Estimating the Effect of Nonlinear Pricing on Overconsumption of Carbonated Soft Drinks

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1 Introduction

Price discrimination is a practice firms often use to extract the consumer surplus from high value customers. Though its effect on the total welfare can be either positive or negative, it usually benefits the producers at the cost of the consumers. Economists have long been interested in this phenomenon (e.g. chapter 3 of Tirole 1988, Stole 2007). One of the main issues in this literature is the relationship between the market structure and the ability of the firms to practice price discrimination. The conventional wisdom is that a competitive firm cannot price discriminate because it is a price taker and a firm with market power can price discriminate as long as it can segment the consumers. Hence, as the market becomes more competitive, there should be less price discrimination. However, studies by Katz (1984), Borenstein (1985), Holmes (1989) and Dana (1998) show price discrimination can exist in pretty competitive markets. And more recently, Liu and Serfes (2006) show that the relationship between market competition and the degree of price discrimination is nonlinear using a second-degree price discrimination model and McAfee, Mialon and Mialon (2006) show that the same relationship can be either positive or negative using a third-degree price discrimination model. Therefore, since theoretical studies do not produce a clear prediction, the relationship between the market structure and the degree of price discrimination becomes an empirical question.

In previous study, I found that part of the price premium enjoyed by the healthy ketchup products over conventional ketchup products can be attributed to the price discrimination practice. In this study, I continue this line of research by examining the relationship between market structure and price differences between the healthy and conventional ketchup products. Studies in this literature have examined the same issue for other industries. Busse and Rysman (2005) find that more competition leads to less price discrimination in the yellow page advertising market. Clerides and Michis (2006) study the detergent market in six countries and find the relationship is positive in some countries, while negative in others. Stavins (2001) and Hernandez and Wiggins (2008) report the relationship being negative using data from the U.S. airline industry. This study offers another piece of empirical evidence on this important theoretical relationship.

2 Industry characteristics

Ketchup is a widely used condiment in U.S., found in 97% of all kitchens, a showing matched only by salt, pepper, and sugar.[1] It is mainly consumed with hot dogs, French fries, hamburgers, pasta and serves as seasoning to make sauces such as salsa and other food. The total annual market sale in 2006 is approximately 5.88 billion U.S. dollars.[2] Heinz is the leading firm whose market share remains stable around 60% in volume in 2006 in ketchup market. Hunt's, a ConAgra Foods brand is the second largest, sharing about 16% of the market. The rest of the market is shared by private label products, Del monte and other local brands.

The business section of annual reports of Heinz and ConAgra Foods provide a description of the ketchup business ranging from procurement to retailing. Ketchup is made starting from developing the recipes originated from individual company's research laboratories and experimental kitchens. Ingredients are inspected and transported to factories. To hedge the spot market price volatility, major ketchup producers usually sign future contracts with farmers growing raw materials such as tomatoes, cucumbers and onions. Ingredients such as sugar and sweeteners (high fructose corn syrup, a major sugar substitute in most of Heinz and Hunt's products) are purchased from approved suppliers. In the factory, raw materials are manufactured into ketchup product after prepared by sterilization, homogenization, chilling, freezing, pickling, drying, freeze drying, baking or extruding, bottling and labeling. Products are sold through their own sales organizations and through independent brokers, agents and distributors to chain, wholesale and other retailers. Besides, according to annual report, Wal-Mart is the number one customer of Heinz and ConAgra Foods, representing approximately 11% and 18% of the firm's total sales respectively in 2010.

3 Data

The data in this paper is constructed based on IRI scanner dataset. The centerpieces of the data are prices and measures of competition. The IRI scanner

[1] Quote from J. Miguel Villas-Boas and Ying Zhao (2005): "Retailer, Manufacturers, and Individual Consumers: Modeling the Supply Side in the Ketchup Marketplace," Journal of Marketing Research, 42,83,95

[2] This figure is calculated by 60% market share and the total revenue of Heinz in ketchup and sauce category in its 2006 annual report.

dataset is cross-sectional dataset including transaction units and dollars of each UPC in each week and store from first day of 2001 to last day of 2006. The stores are randomly sampled from 50 U.S. metropolitan statistical areas. The raw dataset also includes information of price reduction, product display and degree of advertisement by retailer. This analysis includes observations in all kinds of display levels. Manufactures pay retailers allowances to display their products in outstanding places such aisle and lobby. Therefore, these prices reflect manufactures' strategy. When the transaction price is 5% lower than the original price, the observation is ignored, because it is not clear the price reduction is due to retailer or manufactures' pricing strategy. It is possible that the 5% reduction is either due to use of manufacture's coupon or retailer sales. For advertisement, except those transactions with large advertisement such as retailer coupon or rebate, I include them all. Besides, price reflects the strategy of manufactures but retailers.

The raw dataset is sorted into 1199 markets, where a market is defined as a combination of MSA and quarter. Since the definitions of MSA from CPS and region from IRI are very close, I substitute them in the analysis. In each market, each observation is the weighted average price difference between healthy and regular products for each vendor. Only vendors selling both healthy and regular products are included. The weight average price is constructed by averaging price from weekly store level to quarterly vendor level and then weighted each UPC with in category. Besides, msa dummy, quarter dummy, and vendor dummy are created to control the price variation.

To conduct the analysis, measure of competition is required. I construct several of measure of competition, Herfindahl Hirschman Index (HHI), number of vendors in each market and number of brands in each market. Furthermore, HHI is constructed according to total vendor market share and vendor market share in each market segmentation respectively.

Herfindahl Hirschman Index (HHI) is a measure of sizes of firms in relation to the industry and an indicator of amount of competition among them.

$$\mathrm{HHI}_{mt} = \sum_{i=1}^{N} \mathrm{s}_{imt}^2 \tag{1}$$

where, s_{imt} is the market share of firm i in the MSA m and quarter t. The vendor market share is calculated as follows:

$$s_{imt} = \frac{q_{imt}}{\sum_{i=1}^{N} q_{imt}} \tag{2}$$

For HHI in healthy product segmentation, the vendor market share is

$$s_{imt} = \frac{q_{imt}}{\sum_{i=1}^{N_h} q_{imt}} \tag{3}$$

,where N_h is the number of vendors selling healthy products. HHI in regular segmentation is calculated accordingly.

HHI ranges from $1/N$ to 1. When a HHI is smaller than 0.01, it indicates a highly competitive market, a industry without dominant players. When HHI is between 0.1 and 0.18, the market is moderate concentration and above 0.18 indicates high concentration.

4 Identification

Suppose there are two markets with different competitive structure. Then, the hypothesis above can be tested by examining the following relationship:

$$[(\mathrm{P}_m(\mathrm{h}) - \mathrm{C}_m(\mathrm{h})) - (\mathrm{P}_m(\mathrm{r}) - \mathrm{C}_m(\mathrm{r}))] \lessgtr [(\mathrm{P}_d(\mathrm{h}) - \mathrm{C}_d(\mathrm{h})) - (\mathrm{P}_d(\mathrm{r}) - \mathrm{C}_d(\mathrm{r}))] \tag{4}$$

where m indexes the market with less competition and d denotes the market with more competition. Letter h index the healthy and r regular products, respectively. In addition, price discrimination is defined as differences in price-cost margins. Again, since costs are not observed, assumptions need to be made to proceed. Demand and supply structures are assumed to recover the costs. The idea is essentially similar to that of a difference-in-difference estimator. I assume that the cost differences for a firm to supply healthy and regular products to different markets are the same, that is,

$$\mathrm{C}_m(\mathrm{h}) - \mathrm{C}_m(\mathrm{r}) = \mathrm{C}_d(\mathrm{h}) - \mathrm{C}_d(\mathrm{r}) \tag{5}$$

where $C_m(h)$ is the cost of healthy products in market with less competition

and $C_d(h)$ is the cost for healthy products in market with more competition. This is a reasonable assumption as ketchup firms produce both healthy and regular products in the same plant. For distribution cost, I assume the difference across markets is additive, then the difference of distribution cost between healthy and regular products across market will be canceled out. Under this assumption, the hypothesis reduces to :

$$\mathrm{P}_m(\mathrm{h}) - \mathrm{P}_m(\mathrm{r}) \lesseqgtr \mathrm{P}_d(\mathrm{h}) - \mathrm{P}_d(\mathrm{r}) \tag{6}$$

In practice, I estimate the following regression,

$$[\mathrm{P(h)} - \mathrm{P(r)}]_{imt} = \beta_0 + \beta_1 \mathrm{competition}_{mt} + \mathrm{FirmDummy}_i + \mathrm{QuarterDummy}_\mathrm{i} + \mathrm{MSADummy}_\mathrm{i} + \varepsilon_{imt} \tag{7}$$

where $[P(h) - P(r)]_{imt}$ is the weighted average price difference between healthy and regular products produced by firm in market and period . The competition intensity will be approximated by either the number of competitors, the number of brands or the HHI. The parameter of interest is β_1. For (4) to yield a consistent estimate for , another implicit assumption is that the relative demand for healthy and regular ketchup products is constant across different markets. Otherwise, prices for healthy and regular ketchup products may reflect differences in relative demand rather than differences in competition intensity.

Additionally, the model considers the scenario that price discrimination is defined as price and marginal cost ratio, as there isn't unique common definition of price discrimination. Therefore, the objective test is

$$\frac{\frac{\mathrm{P}_m(\mathrm{h})}{\mathrm{C}_m(\mathrm{h})}}{\frac{\mathrm{P}_m(\mathrm{r})}{\mathrm{C}_m(\mathrm{r})}} \lesseqgtr \frac{\frac{\mathrm{P}_d(\mathrm{h})}{\mathrm{C}_d(\mathrm{h})}}{\frac{\mathrm{P}_d(\mathrm{r})}{\mathrm{C}_d(\mathrm{r})}} \tag{8}$$

I assume that the cost ratio for a firm to supply healthy and regular products to different markets is constant, that is,

$$\frac{\mathrm{C}_m(\mathrm{h})}{\mathrm{C}_m(\mathrm{r})} = \frac{\mathrm{C}_d(\mathrm{h})}{\mathrm{C}_d(\mathrm{r})} \tag{9}$$

Under the assumption that the cost difference across markets is multiplicative, the cost ratio between healthy and regular products across market will be

canceled out. The objective hypothesis reduces to:

$$\frac{\mathrm{P}_m(\mathrm{h})}{\mathrm{P}_m(\mathrm{r})} \underset{>}{\leq} \frac{\mathrm{P}_d(\mathrm{h})}{\mathrm{P}_d(\mathrm{r})} \tag{10}$$

The regression equation is

$$\frac{\mathrm{P(h)}}{\mathrm{P(r)}}_{imt} = \beta_0 + \beta_1 \mathrm{competition}_{mt} + \mathrm{FirmDummy}_i + \mathrm{QuarterDummy_i} + \mathrm{MSADummy_i} + \varepsilon_{imt} \tag{11}$$

where $\frac{\mathrm{P(h)}}{\mathrm{P(r)}}_{imt}$ is the weighted average price difference between healthy and regular products produced by firm in market and period .

5 Results

5.1 HHI

The regressions results using HHI as competition measure are divided into two groups using price ratio and price difference as dependent variables respectively. All results are attached at the end of the paper. Results 1-2 are from price difference and 3-4 are results from price ratio. In each group, I regress price ratio or price difference on total HHI and HHI in segmentation with all dummy variables. I tested whether msa dummy provides a better fit of the model by comparing the results with and without it. By comparing the R^2, I didn't find msa dummy improve the fit of model obviously.

Both price ratio and price difference regressions have high R^2about 0.75. Total HHI is the HHI computed in the whole market including both healthy and regular products, while healthy HHI means the HHI computed in healthy product segmentation and regular HHI is the HHI computed in regular product segmentation. Both coefficients of total HHI in regressions of price difference and price ratio are statistically insignificant. However, in regressions including healthy and regular HHI, coefficients of healthy HHI are statistically significant while regular HHI are not. According to results 2 and results 4, if healthy HHI increases by 0.1, the price difference between healthy and regular products will decrease by 0.1 cent per ounce and price ratio between healthy and regular products will decrease 1 cent per ounce. This means when market is more concentrated, the price difference and ratio between healthy and regular products will decrease in U.S. ketchup market. For a typical 24 oz product, price dif-

ference will decrease 2.4 cents per bottle and price ratio will decrease 30 cents per bottle if healthy HHI increase by 0.1. Therefore, the less competition in a market, the lower the price difference and ratio between healthy and regular ketchup products.

5.2 Other competition measure

This section reports the regression results using other competition measures, the number of brands in each market and the number of vendor in each market. Regression results in this section are also divided into two groups according to different dependent variables, price ratio and price difference. In each group, dependent variable is regressed on individual competition measure and the combination of them. All regressions return a R^2about 0.75.

In results 5 and 6, one less brand or vendor in the market will make price difference decrease by 0.05 cent per ounce and 0.07 cent per ounce. Between number of brand and number of vendor, the vendor number plays a more important role in determining the price difference by reading the results 7. If both measures are included in the regression, the number of brands is statistically insignificant.

In results 8 and 9, one less brand or vendor in the market reduce price ratio by 0.8 cent per ounce and 1.0 cent per ounce. Both measure coefficients are statistically insignificant in result 10. These implications above are consistent from results using HHI as competition measure. In more concentrated market, both price difference and price ratio are smaller in U.S. ketchup industry.

6 Conclusion and Future work

This article studies the relationship between market structure and price discrimination in U.S. ketchup industry. By assuming supply cost change is either additive constant or multiplicative constant and the demand side is constant, the analysis examines the price difference and ratio change in 1199 U.S. market and various vendors selling both healthy and regular ketchup products. Empirical results indicate that market concentration and price discrimination has negative relationship, which means the less competitive in the industry, the less price discrimination. Price discrimination is defined as both price cost ratio and price cost difference. Results from both definitions are consistent with each other and results using various competition measures are also consistent

with the conclusion above. This analysis is on MSA quarter and vendor level. The examination of results based on a MSA, quarter and brand level analysis and MSA, month and vendor level are remained as future work. The market competition is measured by HHI on brand level rather than vendor level.

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7 Tabels:

Table 1 Regression of Price difference on total HHI

	Result 1	Result 2
	total HHI	Individual HHI
Price difference	Coefficient	Coefficient
Total HHI	-0.0008393	—
t-stat	-0.07	—
Healthy HHI	—	-0.0100376
t-stat	—	-3.69
Regular HHI	—	-0.0048826
t-stat	—	-0.42
R^2	0.7865	0.7878

Note: All regressions include quarter, MSA and vendor dummy variables.

Table 2 Regression of Price ratio on total HHI

	Result 3	Result 4
	total HHI	Individual HHI
Price Ratio	Coefficient	Coefficient
Total HHI	-0.1512	—
t-stat	-0.98	—
Healthy HHI	—	-0.0998
t-stat	—	-2.86
Regular HHI	—	-0.2159
t-stat	—	-1.43
R^2	0.7546	0.7557

Table 3 Regression of Price Difference on other Competition Measure

	Result 5	Result 6	Result 7
Price difference	Coefficient	Coefficient	Coefficient
# of brands	0.0004903	—	-0.0006033
t-stat	2.18	—	-1.06
# of vendors	—	0.0007164	0.0013415
t-stat	—	2.83	2.09
R^2	0.7869	0.7872	0.7873

Table 4 Regression of Price Difference on other Competition Measure

	Result 8	Result 9	Result 10
Price difference	Coefficient	Coefficient	Coefficient
# of brands	0.007666	—	-0.001573
t-stat	2.67	—	-0.22
# of vendors	—	0.009703	0.01133
t-stat	—	2.99	1.38
R^2	0.7553	0.7555	0.7555