Structural Periodicity in Household Visiting Patterns

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Maintaining a strong repurchasing cycle may be not easy for households, because such routinization requires a significant amount of self-control against consumption uncertainties, external shocks and other schedule conflicts. Are households with "structural" repurchase patterns associated with better self-control, or they simply face constraints which limit their timing choices? We investigate household repurchase periodicity and its impact on product choices using scanner datasets in the Refrigerated Yogurt and Carbonated Beverage categories. Product-market level analysis shows that "structural households"—households with strong periodic purchase patterns—are associated with weaker consumer inertia and have more product switches recorded. The data is more consistent with the explanation that structural households are more variety seeking in product choices due to unobserved constraints.

Keywords: periodic purchase patterns, scanner data, heterogeneity, state dependence

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1. Introduction

In frequently purchased product markets, consumers usually need to follow certain visiting cycles to repurchase the products. For example, a weekly yogurt purchaser can revisit stores at a specific time each week. Alternatively, she can visit stores more randomly across different days in a week. Maintaining a strong periodic pattern may not be an effortless process, because consumers are subjected to possible consumption shocks, changes of product characteristics or other unpredicted external factors. However, it is not uncommon to see them with strong periodic patterns. It is possible that consumers[1] of those households face unobserved cost or time constraints, and thus have a relatively fixed repurchase time. Alternatively, households with fixed repurchase cycles may plan their week's shopping in advance and have better control over their subsequent consumption schedule. This later explanation implies that households view regulating repurchases beneficial. For example, by following a stable periodic pattern, they may organize their alternative activities better. No matter how a household manage to achieve a stronger repurchase periodicity (by fighting for a narrow window or executing a previous plan), those who practicing repurchase in such a periodic way over and over again may demonstrate different product choice patterns. How does the "structural" periodicity affect purchase behavior and brand choices? Do consumers obtain extra benefit if they follow such pattern? What are the main explanation for households to follow a strong repurchase pattern? We empirically investigate the potential behavioral effects of households' periodic purchase patterns using scanner datasets.

[1] Because our data is at the household level, the strong periodic patterns may be due to one or more purchasers of a household. We will use "household" hereafter.

A better understanding of households' (re)purchase patterns benefit business practitioners and marketing researchers. Periodicity is one of the most easily and accessible information for sellers, because repurchases happen in open public and purchase history can be collected in a less aggressive way. Such information, if proven to be predictive for purchase behavior, can be crucial for retailers and manufactures to understand the demand of individual households under an increasingly competitive packaged good markets. For researchers, the heterogeneity in consumers' state dependence can be better explained or segmented based on different repurchase structure. More importantly, the repurchase structure may contain information in variety seeking tendencies, and thus provide an empirical solution to capture such preference.

To empirically test the effects of periodic patterns on product and brand choices, the concept of "structural" periodicity is introduced and explained. Given that consumers are likely to make weekly purchases in the investigated markets; we focus on how repurchase time choices are deviated *within* a week. We provide descriptive evidence to demonstrate the correlation between the household repurchase patterns and the product switch behavior. A set of econometric models are specified in hope to verify the behavioral effect of "structural" households controlling for potential product/ brand characteristics and random effects.

Our estimation shows that in various markets (refrigerated yogurt and carbonated beverage markets in the 2005 IRI dataset, and refrigerated yogurt market in the 1987 ERIM dataset), structural households are all subjected to weaker state dependence. The magnitude of the effect is significant. Depending on markets and products, significant portions of the households (5.6% to 36.5%) with the strongest periodic revisiting patterns in the IRI datasets do not reveal inertia or even illustrate negative state dependence. The highly robust results over 20 years of period suggest

that the behavioral patterns of structural households can be fundamental to their intrinsic preference.

Why structural periodicity explains variations in state dependence in a negative way? The robust behavioral effect discovered can be both explained by theories of variety seeking and self-control. To further explain this improvement of decision making by "structural" households, we investigate the potential links using demographic survey responses as well as households' choices for low calorie and low fat items. We find that households with full work load, lower income as well as lower education levels have a stronger revisiting structure. Those correlations are largely consistent with variety seeking literature. However, it is less documented that self-control is negatively correlated with those variables. Other than reducing consumer inertia, there is no clear evidence that having a strong repurchase structure benefits the households. In contrast, "structural" households tend to choose less healthy items with higher calorie and more fat content—the opposite of what a self-control theory would predict.

Summarizing these findings, we conclude that households periodic purchase patterns have a clear predictive power on product choices. The source of the variations of the measure can be traced to the extensive literature in variety seeking behavior. Therefore, the measure of structural periodicity can be translated to practical implications for managers. For researchers, our results also send important messages: the conventional estimates of "structural" state dependence in product choices may be under-estimated, without accounting for heterogeneity in variety seeking behavior.

2. Literature

Both variety seeking and consumer inertia are well-documented phenomena in marketing literature. Such phenomena can be caused by external factors: for example, in intertemporal product/

brand choice problems, the existence of marketing campaigns may lead to both variety seeking and consumer inertia. However, researchers are more interested in intrinsic motivations causing variety seeking (McAlister and Pessemier 1982) or consumer inertia (Dube, Hitsh and Rossi 2010), because those phenomena reflect individual's fundamental preference and may carry into other decision scenarios.

When modeling intertemporal product/ brand choice problems using transaction based data, conventional choice models tend to assume that, conditional on product characteristics and conditional on households' unobserved types, households are (still) directly affected by (an arbitrary length of) previous purchases/ consumptions (Chandukala et al 2007). A positive coefficient on past purchase is interpreted as (positive) state dependence; a negative one however reflects possible variety seeking. Seetharaman et al (1999), Seetharaman (2004), and Dube et al (2010) all document strong positive state dependence effects after flexibly controlling for unobserved heterogeneity and possible product characteristics (such as price and marketing campaigns). This generally strong dominating effect of structural state dependence, however, does not negate the exist of variety seeking behavior. Although direct empirical evidence is relatively weak (Givon 1984, Bawa 1990), experimental evidence suggests that variety seeking is a robust and fundamental preference related to product switch behavior. For example, earlier studies show that motivations for variety seeking includes sensation seeking (McAlister and Pessemier, 1982, Menon and Kahn 1995) and satiation (McAlister 1982, Lattin and McAlister 1985, Fein et al 1992). More recent studies show that a sense of low personal control may also influence variety seeking tendencies (Su et al 2017, Yoon and Kim 2017).

The challenge from a managerial perspective is how to capture possible heterogeneity in variety seeking preference (or more generally, the state dependence preference) using transaction base

data. Given that each household makes weekly purchases[2], we are interested in the "structural" periodicity, which describes how well the households concentrate their repurchase times within each week. The introduced variation in cyclic visiting patterns may approximate variety seeking tendencies because the visiting patterns can be correlated with important antecedents of variety seeking. The most intuitive explanation for structural households is that they face time and other constraints, so that the "available" time slots are relatively limited. Such constraint may promote variety seeking through several channels: first, those who are constrained may face a more stagnant purchase environment and thus seek variety to fulfill their need for sensation (McAlister and Pessemier, 1982; Menon and Kahn 1995; Van Trijp, Hoyer, and Inman 1996). Second, structural households may devote more attention on the consumption of the purchased items. The increased attention may promote variety seeking (Morewedge et al., 2010, Redden & Haws, 2013, Larson et al., 2014). Third, recent research also suggests that people with constraints may seek for compensations for the lack of personal control and thus result in variety seeking behavior (Su et al 2016, Yoon and Kim 2017). If any of the arguments holds with "structural" households, then we would expect that they have reduced consumer inertia, or even reveal negative state dependence effects.

Rather than a constraint argument, however, another possible explanation for "structural" households is that they purposely choose to focus their revisiting pattern for long-term benefits. Early studies consider how myopic temptations are related to self-control (Mischel et al 1972)[3]. More recent studies demonstrate that resisting a temptation requires energy and the function of self-control resembles a muscle such that regular exertions of self-control may improve its strength (Muraven and Baumeister 2000, Baumeister et al 2006). If households with a stronger structural

[2] This assumption has been widely used in structural modeling (Erdem & Keane 1996) for nondurable experience food.

[3] Self-control or self-discipline in this paper is broadly defined as the capacity for altering one's responses for long-term goals.

periodic visiting patterns have better self-control, we expect they are better at resisting temptations from high fat and high calorie items and make more cautious product choices.

3. Data

We first investigate a recent IRI dataset[4]; and then additional estimations are provided based on an ERIM[5] dataset for robustness tests[6]. Two IRI categories from 2004 and 2005 are selected. The first involves the refrigerated yogurt category and because ERIM data also has this category, we can compare estimation results cross periods. The second one is the carbonated beverage category so that we can test if the phenomenon is market-specific or more general. Approximately 2783 households in the yogurt markets and 3583 households in the carbonated beverage market are selected into our sample, because they are frequent shoppers with visiting records in most of the weeks in a year. We collect those households' product choices in the corresponding markets, as well as product characteristics at the shopping occasions. To avoid the simultaneity problem due to the joint decisions of timing and product choices, we use the 2004 data to calculate the periodicity measure and use the measure to predict product choices in the year 2005. *Table 1* lists summary statistics of the IRI data: two top brands and their best selling products are considered in each market. In the refrigerated yogurt market, Brand Yoplait and Dannon take roughly 61% of the total market share, while Coca cola and Pepsi take about 68% of the carbonated beverage market in the sample. We list each brand's core products: they are well known to consumers and share similar price distributions.

[4] Please see Bronnenberg et al (2008) for more detail of the data.
[5] The ERIM datasets consist of household level purchase history data from year 1986 to 1988 in two mid-sized cities in US (Sioux Falls, South Dakota and Springfield, Missouri).
[6] Note that the IRI scanner datasets provide market based shopping trip information (rather than product based), so that the periodicity measure contains repurchases related to all products (See IRI Dataset Manual Version 1.5 Page 17 footnote 15, or discussions in the Appendix).

[Table 1 about Here]

Assuming households make weekly decisions, we plot the distribution of the shopping trips on each day of a week in Figure 1. While the top figure shows great dispersion at the aggregate level, at the individual (household) level, households are subjected to great heterogeneity in periodic shopping patterns. For example, the household in the center figure have similarly dispersed revisiting patterns, yet the household in the bottom figure concentrates most of the purchases on Monday and Saturday. In order to characterize such periodicity for weakly purchasers, we define the following variable, by comparing the sum of the absolute difference between an individual household i's visiting frequency and a uniform benchmark, that is,

$$struc_i \equiv \frac{7}{12}\sum_{j=1}^{7} \left|\frac{\sum_t D_{ijt}}{TD_i} - \frac{1}{7}\right|,$$

where $j \in \{1,2,\ldots,7\}$ represents each day for a week, $D_{ijt} = 1$ if household i has yogurt shopping records in week t, and $TD_i = \sum_j \sum_t D_{ijt}$ is the total number of visiting days for household i. For each day j, we compare the probability of visiting with the uniform case where the household visit each day at equal probability (1/7). The deviations are summed up and normalized to be within unit value. The measure allows us to capture the tendency for a household to focus her shopping days within each week. For example, when $struc_i = 1$, the measure suggests that households only focus on one of the seven days; when $struc_i \approx 0$, it suggests that households make their yogurt purchase trips within a week almost randomly. A possible combination for the mid-point $struc_i = 0.5$ is that households choose four out of the seven days to make grocery purchases. [7]

[Figure 1 about Here]

[7] The two examples illustrated in Figure 1 have the measure $struc_i$ equal to 0.05 and 0.50 respectively.

This measure captures the "structure" of households' revisiting pattern within each week. In an ideal setting, we hope to compare brand and product choices of households when varying only the measure of variable "struc". However, in reality, this measure may be correlated with the total visiting frequency: in the extreme case with only one shopping visit, the "struc" becomes one, since there is no variation of visiting days. To avoid the effect of total visiting days, we explore frequent purchasers with total visiting trips covering 80% of the weeks in the year 2004 (for IRI data) and year 1986 (for ERIM data). More than half of the households meet this criterion (80% in the refrigerated yogurt data and 78% in the carbonated beverage data). In addition, in the regression analysis, we directly control for the total number of shopping trips. *Figure 2* shows the distribution of the "struc" measure for the year 2004 in both IRI categories. The distributions show wide heterogeneity in terms of the repurchase structure. For example, for the yogurt sample, the structural periodicity measure ranges from 0.04 to as high as 0.93. Meanwhile, the majority of the households have relatively low structural periodicity, with the average structural periodicity level around 0.2 and standard deviation around 0.13. In the ERIM data sets, the periodicity measure is market-specific, and thus the measure is relatively higher[8].

[Figure 2 about Here]

Admittedly, there are multiple ways to measure households' purchase periodicity, and the measures also rely on the assumption of the unit of a decision period (which is one week in our case). Readers may be curious why we care about the "structural" perspective of the periodicity

[8] Figure 4 in the Appendix provides the histogram for the structural periodicity measure in the ERIM data set.

pattern defined above (the ability to focus their purchases on specific schedule *within each period*), rather than the "distributional" periodicity (the ability of maintaining regular consumption *across each period*). The later measure is likely to be affected by one's consumption preference and the persistence of the preference, which is subjected to endogeneity issues and more importantly, households in our IRI data have weekly visiting trips 80% of the time, leaving us with little variations in distributional periodicity. The structural periodicity can be more innocent and effectively reflect household visiting stableness. Therefore, we focus on buyers who have different levels of structural periodicity.

[*Table 6* about Here]

We explore the potential link between product choices and the structural periodicity measure. Previous literature concludes strong inertial effects for households in package good markets, leading to lower probability of brand switches. Because both self-control and variety seeking may lead to less consumer inertia, we examine product switches using IRI 2004 and 2005 data. To be specific, we use the 2004 data to calculate households' (structural) periodicities for visit timings and compare statistics on brand switches in 2005 at different levels of structural periodicity. We plot the average number of switches from main brands in the two IRI markets (clustered at the individual household level) and demonstrate the potential differences in *Figure 3*[9]. In the 2005 refrigerated yogurt market, there are significant increases in brand switches for the two major brands (Yoplait and Dannon). There is a similar trend in the 2005 carbonated beverage market, yet with much more noise at high periodicity levels. The switch statistics are suggestive that structural

[9] When drawing the figure, extremely structural households (top 1% and bottom 1 %) are excluded. Those households reveal great noise in product choices.

households are more likely to switch. However, switching behavior can also be affected by variations of product characteristics. In the next section, we use regression models to control for product characteristics and test the robustness of the possible correlation at both market-product level.

3. Estimation Models and Results

3.1 Model Specifications

To compare more detailed product responses, we pick well-received and commonly purchased products in different markets based on market shares. Those products are selected and summarized in *Table 1*. There are additional benefits of picking well-known products with high household exposure. First, main products suffer less from the availability issue and thus it is more appropriate to assume such products are in households' choice set for all stores and weeks. Second, due to a large number of purchases, those products have more accurate price information recorded at the different time and places. Third, households are mostly familiar with those staple products, so that learning effects are minimum. Those benefits keep us focusing on the research question and rule out additional explanations for product switches.

We use the data in year 2004 to calculate the "struc" variable and that in year 2005 to test possible differences. At the product level, the regression analysis considers full interactions of main choice determinants (the price and the state dependence dummy variable of last period choice) and two forms of household type variables (the household income and the household structural periodicity). In addition, the models also flexibly control for possible dynamic effects (the cumulative past consumption, weekly dummies). That is,

$$Y_{hjt}^{p} = 1\ if\ \left(1, Price1_{jt}, LagChoice_{ht}, struc_h, Income_h\right)\beta^{p} + \cdots$$

$$\ldots + \left(Price1_{jt}, LagChoice_{ht}\right)(struc_h, Income_h)\beta_2^{p} + X\beta_3^{p} + \cdots$$

$$\ldots + \{WK\ Dummies\} + \alpha_h + \epsilon^{p} > 0$$

In the above equation, we directly model household h's choice of the target product at store j and shopping trip t (with refrigerated yogurt or carbonated beverage purchases). $Price1_{jt}$ represents the price for the product at the corresponding time and place under investigation; $LagChoice_{ht}$ captures the state dependence effect; $struc_h$ reflects household h 's structural periodicity; Income_h is a discrete measure of household annual income. We also consider control variables including the price indices for the composite good, past experience (cumulative effects of past consumption), the squared term of past experience, total shopping trips and weekly fixed effects. The estimation data for each selected product is processed at the household-store-trip level and thus each consists an unbalanced panel. Notice that in the above product choice regression specifications, we only consider choices of refrigerated yogurt/ carbonated beverage products in real shopping trips, so that a reduction of state dependence cannot be due to consumption breaks during some weeks. Households' total shopping trips are controlled so that structural periodicity with similar shopping frequencies can be well compared. We estimate the above random effects Logit models for different target products on both frequent refrigerated yogurt and carbonated beverage purchasers who have more than 20 relevant purchases correspondingly in 2005.

Our variable of interest involves the interactive effects of structural periodicity on state dependence. If most make repurchases passively, we expect structural households are more variety seeking and are associated with reduced or even reversed state dependence. If a household with stronger structural periodicity has better self-control and makes more cautious decisions, we should also see a weaker inertia effect. The main difference between the two explanations is that households with strong self-control should also be able to resist temptations that may be harmful in the long run. Other than the state dependence effects, we are also interested in the effect structural periodicity on marginal prices. Other things being equal, if structural households face constraints, they

tend to be less or equally price sensitive, however, if structural households are more cautious about the decisions, they may be more sensitive to the target item's price.

3.2 Product Choices in the IRI Markets

Table 2 lists the random effect Logit models for each of the product-market pairs. All product-market pairs witness significantly positive state dependence effects: given previous choices, households are more likely to choose the same products. The significantly positive coefficients show that households' choices in the markets may be largely affected by habitual decision making. In the soft beverage market, the models report additional lagged effects for all products. Meanwhile, the main effects of structural periodicity do not have a clear pattern.

In order to view the interaction effects more clearly, the marginal effects of the state dependence and price at different levels of structural periodicity are shown in *Table 3* and *Table 4*. The upper panels of the tables show that the state dependence effects for structural households are (monotonically) reduced for all product-market pairs and the differences are significant in the all product-market pairs (P-value < 0.05). Depending on specific products, the impact of the coefficients varies. In our estimation sample, about 7.0% (of 618 households) in the yogurt market and 5.6% (of the 1590 households) in the carbonated beverage market are associated with high structural periodicity ("struc">=0.5). Those two numbers provide a lower bound for the households whose inertia are removed for most commonly purchased goods. The effect of structural periodicity is the strongest for the choice of Diet Coke category: 36.5% (of the 1590 households) do not reveal inertia and 9% reveal significantly negative state dependence.

Conditional on various control variables, the clear trend of the state dependence effect suggests a promising moderating effect of structural periodicity and calls for possible behavioral explana-

tions behind the phenomenon. While both self-control and variety seeking can contribute to a reduced state dependence; only variety seeking leads to negative state dependence. For the choice problem of Diet Coke, the significantly negative coefficient shows that variety seeking plays an important role. We will discuss more in the next section the potential causes of structural periodicity.

In the lower panel of *Table 3* and *Table 4*, most price coefficients have the expected signs and the statistical significance for the majority households (when structural periodicity level is smaller or equal than 0.5). In the yogurt markets, we observed an increasing trend of mean price sensitivities. Although the trend is not statically significant, the economic scale is worth noticing: the semi-elasticities are increased and even doubled (e.g. Dannon L&F) for structural households. For example, one percentage decrease of price for Dannon L&F yogurt leads to a 5.5 percent increase in the choice probability for households with low structural periodicity; yet leads to a 10.3 percentage point increase for those with higher structural periodicity. This number increases to 17.3 percentage points for the extremely structural households.

The increasing trend of marginal price is reversed for the soft beverage market. In *Table 4*, the marginal effects of price are decreasing with the structural periodicity. For example, the semi-elasticity of Coke Classic drops from -0.08 to -0.05, and further drops to -0.03 for the extremely structural households. Perhaps reader may find a decreasing marginal effect on price at higher structural periodicity level more intuitive, because those households face a narrower purchase window and such constraint makes loyal households more likely to tolerate higher price.

Compared with the carbonated beverage market, the contradicting price responses of the refrigerated yogurt market call us to consider possible fundamental market-level differences. Yogurt is usually viewed as a healthy product; and the consumption of yogurt may not generate significant

prestige value. The additional benefit consuming yogurt regularly may provide more motivation for executing self-control and the lack of prestige value makes a brand switch less painful. In contrast, the brand effects of carbonated beverages and the associated image can be considerably stronger, leading to higher willingness-to-pay in the relevant products for structural households. Therefore, self-control may play some roles in specific markets, although the improvements of price sensitivity are not all significant.

3.3 Product Choices in the ERIM Markets

The ERIM datasets are collected by A.C. Nielson from year 1986 to 1988 in two mid-sized cities in US (Sioux Falls, South Dakota and Springfield, Missouri). Again, the dataset contains the refrigerated yogurt category and we follow similar data preparation procedure as described in the data section. The data detail and summary statistics are provided in the Appendix (*Table 8* and *Table 9*). Importantly, in the ERIM dataset, the structural periodicity measure is market specific: the dataset only provides vising tours with yogurt-related purchases. We limit our sample so that households with more than 20 yogurt purchases in 1986 are selected for calculating their structural periodicity[10]. The structural periodicity calculated is more dispersed, and more than 10% house-holds have periodicity levels higher than 0.7[11]. Using the 1986 sample to calculate such measure, we estimate the product-market level choice problems as in Section 3.1.

Although at a much earlier time and over a much smaller sample, *Table 5* shows that the state dependence effects for structural households in the ERIM dataset are also monotonically reduced for all product-market pairs and the differences are significant in the first three product-market pairs (P-value < 0.05). The consistent trend suggests that such inertia reduction is associated with

[10] Note that in the IRI datasets, we select on shopping trips relating to all purchases, yet in the ERIM datasets, we only have yogurt-related shopping trips recorded. This greatly reduced our sample.
[11] See Appendix Figure 4.

fundamental preference rather than time-related shocks. The magnitude of the state dependence coefficient is significantly larger than that in the IRI sample, perhaps due to the selection requirement on heavy yogurt purchasers. Again negative state dependence is observed in one product-market pair.

The ERIM sample also witnesses increasing price sensitivities for structural households in three out of four product-market pairs--with a much larger noise. The lower panel of *Table 5* reports such phenomenon: households whose purchase periodicity is far from both boundaries are significantly affected by price. On average, the price semi-elasticities are significantly larger for the old datasets. This can be caused by limited choices and relatively low income in 1980s.

[*Table 5* about Here]

4. Discussion and Limitation

The marginal effect analysis in the previous section shows that structural households are associated with higher variety seeking tendencies. In specific markets, they seem to be also affected by self-control to some extent. Therefore, it is important to verify the main explanation behind the weakening inertia. If variety seeking really drives the structural households more, it may be due to certain characteristics that the structural households carry. In order to provide further evidence for the variety seeking explanation, we consider the determination of structural periodicity using demographic surveys provided by the IRI data. The IRI data provides us with a set of households' demographic information including household income, family size, education level and work time for both male and female heads in a household. *Table 6* reports the regression results on how demographics are related to structural periodicity for frequent yogurt and carbonated beverage purchasers. Family size is negatively correlated with structural periodicity as expected, because

the visiting trips come from multiple members have to be nosier. Moreover, households with more intensive work load are associated with higher structural periodicity[12]. This result is largely consistent with our constraint based explanation. With such constraint, it becomes reasonable that structural households have less amount of stimulation and tend to be more variety seeking in product choices (McAlister and Pessemier, 1982). Interestingly, household head's education level negatively affects structural periodicity, while household income level does not have a clear impact. Education had been documented to be positively correlated with variety seeking behavior, since higher education leads to higher optimal stimulation level (Raju 1980). Here, households with higher education have lower repurchase structure, which is positively linked to variety seeking in product choices. Yoon and Kim (2017) recently show consumers with lower social-economic status and lower perceived economic mobility seek variety to compensate their lack of personal control. It is possible that structural households with lower education and more constraints are affected by the lack of personal control in similar ways. Based on previous literatures, it seems that the unobserved constraint faced by structural households plays a critical role in explaining the effect of structural periodicity on variety seeking. Jointly with such effect, education illustrates an indirect effect on variety seeking, which is opposite to its direct effect.

Household age seems to have a weak yet positive effect on structural periodicity. This is particularly true for the retired household head. In the regression, we include a set of dummy variables for occupations, in which "retire" is a special category. Most occupation categories[13] are not statistically different from each other, while households with retired heads are associated with

[12] "fulltime" takes values from 0-4 representing whether the male and female household member work and whether they work for part time or full time.

[13] The IRI dataset defines household occupation in 12 categories, including: "Other", "Professional or technical", "Manager or administrator", "Sales", "Clerical", "Craftsman", "Operative", "Cleaning, food, health service worker", "Private household worker", "Retired", "Not employed".

stronger structural periodicity and the difference in the yogurt market is marginally significant (P-value<0.10). This time, retired household heads have no constraint from work, and can allocate their shopping times more freely. Those subsample of households are subjected to weaker overall state dependence[14]. However, the structural periodicity still has a significant effect on them: perhaps they face additional unobserved constraints other than work.

For other control variables, marriage status does not show any significantly differential effects after controlling for the household family size. Potential culture difference is recorded by the dummy variable for Hispanic households: they reveal a significantly lower structural periodicity than others.

How does self-control explain structural periodicity? In the yogurt market, it is very difficult to distinguish, considering that regular intake actually brings health benefits to households (Wertenbroch 1998). In the carbonated beverage market, another useful test can utilize differences between regular products and their diet versions. If self-control explains much of the effect, we expect structural households also choose more diet products due to health consideration. As discussed before, from the product-market level analysis, we already see that the main effect of structural periodicity is indefinite; and no evidence shows that the percentage choice of Diet Coke or Diet Pepsi has been increasing with variable "struc".[15] In *Table 7*, we show another specification of the binary choice model where households make choices between diet products and regular products. Again, we fail to see evidence that the healthier choice (of diet products) positively correlated with structural repurchase patterns. In contrast, the probability is declining (P-value < 0.01) with increasing structural periodicity and for the extremely structural households, only 34% of the

[14] The marginal effects for unemployed and retired households are listed in Table 10 in the Appendix.
[15] In one product-market pair, the coefficient of state dependence actually becomes significantly negative: a negative state dependence cannot be explained by self-control.

choices are with diet products, compared with the group average of 54%. In summary, we find a constraint based explanation more relevant across both categories and such constraint induces variety seeking preference. The constraints that structural household face generate benefits to households through a reduction of positive state dependence, and leads to more active product switches.

The findings are robust against various ways of data selection rules. Specifically, we have two truncation rules in the sample: First, when calculating structural periodicity, we require households to have certain revisits in the previous year (and thus we only select about 80% of the households). Second, we look for serious buyers who have a certain level of product consumption (i.e. 20 minimum shopping trips) in the following year, which further reduces our samples. Considering the missing survey responses, 22% of the original sample from the yogurt dataset and 44.4% from the carbonated beverage dataset are used for our calculation. We test replications of the results using less restrictions: the weakening inertia effect persist in all the product-market pairs, although the trend becomes less significant[16].

Admittedly, refrigerated yogurt and carbonated beverage only represent a small portion of households' weekly purchase. Our analysis can be extended to other categories, especially packaged goods products. Because the measure of structural periodicity is the same over these markets, we expect that our result can carry over to those related markets. Our analysis also relies on the assumption that households make weekly purchases. For those products with less frequent purchases, one may need to define the optimal period before calculating structural periodicity. There-

[16] Table 11 and Table 12 in the Appendix report marginal effects for the less truncated (The half of the threshold in the first year and a minimum of 5 shopping trips in the second year are used.) dataset where most households are included.

fore, more advanced ways of mining sequential patterns may be required for investigating structural periodicity (Agrawal and Srikant 1995, Yang et al 2012). We leave the intriguing question for future research.

5. Conclusion

In this paper, we investigate households' periodic purchase patterns in refrigerated yogurt and carbonated beverage markets. We construct a measure of periodic strength, by which, the households' purchasing behavior can be compared in a novel dimension. We hypothesize that such visit timing decisions may affect product choices through two channels. On the one hand, structural periodicity stimulates variety seeking; on the other hand, it may reflect each household's cautious timing choices. Both channels lead to a weakening consumer inertia for different reasons.

We test the effects of periodic purchase behavior by estimating product-market level choice models. After controlling for individual and time differences, we confirm negative effects on previous choices for structural households. Given that structural periodicity can be better accessed by firms, the robust result can be used for better targeting consumers with potential variety seeking needs or those with a higher probability of switch.

We next investigate the potential explanations for the reduced consumer inertia using various tests. By estimating the effect of demographics on the structural periodicity, it becomes clear that households with lower education and limited leisure time leads to higher structural periodicity. Although retired households and unemployed households are not constrained by work time, they still may face unobserved constraints and we observe the reduction in the state dependence effect for this subgroup of people. By investigating how households choose between diet products or their regular version, we further conclude that the effect of self-control is quite limited in the carbonated beverage market. This result helps us to better understand the motivation behind structural

periodicity in different markets. In market with “vice” products (Wertenbroch 1998), we expect the effect of structural periodicity captures mainly households’ unobserved constraints.

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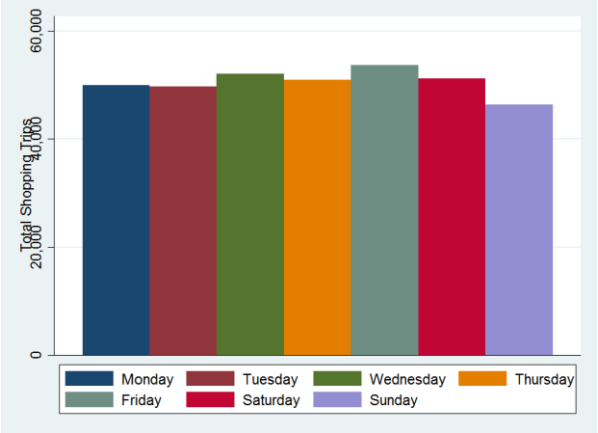
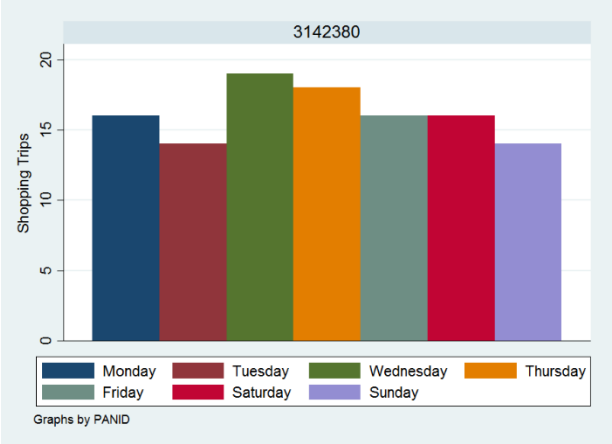
Table 1 Descriptive Statistics in IRI Markets

IRI MKT	Brand	Product	Share	Price	Std.Dev.
Yogurt	Yoplait	Yoplait Orig	13.5	1.57926	0.30965
		Yoplait Light	11.8	1.53388	0.30557
		Others	9.97	2.06631	0.53688
	Dannon	Dannon L&F	10.39	1.56058	0.35565
		Others	14.93	1.80133	0.54836
Bever-age	Coca Cola	Coke Classic	8.38	4.86058	2.49419
		Diet Coke	7.85	5.09427	2.63615
		Others	18.11	4.75103	2.25686
	Pepsi	Pepsi	6.98	4.67532	2.41698
		Diet Pepsi	6.08	5.0825	2.64769
		Others	20.17	4.86211	2.25988

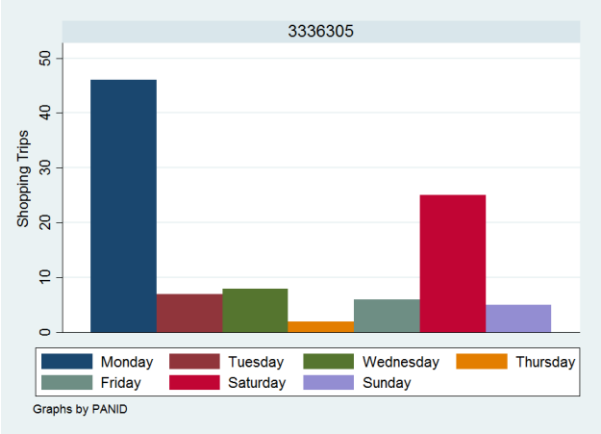
Figure 1 Examples of Periodic Purchase Patterns



A: Aggregate Counts of Visiting Day Choices

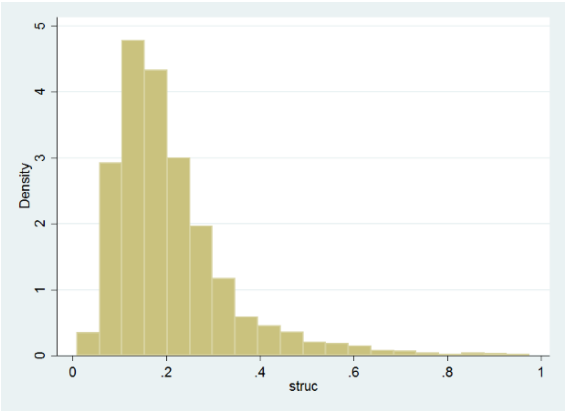


B: Individual Choices of Visiting Days

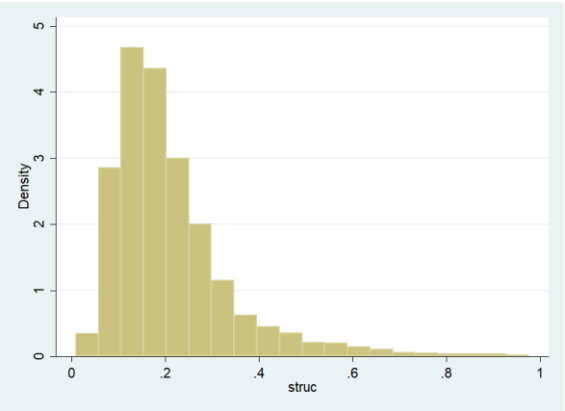


C: Individual Choices of Visiting Days

Figure 2 Histogram for Variable "struc" in Yogurt and Coke Markets



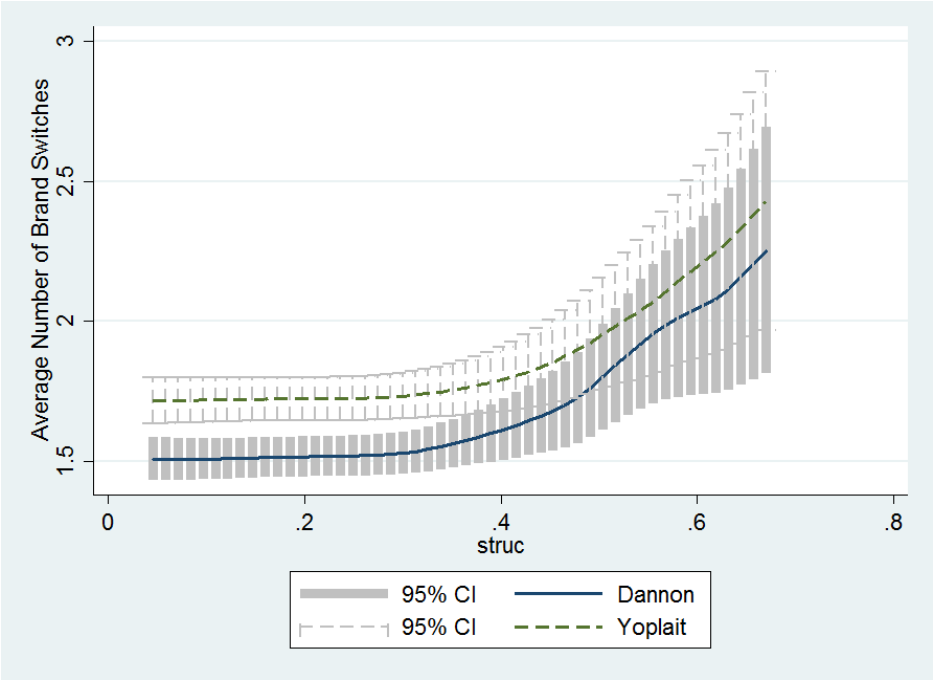
Refrigerated Yogurt Market



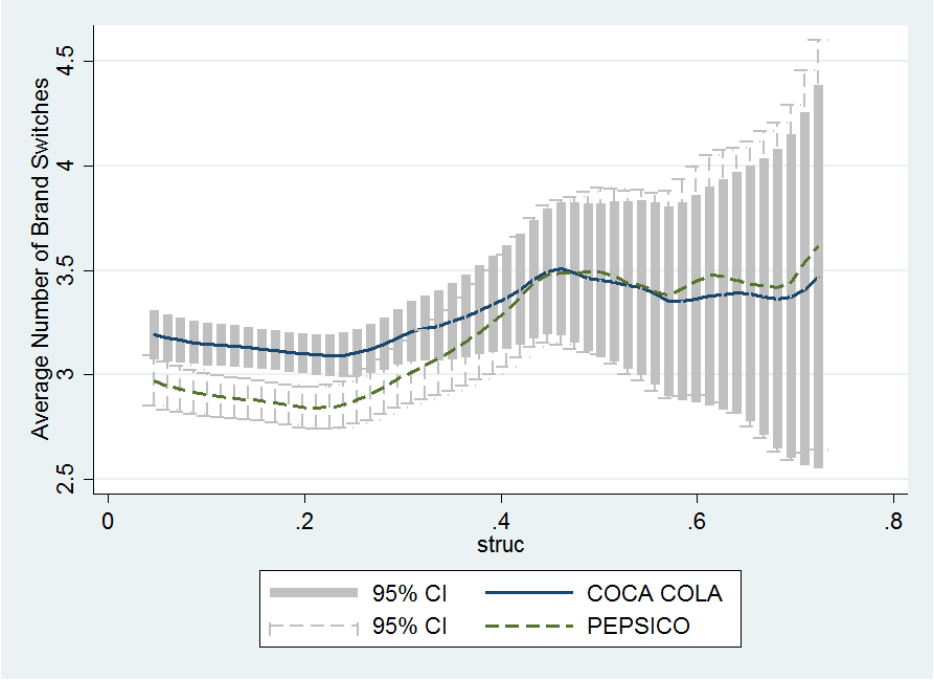
Carbonated Beverage Market

Note: “struc” represents structural periodicity introduced in the data section.

Figure 3 Product Switches and Periodic Shopping Patterns



A: IRI Refrigerated yogurt Market 2005



B: IRI Soft Beverage Market 2005

Table 2 Product Level Choice - Random Effects Logit Model (Coefficients Shown)

	Refrigerated Yogurt			Carbonated Beverage			
	DN L&F	YPLT ORIG	YPLT LIGHT	Coke Classic	Diet Coke	Pepsi	Diet Pepsi
lagC	0.830***	0.923***	0.574***	0.326***	0.383***	0.293***	0.294***
	(0.130)	(0.119)	(0.126)	(0.0713)	(0.0795)	(0.0777)	(0.0777)
price1	-2.787***	-5.004***	-6.166***	-0.209***	-0.111**	-0.187***	-0.180***
	(0.532)	(0.545)	(0.602)	(0.0336)	(0.0353)	(0.0382)	(0.0345)
price0	3.089***	2.151*	4.182***	0.340***	0.0397	0.201**	0.198*
	(0.922)	(0.928)	(1.096)	(0.0741)	(0.0858)	(0.0763)	(0.0776)
struc	3.714	-1.630	1.221	2.855	-3.774*	2.464	3.012
	(2.600)	(2.562)	(2.723)	(1.599)	(1.878)	(1.636)	(1.637)
inc	0.00140	0.0799	0.0779	0.209**	0.325***	0.0846	0.0959
	(0.151)	(0.145)	(0.155)	(0.0666)	(0.0746)	(0.0734)	(0.0727)
lagC* struc	-1.350**	-1.306**	-0.441	-0.591	-1.147***	-0.178	-0.181
	(0.457)	(0.416)	(0.431)	(0.312)	(0.341)	(0.307)	(0.307)
lagC* inc	0.0741**	-0.00555	0.0431	-0.0123	-0.0660***	-0.0336*	-0.0337*
	(0.0273)	(0.0251)	(0.0266)	(0.0143)	(0.0154)	(0.0157)	(0.0157)
price1*struc	-3.731*	-1.290	0.0458	-0.0968	-0.263	-0.0885	-0.108
	(1.731)	(1.730)	(1.840)	(0.139)	(0.153)	(0.153)	(0.140)
price1*inc	0.226*	0.174	0.315**	-0.000796	-0.00611	0.0145	0.00449
	(0.108)	(0.113)	(0.122)	(0.00656)	(0.00651)	(0.00755)	(0.00675)
price0*struc	-1.708	6.199	-1.381	-0.893**	0.610	-0.509	-0.591
	(3.259)	(3.467)	(3.888)	(0.334)	(0.396)	(0.330)	(0.333)
price0*inc	-0.216	-0.269	-0.425	-0.0404**	-0.0171	-0.0395**	-0.0326*
	(0.195)	(0.196)	(0.227)	(0.0140)	(0.0156)	(0.0149)	(0.0151)
exp	-0.00842	0.0559	0.0553	0.00232	0.0553***	0.0542***	0.0523***
	(0.0342)	(0.0300)	(0.0308)	(0.0154)	(0.0154)	(0.0158)	(0.0158)
exp_sq	-0.000148	-0.00143	-0.00180	-0.000216	-0.00215***	-0.00180***	-0.00172***
	(0.00124)	(0.000984)	(0.000940)	(0.000456)	(0.000445)	(0.000440)	(0.000441)
tvisits	-0.00155	0.00405	0.00569	0.000628	-0.000456	0.00262	0.00278
	(0.00303)	(0.00274)	(0.00312)	(0.00166)	(0.00192)	(0.00173)	(0.00173)
constant	-3.957***	-2.488**	-2.021*	-3.776***	-2.608***	-3.472***	-3.407***
	(0.878)	(0.852)	(0.897)	(0.457)	(0.516)	(0.481)	(0.480)
WK fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clusters	618	618	618	1590	1590	1590	1590
N	16874	16874	16874	46176	46176	46176	46176

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 Product Level Choice in IRI Refrigerated yogurt Market (2005)- Random Effects Logit Model with Continuous Measure of Household Periodic Structure (Marginal Effects Shown)

	DANNON LIGHT N FIT	YOPLAIT ORIGINAL	YOPLAIT LIGHT
LagChoice			
struc=0	0.0382***	0.0486***	0.0231**
	(0.0108)	(0.0113)	(0.00741)
struc=0.5	0.00715	0.0184	0.0154*
	(0.00667)	(0.0104)	(0.00752)
struc=1	-0.0204	-0.0334	0.00649
	(0.0172)	(0.0301)	(0.0166)
Price1			
struc=0	-0.0950***	-0.209***	-0.210***
	(0.0266)	(0.0432)	(0.0453)
struc=0.5	-0.182***	-0.359***	-0.238***
	(0.0492)	(0.0781)	(0.0630)
struc=1	-0.311	-0.595*	-0.270
	(0.190)	(0.262)	(0.168)
Clusters	618	618	618
N	16874	16874	16874

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4 Product Level Choice in IRI Soft Beverage Market (2005)- Random Effects Logit Model with Continuous Measure of Household Periodic Structure (Marginal Effects Shown)

	COKE CLASSIC	DIET COKE	PEPSI	DIET PEPSI
LagChoice				
struc=0	0.0260***	0.0197**	0.0129***	0.0127***
	(0.00676)	(0.00609)	(0.00388)	(0.00383)
struc=0.5	0.000937	-0.00495*	0.00748	0.00767
	(0.00346)	(0.00207)	(0.00401)	(0.00407)
struc=1	-0.00349	-0.00408	0.00359	0.00396
	(0.00337)	(0.00221)	(0.00774)	(0.00809)
Price1				
struc=0	-0.0154***	-0.00682**	-0.00761***	-0.00725***
	(0.00290)	(0.00219)	(0.00171)	(0.00155)
struc=0.5	-0.00837***	-0.00486***	-0.00796***	-0.00806***
	(0.00202)	(0.00138)	(0.00212)	(0.00204)
struc=1	-0.00442	-0.00240	-0.00819	-0.00875
	(0.00245)	(0.00143)	(0.00479)	(0.00484)
Clusters	1590	1590	1590	1590
N	46176	46176	46176	46176

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5 Product Level Choice in ERIM Markets (1987)- Random Effects Logit Model with Continuous Measure of Household Periodic Structure (Marginal Effects Shown)

	Sioux Falls		Springfield	
	YPLT ORIG	DN LF FOB	YPLT ORIG	DN LF FOB
LagChoice				
struc=0	0.202**	0.163+	0.113	0.300**
	(0.0649)	(0.0889)	(0.0763)	(0.102)
struc=0.5	0.0667*	0.0570*	0.0210	0.251***
	(0.0292)	(0.0274)	(0.0165)	(0.0466)
struc=1	0.00104	-0.0107	-0.102+	0.183163+
	(0.0315)	(0.0347)	(0.0616)	(0.0955)
Price1				
struc=0	-0.887**	-0.172	-0.0463	-0.240
	(0.274)	(0.152)	(0.0544)	(0.240)
struc=0.5	-0.366**	-0.387*	-0.173*	-0.562**
	(0.127)	(0.154)	(0.0687)	(0.183)
struc=1	-0.0263	-0.697	-0.583	-0.970+
	(0.190)	(0.507)	(0.411)	(0.560)
Clusters	91	91	61	61
N	3411	3411	2477	2477

Standard errors in parentheses
+ P<0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 6 Structural Periodicity and Household Demographics

	Frequent Refrigerated yogurt Purchasers	Frequent Carbonated beverage Purchasers
familysize	-0.00874	-0.00687*
	(0.00570)	(0.00331)
hh_age	0.00281	0.00799+
	(0.00654)	(0.00430)
hh_edu	-0.0122*	-0.00887**
	(0.00496)	(0.00291)
pretaxincome	0.00140	0.000653
	(0.00298)	(0.00183)
fulltime	0.0238**	0.0121**
	(0.00714)	(0.00422)
total visits	-0.00763***	-0.00680***
	(0.00177)	(0.00109)
constant	0.420***	0.453***
	(0.0936)	(0.0678)
occupation	Yes	Yes
marital stat	Yes	Yes
race	Yes	Yes
N	618	1578

Standard errors in parentheses
$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7 Probability of Choosing Diet Products

Prob of Choosing Diet Product	
struc=0	0.599***
	(0.0301)
struc=0.5	0.455***
	(0.0429)
struc=1	0.340***
	(0.0898)
N	18688

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix

A. ERIM Data Summary

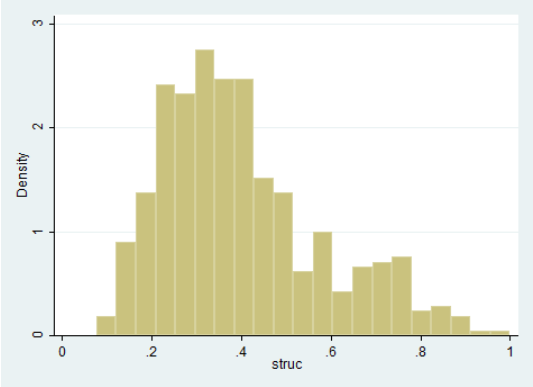
The ERIM dataset is collected by A.C. Nielson. The ERIM datasets consist of household level purchase history data from year 1986 to 1988 in two mid-sized cities in US (Sioux Falls, South Dakota and Springfield, Missouri). Approximately 1400 households (households who have more than 10 shopping trips over around 138 weeks) are selected into our sample. There is data on households' product choices, product characteristics in different categories (Ketchup, Dry Detergents, Canned Soup and Yogurt) as well as the household demographic information. Moreover, the shopping trip information can be used to describe households' periodic purchase patterns. We focus on the Yogurt category where the storage problem may be the weakest due to the products' high storage cost and short expiration date. *Table 8* provides us with brand level descriptive statistics.[17] Compared with Springfield, Sioux Falls has witnessed two local brands with significant market share (30.51%) and yet lower prices. Moreover, the two markets are also different in the dominant brands. In Sioux Falls, the local brand Nordica has slightly higher market share, compared with Yoplait and Dannon, while households seem to purchase Dannon much more frequently in Springfield. The histogram of the structural periodicity measure is provided in *Figure 4* and product level descriptive statistics are listed in *Table 9*. We discuss the estimation results on the ERIM dataset in the main text and list the results in *Table 5*.

[17] The brand abbreviations YPLT is for Yoplait; WW for Weight Watcher; DN for Dannon; NDC for Nordica; WBB for Well's Blue Bunny; CTL for CTL.

Table 8 ERIM: Descriptive Statistics: Brand Level

	Sioux Falls				Springfield		
Brand	Share	Price	Std. Dev.	Brand	Share	Price	Std. Dev.
YPLT	18.29%	0.58	0.11	YPLT	12.80%	0.64	0.12
WW	6.76%	0.45	0.04	WW	5.46%	0.46	0.07
DN	15.61%	0.44	0.07	DN	44.96%	0.43	0.10
NDC	19.35%	0.37	0.07	CTL	13.30%	0.28	0.09
WBB	10.60%	0.28	0.05	OTHR	23.48%	0.23	0.06
CTL	16.22%	0.27	0.03				
OTHR	13.17%	0.30	0.09				

Figure 4 ERIM: Histogram for Variable "struc"



Structural Periodicity in Yogurt Purchases (1986 Data)

Table 9 ERIM Descriptive Statistics: Product Level

	Yogurt Market: Yoplait ORIG		Yogurt Market: Dannon LF	
	Sioux Falls	Spring-field	Sioux Falls	Spring-field
Price	.567	.621	.445	.423
Std. Dev.	.090	0.093	.065	.096
Market Share	13.79%	5.89%	9.91%	24.18%
Shopping Trips	4173	1334	2920	4098

B. Robustness Test

Table 10 Product Level Choice in IRI Refrigerated Yogurt Market (2005)- Random Effects Logit Model (Marginal Effects Shown, Households with no Work)

	DN L&F	YPLT ORIG	YPLT LIGHT
LagChoice			
struc=0	0.0309+	0.0452*	0.0178
	(0.0183)	(0.0202)	(0.0123)
struc=0.5	-0.00727	0.000829	0.00560
	(0.0109)	(0.0146)	(0.0136)
struc=1	-0.0364	-0.0568	-0.0190
	(0.0441)	(0.0577)	(0.0446)
Price1			
struc=0	-0.0978	-0.304**	-0.161*
	(0.0502)	(0.0986)	(0.0700)
struc=0.5	-0.171*	-0.290*	-0.304*
	(0.0866)	(0.118)	(0.144)
struc=1	-0.285	-0.264	-0.529
	(0.328)	(0.283)	(0.512)
Clusters	183	183	183
N	5140	5140	5140

Standard errors in parentheses
+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 11 Product Level Choice in IRI Yogurt Market--Robustness Test

	DANNON LIGHT N FIT	YOPLAIT ORIGINAL	YOPLAIT LIGHT
LagChoice			
struc=0	0.0381***	0.0479***	0.0308***
	(0.00729)	(0.00799)	(0.00640)
struc=0.5	0.0226**	0.0305***	0.0200***
	(0.00736)	(0.00821)	(0.00607)
struc=1	0.00833	0.0154	0.0121
	(0.0156)	(0.0164)	(0.0112)
Price1			
struc=0	-0.162***	-0.282***	-0.278***
	(0.0226)	(0.0324)	(0.0334)
struc=0.5	-0.221***	-0.297***	-0.206***
	(0.0344)	(0.0431)	(0.0352)
struc=1	-0.291**	-0.314**	-0.151*
	(0.105)	(0.109)	(0.0660)
Clusters	2502	2502	2502
N	36295	36295	36295

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 12 Product Level Choice in IRI Carbonated beverage Market--Robustness Test

	COKE CLASSIC	DIET COKE	PEPSI	DIET PEPSI
LagChoice				
struc=0	0.0182***	0.0161***	0.00986**	0.00978**
	(0.00501)	(0.00453)	(0.00312)	(0.00308)
struc=0.5	0.00415	-0.00312	0.00977**	0.0101**
	(0.00373)	(0.00181)	(0.00357)	(0.00362)
struc=1	-0.000744	-0.00366*	0.00970	0.0105
	(0.00446)	(0.00175)	(0.00756)	(0.00801)
Price1				
struc=0	-0.0175***	-0.00788***	-0.00959***	-0.00690***
	(0.00241)	(0.00181)	(0.00156)	(0.00133)
struc=0.5	-0.0105***	-0.00530***	-0.00838***	-0.00671***
	(0.00202)	(0.00122)	(0.00179)	(0.00161)
struc=1	-0.00620*	-0.00282*	-0.00752*	-0.00670
	(0.00281)	(0.00134)	(0.00374)	(0.00354)
Clusters	3253	3253	3253	3253
N	64294	64294	64294	64294

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$