Appendix for: Product Differentiation and Mergers in the Carbonated Soft Drink Industry

Jean-Pierre Dubé[1]

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[1]Graduate School of Business, University of Chicago, jdube@gsb.uchicago.edu.

1 Appendix A: Comparison Models

This appendix explores several comparison models that test the robustness of the results reported in the main body of the paper. To contrast different modeling issues, I compare the price-cost margins in percent (PCM), the marginal costs and the own-price elasticities for each specification. All values reported are medians across the 9 quarters in the data (i.e. we compute each value at the quarterly aggregate level and then report the median). For all models reported, the corresponding demand parameter estimates are available from the author upon request. I also present the full set of own and cross price elasticities from the "Main" model specification.

1.1 Heterogeneity

Table 1 investigates the role of consumer heterogeneity in the perceived quality function, Ψ, by comparing four different specifications. The first model, "Main", is simply the version reported in the paper. Recall this model controls for observed forms of heterogeneity via interactions between product attributes and demographic variables. It also controls for unobserved heterogeneity via random coefficients on various product attributes. The second model, "No Heterogeneity," removes all controls for heterogeneity (both unobserved and observed) leaving only a random intercept. The third model, "Unobserved Heterogeneity only," controls for unobserved heterogeneity via random taste intercepts. However, this model does not include the interaction terms between demographic variables and product attributes, which capture observed forms of heterogeneity. The fourth model, "Guadagni Little loyalty," includes both observed and unobserved heterogeneity. However, it changes the specification of loyalty used to an exponentially-smoothed sum of the entire history of loyalty variables (as in Guadagni and Little 1983). Specifically, loyalty for brand j during trip t is defined recursively as:

$$L_{jt} = \lambda L_{jt-1} + I_{jt-1}$$

where $\lambda \in (0,1)$ and I_{jt-1} is an indicator for whether brand j was purchased during trip $t-1$. The reported results use $\lambda = 0.75$; although the results seem insensitive to changing this value between $\lambda = 0.5, 0.75, 0.9$. In the main results reported in the paper, loyalty is defined simply as the indicator variable I_{jt-1}. Note that loyalty may also help pick up any remaining sources of unmodeled consumer heterogeneity. The reason to check this exponentially-smoothed specification is that it takes into account the entire history of brands chosen, not only the most recent.

Comparing the models, only the own-price elasticities seem to be noticeably sensitive to the specification of heterogeneity used. Although not reported, the correlation between the "Main" model and the comparisons is over 0.8 in each case for marginal cost and PCM estimates. For own-price elasticities, the correlation is also 0.8 compared to the "Guadagni Little" approach, but it is around 0.6 for the other two models. On average, own-price elasticities seem to be lower in the second model that has no controls (beyond an intercept) for unobserved heterogeneity. A similar downward-bias in price-sensitivity related to omitted heterogeneity has been documented previously (Allenby and Rossi 1999). These differences seem to have little impact on margins and marginal costs, probably due to the fact that these latter two values also depend on cross-price elasticities. Overall, the choice

of loyalty specification does not seem to change results much. However, omitting controls for heterogeneity does seems to matter.

1.2 Scope of Products

In table 2 I investigate the sensitivity of the results to the number of products considered. In the "Main" model, I use 26 products according to the requirement that only products with at least 1% of the share of volume sales (e.g. share of ounces of CSD sold during the sample period) are used. One reason for truncating the sample at 26 products is that I want to estimate product-specific fixed-effects. Extending the scope of products not only increases the dimension of the parameter space, it also requires estimating fixed-effects for products with fewer purchase observations (e.g. less information). I look at the sensitivity of the results to using 15, 20 and 30 products.

Comparing the models to the "Main" model, the marginal costs are fairly similar across all specifications. However, the own-price elasticities are much lower when only 15 products are used. Correspondingly, PCMs are a bit higher. This results is likely due to the fact that dropping many of the frequently-purchased products (e.g. treating them as part of the no-purchase outcome) generates an endogeneity bias. In general, shelf prices are correlated across products. In weeks during which an unmodelled product is extremely cheap, it will reduce the relative attractiveness of the inside goods. Hence, a component of the error term may be correlated with observed products' prices. As we add more products, this result seems to dissipate. Note that the model with 30 products generates results fairly similar to the "Main" model. Although not reported, marginal costs and own-price elasticities are quite highly correlated with those of the main specification (0.8 and 0.88 respectively). It is difficult to compare PCMs across models as the unilateral market power will differ by construction. The mark-up reflects own-price elasticity as well as cross-price elasticities with other goods in the product line. Changing the scope of products considered will, effectively, change the product lines of the firms. Overall, however, it appears that increasing the scope of goods beyond 26 does not change results too much. In contrast, focusing on fewer products does seem to change the results.

2 Calculating the Price Elasticity of Demand

All price elasticities are evaluated at the quarterly level. The elasticity of demand for product i with regards to the price of product j during quarter q is computed as:

$$\varepsilon_{i,j}^q = \frac{p_{jt}}{\sum_t Q_{it}} \frac{\partial \left(\sum_t Q_{it} \right)}{\partial p_{jt}}.$$

where t indexes all shopping trips during quarter q. The derivatives are evaluated using a centered numerical derivative. The elasticities reported in the paper are medians across quarters (i.e. $\varepsilon_{i,j} = median \left(\varepsilon_{i,j}^1, ..., \varepsilon_{i,j}^9 \right)$).

product	Main			No Heterogeneity			Unobserved Heterogeneity Only			GL loyalty		
	PCM	MC	elas	PCM	MC	elas	PCM	MC	elas	PCM	MC	elas
PSI R CL CN 12P	51.49	0.14	-3.33	52.20	0.15	-3.27	48.13	0.16	-3.54	54.43	0.14	-2.94
COKE CLS R CL CN 12P	43.29	0.17	-3.47	45.47	0.16	-3.09	42.29	0.17	-3.40	40.90	0.17	-3.48
PSI R CL CN	55.74	0.11	-3.32	59.38	0.10	-3.12	55.49	0.12	-3.27	54.18	0.12	-3.20
COKE DT CL CN 12P	47.45	0.15	-4.03	43.18	0.16	-3.53	46.40	0.16	-3.62	38.68	0.18	-3.94
PSI R CL NB PLS	60.40	0.07	-3.30	67.62	0.06	-2.71	66.57	0.06	-3.05	60.58	0.07	-3.20
PSI DT CL CN 12P	63.94	0.11	-3.36	63.37	0.11	-2.73	55.35	0.13	-3.58	63.12	0.11	-3.40
COKE CLS R CL CN	33.89	0.18	-3.55	39.55	0.15	-3.17	37.99	0.16	-3.56	34.93	0.17	-4.01
PSI DT CL CN	50.00	0.13	-4.38	60.59	0.10	-3.63	51.44	0.12	-3.87	49.29	0.14	-4.09
COKE CLS R CL NB PLS	42.38	0.11	-3.98	46.83	0.10	-3.25	45.35	0.10	-3.41	47.21	0.10	-3.74
PSI DT CL NB PLS	58.11	0.08	-3.99	55.34	0.08	-3.62	57.71	0.08	-3.97	69.88	0.06	-3.84
COKE DT CL CN	34.72	0.17	-4.44	44.46	0.14	-2.95	44.16	0.15	-3.67	35.09	0.17	-4.02
DR PR R PEPR CN 12P	27.96	0.23	-3.71	23.51	0.22	-4.55	26.81	0.23	-4.20	25.60	0.23	-4.01
MT DW R CITR CN 12P	37.38	0.19	-4.27	45.80	0.16	-4.20	52.42	0.14	-3.75	42.46	0.18	-4.20
DR PR R PEPR CN	19.91	0.21	-5.55	24.96	0.21	-4.51	29.34	0.18	-4.18	22.67	0.21	-4.41
7UP R LN/LM CF NB PLS	29.98	0.13	-4.42	29.27	0.12	-3.98	38.62	0.11	-3.57	35.21	0.12	-3.94
COKE DT CL CF CN 12P	32.21	0.19	-5.32	37.35	0.19	-5.12	30.85	0.20	-6.71	51.93	0.15	-4.73
COKE DT CL NB PLS	42.29	0.11	-4.30	49.02	0.09	-3.34	40.20	0.11	-3.90	43.10	0.11	-4.05
7UP DT LN/LM CF NB PLS	39.10	0.11	-3.56	38.92	0.11	-3.58	40.63	0.11	-3.52	39.40	0.11	-3.34
MT DW R CITR CN	55.48	0.12	-4.55	37.59	0.16	-4.42	57.80	0.11	-3.80	47.67	0.13	-4.30
SP R LN/LM CF CN 12P	44.57	0.17	-3.70	49.50	0.15	-3.93	43.35	0.17	-3.64	47.59	0.15	-3.64
PSI DT CL CF CN 12P	47.54	0.15	-4.91	43.01	0.18	-5.14	80.34	0.06	-4.11	39.44	0.19	-5.08
DR PR R PEPR NB PLS	30.26	0.13	-3.89	33.51	0.12	-3.77	33.72	0.12	-4.02	29.96	0.13	-3.90
MT DW R CITR NB PLS	50.27	0.09	-3.65	74.93	0.05	-3.32	57.10	0.08	-3.25	54.00	0.09	-3.74
PSI R CL NB	50.08	0.15	-3.22	45.17	0.18	-4.37	48.97	0.17	-3.93	55.61	0.16	-3.58
PSI DT CL CF CN	37.45	0.17	-3.72	63.09	0.09	-3.94	60.71	0.10	-4.53	43.53	0.14	-4.18
A&W R RTBR CF CN	31.38	0.20	-3.97	30.88	0.18	-3.82	31.87	0.18	-3.64	36.27	0.16	-3.52
mean	42.97	0.14	-4.00	46.33	0.14	-3.73	47.06	0.13	-3.83	44.72	0.14	-3.87
st. dev.	11.18	0.04	0.61	13.12	0.04	0.66	12.46	0.04	0.67	11.39	0.04	0.48

Table 1: Model Comparisons based on heterogeneity

product	Main			15 prods			20 prods			30 prods		
	PCM	MC	elas	PCM	MC	elas	PCM	MC	elas	PCM	MC	elas
PSI R CL CN 12P	52.20	0.15	-3.27	65.09	0.10	-2.71	47.57	0.15	-3.47	41.21	0.17	-3.58
COKE CLS R CL CN 12P	45.47	0.16	-3.09	45.27	0.16	-2.95	40.48	0.18	-3.87	42.12	0.17	-3.43
PSI R CL CN	59.38	0.10	-3.12	65.89	0.09	-2.61	56.37	0.11	-3.33	51.46	0.13	-3.41
COKE DT CL CN 12P	43.18	0.16	-3.53	37.13	0.18	-3.80	42.16	0.17	-3.81	45.55	0.17	-3.38
PSI R CL NB PLS	67.62	0.06	-2.71	73.30	0.05	-2.80	59.19	0.07	-2.95	54.19	0.08	-3.54
PSI DT CL CN 12P	63.37	0.11	-2.73	76.60	0.07	-3.00	66.66	0.10	-3.28	49.79	0.15	-3.40
COKE CLS R CL CN	39.55	0.15	-3.17	49.56	0.14	-3.01	39.90	0.16	-3.49	35.79	0.17	-3.83
PSI DT CL CN	60.59	0.10	-3.63	50.71	0.14	-4.22	41.62	0.15	-4.71	49.53	0.13	-4.10
COKE CLS R CL NB PLS	46.83	0.10	-3.25	45.48	0.10	-2.82	44.86	0.11	-3.85	39.71	0.12	-4.01
PSI DT CL NB PLS	55.34	0.08	-3.62	66.67	0.06	-3.73	53.14	0.09	-4.29	46.51	0.10	-4.42
COKE DT CL CN	44.46	0.14	-2.95	42.30	0.16	-3.65	43.49	0.15	-3.61	34.86	0.17	-3.73
DR PR R PEPR CN 12P	23.51	0.22	-4.55	28.50	0.22	-3.61	25.16	0.23	-4.17	28.16	0.22	-4.33
MT DW R CITR CN 12P	45.80	0.16	-4.20	42.69	0.17	-5.25	64.62	0.10	-3.54	54.93	0.13	-3.52
DR PR R PEPR CN	24.96	0.21	-4.51	21.35	0.20	-4.81	25.07	0.21	-4.75	22.05	0.21	-5.03
7UP R LN/LM CF NB PLS	29.27	0.12	-3.98	38.03	0.11	-2.79	31.00	0.13	-4.02	37.15	0.12	-3.50
COKE DT CL CF CN 12P	37.35	0.19	-5.12				78.60	0.06	-3.28	52.44	0.14	-6.44
COKE DT CL NB PLS	49.02	0.09	-3.34				60.13	0.07	-3.29	46.93	0.10	-3.58
7UP DT LN/LM CF NB PLS	38.92	0.11	-3.58				32.53	0.12	-3.88	28.11	0.13	-3.89
MT DW R CITR CN	37.59	0.16	-4.42				56.01	0.12	-4.31	43.70	0.15	-4.88
SP R LN/LM CF CN 12P	49.50	0.15	-3.93				48.04	0.15	-3.91	41.02	0.17	-3.79
PSI DT CL CF CN 12P	43.01	0.18	-5.14							39.86	0.19	-6.15
DR PR R PEPR NB PLS	33.51	0.12	-3.77							36.22	0.12	-3.44
MT DW R CITR NB PLS	74.93	0.05	-3.32							48.63	0.09	-3.21
PSI R CL NB	45.17	0.18	-4.37							45.62	0.17	-3.78
PSI DT CL CF CN	63.09	0.09	-3.94							59.60	0.12	-4.53
A W R RTBR CF CN	30.88	0.18	-3.82							29.62	0.18	-3.65
7UP R LN/LM CF CN										33.50	0.20	-0.93
DR PR DT PEPR CN 12P										3.28	0.31	-1.40
SP R LN/LM CF NB PLS										37.79	0.11	-4.47
COKE DT CL CF CN										31.60	0.19	-0.66
mean	46.33	0.14	-3.73	49.90	0.13	-3.45	47.83	0.13	-3.79	40.36	0.15	-3.73
st.deviation	13.34	0.04	0.67	16.43	0.05	0.81	14.52	0.05	0.49	11.60	0.05	1.23

Table 2: Model Comparisons Based on Scope of Products used

Product	PEPSI	PEPSI DT	PEPSI DT CF	PEPSI 16oz	MT DW	COKE CLS	COKE DT	DR PR	A and W CF
PEPSI 12P	0.13	0.16	0.31	0.29	0.08	0.22	0.11	0.18	0.33
PEPSI 6P	-3.25	1.36	0.63	0.14	0.66	0.68	0.77	0.80	0.47
PEPSI 67.6oz	0.15	0.16	0.51	0.18	0.13	0.22	0.13	0.24	0.09
PEPSI DT 12P	0.07	0.03	0.00	0.08	0.05	0.07	0.16	0.20	0.04
PEPSI DT 6P	0.55	-4.05	0.86	0.12	0.61	0.46	0.52	0.61	0.53
PEPSI DT 67.6oz	0.05	0.04	0.00	0.13	0.10	0.05	0.03	0.05	0.04
PEPSI DT CF 12P	0.00	0.00	0.12	0.02	0.05	0.03	0.00	0.00	0.00
PEPSI DT CF 6P	0.02	0.03	-4.90	0.06	0.03	0.02	0.08	0.63	0.05
PEPSI 16oz	0.08	0.07	0.24	-3.36	0.15	0.08	0.04	0.00	0.12
MT DW 12P	0.02	0.04	0.13	0.04	0.06	0.05	0.09	0.00	0.10
MT DW 6P	0.26	0.17	0.08	0.02	-4.29	0.12	0.08	0.08	0.17
MT DW 67.6oz	0.04	0.05	0.03	0.04	0.14	0.05	0.12	0.12	0.07
COKE CLS 12P	0.16	0.24	0.13	0.16	0.24	0.14	0.16	0.24	0.07
COKE CLS 6P	0.46	0.37	0.04	0.13	0.22	-3.94	0.98	0.86	0.54
COKE CLS 67.6oz	0.09	0.08	0.19	0.19	0.09	0.08	0.08	0.22	0.15
COKE DT 12P	0.03	0.07	0.43	0.07	0.21	0.11	0.01	0.10	0.06
COKE DT 6P	0.28	0.22	0.04	0.04	0.40	0.63	-4.16	0.27	0.26
COKE DT CF 12P	0.00	0.01	0.00	0.00	0.05	0.01	0.00	0.06	0.00
COKE DT 67.6oz	0.05	0.15	0.03	0.10	0.03	0.10	0.07	0.02	0.07
SP CF 12P	0.06	0.04	0.00	0.08	0.03	0.01	0.04	0.09	0.02
7UP R CF 67.6oz	0.07	0.09	0.07	0.08	0.09	0.06	0.03	0.01	0.17
7UP DT CF 67.6oz	0.05	0.06	0.06	0.09	0.12	0.08	0.03	0.12	0.03
DR PR 12P	0.04	0.08	0.00	0.02	0.17	0.03	0.03	0.11	0.04
DR PR 6P	0.09	0.18	0.66	0.07	0.02	0.19	0.12	-5.76	0.24
DR PR 67.6oz	0.10	0.02	0.04	0.09	0.06	0.06	0.08	0.09	0.07
A and W CF 6P	0.13	0.14	0.00	0.10	0.18	0.17	0.20	0.23	-4.04

Table 3: Price Elasticities for 6-packs of cans (quarterly median)

Product	PEPSI	PEPSI DT	PEPSI DT CF	MT DW	COKE CLS	COKE DT	COKE DT CF	SP CF	DR PR
PEPSI 12P	-3.10	0.48	0.59	0.77	0.39	0.41	0.62	0.23	0.66
PEPSI 6P	0.15	0.05	0.00	0.15	0.12	0.16	0.23	0.31	0.33
PEPSI 67.6oz	0.21	0.17	0.15	0.21	0.14	0.13	0.57	0.13	0.18
PEPSI DT 12P	0.53	-3.43	0.27	0.45	0.30	0.21	0.09	0.20	0.33
PEPSI DT 6P	0.08	0.07	0.00	0.01	0.15	0.15	0.00	0.05	0.05
PEPSI DT 67.6oz	0.06	0.11	0.06	0.05	0.05	0.05	0.27	0.10	0.07
PEPSI DT CF 12P	0.03	0.10	-5.19	0.00	0.03	0.01	0.00	0.00	0.03
PEPSI DT CF 6P	0.02	0.02	0.00	0.04	0.01	0.02	0.00	0.00	0.00
PEPSI 16oz	0.07	0.04	0.08	0.12	0.05	0.11	0.34	0.07	0.04
MT DW 12P	0.08	0.08	0.00	-4.42	0.14	0.01	0.38	0.17	0.11
MT DW 6P	0.00	0.00	0.07	0.07	0.03	0.12	0.00	0.01	0.05
MT DW 67.6oz	0.05	0.02	0.24	0.08	0.04	0.03	0.00	0.04	0.03
COKE CLS 12P	0.34	0.45	0.29	0.50	-3.52	1.15	0.33	0.45	0.40
COKE CLS 6P	0.12	0.20	0.07	0.23	0.11	0.08	0.19	0.10	0.24
COKE CLS 67.6oz	0.06	0.08	0.52	0.03	0.06	0.21	0.17	0.06	0.07
COKE DT 12P	0.11	0.29	0.00	0.21	0.55	-3.96	0.96	0.30	0.42
COKE DT 6P	0.11	0.05	0.23	0.02	0.03	0.05	0.20	0.03	0.03
COKE DT CF 12P	0.02	0.08	0.00	0.07	0.06	0.08	-7.10	0.17	0.00
COKE DT 67.6oz	0.05	0.08	0.10	0.04	0.11	0.05	0.14	0.09	0.13
SP CF 12P	0.07	0.07	0.26	0.18	0.17	0.09	0.38	-3.61	0.18
7UP R CF 67.6oz	0.08	0.08	0.12	0.10	0.06	0.07	0.13	0.14	0.07
7UP DT CF 67.6oz	0.05	0.01	0.27	0.17	0.08	0.08	0.18	0.13	0.03
DR PR 12P	0.26	0.32	0.76	0.17	0.29	0.10	0.32	0.16	-4.17
DR PR 6P	0.01	0.01	0.00	0.02	0.01	0.04	0.31	0.08	0.01
DR PR 67.6oz	0.06	0.04	0.11	0.06	0.05	0.04	0.00	0.06	0.06
A and W CF 6P	0.05	0.04	0.00	0.02	0.02	0.04	0.12	0.06	0.02

Table 4: Price Elasticities for 12-packs of cans (quarterly median)

Product	PEPSI	PEPSI DT	MT DW	COKE CLS	COKE DT	7UP R CF	7UP DT CF	DR PR
PEPSI 12P	0.27	0.23	0.37	0.46	0.23	0.31	0.34	0.22
PEPSI 6P	0.32	0.19	0.25	0.36	0.16	0.42	0.19	0.35
PEPSI 67.6oz	-3.23	0.83	0.85	0.53	0.37	0.44	0.48	0.54
PEPSI DT 12P	0.12	0.24	0.07	0.11	0.10	0.24	0.13	0.21
PEPSI DT 6P	0.16	0.25	0.20	0.07	0.19	0.15	0.21	0.21
PEPSI DT 67.6oz	0.50	-4.05	0.23	0.20	0.29	0.24	0.15	0.24
PEPSI DT CF 12P	0.02	0.02	0.01	0.06	0.04	0.03	0.03	0.03
PEPSI DT CF 6P	0.01	0.03	0.01	0.04	0.05	0.02	0.05	0.00
PEPSI 16oz	0.09	0.16	0.11	0.11	0.09	0.16	0.12	0.10
MT DW 12P	0.06	0.09	0.08	0.04	0.03	0.05	0.09	0.03
MT DW 6P	0.07	0.08	0.11	0.01	0.03	0.11	0.19	0.00
MT DW 67.6oz	0.21	0.14	-3.75	0.12	0.20	0.17	0.15	0.28
COKE CLS 12P	0.25	0.22	0.27	0.18	0.22	0.25	0.38	0.54
COKE CLS 6P	0.17	0.15	0.24	0.16	0.26	0.20	0.23	0.30
COKE CLS 67.6oz	0.41	0.40	0.21	-3.89	1.17	0.30	0.27	0.29
COKE DT 12P	0.11	0.10	0.05	0.36	0.14	0.16	0.21	0.09
COKE DT 6P	0.10	0.05	0.08	0.10	0.06	0.11	0.07	0.13
COKE DT CF 12P	0.01	0.09	0.00	0.03	0.00	0.02	0.01	0.04
COKE DT 67.6oz	0.32	0.24	0.20	0.81	-4.01	0.27	0.24	0.21
SP CF 12P	0.05	0.13	0.10	0.05	0.07	0.11	0.11	0.06
7UP R CF 67.6oz	0.20	0.12	0.24	0.12	0.18	-4.25	0.42	0.18
7UP DT CF 67.6oz	0.14	0.17	0.25	0.15	0.10	0.95	-3.50	0.22
DR PR 12P	0.09	0.07	0.08	0.09	0.14	0.20	0.06	0.17
DR PR 6P	0.03	0.06	0.06	0.09	0.06	0.02	0.06	0.03
DR PR 67.6oz	0.16	0.53	0.28	0.26	0.21	0.16	0.16	-3.84
A and W CF 6P	0.01	0.05	0.02	0.03	0.07	0.07	0.05	0.15

Table 5: Price Elasticities for 67.6 oz bottles (quarterly median)