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Effect of Sales on Brand Loyalty

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Abstract

Although many theoretical industrial organization models are based on the existence of a critical mass of exogenously "brand loyal" consumers, we find little empirical evidence supporting these assumptions in the orange juice retail market. There are very few loyal consumers. More importantly, the frequency with which stores conduct sales affects the share of loyal types so that loyalty is endogenous rather than exogenous. Households' demographics have statistically significant but economically minor effects on switching behavior. Switching across frozen and refrigerated states is very common, leading to more complicated substitution patterns and less loyalty than one observes looking at each state separately.

Effect of Sales on Brand Loyalty [†]

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Although many theoretical industrial organization models are based on the existence of a critical mass of exogenously "brand loyal" consumers, we find little empirical evidence supporting these assumptions in the orange juice retail market. There are very few loyal consumers. More importantly, the frequency with which stores conduct sales affects the share of loyal types so that loyalty is endogenous rather than exogenous. Households' demographics have statistically significant but economically minor effects on switching behavior. Switching across frozen and refrigerated states is very common, leading to more complicated substitution patterns and less loyalty than one observes looking at each state separately.
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Most theoretical models of sales (e.g., Varian, 1980; Narasimhan, 1988; Lal, 1990) and theoretical and empirical work on firm's strategic pricing and advertising behavior (e.g., Agrawal, 1996; Fishman, 1994) assume that a critical mass of consumers have an intrinsic loyalty to a brand, so that they buy only that brand over time.[1] However, our empirical evidence of switching behavior by orange juice consumers shows that firms' pricing behavior affects whether orange juice consumers switch and that few consumers are actually loyal to one brand.[2] Moreover, we find that switching is more complex than generally assumed in these theoretical models: Consumers switch between two types of products: frozen and refrigerated orange juice.

Some theoretical models also require that firms be able to identify loyal customers, where an extensive marketing literature concentrates on identifying loyal customers (Jacoby and Chestnut, 1978; Grover and Srinivasan, 1987; Colombo and Morrison, 1989). Among the many explanations for brand loyalty, marketing researchers have identified customer inertia, decision biases, uncertainty in the quality of other brands, or other issues. As many of these characteristics cannot be observed, we try to predict switching behavior using only observable household demographic and store characteristics.

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[1] Similarly, in many other models, consumers are assumed to have different search costs, making the high-search-cost consumers "loyal" (e.g., Salop and Stiglitz, 1977), or different switching costs (e.g., Grabowski and Vernon, 1992, and Frank and Salkever, 1997).

[2] Our results are consistent with a literature that focuses on firm strategies and investments to affect brand loyalty by increasing switching cost across brands (for example, Beggs and Klemperer 1992, Farrell and Shapiro, 1988, Klemperer 1995, Schmalensee and Willig 1986), however, the strategies examined in these models do not seem particularly relevant for orange juice.

In our model, loyalty or switching behavior depends on consumer characteristics and the frequency with which stores conduct sales: temporary reductions in price from the usual or modal price. We examine switching behavior for the two best-selling types of orange juice products: refrigerated and frozen orange juice.[3] We chose orange juice because we were interested in whether switching depended on the ability to store goods bought on sale, which is possible with frozen but not refrigerated juice.

We now turn to our empirical model. Next, we describe the data and define our variables. Then, we present summary statistics and our formal empirical results and briefly draw conclusions.

THE EMPIRICAL MODEL

We investigate the relationship between switching behavior and consumer demographics using multinomial logit analyses. The classified response variable is the group membership of a household, where the groups reflect loyal or switching behavior.

We use cross-sectional, time series data on household purchases of orange juice from cities across the country. We use two main types of explanatory variables as well as city dummies. First, we include household characteristics. These characteristics include ages of female and male heads, income, household size, education and occupation of the heads, and presence of young kids. Wealthy families may ignore sales. Presumably, a lower-income, larger-size household is more prone to buy the least expensive product—switch when sales occur—and thus exhibit less loyalty to particular brands. Similarly, brand loyalty may differ with the age of children. Older children may prefer brands more strongly than younger ones or

[3] Refrigerated, frozen, and shelf stable orange juice are sold in most stores. We examine consumers' switching behavior for only refrigerated and frozen orange juice because shelf stable sales account for less than 1 percent of the total purchases of orange juice in our household level data.

parents who believe that certain brands of orange juice are more nutritious may be more inclined to buy a single brand for younger children. Some speculation in the press holds that educated families are more likely to buy generics—be less loyal—than other families.

Second, we use two variables to capture the frequency of sales at each store. One variable is the frequency of sales, while the other is a dummy that equals one if the store never has a sale (to capture nonlinear effects at zero). Presumably in the absence of sales, even non-loyal consumers have little incentive to switch between brands. It is this presumption that the theoretical literature implicitly rejects by assuming that loyalty is inherent or exogenous.

DATA

We use Information Resources Incorporated's (IRI) InfoScan® Household Paneldata for 1997 through 1999. IRI collects data on individual purchases from grocery stores and on prices directly from grocery stores' databases and in other ways. The store-level data set includes weekly prices, total sales quantities, promotion activities (price reduction, special display, retail ads, and any other type of promotion excluding coupons), and other information by product UPC (Universal Product Code).

The IRI customer database includes weekly purchases by individual households and annual (or time-invariant) demographic information for each household. This dataset has detailed information on the number of visits to grocery stores by a household, total units of products the household bought by UPC in each visit, and price per unit paid. We have annual demographic data for each household on annual household income, household size, age, employment status/occupation, and educational levels of the female and male heads of the

households. Our sample consists of 39,834 observations of purchases at weekly intervals by households in 24 cities.[4]

We construct three subsamples from our IRI datasets: refrigerated orange juice, frozen orange juice, and both types ("combined") of orange juice. In each sample, we assign households to one of a mutually exclusive and exhaustive set of groups based on their switching behavior. Our categories are similar but not identical across our three samples. For the frozen and refrigerated samples, the first group consists of loyal consumers who purchase a top-selling national brand; the second consists of those who are loyal to the store's private-label product; and the other two include people who switch between top national brands and private labels or who purchase other brands.[5]

The combined sample has customers who are loyal to a national brand, those who switch within a type, and those who switch between types.[6] We experimented with an alternative categorization of the groups, which further divided the first groups into three subgroups. The first two subgroups are those loyal to Tropicana and Minute Maid and who never switches, and the third subgroup are those consumers who do not buy anything else than these two brands, but switch between the two. We did not find our results sensitive to this alternative way of

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[4] The IRI cities are Atlanta; Boston; Cedar Rapids, IA; Chicago; Denver; Detroit; Eau Claire, WI; Grand Junction, CO; Houston; Kansas City; Los Angeles; Memphis; Midland, TX; Minneapolis/St. Paul; New York; Philadelphia; Pittsburgh; Pittsfield, MA; Rome, GA; San Francisco/Oakland; Seattle/Tacoma; St. Louis; Tampa/St. Petersburg; and Visalia, CA.

[5] Our definition of loyalty is based on only purchasing one brand during a fixed period of time; however, several alternative approaches have been used in other settings (Jacoby and Kyner, 1973; Jacoby and Chestnut, 1978; Colombo and Morrison, 1989; and Bayus, 1992).

[6] It does not include separate categories for those who are loyal to private labels because those categories are extremely small. Through experimentation, we have found that our results are robust to changes in our categorization schemes.

categorization. Therefore, we are presenting the simpler version as follows. The specific categories are:

Refrigerated sample

1. *Name brand loyal*: Households that bought only one or both of the two leading brands, Tropicana and Minute Maid in a year.
2. *Private label loyal*: Households that always bought the private label in a year.
3. *Switch between private label and top name brands*: Households that bought the private label and at least one of the two leading brands, but no other brands in a year.
4. *Others*: Consumers who buy minor brands (who may or may not switch between them and name-brand or private label products).

Frozen Sample[7]

1. *Name brand loyal*: Households that bought only the leading national brands (Minute Maid, Tropicana, Old Orchard Premium, Florida Golden, Sun Bright, and Sunkist) during a year.
2. *Private label loyal*: Households that bought only the private label during a year.
3. *Switch between private label and top name brands*: Households that switch between the private label and the top national brands during a year.
4. *Others*.

[7] In some of the 24 IRI sample cities, we do not observe consumers in all four groups for the frozen orange juice sample. We use only the 11 cities for which all four groups are observed: Eau Claire, WI; Midland, TX; Visalia, CA; Cedar Rapids, IA; Memphis; Houston; Pittsburgh; Seattle/Tacoma; Detroit; St. Louis; Kansas City; and Minneapolis/St. Paul.

Combined Sample

1. *Only frozen, name brand loyal*: Households that bought exclusively the leading national brands of frozen orange juice.
2. *Only frozen, bought non-name-brand products*: Households that bought exclusively frozen orange juice and bought the private label, minor brands, or switched between leading national brands and other products during a year.
3. *Only refrigerated, name brand loyal*: Households that bought exclusively the top refrigerated national brands during a year.
4. *Only refrigerated, bought non-name-brand products*: Households that bought exclusively refrigerated orange juice and bought the private label, minor brands, or switched between leading national brands and other products during a year.
5. *Switched between frozen and refrigerated*: Households that switched between frozen and refrigerated orange juice during a year.

We observe a household's purchasing behavior over a year. For each of the subsamples, we excluded households that made fewer than two purchases in a year, because group memberships are indeterminate for such households as we cannot observe switching behavior. We dropped 10,285 household-years out of 65,529 household-year observations in the refrigerated dataset (16%), 10,734 (30%) out of 36,101 observations in the frozen dataset, and 9,864 household-years (13%) were dropped from a total of 77,102 observations in the combined sample.

Our second step was to match the group indexed household level data with household demographics by household and by year. Because of an inability to properly assign demographic information to some households, we dropped 9,869 household-year observations (18%) of the

55,244 observations in the refrigerated household level data, 4,017 (16%) out of 25,367 in the frozen sample, and 11,933 (18%) out of 67,238 in the combined data set. Our third step was to match store-specific information from the store-level data set to our household data.

We want to investigate how a household's tendency to switch between brands is conditional on the frequencies of sales in the stores that a household visits. To do so, we need to define a sale and decide how to treat households that shop at more than one grocery store. In most previous research, a *sale* is defined as occurring if the price is below a specified fraction of the modal (regular) price within a given period. Hendel and Nevo (2002) considered the fractions 5%, 10%, 25%, or 50%. We define a sale as occurring when the price is at least 25% below the modal price during a year; however our experiments show that our results are qualitatively robust to other choices of the threshold. We define a stores' *sales frequency* during a year as the percentage of weeks that a product is on sale.

If a household shops at several stores during a year, we focus on the store that it visited the most times during the year. We define the *sales frequency* as the average fraction of weeks that the five best-selling orange juice UPCs are on sale (based on store-level data) for each type of orange juice.[8] If the store does not carry each of the top five UPCs, the mean is computed from the subset that the store carries. If none of the five UPCs is available at a store for a year, then we set the sales frequency equal to zero. We also define a binary dummy for *no sales* for each state of orange juice that equals one if there are no sales for the five top-selling UPCs and zero otherwise.

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[8] We determine the top selling brands using the household level data. Of the five best-selling refrigerated products (UPCs), the first three are Tropicana products, the fourth is produced by Florida Natural, and the final one by Minute Maid. Of the five best-selling frozen UPCs, the first, second, and fifth are Minute Maid products, the third is manufactured by Old Orchard, and the fourth by Tropicana.

We then match these measures to the group-indexed household demographics by store and by year. We have 45,330 observations in the refrigerated dataset, 21,345 in the frozen dataset, and 55,291 in the combined dataset. We had to drop 45 (0.1%), 5 (0.2%), and 44 (0.1%) observations in these datasets respectively where we could not match properly because we could not determine the year to which the demographic characteristics applied. In addition, we kept only 12,359 household year observations in the frozen dataset when we drop the cities for which not all four groups are present.

SUMMARY STATISTICS

We present the summary statistics in Table 1 for the three samples: refrigerated orange juice, frozen orange juice, and the combined sample. The summary statistics alone allow us to draw five results about loyalty.

Result 1: *Switching behavior is extremely common and brand loyalty is relatively uncommon for orange juice.* If we look at just one type of orange juice at a time, we find that 61 percent of the frozen orange juice customers and 77 percent of the refrigerated orange juice customers switch or buy minor brands (Groups 3 and 4). In the combined data set, all but 8 percent of the sample (Group 1 + Group 3) switch within or between types of juice. Perhaps most striking is that 60 percent of all consumers switch between refrigerated and frozen orange juice products.

There is even more switching than our figures indicate for two reasons. First, some of the consumers whom we describe as loyal to leading national brands actually switch between these brands. Second, our analysis ascribes loyalty to a consumer who did not switch within a year; however, were we to change our horizon to two or three years, virtually no household is loyal.

Result 2: *Roughly twice as many consumers of refrigerated or frozen juice are loyal to the leading national brands as to a private label.* Of frozen orange juice consumers, 25 percent are loyal to a leading brand-name product (Group 1) and 14 percent to the private label (Group 2).[9] In contrast for those who consume refrigerated orange juice, only 16 percent are loyal to the top brand name (Group 1) and only 6 percent to the private label (Group 2).

Result 3: *The share of loyal customers varies substantially across types of orange juices.* The share of loyal customers (Groups 1 and 2) is 39 percent for the frozen orange juice sample compared to only 22 percent for the refrigerated juice sample. However, in the combined sample (where switching between frozen and refrigerated products becomes possible), 3 percent are loyal to a name-brand frozen orange juice, and 5 percent are loyal to a refrigerated name-brand product.

Result 4: *Frozen orange juice consumers are more likely to be loyal than are refrigerated juice consumers*. The share of consumers who are loyal to a leading national brand is 18 percent for frozen juice and 8 percent for refrigerated. The corresponding figures for loyalty to a private label are 14 and 6 percent. Because it is easier to store frozen juice, there may be more of an incentive to respond to sales. However, the leading frozen brand dominates its category more than does the leading refrigerated brand.[10] In addition, sales are also less common for frozen than refrigerated juice: One third of the stores never have sales of frozen juice, whereas only a quarter fails to put refrigerated juice on sale.

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[9] Brand loyalty may be greater in other processed foods (see for example, Villas-Boas, 1995).

[10] All the stores carry the leading frozen brand, and virtually all carry one or the other (but not both) of the second and third best-selling frozen brands. It is much more common for stores to carry all three leading refrigerated brands.

Result 5: *Looking only within frozen or within refrigerated juices provides a misleading picture that there is more loyalty than when we take account of switching between types.* We find substantially less national brand loyalty if we allow consumers to switch between frozen and refrigerated products than if we look at just one or the other type of juice: The share of consumers who buy only leading national brands drops from 25 percent to 3 percent for frozen and from 16 percent to 5 percent for refrigerated.

Table 1 also shows very small difference in the summary statistics for the explanatory variables across the samples. Moreover, there are only a couple patterns in the explanatory variables across the samples. Families with small children are slightly more likely to buy frozen orange juice or switch than to buy the more expensive refrigerated juice. Slightly more of families with incomes over $100,000 buy refrigerated rather than frozen juice.[11]

MULTINOMIAL LOGIT RESULTS

We can only infer a limited amount from summary statistics. We want to know how various consumer characteristics and stores' frequency of sale affect consumers' switching behavior holding other factors constant. To do that, we use multinomial logit to estimate our full model for each of our three samples.

We believe that it is reasonable to assume that consumers view the sales frequency variables as exogenous. It seems unlikely that the frequency of sales of orange juice products alone substantially affects consumers' choice of which grocery store they are most likely to shop in over a year. The average probability that a consumer buys orange juice on sale is 17.2 percent

[11] IRI reports income in ranges and top codes incomes above $100,000. Consequently, we use two income measures. One is the midpoint of a household's annual income bracket if its income is less than $100,000. The other is a dummy if the income exceeds $100,000.

if the consumer shops at the store the consumer visits most frequently and 17.4 percent at other stores for the combined sample.[12] We also lack appropriate instruments so as to deal with potential endogeneity directly.

One might also be concerned about endogeneity problems arising from stores' reactions to consumers' choices. We regressed the frequency of sales in stores on the characteristics of its customers and found no correlation (indeed, no coefficient had a t-statistic as high as one). In short, we have no compelling evidence as to why the frequency of sales varies across stores and view these decisions as essentially exogenous for our purposes.

Consequently, for those readers who question the endogeneity of the sales frequency variable, we also estimated restricted (reduced-form) models, where we dropped the sales frequency variables and included only the consumer characteristics and city dummies.

The estimated multinomial logit results for both the full models and the restricted models and the associated outcome matrices are presented in Appendix 1. The individual dummy variables are listed there. The models fit reasonably well for large cross sections (the time series is relatively short), as shown by the outcome matrices. The pseudo-R^2 measures for the full models are 0.076 for frozen orange juice, 0.108 for refrigerated juice, and 0.074 for the combined model.[13]

As the estimated coefficients themselves are of relatively little interest by themselves, we concentrate on hypothesis tests of the coefficients and simulation results based on the estimated models. In Table 2, we report a large number of hypothesis tests. We use imprecise terminology

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[12] Rhea and Bell (2002) report that they fail to find a relationship between consumers' observable demographics and their decisions to switch between stores after controlling for unobserved heterogeneity. Bell, Ho, and Tang (1998) cite industry research that location explains up to 70 percent of the variance in consumers' supermarket choice decisions.

[13] The pseudo R^2 is 1 - L_1/L_0, where L_0 is the constant-only log likelihood and L_1 is the full-model log likelihood.

and say that a result is “statistically significant” if we can reject the null hypothesis of no effect at the 0.05 level. The next to last row of the table shows that all six multinomial logit analyses are statistically significant (we can reject the null hypothesis that only the constant matters—all the slope coefficients are collectively zero).

The first row of Table 2 shows the likelihood-ratio test statistics against the hypothesis that all the coefficients for the sales frequency and the sales dummy are collectively zero. (In addition, each variable is statistically significant in all three full-models, though the table does not show those statistics.) That is, if one accepts that the sales frequency variables are exogenous, one can reject dropping these variables from the full model to obtain the restricted model.

Most of the demographic variables are also statistically significant in some or all models. All the variables related to income and wealth (own your own house), household size (number of members in the family), and the city dummies are statistically significant in all the analyses. The only set of variables that is never statistically significant is the set of dummies related to the male head of household’s occupation. The other sets of demographic variables are statistically significant in some (usually half or more) but not all the analyses.

SIMULATION RESULTS

We also want to know if variables have economic significance. Do changes in the explanatory variables have a substantial effect on the shares of the various loyalty groups? Because the multinomial logit is highly nonlinear, we cannot answer this question by inspecting the corresponding coefficients. One standard method of showing the impact of a variable is to report marginal effects using elasticities or partial derivatives. However, because most of our variables are discrete or have known ranges, we find that an equivalent simulation approach is

clearer. We use our estimated model to simulate the impact of changes in only one explanatory variable at a time on the probability that a typical household belongs to each group, where we hold the other explanatory variables fixed (continuous explanatory variables at the sample means and the discrete characteristics at the values taken by the majority of households in the sample).

The simulation results are reported in Tables 3, 4, and 5 for the refrigerated, frozen, and combined samples respectively. We report simulations for the statistically significant variables except the 24 city dummies.

Result 6: *When the frequency of sales rises, fewer consumers of orange juice remain loyal to a national brand and switching behavior increases.* Holding the other right-hand variables fixed, as we increase the percentage of weeks that the store visited most often by a household has sales within a year, the probabilities of remaining loyal to a national brand shrinks monotonically, and the probability of being a switcher rises. If a store were to increase its frequency of sales from 0% to 15% (the observed range), the probability of its refrigerated orange juice customers being loyal to a national brand (Group 1), falls from 8 percent to 2 percent, the probability of being loyal to a private label (Group 2) drops negligibly, so the share who are switchers (Groups 3 and 4) rises from 86 percent to 93 percent.[14] The comparable figures for frozen juice consumers are: 20 percent to 4 percent, 12 percent to 6 percent, and 68 percent to 90 percent. For the combined sample, an increase in the frequency of both types of juice reduces the share of consumers who are loyal of a national brand or frozen or refrigerated juice, switching within a type of juice falls, but switching between types of juices rises substantially. If we set the sales frequency for refrigerated juice at 0.1 percent and increase the frequency of sales of frozen, we again see a decline in national brand loyalty. However, if we set

[14] If we allow the sales frequency to rise well outside of the observed range to 40 percent, the share in the first group falls to essentially zero and the share of the fourth group prices to 95 percent.

the frequency of sales for frozen at 0.1 percent and raise the frequency for refrigerated juice, strangely loyalty to both types of national brands rises. Thus, with one exception, as the frequency of sales increases, a household becomes less loyal to a national brand and more willing to switch.

Although demographic characteristics tend to affect switching behavior in the direction that we would have expected, changes in these characteristics have smaller effects than does a change in the frequency of sales. For some statistically significant variables, such as the female education dummies, the effects are negligible. In the following, we discuss a few of the larger effects.

Result 7: *As household income rises, consumers are more likely to be loyal to a national brand, less likely to be loyal to a private label, and less likely to switch*. In short, wealthy households buy a leading national brand and stick with it, even though it may cost more than other brands. As household income rises from $30,000 to over $100,000, the share of refrigerated juice consumers who are loyal to the national brand nearly doubles from 7 to 13 percent, while the share who buy frozen drops from 6 to 3 percent. The comparable figures for frozen juice consumers are 17 to 27 percent and 14 to 9 percent. As income rises, the share of the combined sample who are loyal consumers of the leading brands falls from 0.7 to 0.5 percent for frozen and from 0.9 to 0.3 percent for refrigerated.

Result 8: *As household size increases, consumers are more likely to buy a private label*. The reward to buying inexpensive brands rises with family size. This increase comes at the expense of leading national brands; however, the share of switchers remains relatively unchanged. As the household size rises from 2 to 5 people, the share that are loyal to the national brand falls from 8 to 6 percent and the share that buys the private label rises from 5 to 7

percent for the refrigerated sample. The comparable figures for the frozen sample are 20 to 14 percent and 13 to 16 percent.

Result 9: *Renters are more likely to be loyal than are home-owners*. Surprisingly, renters are slightly more likely to be loyal to both leading national brands and to a private label than are home-owners. Consequently, renters are less likely to be switchers.

Result 10: *Race affects loyalty to a national brand for refrigerated orange juice*. The race variables are not collective statistically significant for the frozen sample. For refrigerated juice, the probability that a white consumer is loyal to a leading national brand is 8 percent compared to 7 percent for Hispanic consumers, and 6 percent for black consumers. Race has negligible effects on loyalty to a private label.

Result 11: *Senior citizens exhibit less brand loyalty for refrigerated orange juice than do younger consumers*. Age variables are not statistically significant determinants of switching behavior in the frozen or combined samples. In the refrigerated sample, older consumers are less likely to be loyal to either a name brand juice or a private label. This result contrasts with pharmaceuticals, where older consumers were more likely than others to buy a name-brand instead of a generic drug.[15] One possible explanation here is that older consumers are more likely to have sampled various brands and found them to be generally equivalent in taste than younger consumers.

By comparing the full-model and the restricted-model (in Appendix 2) simulations, we find that the magnitudes of the demographic effects for the full model are slightly smaller than

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[15] A survey of the American Association of Retired Persons found that people aged 65 and older were 15 percent less likely than people aged 45 to 64 to request generic versions of a drug from their doctor or pharmacist ("Generics, the Impact at the Grass Roots," *Drug Topics Supplement*, 1994). Perhaps in response of legislation and insurance rules that require generics be offered or provided, older citizens have become more accepting of generics recently (research.aarp.org/health/ib61_generic.pdf).

those of the restricted model, but the directions of these effects are generally the same. Consequently, all but the sales frequency results hold for the restricted model.

CONCLUSIONS

We have studied how demographic characteristics and the frequency of sales affect consumers' switching behavior. Our results are generally consistent with our expectations. However, these empirical results are not consistent with the assumptions commonly made in theoretical industrial organization models that there is a critical mass of exogenously brand-loyal consumers. Some theoretical models also require that a store be able to identify switchers, which our results suggest is difficult because, although many observable consumer characteristics are statistically significantly related to switching behavior, we find that changes in most consumer characteristics have relatively small effects on such behavior.

We find that switching behavior by orange juice consumers is extremely common and brand loyalty is relatively uncommon especially among consumers of frozen orange juice. When the frequency of sales rises, fewer consumers of orange juice remain loyal to a national brand and switching behavior increases. Looking only within frozen or within refrigerated juices provides a misleading picture that there is more loyalty than when we take account of switching between types.

Demographic characteristics are more likely to be statistically significant than economically significant. As household income rises, consumers are more likely to be loyal to a national brand, less likely to be loyal to a private label, and less likely to switch. Larger households are more likely to buy a private label. Perhaps surprisingly, renters and younger consumers are more likely to be brand loyal than others.

Perhaps our most unusual result, which has not been discussed in either theoretical or empirical papers, is that consumers are very willing to switch between frozen and refrigerated orange juice. By failing to notice these more complicated substitution patterns across types of products, firms and researchers may conclude that consumers are more brand loyal than is actually true.

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Table 1

Summary Statistics

Discrete Variables (Percentage)						
Consumers' Group Membership		*Group1*	*Group2*	*Group3*	*Group4*	*Group5*
	Frozen	24.9	14.4	37.0	23.7	
	Refrigerated	16.1	6.4	12.9	64.5	
	Combined	3.5	6.7	4.8	24.9	60.2
Binary Explanatory Variables	*Frozen*		*Refrigerated*		*Combined*	
No frozen sales	34.7				37.5	
No refrigerated sales			23.0		24.3	
Income exceeding $100,000	1.3		1.8		1.6	
Presence of young kids	11.4		9.0		9.5	
Owns house	88.2		84.5		84.8	
Other Discrete Explanatory Variables		1	2	3	4	5
Female employment status (1- full time, 2-part time, 3-others)	Frozen	55.7	18.9	25.5		
	Refrigerated	56.0	17.8	26.2		
	Combined	55.7	17.8	26.6		
Male employment status (1- full time, 2-part time, 3-others)	Frozen	55.6	3.2	41.2		
	Refrigerated	52.7	3.0	44.3		
	Combined	52.6	3.1	44.4		
Female Occupation (1-White-collar, 2-Blue-collar, 3-others)	Frozen	44.9	9.4	45.7		
	Refrigerated	45.3	8.3	46.4		
	Combined	44.6	8.4	46.9		
Male Occupation (1-White-collar, 2-Blue-collar, 3-others)	Frozen	39.9	16.9	43.2		
	Refrigerated	37.1	16.4	46.5		
	Combined	37.1	16.3	46.6		
Female Education (1-no college, 2-college, 3-grad school, 4-tech school, 5-others)	Frozen	34.0	35.2	22.8	6.5	1.6
	Refrigerated	39.5	31.8	19.4	6.9	2.3
	Combined	38.6	32.3	19.9	6.9	2.2
Male Education (1-no college, 2-college, 3-grad school, 4-tech school, 5-others)	Frozen	23.2	28.4	20.6	10.0	17.8
	Refrigerated	26.8	25.1	17.5	9.0	21.5
	Combined	26.3	25.5	17.8	9.2	21.2

Continuous Explanatory Variables						
	Frozen		*Refrigerated*		*Combined*	
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*
Frozen sales frequency (percentage)	0.6	0.9			0.6	0.9
Refrigerated sales frequency (percentage)			1.4	2.2	1.3	2.1
Midpoint of household income bracket ($1,000)	39.5	21.4	39.7	23.1	39.4	22.9
Household Size (number)	2.9	1.4	2.8	1.3	2.8	1.3
Age of male head (years)	43.5	24.9	42.5	26.4	42.6	26.3
Age of female head (years)	52.7	16.2	53.4	16.7	53.3	16.7
# Observations	12,310		45,047		54,960	

Table 2
Likelihood Ratio Hypothesis Tests

	Degrees of Freedom		*Full Model*			*Restricted Model*		
	Frozen & Refrig.	*Comb.*	*Frozen*	*Refrig.*	*Combined*	*Frozen*	*Refrig.*	*Combined*
Sales (frequency & dummy)	6	16	**124.49**	**184.30**	**1359.39**	NA	NA	NA
Income (midpoint & dummy)	6	8	**66.08**	**157.60**	**108.23**	**66.12**	**161.11**	**114.40**
Household size	3	4	**42.84**	**92.39**	**52.79**	**42.76**	**93.11**	**51.23**
Presence of young kids	3	4	**35.59**	4.25	**47.27**	**34.20**	4.80	**46.72**
Age of male head	3	4	2.97	7.73	**37.03**	3.01	7.69	**36.20**
Age of female head	3	4	1.02	**40.27**	8.37	1.29	**44.70**	**10.43**
Male employment status	6	8	8.20	**16.56**	**13.36**	8.30	**17.73**	15.10
Female employment status	6	8	**15.03**	10.21	**19.51**	15.27	10.47	**19.53**
Male Occupation	6	8	7.39	10.81	4.33	7.62	11.90	5.30
Female Occupation	6	8	**12.67**	9.50	**24.55**	12.52	9.87	**25.18**
Male Education	12	16	8.35	11.07	**66.39**	8.51	11.00	**66.01**
Female Education	12	16	**35.17**	**27.91**	**97.26**	**34.91**	**28.79**	**102.55**
Race	6	8	12.56	**35.87**	**90.83**	12.58	**32.41**	**86.91**
Own house	3	4	**9.70**	**13.28**	**13.28**	**10.48**	**10.91**	**9.59**
City fixed effects	30/69*	92	**1480.87**	**6737.87**	**4817.60**	**1967.25**	**7262.71**	**5291.15**
All slope coefficients for restricted models	108/147	196	NA	NA	NA	**2365.44**	**9694.65**	**7423.97**
All slope coefficients for full models	114/153*	212	**2492.16**	**9892.81**	**8867.94**	NA	NA	NA
Pseudo R2			0.0759	0.1080	0.0737	0.0720	0.1058	0.0617

*The number before the slash is the degrees of freedom for the frozen sample, and the one after the slash is that for the refrigerated sample.

Note: Bold indicates that we can reject at the 0.05 level the null hypothesis that the coefficients for this category are collectively zero.

Table 3
Refrigerated Orange Juice Switching Behavior

Group	1	2	3	4
Probability that a typical household belongs to a given group	0.076	0.058	0.130	0.736
Sales frequency (percentage)				
0	0.080	0.059	0.152	0.709
1	0.079	0.058	0.132	0.732
5	0.053	0.058	0.109	0.780
10	0.032	0.056	0.084	0.828
15	0.018	0.054	0.063	0.864
Age				
Age of female head is 25	0.089	0.065	0.146	0.700
Age of female head is 55	0.076	0.057	0.129	0.738
Age of male head is 25	0.081	0.060	0.131	0.728
Age of male head is 55	0.073	0.056	0.129	0.742
Household Size				
Household size is 2	0.083	0.054	0.128	0.735
Household size is 5	0.061	0.071	0.133	0.735
Income				
Household annual income is $30,000	0.071	0.063	0.130	0.736
Household annual income is $50,000	0.082	0.053	0.130	0.735
Household annual income exceeds $100,000	0.133	0.030	0.132	0.705
House ownership				
Owns	0.076	0.058	0.130	0.736
Rent	0.082	0.067	0.138	0.714
Presence of young children				
Children under six years old	0.084	0.055	0.131	0.730
No children under six	0.076	0.058	0.130	0.736
Female Education				
No college	0.076	0.058	0.130	0.736
College	0.077	0.057	0.132	0.733
Grad school	0.079	0.054	0.134	0.734
Technology School	0.072	0.050	0.135	0.742
No female head	0.050	0.069	0.101	0.780
Race	**s**			
White	0.076	0.058	0.130	0.736
Black	0.055	0.059	0.116	0.769
Hispanic	0.066	0.052	0.131	0.752
Others	0.071	0.043	0.105	0.781

Table 4
Frozen Orange Juice Switching Behavior

Group	1	2	3	4
Probability of a typical household	0.181	0.141	0.513	0.165
Sales frequency (percentage)				
0	0.199	0.123	0.569	0.109
1	0.178	0.141	0.533	0.148
5	0.133	0.121	0.699	0.047
10	0.078	0.085	0.828	0.009
15	0.042	0.055	0.902	0.002
Household size				
Household size is 2	0.199	0.133	0.510	0.158
Household size is 5	0.144	0.163	0.515	0.179
Income				
Household annual income is $30,000.	0.166	0.144	0.524	0.166
Household annual income is $50,000.	0.199	0.138	0.500	0.163
Household annual income exceeds $100,000	0.274	0.088	0.474	0.164
House ownership				
Own	0.181	0.141	0.513	0.165
Rent	0.209	0.154	0.490	0.147
Presence of young children				
Children under six years old	0.240	0.112	0.519	0.129
No children under six	0.181	0.141	0.513	0.165
Female Occupation				
White-collar	0.181	0.141	0.513	0.165
Blue-collar	0.177	0.145	0.508	0.169
Other	0.201	0.132	0.477	0.191
Female Education				
No-college	0.184	0.141	0.508	0.167
College	0.181	0.141	0.513	0.165
Grad school	0.144	0.135	0.545	0.176
Technology school	0.163	0.130	0.551	0.157
No female head	0.115	0.227	0.510	0.149

Table 4
Combined Sample Switching Behavior

Group	*1*	*2*	*3*	*4*	*5*
Probability of a typical household	0.007	0.053	0.008	0.368	0.563
Sales frequency					
Both sales frequency at					
0	0.013	0.074	0.016	0.486	0.411
0.5	0.007	0.056	0.008	0.352	0.578
1	0.006	0.052	0.007	0.334	0.601
5	0.004	0.026	0.006	0.204	0.760
10	0.002	0.010	0.003	0.096	0.889
15	0.001	0.003	0.002	0.041	0.953
Sales frequency of refrigerated fixed at 0.1%, while that of frozen orange juice is					
0.5	0.010	0.070	0.010	0.402	0.508
1	0.011	0.068	0.011	0.417	0.494
5	0.016	0.049	0.016	0.538	0.380
10	0.026	0.030	0.024	0.672	0.248
15	0.011	0.065	0.012	0.432	0.480
Sales frequency of frozen fixed at 0.1%, while that of refrigerated orange juice is					
0.5	0.009	0.061	0.012	0.437	0.481
1	0.008	0.059	0.011	0.404	0.519
5	0.003	0.037	0.005	0.175	0.780
10	0.001	0.015	0.001	0.044	0.938
15	0.000	0.006	0.000	0.010	0.984
Age					
Age of female head is 25	0.007	0.059	0.008	0.370	0.555
Age of female head is 55	0.007	0.052	0.008	0.368	0.564
Age of male head is 25	0.007	0.053	0.009	0.344	0.587
Age of male head is 55	0.007	0.053	0.007	0.385	0.547
Household size					
Household size is 2	0.008	0.056	0.008	0.377	0.552
Household size is 5	0.006	0.046	0.008	0.344	0.595
Income					
Household annual income is $30,000	0.007	0.051	0.009	0.362	0.571
Household annual income is $50,000	0.007	0.055	0.007	0.376	0.555
Household income exceeds $100,000	0.005	0.058	0.003	0.344	0.590
House ownership					
Own	0.007	0.053	0.008	0.368	0.563
Rent	0.007	0.056	0.007	0.352	0.577
Presence of young children					
Children under six years old	0.011	0.052	0.010	0.324	0.603
No children under six	0.007	0.053	0.008	0.368	0.563
Female Occupation					
White-collar	0.007	0.053	0.008	0.368	0.563
Blue-collar	0.009	0.051	0.010	0.365	0.566
Others	0.008	0.052	0.009	0.344	0.587

Race					
White	0.007	0.053	0.008	0.368	0.563
Black	0.002	0.048	0.003	0.430	0.516
Hispanic	0.004	0.054	0.006	0.405	0.531
Others	0.003	0.042	0.006	0.392	0.556

Appendix I
Multinomial Logit Results

Table A1.1
Refrigerated Orange Juice Multinomial Regression Results
(coefficients in first row; asymptotic standard errors in second row)

	FULL MODEL			*RESTRICTED MODEL*		
	LR statistic=198			p-value=0		
	Number of obs. = 45,047			Number of obs. = 45,047		
	Pseudo R^2 = 0.1080			Pseudo R^2 = 0.1058		
	Log likelihood = -40858.155			Log likelihood = -40957.231		
Group (base is Group 4)	*1*	*2*	*3*	*1*	*2*	*3*
Sales frequency	-11.680	-1.708	-6.447			
	0.965	1.537	1.115			
No sales dummy	-0.083	0.032	0.106			
	0.037	0.058	0.041			
Midpoint of household Income	0.007	-0.008	0.000	0.007	-0.008	0.000
	0.001	0.001	0.001	0.001	0.001	0.001
Household income > $100,000	0.873	-0.921	0.059	0.887	-0.920	0.060
	0.105	0.222	0.133	0.105	0.222	0.133
Household size	-0.102	0.090	0.012	-0.103	0.090	0.011
	0.014	0.019	0.014	0.014	0.019	0.014
Presence of young children	0.099	-0.039	0.019	0.107	-0.037	0.027
	0.052	0.077	0.057	0.052	0.077	0.057
Age of male head	-0.004	-0.003	-0.001	-0.004	-0.003	-0.001
	0.001	0.002	0.002	0.001	0.002	0.002
Age of female head	-0.007	-0.006	-0.006	-0.008	-0.006	-0.006
	0.001	0.002	0.001	0.001	0.002	0.001
Male head employed full time	0.160	0.115	0.248	0.164	0.118	0.254
	0.104	0.136	0.104	0.104	0.136	0.103
Male head employed part time	-0.080	-0.007	0.039	-0.086	-0.007	0.037
	0.135	0.183	0.138	0.135	0.182	0.138
Female head employed full time	0.064	0.175	0.068	0.068	0.175	0.067
	0.051	0.075	0.056	0.051	0.075	0.056
Female head employed part time	0.087	0.125	0.004	0.097	0.126	0.006
	0.066	0.096	0.072	0.066	0.096	0.072
Male head has white-collar job	-0.006	-0.140	-0.115	-0.002	-0.141	-0.119
	0.100	0.131	0.099	0.100	0.131	0.099
Male head has blue-collar job	-0.121	-0.152	-0.198	-0.124	-0.155	-0.205
	0.102	0.132	0.101	0.102	0.132	0.101
Female head has white-collar job	-0.049	0.070	0.036	-0.057	0.068	0.034
	0.041	0.060	0.045	0.041	0.060	0.045
Female head has blue-collar job	-0.156	0.071	0.039	-0.158	0.070	0.041
	0.064	0.084	0.065	0.064	0.084	0.065
Male head has no college	0.014	0.145	-0.063	0.005	0.145	-0.061

	0.115	0.161	0.125	0.115	0.161	0.125
Male head has some college	-0.053	0.069	-0.164	-0.058	0.069	-0.163
	0.114	0.161	0.125	0.114	0.161	0.125
Male head has some grad school	-0.055	0.113	-0.092	-0.057	0.115	-0.088
	0.117	0.166	0.128	0.117	0.166	0.128
Male head went to technology school	0.000	0.165	-0.122	-0.003	0.166	-0.121
	0.123	0.180	0.137	0.123	0.180	0.137
Female head has no college	0.483	-0.123	0.313	0.494	-0.120	0.317
	0.127	0.169	0.136	0.127	0.169	0.136
Female head has some college	0.499	-0.135	0.334	0.516	-0.131	0.337
	0.126	0.168	0.135	0.126	0.168	0.135
Female head has some grad school	0.513	-0.196	0.349	0.533	-0.192	0.353
	0.127	0.171	0.137	0.127	0.171	0.137
Female head went to technology school	0.420	-0.270	0.344	0.447	-0.264	0.350
	0.135	0.189	0.146	0.135	0.189	0.146
White	0.135	0.353	0.270	0.136	0.355	0.266
	0.101	0.205	0.119	0.100	0.205	0.119
Black	-0.236	0.331	0.115	-0.213	0.342	0.134
	0.120	0.218	0.133	0.120	0.218	0.133
Hispanic	-0.040	0.219	0.258	-0.046	0.219	0.254
	0.122	0.246	0.140	0.122	0.246	0.140
House owner	-0.098	-0.172	-0.088	-0.075	-0.166	-0.081
	0.042	0.060	0.044	0.042	0.060	0.044

Notes: Group 4 is the based group. The city dummies and the constant are not reported.

		actual group membership			
		Full Model			
		1	2	3	4
Predicted group membership	1	1124	87	562	656
	2	17	119	66	75
	3	161	46	205	120
	4	5943	2639	4984	28243
		Restricted Model			
	1	1105	89	536	663
	2	17	121	67	80
	3	153	43	213	101
	4	5970	2638	5001	28250

Table A1.2
Frozen Multinomial Regression Results
(coefficient in first row; asymptotic standard errors in second row)

	FULL MODEL			RESTRICTED MODEL		
	LR statistic =126			p-value=0		
	Number of obs. = 12310			Number of obs. = 12310		
	Log likelihood = -15182.003			Log likelihood = -15245.362		
	Pseudo R^2 = 0.0759			Pseudo R^2 = 0.0720		
Variables	Group1	Group2	Group3	Group1	Group2	Group3
Sales Frequency	-14.096	-10.491	-35.678			
	3.957	4.999	4.391			
No Sales Dummy	-0.093	-0.306	-0.728			
	0.070	0.082	0.076			
Midpoint of Household income	0.011	0.000	0.001	0.011	0.000	0.001
	0.002	0.002	0.002	0.002	0.002	0.002
Household income > $100,000	0.937	-0.385	0.124	0.942	-0.365	0.169
	0.225	0.326	0.240	0.225	0.326	0.240
Household Size	-0.112	0.066	0.039	-0.110	0.066	0.041
	0.025	0.028	0.025	0.025	0.028	0.025
Presence of young children	0.271	-0.243	-0.255	0.272	-0.235	-0.240
	0.086	0.108	0.093	0.086	0.108	0.092
Age of male head	-0.003	0.002	-0.001	-0.003	0.003	-0.001
	0.003	0.003	0.003	0.003	0.003	0.003
Age of female head	-0.003	-0.001	-0.001	-0.003	-0.002	-0.002
	0.003	0.003	0.003	0.003	0.003	0.003
Male head employed full time	-0.076	0.148	-0.092	-0.077	0.149	-0.089
	0.197	0.196	0.191	0.196	0.196	0.190
Male head employed part-time	-0.415	0.043	-0.015	-0.419	0.045	-0.011
	0.244	0.252	0.232	0.244	0.252	0.230
Female head employed full time	0.157	0.144	0.001	0.154	0.143	-0.003
	0.091	0.106	0.092	0.091	0.106	0.092
Female head employed part-time	0.137	0.052	0.174	0.138	0.050	0.174
	0.117	0.137	0.118	0.117	0.137	0.118
Male head has white-collar job	0.200	-0.250	0.067	0.202	-0.243	0.072
	0.190	0.188	0.185	0.189	0.188	0.184
Male head has blue-collar job	0.168	-0.370	-0.007	0.167	-0.369	-0.013
	0.192	0.191	0.187	0.191	0.191	0.186
Female head has white-collar job	-0.175	-0.003	-0.221	-0.173	0.000	-0.217
	0.074	0.088	0.077	0.073	0.088	0.076
Female head has blue-collar job	-0.188	0.034	-0.183	-0.186	0.042	-0.171
	0.106	0.119	0.108	0.106	0.119	0.107
Male head has no college education	-0.079	-0.106	0.187	-0.087	-0.125	0.170
	0.213	0.237	0.212	0.213	0.237	0.211
	-0.059	-0.141	0.155	-0.066	-0.158	0.135
Male head has some college	0.211	0.235	0.210	0.211	0.235	0.209

Male head has some grad school	-0.033	-0.299	0.115	-0.041	-0.318	0.091
	0.216	0.242	0.216	0.216	0.242	0.215
Male head went to technology school	-0.012	-0.213	0.203	-0.020	-0.226	0.189
	0.226	0.255	0.226	0.225	0.255	0.225
Female head has no college education	0.477	-0.476	0.116	0.493	-0.471	0.154
	0.251	0.263	0.246	0.251	0.262	0.245
Female head has some college	0.451	-0.481	0.096	0.464	-0.476	0.135
	0.249	0.260	0.245	0.249	0.260	0.243
Female head has some grad school	0.162	-0.586	0.104	0.177	-0.586	0.133
	0.253	0.265	0.248	0.253	0.265	0.247
Female head went to technology school	0.272	-0.633	-0.024	0.290	-0.628	0.017
	0.268	0.286	0.265	0.268	0.286	0.263
White	0.036	0.375	-0.074	0.044	0.376	-0.073
	0.241	0.291	0.249	0.241	0.290	0.248
Black	-0.184	0.286	0.235	-0.169	0.294	0.241
	0.289	0.338	0.292	0.289	0.338	0.290
Hispanic	-0.202	0.160	0.112	-0.198	0.166	0.112
	0.290	0.330	0.294	0.290	0.330	0.292
House owner	-0.189	-0.132	0.064	-0.189	-0.122	0.083
	0.081	0.092	0.087	0.081	0.092	0.087

Notes: Group 3 is the base group. The constant and city dummies are not reported.

		actual group membership			
		Full Model			
predicted group membership		1	2	3	4
	1	1151	235	741	460
	2	40	142	97	97
	3	1231	956	2805	943
	4	636	446	914	1416
		Restricted Model			
	1	1181	238	762	469
	2	41	144	101	101
	3	1189	843	2646	858
	4	647	554	1048	1488

Table A1.3
Combined Multinomial Regression Results
(coefficient in first row; asymptotic standard errors in second row)

	Full Model				Restricted Model			
	LR statistic=1443				p-value=0			
	Number of obs = 54960				Number of obs = 54960			
	Log likelihood = -55755.945				Log likelihood = -56477.933			
	Pseudo R2 = 0.0737				Pseudo R2 = 0.0617			
	1	2	3	4	1	2	3	4
Frozen sales frequency	-36.504	-21.452	-29.220	-31.152				
	5.016	2.628	4.246	1.645				
No frozen sales	0.350	0.247	0.307	0.108				
	0.067	0.051	0.059	0.031				
Refrigerated sales frequency	17.494	-1.299	16.391	12.941				
	2.574	1.368	2.204	0.736				
No refrigerated sales	0.593	0.257	0.704	0.467				
	0.059	0.047	0.053	0.030				
Midpoint of household Income	-0.002	0.005	-0.008	0.003	-0.002	0.006	-0.008	0.003
	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Household income > $100,000	-0.438	0.259	-1.239	0.016	-0.487	0.246	-1.295	-0.024
	0.237	0.151	0.246	0.098	0.236	0.150	0.245	0.097
Household size	-0.088	-0.088	-0.013	-0.056	-0.086	-0.087	-0.011	-0.054
	0.025	0.018	0.021	0.011	0.025	0.018	0.021	0.010
Presence of young Children	0.377	-0.076	0.124	-0.197	0.379	-0.070	0.126	-0.193
	0.088	0.068	0.076	0.043	0.087	0.068	0.076	0.043
Age of male head	0.002	0.002	-0.005	0.006	0.002	0.002	-0.005	0.006
	0.003	0.002	0.002	0.001	0.003	0.002	0.002	0.001
Age of female head	-0.001	-0.005	-0.002	-0.001	-0.002	-0.005	-0.002	-0.001
	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001
Male head employed full time	-0.123	0.200	-0.081	0.158	-0.097	0.222	-0.055	0.178
	0.183	0.125	0.150	0.075	0.182	0.125	0.150	0.074
Male head employed part time	-0.121	-0.003	0.108	0.168	-0.099	0.007	0.137	0.188
	0.229	0.169	0.186	0.096	0.228	0.168	0.185	0.095
Female head employed full time	-0.001	0.118	-0.147	-0.031	-0.009	0.112	-0.152	-0.037
	0.085	0.065	0.076	0.038	0.085	0.064	0.075	0.037
Female head employed part time	0.050	-0.022	-0.125	-0.098	0.047	-0.022	-0.127	-0.103
	0.112	0.085	0.098	0.050	0.112	0.084	0.098	0.049
Male head has white-collar job	0.074	-0.064	-0.031	-0.105	0.044	-0.079	-0.061	-0.125
	0.178	0.121	0.145	0.073	0.178	0.120	0.145	0.072
Male head has blue-collar Job	0.096	-0.123	-0.070	-0.112	0.072	-0.140	-0.092	-0.126
	0.182	0.123	0.148	0.074	0.182	0.123	0.147	0.073
Female head has white-collar job	-0.117	0.049	-0.027	0.111	-0.114	0.049	-0.026	0.116
	0.073	0.052	0.064	0.032	0.072	0.052	0.064	0.032
Female head has	0.048	0.007	0.169	0.096	0.044	0.011	0.162	0.104

blue-collar job	0.104	0.078	0.088	0.047	0.104	0.078	0.087	0.047
Male head has no college	-0.131	-0.303	0.449	-0.396	-0.142	-0.307	0.444	-0.382
	0.200	0.142	0.172	0.087	0.199	0.142	0.171	0.086
Male head has some College	-0.068	-0.489	0.504	-0.406	-0.081	-0.495	0.499	-0.402
	0.198	0.142	0.171	0.087	0.197	0.142	0.170	0.086
Male head has some grad school	0.016	-0.516	0.526	-0.441	0.000	-0.521	0.518	-0.440
	0.203	0.146	0.175	0.089	0.202	0.145	0.175	0.088
Male head went to technology school	0.095	-0.479	0.558	-0.455	0.066	-0.492	0.541	-0.456
	0.213	0.155	0.185	0.095	0.213	0.155	0.184	0.094
Female head has no College	-0.008	-0.366	0.475	-0.254	0.022	-0.343	0.510	-0.241
	0.218	0.148	0.203	0.093	0.218	0.148	0.202	0.092
Female head has some College	-0.092	-0.432	0.579	-0.339	-0.069	-0.414	0.607	-0.339
	0.217	0.147	0.201	0.093	0.216	0.147	0.201	0.092
Female head has some grad school	0.063	-0.546	0.697	-0.443	0.085	-0.528	0.724	-0.442
	0.219	0.149	0.204	0.094	0.219	0.149	0.203	0.093
Female head went to technology school	0.010	-0.533	0.782	-0.411	0.024	-0.517	0.807	-0.422
	0.234	0.160	0.216	0.101	0.234	0.160	0.215	0.100
White	0.734	0.210	0.268	-0.075	0.738	0.215	0.273	-0.078
	0.260	0.153	0.176	0.087	0.260	0.152	0.175	0.086
Black	-0.246	0.212	-0.514	0.169	-0.225	0.245	-0.494	0.154
	0.323	0.170	0.238	0.098	0.322	0.169	0.237	0.097
Hispanic	0.260	0.293	0.030	0.080	0.288	0.293	0.062	0.091
	0.292	0.179	0.207	0.105	0.291	0.178	0.206	0.104
House owner	0.003	-0.041	0.187	0.069	-0.016	-0.041	0.170	0.046
	0.075	0.052	0.067	0.032	0.075	0.052	0.066	0.032
	0.356	0.268	0.300	0.173	0.352	0.265	0.296	0.170

Notes: Group 5 is the base group. The city dummies and the constant are not reported.

		actual group membership				
Pred. group membership		*Full Model*				
		1	2	3	4	5
	4	46	266	34	1862	1565
	5	1871	3426	2580	11813	31497
		Restricted Model				
	4	12	180	11	874	893
	5	1905	3512	2603	12801	32169

Note: Predicted memberships are zeros for groups 1, 2, and 3.

Appendix 2
Simulation Results for the Restricted Models

Table A2.1
Simulation Results for Refrigerated Restricted Model

Group	*1*	*2*	*3*	*4*
Probability of a typical household	0.077	0.060	0.133	0.731
Age				
When age of female head is 25	0.090	0.067	0.150	0.693
When age of female head is 55	0.076	0.059	0.132	0.733
When age of male head is 25	0.081	0.062	0.133	0.724
When age of male head is 55	0.073	0.058	0.133	0.736
Household Size				
When household size is 2	0.083	0.055	0.132	0.730
When household size is 5	0.061	0.073	0.137	0.730
Household Income				
When household annual income is $30,000	0.071	0.064	0.134	0.731
When household annual income is $50,000	0.083	0.055	0.133	0.730
When household income exceeds $100,000	0.133	0.031	0.137	0.699
House ownership				
Own	0.077	0.060	0.133	0.731
Rent	0.080	0.068	0.141	0.711
Presence of young children				
Children under six years old	0.084	0.057	0.136	0.723
No children younger than six	0.077	0.060	0.133	0.731
Employment status of male head				
Full-time	0.077	0.060	0.133	0.731
Part-time	0.063	0.055	0.113	0.769
Others	0.068	0.056	0.109	0.767
Employment status of female head				
Full-time	0.077	0.060	0.133	0.731
Part-time	0.079	0.057	0.126	0.737
Others	0.073	0.051	0.128	0.748
Occupation of male head				
White-collar	0.077	0.060	0.133	0.731
Blue-collar	0.069	0.060	0.125	0.746
Others	0.075	0.067	0.146	0.712
Occupation of female head				
White-collar	0.077	0.060	0.133	0.731
Blue-collar	0.070	0.060	0.135	0.735
Others	0.081	0.056	0.129	0.733
Education of male head				
No college	0.077	0.060	0.133	0.731
College	0.073	0.056	0.123	0.747
Grad school	0.073	0.058	0.131	0.738

Technology School	0.076	0.061	0.127	0.736
No female head	0.076	0.052	0.142	0.731
Education of female head				
No college	0.077	0.060	0.133	0.731
College	0.078	0.059	0.136	0.728
Grad school	0.079	0.055	0.138	0.728
Technology School	0.074	0.052	0.139	0.736
No female head	0.050	0.071	0.103	0.776
Race				
White	0.077	0.060	0.133	0.731
Black	0.056	0.061	0.122	0.761
Hispanic	0.065	0.053	0.135	0.747
Others	0.071	0.044	0.109	0.776

Table A2.2
Simulation Results for Frozen Restricted Model

Group	1	2	3	4
The probability of a typical household	0.193	0.129	0.549	0.129
Age				
When age of female head is 25	0.202	0.131	0.534	0.133
When age of female head is 55	0.192	0.129	0.550	0.129
When age of male head is 25	0.202	0.122	0.545	0.130
When age of male head is 55	0.186	0.134	0.551	0.128
Household Size				
When household size is 2	0.211	0.121	0.545	0.123
When household size is 5	0.154	0.150	0.554	0.142
Household income				
When household annual income is $30,000	0.177	0.132	0.561	0.130
When household annual income is $50,000	0.211	0.126	0.535	0.128
When household income exceeds $100,000	0.288	0.081	0.499	0.132
House ownership				
Own	0.193	0.129	0.549	0.129
Rent	0.222	0.140	0.525	0.113
Presence of young children				
Children under six years old	0.252	0.102	0.546	0.101
No children under six	0.193	0.129	0.549	0.129
Employment status of male head				
Full-time	0.193	0.129	0.549	0.129
Part-time	0.145	0.124	0.583	0.148
Others	0.206	0.110	0.544	0.140
Employment status of female head				
Full-time	0.193	0.129	0.549	0.129
Part-time	0.188	0.117	0.543	0.152
Others	0.173	0.117	0.574	0.135
Occupation of male head				
White-collar	0.193	0.129	0.549	0.129
Blue-collar	0.192	0.118	0.567	0.123
Others	0.159	0.166	0.554	0.121
Occupation of female head				
White-collar	0.193	0.129	0.549	0.129
Blue-collar	0.188	0.134	0.544	0.134
Others	0.215	0.121	0.514	0.150
Education of male head				
No college	0.193	0.129	0.549	0.129
College	0.201	0.113	0.560	0.126
Grad school	0.200	0.120	0.545	0.135
Technology School	0.303	0.085	0.494	0.118
No female head	0.202	0.149	0.539	0.111
Education of female head				

No college	0.197	0.129	0.544	0.130
College	0.193	0.129	0.549	0.129
Grad school	0.154	0.124	0.585	0.137
Technology School	0.173	0.119	0.586	0.122
No female head	0.122	0.210	0.554	0.114
Race				
White	0.193	0.129	0.129	0.549
Black	0.156	0.119	0.177	0.549
Hispanic	0.157	0.109	0.162	0.572
Others	0.192	0.092	0.144	0.571

Table A2.3
Simulation Results for Combined Restricted Model

Group	1	2	3	4	5
The probability of a typical household	0.009	0.058	0.010	0.391	0.532
Age					
When age of female head is 25	0.009	0.066	0.010	0.392	0.522
When age of female head is 55	0.009	0.058	0.010	0.391	0.532
When age of male head is 25	0.009	0.058	0.011	0.367	0.555
When age of male head is 55	0.009	0.058	0.009	0.408	0.516
Household size					
When household size is 2	0.009	0.061	0.010	0.400	0.520
When household size is 5	0.008	0.051	0.010	0.368	0.563
Income					
When household annual income is $30,000	0.009	0.056	0.011	0.385	0.539
When household annual income is $50,000	0.008	0.061	0.009	0.399	0.523
When household income exceeds $100,000	0.006	0.064	0.004	0.358	0.568
House ownership					
Own	0.009	0.058	0.010	0.391	0.532
Rent	0.009	0.062	0.009	0.380	0.540
Presence of young children					
Children under six years old	0.014	0.058	0.012	0.346	0.570
No children under six	0.009	0.058	0.010	0.391	0.532
Employment status of male head					
Full-time	0.009	0.058	0.010	0.391	0.532
Part-time	0.009	0.047	0.012	0.397	0.534
Others	0.010	0.051	0.011	0.354	0.574
Employment status of female head					
Full-time	0.009	0.058	0.010	0.391	0.532
Part-time	0.010	0.053	0.011	0.378	0.549
Others	0.009	0.052	0.011	0.402	0.526
Occupation of male head					
White-collar	0.009	0.058	0.010	0.391	0.532
Blue-collar	0.009	0.055	0.010	0.392	0.534
Others	0.008	0.060	0.010	0.419	0.503
Occupation of female head					
White-collar	0.009	0.058	0.010	0.391	0.532
Blue-collar	0.010	0.056	0.012	0.388	0.533
Others	0.010	0.058	0.011	0.365	0.556
Education of male head					
No college	0.009	0.058	0.010	0.391	0.532
College	0.009	0.049	0.011	0.390	0.541
Grad school	0.010	0.049	0.011	0.381	0.549
Technology School	0.011	0.050	0.011	0.376	0.551
No female head	0.008	0.066	0.005	0.477	0.443

Education of female head					
No college	0.009	0.058	0.010	0.391	0.532
College	0.008	0.057	0.011	0.370	0.554
Grad school	0.010	0.053	0.013	0.347	0.577
Technology School	0.009	0.053	0.014	0.351	0.572
No female head	0.008	0.073	0.005	0.442	0.472
Race					
White	0.009	0.058	0.010	0.391	0.532
Black	0.003	0.055	0.004	0.451	0.486
Hispanic	0.005	0.059	0.007	0.432	0.496
Others	0.004	0.047	0.007	0.417	0.524