potential impact of 'size-regulation' or 'cap-rule' policy which would restrict the upper limit of the size in which SSBs can be served. In this paper, we compare the relative efficacy of the two policies (soda-tax and cap-rule) aimed at reducing the consumption of energy drinks. Red Bull's introduction of larger package sizes in 2007 gives us the opportunity to construct counterfactual scenarios in our structural model to quantify and compare the relative efficacy of the two polocies.

Our model builds on literature using household scanner panels to estimate expected demand with discrete choice models (Guadagni & Little (1983), Chintagunta (1993), , Dube (2004)). We use a structural approach that allows for consumers' choices of brands, package size and purchase quantities. We also incorporate habit formation (Erdem (1996)) by which past purchases affect current choice via habit persistence. Our modeling approach follows Lambrecht et al. (2007) that considers both product and its quantity choice.

3 Energy Drink Market

An energy drink is a type of drink containing sugar and caffeine, which is marketed as providing mental and physical stimulation. Comparing to the coffenine content of coffee with 80 tp 100 mg per 8 fluid ounce serving, the caffeine content of energy drinks is in the range of 40 to 250 mg per 8 fluid ounce serving. The Food and Drug Administration recommends that 400 mg per day is safe for adults, while 1200 mg per day can be toxic.[7] Excessive consumption of energy drinks can have serious health effects resulting from high caffeine and sugar intakes, particularly for children, teens, and young adults ((Al-Shaar et al. 2017)). The consumption of energy drinks is rapidly increasing worldwide and within the United States. In 2012, the energy drink sales in the US is over $12.5 billion, and the sales is expected to reach $84 billion worldwide in 2024.

The major players in this market are Red Bull, Monster Beverage Corporation, Rockstar Inc, Coca Cola and PepsiCo. Red Bull, with the largest market share of energy drink in the world, is owend by the Austrain company that introduced its energe drink in 1987 and expanded to the US market in 1997. Red Bull initially comes in 8.4-ounce cans in handful varieties: original, sugar-free (5 calories), Total zero (no calo-

[7]https://www.fda.gov/consumers/consumer-updates/spilling-beans-how-much-caffeine-too-much?source=govdelivery

ries) and editions. In 2007, Red Bull launched larger size packages in $12oz, $16oz and $24oz cans. The new product in $12oz soon became a popular product and gained a large market share. We will discuss the details in the data section.

Monster was the second in market share after Red Bull world wide. The California-based Monster Beverge Corp. was founded in 1990 and began selling Monster Energey Drink in 2002. It comes in 16oz cans that have about the same price point as Red Bull's 8.4oz cnas. There are more varieties offered by Monster. Rockstar energy drinks were also introduced in California first in 2001. It comes in 8.4oz, 16oz and 24 oz cans. It also have more than 20 varieites in different calaroies contents and flavors. Similar to Monster, Rockstar has the same $2 price point as Red Bull, but its cans are nearly dubled in size.

As a new growing market, there is a significant lack of regulation on energy drinks in the U.S. While the Food and Drug Administration (FDA) enforces a caffeine limit of 71 mg per 12 fluid ounces for soda, but no such restriction for energy drinks since energe drink manufacturers classify their product as a supplement. In 2014, the American Beverage Association published the Guidance for the Responsible Labeling and Marketing of Energy Drinks". The goals is to ask the companies to committed to report total quantities of caffeine from all sources, restrict marketing to children, and voluntarily report adverse events to the FDA. However, it is challeging to enforce these regulations. Other countries facing similar challenge to the U.S. have implemented various approaches to regulate energe drinks. For example, Australia and New Zealand set the upper limit of caffeine from any source to be 320 mg/L ((Heckman et al. 2010)). To get aroud this restriction, Since 2002, there has been a growing trend for packaging energy drinks in bigger cans. The manufacturers include a greater amount of caffeine by including multiple servings per container. Therefore, it is worthwhile to explore how the change of package size affects consumers' consumptions. In addition to the regulation on caffeine content, some countries have implemented taxation policies as a deterrent to energe drinks consumption, such as the sugar-tax implemented in the US.

4 Data

4.1 Data Description

Our main data source for consumers' purchases of energy drinks is individual-level Homescan and store-level data from Kilts-Nielsen Consumer Panel Dataset. The

Homescan consumer-level data are from a panel dataset that tracks the shopping behavior of approximately 60,000 households from 2006 through 2009. The households are from 54 Scantrack markets. Their demographic information is recorded annually, including age, education, household size, income, marital status, employment, type of residence and race. The panel data provide information about each shopping trip by the panelists. We observe the time of purchase, store code, UPC code, price, promotion and purchase quantity of each item.

Table 1 shows the market share of major brands of energy drinks for 2006-09. The market is hight concentrated during this time period. As shown, Red Bull is the leading brand with a market share of 47% followed by Monster and Rockstar with 29% and 14% market shares respectively.

To construct a consumer's choice set, we use each unique brand-can size-multi-pack pair to define a product. We keep the six major umbrella brands in the individual dataset, resulting in 96 products in the estimation sample. Table 2 shows the market share and average price of the major products with the highest market shares from 2006 through 2009. First, different from other brands, we observe that Red Bull only had 8oz can in 2006 but introduced larger packages in 2007. Red Bull 12oz single can package gain 8% market share right after its introduction. Second, firms offered quantity discount in two ways. The unit price (price per oz) of a product is lower for larger package size or multi-pack products. For example, in 2008, the unit price for Red Bull 8oz single can is $0.25 per oz, wheras the unit price is $0.17 per oz for 24 can pack 8oz products, and $0.23 per oz for 12oz single can. Third, the unit price is much higher for Red Bull than its competitors. Red Bull's unit price is more than doubled of the prices for its competitors.

We use store-level data to construct the price matrix of the choice set that each household faces every week. We construct a different price matrix for each of four different regions: East, Central, South and West. Figure 1 shows prices for one 8 oz can of Red Bull in grocery stores in the four regions, indicating a significant variation in prices across regions. Figure 2 shows prices for one 8 oz can of Red Bull across three major channels in the eastern region, also indicating a significant variation in prices across channels. Compared to grocery stores prices, we see more price variation in service stations and drug stores .

The price index for each product in each week of a particular channel type in a region is computed by dividing its total revenue by its total sales. We merge store-level data with individual-level data using region-channel type-week-product to construct the estimation sample. For item purchased, the correlation between the price index constructed from the store- level data and the actual price paid from individual-level data is 0.9894. This high correlation indicates that our price index is reasonable.

In this paper, we focus on consumers' purchase decision for energy drinks. Unlike other frequenlty purchased products such as coffee or yogurt that are purchased by most of the households, only a small percentage of households bought energey drink regularly. From 2006 to 2009, 12,626 households in our data set bought energy drinks at least once. Among these households, 5,774 of them (around 46%) bought an energy drink only once during this time period, and 2001 of them (around 16%) bought energy drinks twice during this time period. 1,617 of them (around 12%) are heavy users who bought energy drinks at least 10 times during this period. Similar to Guadagni & Little (1983) who exclude light and nonusers of ground coeffe in their estimation sample, we keep households that have bought at least three weeks of energy drinks a year and, in total, have at least five purchases of energy drinks, resulting in 1,216 households in the estimation sample.

From 2, we observe that Red Bull only offered 8oz drinks in 2006. In 2007, 12oz and 16oz Red Bull were introcued to the market. The introduction of the large size Red Bull potentially could impact both the non-users of the energy drinks and the regular users. Figure 4 shows the number of adopters of energy drinks over time. We observe strong seasonal patterns, in which the number of first time energy users is higher during summer. However, there is no significant change of pattern in terms of adoption around the time larger size Red Bull is introduced. Therefore we focus on the purchase decision of the regular energy drinks users and do not model the adoption decision in our paper.

4.2 Model-free Evidence

To look at model-free evidence, we examine the loyal Red Bull households that bought Red Bull only and bought at least three weeks in 2006. We assume that the first week of 2007 is the week when larger-sized Red Bull was introduced. The sample consists of 169 households. Table 3 shows the purchase pattern of these loyal households after the larger-sized Red Bull was introduced. In the first column of Table 3, we conduct a fixed-effect regression of the logarithm of the weekly purchase amount (we define purchase amount as the total volume in terms of oz) of the Red Bull on larger-sized dummy, controlling for time trend. We could see that households' weekly volumes increase by 12% after the introduction of the larger-sized Red Bull. To decompose the effect of this volume increase into the effect of the can size increase and the effect of change in the the number of cans purchased, we conduct fixed- effect regressions of the logarithm of the average can size and of the logarithm of the number of cans of energy drinks on the size-increase dummy (households that had already bought larger-sized Red Bull), in the second and third columns of Table 3. Results show that households, on average, switched to the larger-sized cans of Red Bull, but they did not significantly change the number of cans that they bought. This result demonstrates that the larger size is the main reason for the increase in the purchase volume of energy drinks and that there is no substitution effect between can size and the number of cans purchased.

5 Model Development and Estimation

5.1 Model Setup

We use a utility framework that considers a household's product and quantity choices. Similar to Lambrecht et al. (2007), we assume that a consumer chooses a product among the set offered by the store she visits. The product choice is a discrete choice that reflects the expected utility given the optimal quantity choices. A consumer's continous decision on purchase quantity is conditional on her product choice.

5.1.1 Utility Function

The model is set up as follows: household h decides at week t whether to purchase a product j and how much to purchase at each week. We define product j as a combination of brand, bottle size and package size. For example, a choice alternative could be one 4-can 8oz Red bull energy drink purchase.

We assume that household h in week t chooses a purchasing quantity for energy drinks of product j ,q_{hjt}, and the outside good q_{h0t} to maximise its utility subject to a budget constraint. We assume that the utility on product j is represented by the following quadratic utility function:

$$u(q_{hjt}) = \frac{1}{\alpha_h}(d_{hjt}q_{hjt} - \frac{q_{hjt}^2}{2}) + q_{h0t} + \epsilon_{hjt} \tag{1}$$

with the following constraints: budget constraint:

$$y_{ht} = q_{h0t} + p_{jt} * q_{hjt} \tag{2}$$

and

$$q \geq 0 \tag{3}$$

where d_{hjt} is specified as follows:

$$d_{hjt} = \vec{\beta}'_{1h}\vec{S}_j + \vec{\beta}'_{2h}\vec{M}_j + \vec{\beta}'_{3h}\vec{B}_j + \vec{\beta}'_4 Q\vec{tr}_t + \gamma_{1h}\mathbb{1}_{(S_{pj}=S_{tk})} + \gamma_{2h}\mathbb{1}_{(M_{pj}=M_{tk})} + \gamma_{3h}\mathbb{1}_{(B_{pj}=B_{tk})} + \omega_{hjt}, \\ \text{with } j,k = 1,\ldots,J \tag{4}$$

Where $\vec{S}$ is a vector of can size dummies; $\vec{M}$ is a vector of can multi-pack dummies ; and $\vec{B}$ is a vector of brand dummies. p indicates the week when the last non-zero purchase of energy drinks occurred.

ω_{hjt} is the unobservable quantity demand shocks of household h for product j in week t, which is assumed to follow a normal distribution with mean 0 and standard deviation σ. ϵ_{hjt}, on the other hand, is unobservable preference demand shocks of household h for product j in week t, which is assumed to follow a type 1 extreme value distribution.[8]

5.1.2 Heterogeneity

We incorporate heterogeneity for the probability of household h buying in week t in the following way:

$$\vec{\beta_{kh}} = \vec{\eta_0} + \vec{D}'\eta_1 + \psi_h, k = 1,2 \tag{5}$$

where $\vec{D}$ are demographic variables of the household and ψ_h denotes unobserved heterogeneity for consumers' preferences.

For the brand preference parameters, we incorporate the heterogeneity in the following way:

$$\beta_{3hb_j} = \rho I^P_{hb_j 1} + \nu_{jh}, \tag{6}$$

$I^P_{hb_j t}$ denotes an indicator variable that is one if household h purchases product j of brand b in week t. ν_{jh} denotes the unobservable heterogeneity. We assume that ν_{jh} follows the normal distribution $N(0, \sigma^2_\nu)$, where the standard deviation σ_ν is to be estimated.

We specify the price coefficient as follows:

$$\alpha_h = \delta_0 + \delta_1 Income, \tag{7}$$

where Income specifies the income level of the household.

[8] Conditional on purchase, 89% of household weekly purchase consists of one unique product.

5.1.3 Product and Quantity Choice

Conditional on choosing product j, household h's optimal purchase quantity q^*_{hjt} is given as follows,

$$q^*_{hjt} = \max[0, d_{hjt} - \alpha_h P_{jt}] \tag{8}$$

Hence

$$E_\omega(u(q^*_{hjt})) = E_\omega[(\frac{(d_{hjt} - \alpha_h P_{jt})^2}{2\alpha})|d_{hjt} - \alpha_h P_{jt} > 0] * prob(d_{hjt} - \alpha_h P_{jt} > 0) \tag{9}$$

5.2 Model Estimation

Estimation is based on two observed decisions: the household's actual product choice and the purchase quantity. We estimate the model parameters by maximizing the joint likelihood of these two observed outcomes. We denote the household's observed product choice by an indicator, $\hat{I}_{hjt}$, that is one if household h chooses product j, and zero otherwise, and its observed purchase quantity choice by $\hat{q}_{hjt}$. Estimation of the model proceeds via simulated maximum likelihood. The likelihood of the observed behavior of a household is the joint probability of its product choice in week t and its purchase quantity.

I^P_{hjt} denotes indicator variables that are one if household h purchases product j in week t, and let $g(q_{hjt})$ denote the probability density of observing purchase quantity q_{hjt}.

Household h's contribution to the likelihood,l_{ht}, then equals

$$l_{ht} = \begin{cases} \prod_{j\in J} Pr(I^P_{hjt} = 1) g(\hat{q}_{hjt}|I^P_{hjt} = 1, q_{hjt} > 0))^{\hat{I}_{hjt}} & \text{if purchase in week } t \\ \sum_{j\in J} Pr(I^P_{hjt} = 1) prob(q_{hjt} = 0) & \text{if not purchase in week } t \end{cases} \tag{10}$$

where

$$prob(q_{hjt} = 0) = prob(d_{hjt} - \alpha_h P_{jt} <= 0) \tag{11}$$

Since ϵ_{hjt}, the unobservable preference demand shock of household h for product j in week t is assumed to follow a type 1 extreme value distribution, we have

$$Pr(I^P_{hjt} = 1) = \frac{exp(E_\omega(u(q^*_{hjt})))}{\sum_{j\in J} exp(E_\omega(u(q^*_{hjt})))}. \tag{12}$$

The assumption of normal distribution of unobservable quantity demand shocks leads to a probability density of observing the actual purchase quantity of

$$g(\hat{q}_{hjt}|I^P_{hjt}=1, q_{hjt}>0) = \frac{\frac{1}{\sigma_\omega}\phi(\frac{\hat{q}_{hjt}-(E(d_{hjt})-\alpha_h P_j}{\sigma_\omega}))}{prob(d_{hjt}-\alpha_h P_{jt}>0)}. \quad (13)$$

5.3 Discussion of model specification

Compared with Dube (2004), our specification of the model allows the probability of purchasing a product to depend on the observable characteristics of other products: for example, for the same Red Bull regular energy drinks, if the price of one 16 oz can decreases, the probability of the household purchasing an 8 oz can will be affected. This specification advantage is crucial for our paper since the interplay of different packaging of products is our main focus.

6 Results

6.1 Estimation Results

The purpose of this study is to quantify consumers'preferences for different package sizes of energy drinks and how the preferences can be reinforced by past consumptions. In our estimation, we select the households that have bought energy drinks for at least three weeks in each year and in total have at least 10 purchases from 2006 to 2009[9]. In total, we have 590 households in our estimation sample. Table 4 presents the parameter estimates of the proposed model. We first present consumers' preferences for price, different package sizes, brands, and loyalty for different product attributes. We then summarize how the preference vary across different demographic groups.

The identification of consumers' preferences for different package sizes relies on the variations of product attributes in consumers' choice sets. For example, we observe consumers'choice probabilities for single bottle Red Bull 8oz, 12oz and 16 oz drinks. After controlling for the price differences, we are able to attribute the differences in choice probabilities among the three alternatives to consumers' preferences for different bottle sizes. According to table 4, based on our parameter estimate for the price coefficient for the consumers at the average income level, (-0.502 = -0.540 + 61669 * 6.149E-07, where $61669 is the average income among the estimation sample), we are able to quanity the consumers' higher preference for larger size drinks and multi pack drinks. To do so, we divide our estimate for each size dummy and

[9]There are some missing values for some households in certain years from the data.

each multi pack dummy by the absolute value of price coefficient for the consumer at the average income level. Consumers are willing to pay $0.75, $1.24 and $1.98 more for 12 oz, 16 oz and 24 oz drinks relative to 8 oz drinks respectively. The results are consistent with the product prices we observed in the market. For example, according to Table 3, the average price for a single package 8oz Red Bull is $2.00 and the average price for a 12oz Red Bull is $2.81 in 2007. The price difference is about $0.81. Next, we estimate the consumers' preferences for different packages. For example, consumers are willing to pay $2.51, $5.64 and $10.00 more for 4 cans, 12 cans and 24 cans energy drinks relative to 1 can 8oz energy drink. The observed price differences are $5.12 between 4-can-8oz Red Bull and 1-can-8oz Red Bull in 2007. However, the price differences are much larger between 12-can Red Bull and 1-can Red Bull than the estimates from the demand model. The discrepancy can be explained by higher market share for 1-can Red Bull than the 12-can and 24-can packages. We also acknowlege that for the simplity of our model, we don't allow the interaction effects of multi-pack and package size. In reality, we expect larger difference in preference between multi pack and single pack for larger size cans. [10]

In our model, we allow for the interactions of different demographic variables with different bottle and package sizes. We find that young consumers have higher preference for larger size drinks. They prefer 12 oz, 16 oz and 24 oz energy drinks compared with 8 oz energy drinks by willing to pay $0.69, $0.97 and $1.58 more than the general population. Families with teenagers have higher preference with multi pack drinks. They prefer 4 cans, 12 cans and 24 cans energy drinks compared with 1 can energy drink by willing to pay $1.70, $2.34 and $2.95 more than the general population. The results are consistent with our data that younger consumers are more likely to purchase large size energy drinks and family with teenagers are more likely to purchase multi pack drinks.

The estimates for the brand intercepts indicate consumers' relative preferences for different brands. We find that the preferences are significantly stronger for the leading brands, including Red Bull and Monster. Among the other brands, consumers on average prefer Rockstar over AMP, Full Throttle and NOS. The estimates show strong regional effects for the two leading brands – Red Bull and Monster. Monster, produced by Monster Corporation based in California, is more preferred by consumers in the west coast than in other regions. In contrast, consumers in the east have higher preference for Red Bull, which is imported from Austria. We find that while con-

[10] An alternative explanation for the discrepancy is that the big package product (12-can and 24-can) are not widely available as the 1-can product. However, since we aggregate our choice sets at the time-region-channel level, we are not able to disentangle consumers' preference and product availability.

sumers in the west region value Monster $2.19 more than the consumers in other region, consumers in the east region value Red Bull $2.09 more than the consumers in other regions. Our estimates also show strong seasonal effects for energy drinks. The demand is higher in the second and third quarters than in the first and fourth quarters of the year. We also find there is significant unobserved heterogeneity on consumers' preference for Red Bull and Monster. The standard deviation of the unobserved heterogeneity for Red Bull is higher than that for Monster.

The significant positive parameter estimates of Size loyalty, multi pack pack loyalty and brand loyalty confirm that consumers have inertia towards size, multi pack and brand. The estimate for Size loyalty suggests that consumers are willing to pay $0.91 premium to stay with the same size of energy drink as that in their previous purchases; the estimate for multi-pack loyalty suggests that consumers are willing to pay $1.12 premium to stay with the same multi-pack package; and the estimate for brand loyalty suggests that consumers are willing to pay $1.53 premium to stay with the same brand. It is interesting that among the three loyalty estimates, consumers show strongest persistence in size inertia.

7 Counterfactual Analysis

7.1 Red Bull's New Product Introudction

We first analyze the impact of bottle size changes of energy drinks on consumers' energy drink consumptions. We highlight the total volume consumption changes for different consumer segments, especially for young consumers and the families with teenagers. We consider several scenarios. In the base case scenario, we assume that there was no introduction of 12oz and 16oz Red Bull and then try to measure how much energy drinks consumers would have purchased under different counterfactual scenarios. As we discussed earlier,there are two possible complementary mechanisms that may have played a role to affect consumers' energy drink consumption after the introduction of large size Red Bull. First, a new package with larger volume provides quantity discounts for the same product with smaller sizes. Lower unit price encourages consumers to switch to the new product from other products. Second, consumption habits like preference for bigger sizes could be playing an important role in energy drink consumption. To quantify these two effects we run two simulations. To compare with the base case, in the first simulation, we introduce only 12 oz Red Bull and then in the second,,we introduce only 16 oz. Comparison of consumptions changes under these two different scenarios would help us quantify the effects of size preference vis-a -vis price discounts. Table 5 and Table 6 summarize the results from all the counterfactual scenarios.

7.1.1 Introduction of 12oz for Red Bull only

In this scenario, we first dropped the 12oz and 16oz Red Bull as the choice alternatives from the consumers' choice sets from 2007, but keep everything else the same as what we observed in the data. Then we introduced the 12 oz for Red Bull only. Compared to the base case, with the introduction of 12 oz Red Bull the total consumption of Red Bull increased by 34.15%. However, the total consumption marginally fell by .73%. This result supports switching of consumers to Red Bull brand. Consumers switched from 16 oz bottles of other brands to the Red Bull 12oz. The consumption fell by almost 2% for household with teenagers whereas for households with a young head the consumption remained all the same.

7.1.2 Introduction of 16oz for Red Bull only

Compared to the base case, with the introduction of 16oz Red Bull only, the total consumption of Red Bull increased by 25.90%. The total consumption also increased by 1.6%. The consumption rose by almost 2% for household with young heads when Red Bull 16oz was introduced whereas it fell marginally for households with teenagers. Now if we compare these results with what we got in our first counterfactual, we can see that the impact of price discounts dominate over the impact of size preference. The monetary value of the size preference is the difference in consumer's willingness to pay for 12 oz, 16 oz drinks relative to 8 oz drinks respectively; which is: \$0.49 (=\$1.24 - \$0.75). On the other hand, the price difference between the two sizes is \$0.54 (=\$3.30 - \$2.76). Since the price difference is higher than the monetary value of the size preference, the consumers do not increase their consumption as much as they do in case of introduction of 12oz only.

7.2 Red Bull's Price Reduction

In this analysis, we assume that Red Bull simply lower its unit price for its 8oz package product. We predict how the demand the entire category of energy drinks changes with Red Bull's price reduction. According to Table 5, the total category consumption will increase more than the previous senario with the new product introduction. When Red Bull's unit price changes to \$1.84/can, similar to the unit price of the newly introduced 12oz Red Bull, the total demand increases 4.15%. When the Red Bull price further decreases to $1.65/can, same as the unit price of 16oz can, the category demand increases 8.93%. These findings confirm that the demand is elastic in the enery drink market. As a premium brand, Red Bull is able to attract consumers' to consumer more when it lowers its price. (*****IT would be interesting to see how much from demand expansion and how much from switching ***)

7.3 Impact of Size Regulation – All energy drink were offered 8oz can only

In this counterfactual we look at the scenario where energy drinks can be offered only in 8oz cans. We consider two cases under this scenario. In the first case, per unit prices are adjusted by the price ratio of 8oz to 16oz. 1 can 16 oz Red Bull costs $ 3.30 and 1 can 8 oz Red Bull costs $2; so the price of all 16 oz energy drinks were adjusted to 2/3.30 of its original price. In this case, when all energy drinks were offered 8 oz with price adjusted as mentioned above, we see that consumers would decrease their consumption by 54%. In the second case, for the brands which were not previously offering any 8oz cans, we set the price of 8 oz of that brand to be half of the price of its original price of 16 oz cans. Under this scenario, we see that consumers would decrease their consumption by 49%. This reduction is due to the fact that consumers now face a smaller choice set with products coming in only significantly lower sizes. Also, the strong preference for 16oz cans as evidenced by a high standard deviation (0.99) of unobservable heterogeneity for size 16 is another reason why we see such a reduction when cans come in only 8 oz. Furthermore, the reduction in consumption is higher in the first case. This result is consistent since consumers face a higher price compared to the second case.

7.4 Effects of an excise tax on energy drinks

In our last counterfactual, we quantify the effects of an excise tax (1 cent per oz) on energy drinks on consumption. The rationale for doing this counterfactual is to see whether size regulation or the so called 'soda-tax' is more efficient way to reduce consumption. According to (Seiler et al. 2019), they find that the tax is passed through at an average rate of 97%. In our analysis, when 1 cent per oz tax is imposed on energy drinks (with 100% pass through to the consumer), or approximately 5% increases in prices, we find that the consumers would reduce their consumption by 15.64%. This reduction is only due to the higher price consumers are now facing. Also, the reduction in consumption due to the excise tax is way smaller than the reduction in consumption due to size regulation (54% when only 8 oz cans are offered).

8 Discussions

As a new growing market, there is a significant lack of regulation on energy drinks in the U.S. While the Food and Drug Administration (FDA) enforces a caffeine limit of 71 mg per 12 fluid ounces for soda, but no such restriction for energy drinks since energe drink manufacturers classify their product as a supplement. In 2014, the American Beverage Association published the Guidance for the Responsible Labeling and Marketing of Energy Drinks". The goals is to ask the companies to committed to report total quantities of caffeine from all sources, restrict marketing to children, and voluntarily report adverse events to the FDA. However, it is challeging to enforce these regulations. Other countries facing similar challenge to the U.S. have implemented various approaches to regulate energe drinks. For example, Australia and New Zealand set the upper limit of caffeine from any source to be 320 mg/L ((Heckman et al. 2010)). To get aroud this restriction, Since 2002, there has been a growing trend for packaging energy drinks in bigger cans. The manufacturers include a greater amount of caffeine by including multiple servings per container. Therefore, it is worthwhile to explore how the change of package size affects consumers' consumptions. In addition to the regulation on caffeine content, some countries have implemented taxation policies as a deterrent to energe drinks consumption, such as the sugar-tax implemented in the US.

In this paper, we study the impact of introduction of larger size energy drink on consumption patterns for the regular users. We find sizable effects on the total consumptions on the regular users. While introduction of larger package size may be profitable for manufacturers like, Red Bull, it might impose social costs as a large and growing body of scientific evidence demonstrates that energy drinks are harmful to health. As a consequence, policy options such 'soda-tax' or 'cap-rule' have been suggested. We compare the relative efficacy of these options in our counterfactual analysis and find that a 'cap-rule' which limits the size of a can 8 oz is way more effective than a 1 cent per oz soda tax in reducing consumers' energy drink consumptions. One coveat of our study is that we don't model the energy drink adoption decisions for new users. Potentially, the availability of large size and lower unit price product may induce more consumers to adopt the product. In our current analysis, we do not capture this effect.

References

Al-Shaar, L., Vercammen, K., Lu, C., Richardson, S., Tamez, M. & Mattei, J. (2017), 'Health effects and public health concerns of energy drink consumption in the united states: a mini-review', *Frontiers in public health* **5**, 225.

Alsunni, A. A. & Badar, A. (2011), 'Energy drinks consumption pattern, perceived benefits and associated adverse effects amongst students of university of dammam, saudi arabia', *J Ayub Med Coll Abbottabad* **23**(3).

Attila, S. & Çakir, B. (2011), 'Energy-drink consumption in college students and associated factors', *Nutrition* **27**(3), 316–322.

Bollinger, B. & Sexton, S. (2018), 'Local excise taxes, sticky prices, and spillovers: Evidence from berkeley's soda tax', *Sticky Prices, and Spillovers: Evidence from Berkeley's Soda Tax (January 12, 2018)* .

Chandon, P. (2013), 'How package design and packaged-based marketing claims lead to overeating', *Applied Economic Perspectives and Policy* **35**(1), 7–31.

Chintagunta, P. K. (1993), 'Investigating purchase incidence, brand choice and purchase quantity decisions of households', *Marketing Science* **12**(2), 184–208.

Dube, J.-P. (2004), 'Multiple discreteness and product differentiation: Demand for carbonated soft drinks', *Marketing Science* **23**(1), 66–81.

Erdem, T. (1996), 'A dynamic analysis of market structure based on panel data', *Marketing Science* **15**(4), 359–378.

Guadagni, P. M. & Little, J. D. (1983), 'A logit model of brand choice calibrated on scanner data', *Marketing science* **2**(3), 203–238.

Heckman, M., Sherry, K. & De Mejia, E. G. (2010), 'Energy drinks: an assessment of their market size, consumer demographics, ingredient profile, functionality, and regulations in the united states', *Comprehensive Reviews in food science and food safety* **9**(3), 303–317.

Lambrecht, A., Seim, K. & Skiera, B. (2007), 'Does uncertainty matter? consumer behavior under three-part tariffs', *Marketing Science* **26**(5), 698–710.

Seiler, S., Tuchman, A. & Yao, S. (2019), 'The impact of soda taxes: Pass-through, tax avoidance, and nutritional effects'.

Wansink, B. (1996), 'Can package size accelerate usage volume?', *The Journal of Marketing* pp. 1–14.

Wansink, B. & Kim, J. (2005), 'Bad popcorn in big buckets: portion size can influence intake as much as taste', *Journal of nutrition education and behavior* **37**(5), 242–245.

Young, L. R. & Nestle, M. (2002), 'The contribution of expanding portion sizes to the us obesity epidemic', *American Journal of Public Health* **92**(2), 246–249.

9 Figures and Tables

Figure 1: Red Bull Price Variation Across Regions

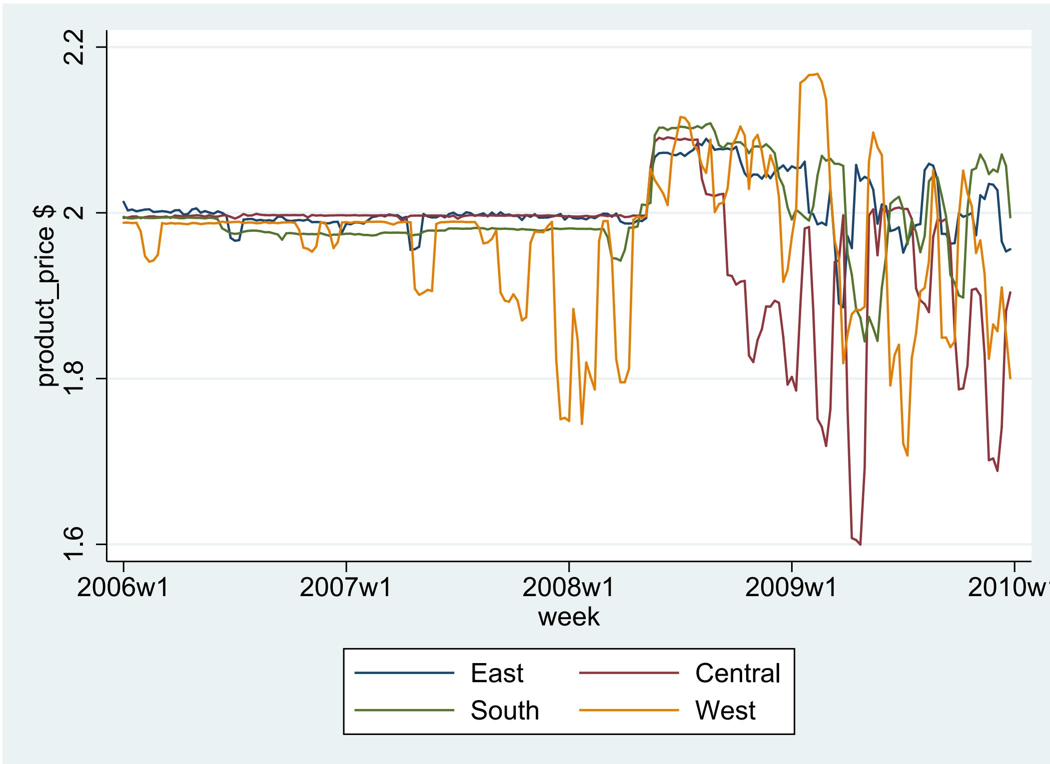

Figure 2: Red Bull Price Variation Across Three Major Channels

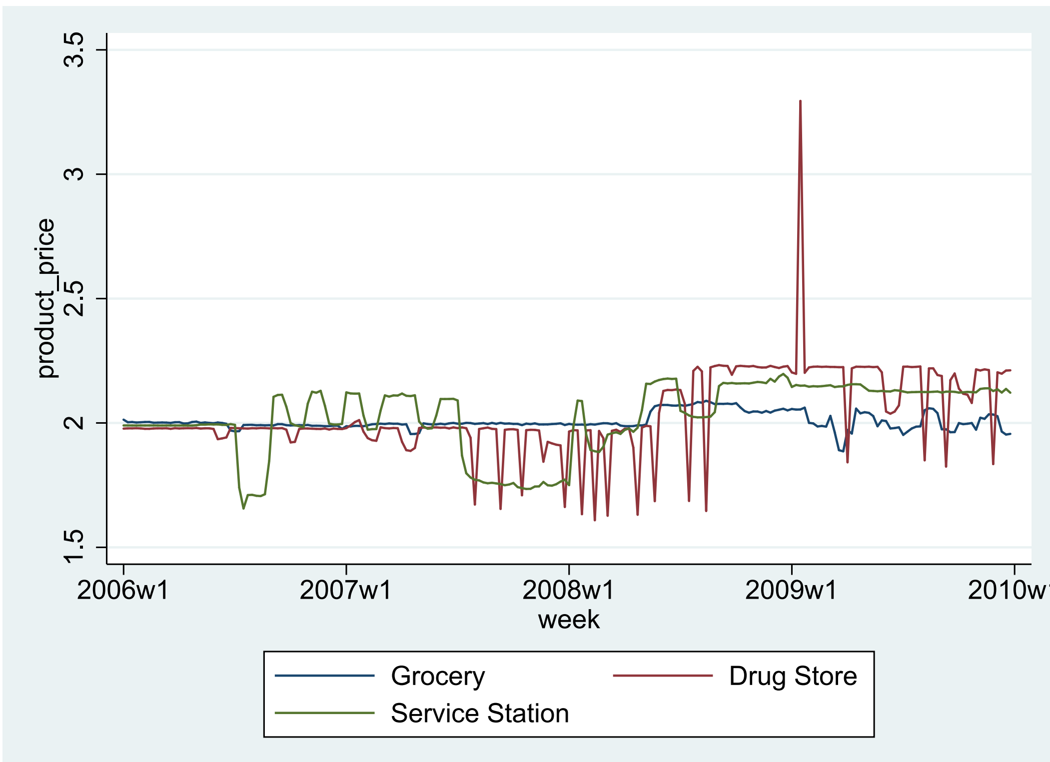

Figure 3: Number of Purchases Among Households from 2006 to 2009

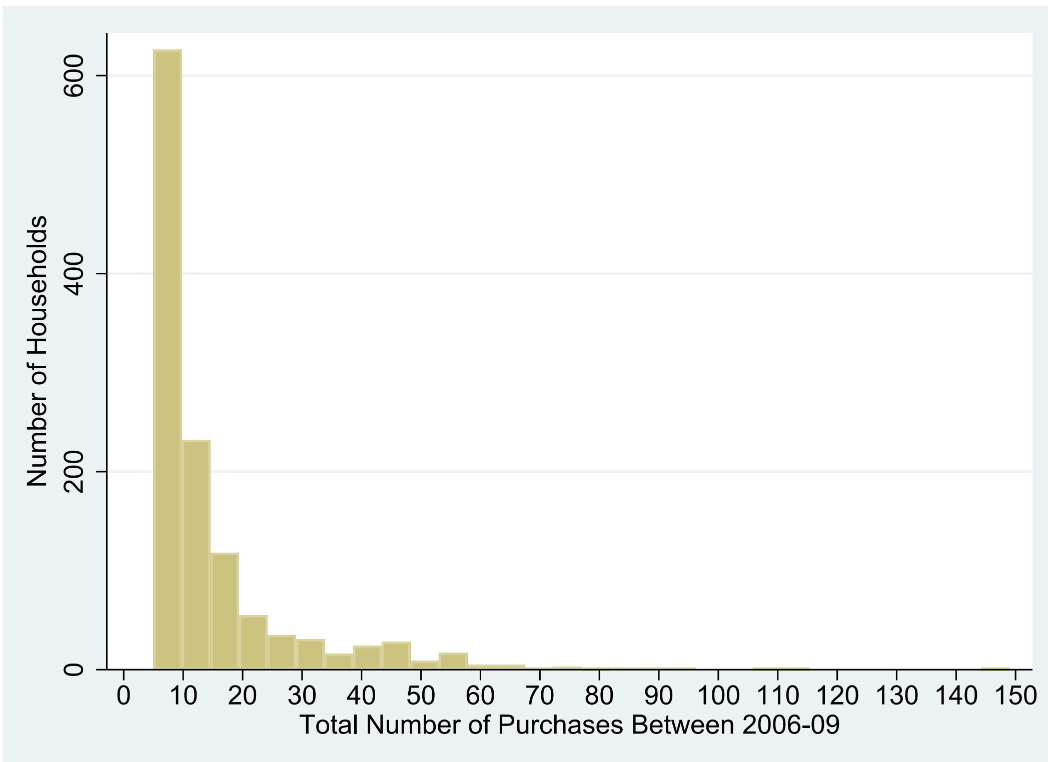

Figure 4: The number of adopters of energy drinks over time

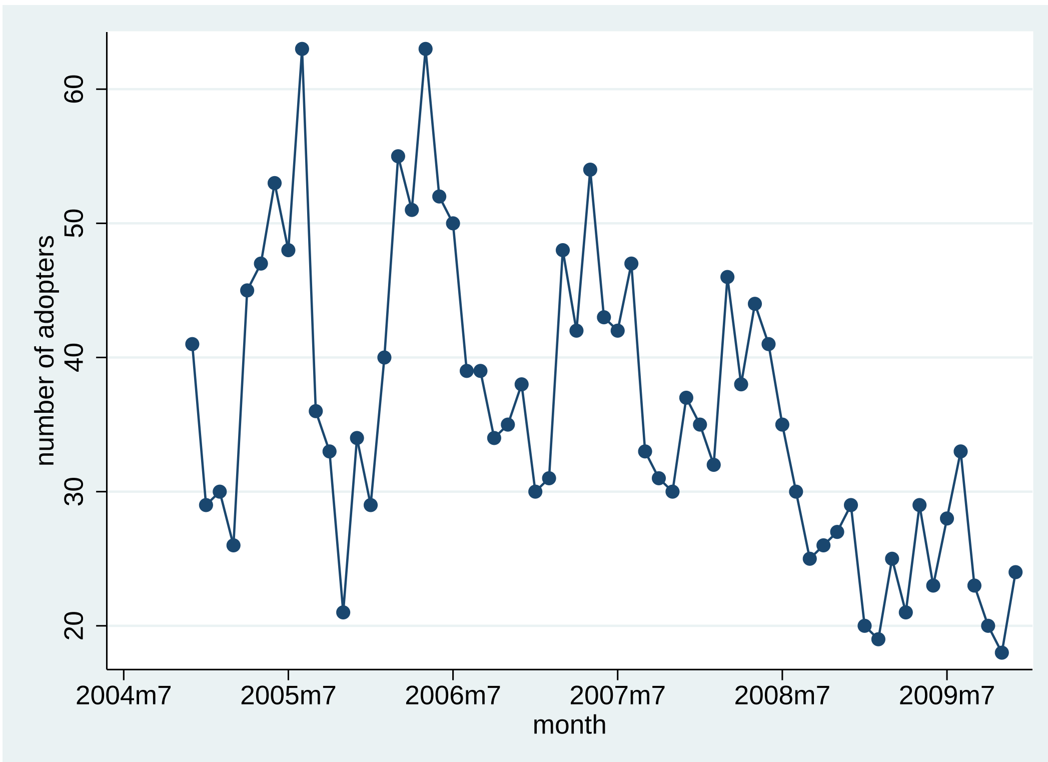

Figure 5: Weekly total consumption of energy drinks for top 10 percent heavy drinkers

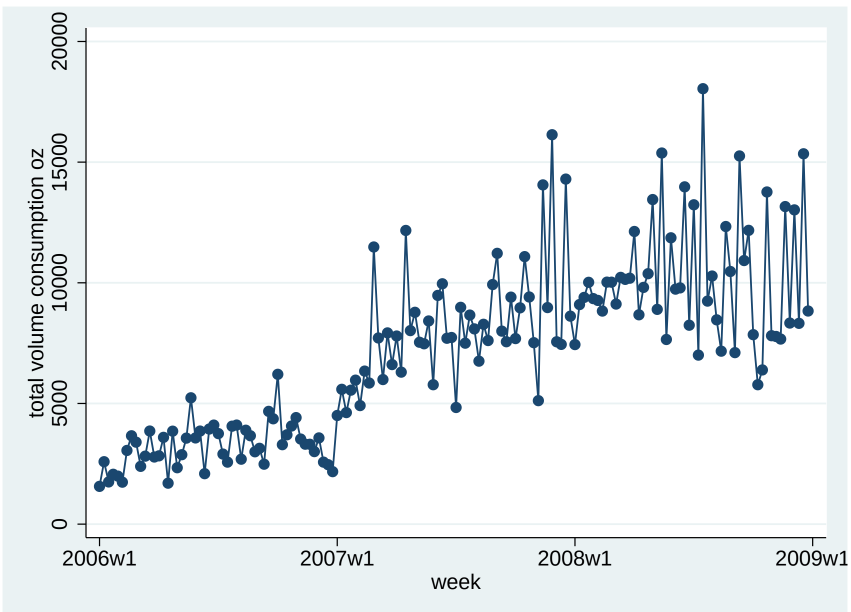

Table 1: Market share of major brands 2006-09

Brand	**Market Share**
AMP	6%
Full Throttle	4%
Monster	29%
NOS	0%
Red Bull	47%
Rockstar	14%

Table 2: Market share and average price of major products

brand	multi	size	market share	average price $	oz	price per oz$
year 2006						
RED BULL R	24	8	0.19	31.89	192	0.17
RED BULL R	1	8	0.18	1.93	8	0.24
RED BULL DT	4	8	0.15	6.68	32	0.21
MONSTER R	24	16	0.15	27.37	384	0.07
ROCKSTAR R	1	16	0.06	1.89	16	0.12
MONSTER R	1	16	0.05	1.91	16	0.12
MONSTER R	4	16	0.04	6.60	64	0.10
RED BULL R	12	8	0.04	19.55	96	0.20
ROCKSTAR R	4	16	0.03	6.48	64	0.10
FULL THROTTLE R	4	16	0.03	6.20	64	0.10
year 2007						
RED BULL R	24	8	0.13	32.45	192	0.17
RED BULL R	1	8	0.12	1.94	8	0.24
MONSTER R	24	16	0.12	27.83	384	0.07
RED BULL DT	4	8	0.12	6.56	32	0.21
MONSTER R	4	16	0.09	6.59	64	0.10
RED BULL R	1	12	0.08	2.76	12	0.23
RED BULL DT	12	8	0.06	19.81	96	0.21
ROCKSTAR JUICED R	4	16	0.06	6.38	64	0.10
ROCKSTAR R	1	16	0.05	1.87	16	0.12
MONSTER ASSAULT R	1	16	0.04	1.88	16	0.12
year 2008						
MONSTER R	24	16	0.14	29.06	384	0.08
MONSTER R	4	16	0.11	6.50	64	0.10
RED BULL R	1	8	0.10	1.99	8	0.25
RED BULL R	4	8	0.09	6.53	32	0.20
RED BULL DT	24	8	0.09	33.36	192	0.17
RED BULL DT	1	12	0.08	2.72	12	0.23
ROCKSTAR R	4	16	0.06	6.33	64	0.10
MONSTER R	1	16	0.05	1.92	16	0.12
RED BULL R	12	8	0.05	20.40	96	0.21
ROCKSTAR R	24	16	0.05	25.49	384	0.07
year 2009						
MONSTER R	24	16	0.15	28.70	384	0.07
RED BULL DT	24	8	0.12	33.25	192	0.17
MONSTER R	4	16	0.09	6.38	64	0.10
RED BULL DT	1	8	0.09	1.90	8	0.24
RED BULL R	1	12	0.09	2.63	12	0.22
RED BULL R	4	8	0.07	6.41	32	0.20
MONSTER R	1	16	0.07	1.92	16	0.12
AMP R	1	16	0.05	1.89	16	0.12
RED BULL DT	12	8	0.04	19.59	96	0.20
ROCKSTAR DT	4	16	0.04	6.43	64	0.10

Table 3: Monthly Consumption Increase of Heavy Red Bull Drinkers after buying Larger Size Red Bull

	log week volume	**log average size**	**log ncan**
introduction of larger size Red Bull	0.12***	0.14***	-0.02
	(0.04)	(0.01)	(0.04)
number of observations	2074	2074	2074

Table 4: Parameter Estimates

	Parameter Estimates	Std
price coefficient	-0.540	1.1825E-04
income effect	0.0000006149	7.9965E-10
12 oz dummy	0.375	0.0017
16 oz dummy	0.621	0.0031
24 oz dummy	0.992	0.0034
4 cans dummy	1.259	0.0010
12 cans dummy	2.831	0.0039
24 cans dummy	5.020	0.0137
young dummy interacting with size 12 oz	0.345	0.0019
young dummy interacting with size 16 oz	0.486	0.0006
young dummy interacting with size 24 oz	0.795	0.0021
teenager dummy interacting with 4 can	0.852	0.0013
teenager dummy interacting with 12 can	1.176	0.0128
teenager dummy interacting with 24 can	1.482	3.9440
AMP dummy	0.020	0.0033
Full Throttle dummy	0.558	0.0037
Monster dummy	0.936	0.0033
NOS dummy	0.122	0.0061
Red Bull dummy	1.148	0.0016
Rockstar dummy	0.724	0.0033
brand first time purchase boost	0.672	0.0007
Monster West Region Dummy	1.185	0.0007
Red Bull East Region Dummy	1.128	0.0012
Size Loyalty	0.459	0.0015
multi pack loyalty	0.560	0.0014
brand loyalty	0.769	0.0015
second quarter dummy	0.766	0.0015
third quarter dummy	0.911	0.0015
fourth quarter dummy	0.117	0.0015
standard deviation of omega	0.581	0.0000
Monster unobservable heterogeneity std	0.605	0.0007
Red Bull unobservable heterogeneity std	0.600	0.0002
Std of unobservable heterogeneity for size 16	0.9985	4.8188E-04

Table 5: Counterfactual Results- Scenario 1 & 2

	Choice Set	Price	Red Bull Consumption Change	Total Consumption Change	Total Consumption Change : Teenager	Total Consumption Change : Young
base case	8 oz Red Bull	$2/can				
scenario 1.1	8 oz Red Bull, 12 oz Red Bull	$2/can, $2.76/can	34.15%	-0.73%	-1.68%	0.00%
scenario 1.2	8 oz Red Bull, 16 oz Red Bull	$2/can, $3.3/can	25.90%	1.6%	0.49%	1.78%
scenario 2.1	8 oz Red Bull	$1.84/can		4.15%		
scenario 2.2	8 oz Red Bull	$1.65/can		8.93%		

Table 6: Counterfactual Results- Scenario 3

	Choice set	Price	Total Consumption Change
scenario 3.1.1	all firms offer only 8 oz	adjust 8oz price as 2/3.3 of 16oz price	-54%
		AMP	-100%
		Full Throttle	-40%
		Monster	-73%
		NOS	-8%
		Red Bull	-4%
		Rockstar	-60%
scenario 3.1.2	all firms offer only 8 oz	adjust 8oz price as half of 16oz price	-49%
		AMP	-100%
		Full Throttle	-35%
		Monster	-74%
		NOS	32%
		Red Bull	10%
		Rockstar	-60%
scenario 3.2	Soda Tax 1 cent per oz	100% pass through to price	-15.64%