The Impact of Package Size on Consumption

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Abstract

Using consumer panel data we explore the impact of food package size on food-at-home consumption. We exploit food manufacturer package downsizing strategy to track shifts in household purchase volume before and after package size changes. Focusing on shelf-stable tuna and peanut butter markets, we design a difference-in-difference analysis to compare the changes in purchase volume of products that are affected by package downsizing (treatment group) to the changes in purchase volume of products that are not affected by package downsizing (control group). Our main finding is that on average smaller package size significantly reduced household purchase volume in both product categories. This result implies that package size is positively correlated with food–at–home consumption, which is consistent with results of the experimental studies showing that larger package sizes leads to higher usage volume compared with smaller package sizes.

Keywords: consumer behavior, food consumption, package size, package downsizing, difference–in–difference

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1 Introduction

The heightened prevalence of obesity in most developed countries has raised much interest in examining the effects of marketing activities on food consumption. This interest has led to a surge in experimental work focusing on evaluating the impact of food portion and package sizes on consumption. Food portion size has been singled out as one of the primary causes of higher obesity rates in the United States (Young and Nestle, 2002). Closely linked to this, food package size is considered to be one of the important environmental cues that affects consumers' food-at-home consumption (e.g., Chandon 2013). For example, the Centers for Disease Control and Prevention (2012) advise that consumers should be aware of large packages in avoiding portion size pitfalls for healthy eating. This research provides new evidence on the extent to which package size affects food-at-home consumption using a novel approach. In our analysis, we take advantage of manufacturer package-downsizing strategy to examine household response in a market environment.

Package downsizing refers to the manufacturer strategy of introducing a new smaller size that replaces the old larger size. In recent years, a large number of leading producers in the U.S. packaged food market downsized their products primarily due to the increased costs of raw material inputs. For example, in 2007 General Mills downsized its Cheerios boxes from 10 oz., 15 oz., and 20 oz. to 8.9 oz., 14 oz., and 18 oz., respectively. Similarly, in 2008 leading ice cream brands Breyers and Edy's downsized their products from 16 oz. to 14 oz. and from 56 oz. to 48 oz. All of the canned tuna brands downsized their products from 6 oz. to 5 oz. This trend provides a unique opportunity to analyze the impact of a plausibly exogenous marketing strategy on household shopping behavior. We estimate the impact of package downsizing on household purchase volume using household scanner data for a period of seven years, 2004–2010.

Our study is important for at least two reasons. First, we provide new evidence on how package size affects food consumption based on household choices in the marketplace. The extant literature on the effects of package size on consumption primarily uses experimental methods. These studies have greatly improved our understanding of the impacts of food portion and package sizes on consumption,

however they are not without their limitations. For example, experiments are typically designed to measure consumption for a package or portion size in a single, given meal, and thus ignore the effects on food consumption over time (see Chandon, 2013 for a review). Another limitation is that the experiments typically disregard food purchase behavior, which precedes consumption; thus, these experiments ignore the role of product price or promotion that influence purchase behavior. We overcome these limitations by using market data.

Second, we are able to exploit package downsizing as a plausibly exogenous shock allowing us to track shifts in the food purchase volume of households. This is particularly important, as policy makers have proposed legal restrictions on food package size as an instrument in fighting overconsumption. However, there is no evidence on the efficacy of such a policy. The estimates from our econometric model can be used to simulate the effects of a policy on food package size in a market environment.

The remainder of the paper proceeds as follows. Section 2 provides a brief discussion of previous literature on the effects of portion and package sizes on consumption. Section 3 presents package downsizing in the U.S. shelf stable tuna and peanut butter markets. Section 4 lays out our empirical strategy for identifying the impact of package downsizing on food consumption. Section 5 describes the data and provides descriptive analysis. Section 6 reports the econometric results and the last section concludes.

2 Background

Research on the effects of portion and package size on consumption generally predicts that larger portion or package sizes lead to increased food consumption, thereby increasing caloric intake (Ello-Martin, Ledikwe, and Rolls, 2005). For example, in an experimental study Rolls, Morris and Roe (2002) offered macaroni and cheese to the participants in different portion sizes. They found that participants consumed 30% more energy when they were given 1,000-gram portions compared to 500-gram portions. In another study Wansink, Painter and North (2005) provided some participants with unlimited refills of tomato soup. They found that people ate 73% more soup when it was served in

bowls with unlimited refills compared to normal bowls.

A few studies focused on the effects of package size on food consumption and found similar results. For example, Rolls et al. (2004) served potato chips to participants in five different package sizes on five separate days. They showed that subjects consumed significantly more potato chips as the package size increased. In a similar study Wansink (1996) provided participants with spaghetti and oil and asked how much of the products they would use if they were to cook for two adults. Participants were given the same amount of spaghetti and oil but in a small or large package size. The study found that participants used more spaghetti and oil when products were in larger package sizes.

An important reason why large sizes lead to increased food consumption is that consumers size perceptions are biased. Chandon and Wansink (2007b) found that consumers underestimate actual meal size as the size of the meal increases. Similarly, research on consumer visual biases of size and shape effects found that consumers' size perceptions are inelastic and that they underestimate size changes of objects (Krishna, 2006; Raghubir and Krishna, 1999). The underestimation of actual size is aggravated when objects, i.e., packages or serving containers, change in multiple dimensions as compared to one dimensional changes (Chandon and Ordabayeva, 2009). These findings are also supported by empirical work using market data. In a recent study, Çakır and Balagtas (2013) investigated the causes of manufacturers' package downsizing strategy and analyzed whether consumers have differential sensitivity to equivalent price and package size changes, i.e., the resulting unit price from changing price or package size will be the same. They estimated price and package size elasticities of half gallon ice cream using scanner data and found that consumers are less sensitive to package size changes than to price changes.

Price is another important factor that effects consumers' response to food portion and package size. Typically, marketers offer quantity discounts on large sizes. That is, larger size products are typically cheaper on a per unit basis than small size products. Research shows that quantity discounts can accelerate consumption (Wansink, 1996). Furthermore, quantity discounts and price promotions can lead to stockpiling which could also accelerate consumption (Chan, Narasimhan, and Zhang, 2008; Neslin and Van Heerde, 2008).

In sum, the experimental literature has shown that consumers eat more from large portion and package sizes than small portion and package sizes, respectively. The important reasons why large sizes increase consumption include the effects of consumers' biased perceptions and product price. One limitation of the previous research is that studies primarily focus on short term effects. However, the impact of portion and package size on consumption over longer time horizons may be important, especially with respect to health concerns. For example, consumer response can diminish over time if they are repeatedly served large packages/portions. Similarly, consumers can compensate a large portion by eating smaller portions in subsequent meals. In other words, habituation and compensation can take place over longer time periods and these behaviors could offset short term effects (Chandon, 2013). Furthermore, previous research typically overlooks food purchase behavior. Because consumers purchase food prior to its consumption, factors that impact purchase behavior, such as price, promotion and availability of close competitors, need to be accounted for in order to identify the effect of package/portion size on consumption. In our study, we overcome these limitations by using Nielsen Homescan household panel data. We focus on purchases of shelf-stable tuna and peanut butter products between 2004 and 2010 and take advantage of manufacturers' downsizing strategy in order to track shifts in household purchase volume before and after package size changes.

3 The U.S. Shelf Stable Tuna and Peanut Butter Markets

3.1 Market structure and the degree of downsizing

We use the Nielsen homescan dataset between 2004 and 2010 to analyze the shelf-stable tuna (henceforth, tuna) and peanut butter (henceforth, PB) markets. The tuna and PB markets in the United States are highly concentrated oligopolistic markets. Figure 1 presents the volume share of major manufacturers in each market. In both markets the the top three nationally branded tuna manufacturers hold over 70 percent of the total volume of the market. Other national brands have low national market shares, but the total store brand shares are significant as well with over 20 percent of each market.

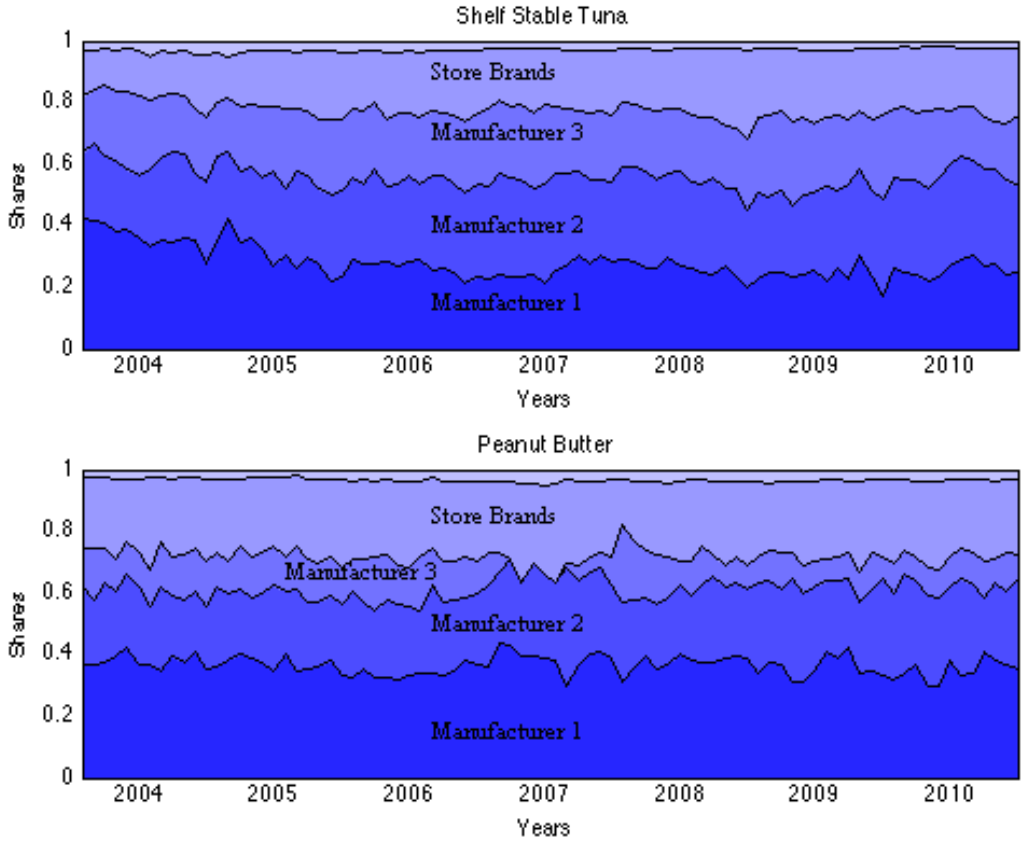

Figure 1: Volume (ounces sold) market shares by manufacturers

Package downsizing in both markets is common. In the tuna market, brands downsized from 6 oz. and 6.5 oz. packages to 5 ounces starting in 2006. At the beginning of the study period the total volume sales of 6 oz. tuna was approximately 80 percent of the market. By 2010, 5 oz. tuna products became the norm size, comprising approximately 75 percent of the market.

Unlike tuna, there does not exist a single norm size for peanut butter. Approximately 80 percent of the PB sales are in 18 oz., 28oz., and 40oz. packages. Most of the top brands have all three popular sizes in their product lines. In 2008, manufacturers 2 and 3 downsized their 18 oz. packages to 16.3 ounces. However, manufacturer 1 and the top store brands did not downsize any of their products. In 2010, the volume sales of downsized packages was approximately 20 percent of the total market.

The tuna and PB markets exhibit desirable characteristics for our research purposes. First, the degree of

downsizing measured as the volume share of downsized products in total market volume is different between the markets. This is important because the impact of downsizing on the category purchase volume could impact how easily consumers can switch away from downsized products. A high degree of downsizing in a product category could imply less availability of non–downsized competing products. In our study, the tuna and PB markets display variation in the degree of downsizing. Figure 2 presents purchase volume shares of the downsized products in both product categories. The shares of downsized products in the tuna and PB markets are more than 80 and 20 percent, respectively. In the tuna market the volume share of non–downsized products has significantly increased by about 10 percent in the post–downsizing period. Whereas in the PB market the share of non–downsized products has stayed relatively stable in the pre– and post–downsizing periods.

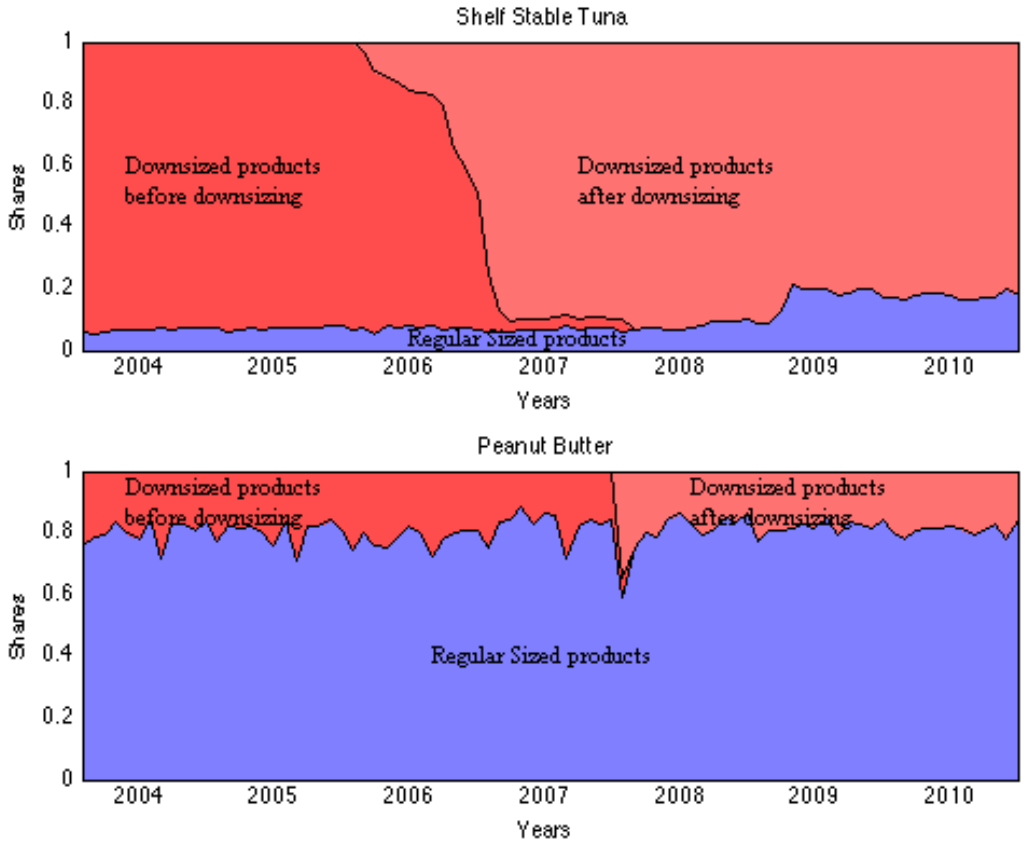

Figure 2: Volume (ounces sold) market shares by package size

A second useful feature is that tuna and PB products represent two different examples of the

interrelationship between package size, serving size and consumption. The impact of downsizing on purchase can be different for the products that are served and consumed differently. On one hand, a regular PB product is designed to include multiple servings and be consumed intermittently. Also, a PB serving size does not necessarily depend on the package size. For example, consumers who regularly prepare PB sandwiches can easily maintain the same amount of PB spread on their sandwiches even after the package downsizing. On the other hand, a regular tuna product is not designed to be used intermittently; in most cases the package size is equal to the serving size. For example, consumers who regularly prepare tuna sandwiches will find it difficult to maintain using 6 oz. of tuna on a sandwich after the package downsizing.

Finally, a unique feature of the downsizing in the tuna and PB markets plays a key role in facilitating our research design. We observe that both tuna and PB brands are sold in multiple package sizes. However, the manufacturers downsize the products in only one of the size categories. In the section that follows, we will discuss how we exploit this observation in designing our difference–in–difference analysis.

3.2 Purchase volume and price trends

In table 1 we report annual average per-household purchases, in terms of volume (ounces) and number of packages, and expenditure for both tuna and PB. The trends show that household purchase volume of tuna has decreased considerably after the downsizing events, while household expenditure increased. At the beginning of the study period the average annual household purchase volume of tuna was 98 oz., or approximately 12.5 packages. From 2004 to 2006 average purchase volume fell by about one package corresponding to an approximately 7-ounce decrease. Starting from 2007, which is the period after downsizing, we observe a different trend. In this period the purchase volume fell by approximately 10 percent, in spite of an increase in the number of packages of 1.3 units and an increase in average expenditure of 14 percent. These trends imply that on average the unit price of tuna has increased proportionately more than its package price, providing some evidence that downsizing has effectively increased the unit price. The corresponding purchase trends for peanut butter are different. Households'

peanut butter purchases both in terms of the average volume and number packages has increased by approximately 3 percent; whereas average expenditure has increased by approximately 15 percent.

Table 1: Annual Household Purchase Volume and Expenditure

Shelf-Stable Tuna				
	Number of Households	Purchase		Expenditure
		(Ounces)	(Packages)	(Dollars)
2004	17991	98.8945	12.4935	11.2939
2005	17169	96.1739	12.2273	11.5209
2006	16440	91.7768	11.6103	11.6678
2007	21244	90.0452	11.2993	11.6721
2008	20247	86.3954	10.7632	12.4744
2009	20128	80.6059	11.8592	13.9309
2010	20077	81.3869	12.6045	13.3363
Peanut Butter				
	Number of Households	Purchase		Expenditure
		(Ounces)	(Packages)	(Dollars)
2004	18089	121.1092	4.8782	10.3969
2005	17680	120.8165	4.9571	10.0173
2006	16991	119.4237	4.9956	10.1499
2007	22497	122.9074	4.8402	10.8493
2008	21827	123.9924	4.9333	12.0001
2009	21607	128.5546	5.0643	12.6093
2010	21391	125.4528	5.0408	11.9890

Note: The first year of in which downsizing is observed is highlighted in bold.

In table 2 we compare average price per ounce and price per package of downsized brands before and after the downsizing event. After downsizing the increase in price per ounce of all brands is considerably higher than the increase in price per package. For tuna brands (both national and store) the price per ounce has increased between 27 and 33 percent, whereas the price per package has increased between 15 and 21 percent. Similarly, for PB brands the comparable changes are between10 and 20 percent and 5 and 9 percent, respectively. These trends provide evidence that manufacturers used downsizing as a hidden price increase.

Table 2: Per Unit and Per Package Prices of Downsized Products Before and After Downsizing

Shelf-Stable Tuna						
	Price Per Ounce			Price Per Package		
	Before	After	Percent Change	Before	After	Percent Change
National Brand 1	0.1363	0.1780	30.5845	0.8180	0.9587	17.2071
National Brand 2	0.1565	0.1998	27.7132	0.9388	1.0848	15.5578
National Brand 3	0.1309	0.1747	33.4701	0.7852	0.9536	21.4370
Store Brand 1	0.0958	0.1280	33.6792	0.5747	0.6837	18.9713
Store Brand 2	0.0982	0.1265	28.8570	0.5952	0.6950	16.7607
Store Brand 3	0.0915	0.1184	29.4400	0.5771	0.6556	13.5972
All other SB	0.1214	0.1532	26.2428	0.7315	0.8542	16.7726
All other NB	0.1572	0.2036	29.5454	0.9535	1.1452	20.1061
Peanut Butter						
	Price Per Ounce			Price Per Package		
	Before	After	Percent Change	Before	After	Percent Change
National Brand 1	0.1030	0.1228	19.2801	1.8536	2.0144	8.6759
National Brand 2	0.1159	0.1359	17.2572	1.8890	2.0488	8.4611
National Brand 3	0.0975	0.1070	9.8292	1.7543	1.8469	5.2790
National Brand 4	0.0986	0.1117	13.2441	1.7362	1.8942	9.0985

Note: "Before" and "After" denote the Pre- and Post-Downsizing periods.

On one hand, the data suggests that package downsizing is very common in the tuna market, and provide some evidence that the household purchase volume might have decreased due to downsizing. On the other hand, package downsizing is less common in the PB market, and there is no evidence to suggest that downsizing impacted the purchase volume. We now turn to our empirical analysis which allows us to control for the effects of household, product and time specific confounding factors. We perform a difference–in–difference analysis to evaluate the impact of package size on purchase volume.

4 Empirical Strategy

We investigate the impact of food package size on consumption by exploiting the package downsizing strategy of manufacturers. Our goal is to estimate the impact of package downsizing (i.e., the treatment) on household purchase volume (i.e., the outcome). To achieve this goal, our empirical strategy is to compare purchase volume of products, which we define below, that are affected by package downsizing

(treatment group, g=1) to the changes in purchase volume of products, which are in the same product category, but, are not affected by package downsizing (control group, g=0). This comparison takes a form of a difference–in–difference (DD) analysis. Formally, let v_{ijt} denote household i's purchase volume of a product j in month t. Also, let t_c^* denote the month in which package downsizing is observed in city c. The unconditional average treatment effect is estimated as:

$$\gamma = E[v_{j,t\geq t_c^*} - v_{j,t<t_c^*} | g=1] - E[v_{j,t\geq t_c^*} - v_{j,t<t_c^*} | g=0], \tag{1}$$

where $E(.)$ denotes the expectation operator.

To define the treatment and control groups we follow a strategy that is similar to those employed in the literature focused on mergers in retail markets (Allain et al., 2013; Houde, 2012). In this literature the treatment group is defined as the stores that are affected directly (i.e., merging stores), or indirectly (close competitors). The close competitors are determined based on a pre-defined spatial proximity measure. The stores that are not close competitors are used as the control group.

In our study, we conjecture that a downsizing event could impact the volume sales of the downsized product as well as the volume sales of its close competitors. We define a product as a specific brand-size combination, such that two different sizes of a single brand are two different products. We determine a close competitor product based on its proximity to the downsized product in the product space. To fix ideas, suppose that there are two competing brands of a product (Brand 1 and Brand 2) and each brand is sold in three different package sizes (small, S; medium, M; and large, L). Suppose Brand 1 downsized only its small package size (i.e., 1–S), whereas brand 2 did not downsize any of its packages. We maintain that downsizing of 1–S could potentially affect the sales of 1–M, 2–S, and 2–M due to consumers switching brands and sizes but not the sales of 1–L and 2–L. Categorized in this way the treatment and control groups would be formed as (1–S, 1–M, 2–S, 2–M) and (1–L, 2–L), respectively.

The rationale behind our group definitions is based on an analysis of consumer switching behavior. A downsized product has less content and higher per–unit price, ceteris paribus. On one hand, when a small product is downsized buyers of the product might switch after downsizing if they perceive the

new product as “too small”. In this case, assuming consumers view products as being located in characteristics space based on their package size, the medium-size packages will be more preferable to the buyers of small-size products than the large size.

On the other hand, buyers might switch after downsizing if they perceive the new product as “too expensive”. Similarly, in this case we would expect buyers to switch to the medium-size products rather than the large-size. To illustrate, suppose buyers differ in their price sensitivities because some buyers are better informed about prices than others (Salop, 1977; Stigler, 1961). A brand manufacturer can exploit buyers’ heterogeneous price sensitivity by offering quantity discounts as a tool for price discrimination (Cohen, 2008), such that larger sizes would have lower per–unit price and appeal to more price-sensitive buyers. The self-selection of buyers into size categories would imply that buyers of small-size products are more similar in type to the buyers of medium-size products than to the buyers of the large-size products.

The estimator in equation 1 assumes that the purchase volume trends of both product segments would be the same in the absence of package downsizing. That is, package downsizing induces a deviation from this common trend, which is captured by group fixed effects. This identifying assumption would be tenuous if the factors that are unrelated to package downsizing affects consumption of the larger package sizes relative to the small packages. This would happen if household types were systematically different across product segments. It is likely that households who buy larger packages, and thus presumably are not affected from package downsizing, may be larger households, or households that have less storage costs, and thus have more inelastic category demand. Also, the impact of demand shocks on large-size buyers can be different than the impact on small-size buyers. In other words, the decision to downsize a specific sized product can be based on the household types. To account for this self-selection bias we specify the following regression DD model which includes household fixed effects and product level time varying covariates that control for the differences between the two groups:

$$\ln v_{ijt} = \alpha_0 + D_t + G_j + \gamma D_t \times G_j + \ln Z_{jt} + \lambda_i + \lambda_j + \lambda_t + \varepsilon_{ijt} \tag{2}$$

where ln denotes the logarithmic operator, D_t is a dummy variable that takes on a value of 1 if the purchase is made post–downsizing, G_j takes on a value of 1 if the product j belongs to the downsized group. The vector $Z_{jt} = [\ln p_{jt}\ prom_{jt}]$ includes product-level information on purchase price and promotion. The regression also includes fixed effects to control for household and product fixed factors affecting purchase volume, (i.e., λ_i and λ_j, respectively) and time changing determinants of purchase volume (λ_t). The coefficient of interest is the average effect of downsizing and is captured by γ. It is important to keep in mind that because package downsizing is not randomly assigned γ captures the average treatment effect on the treated.

In our subsequent analysis, we separate the average effect of package downsizing into a direct and a competitive effect (Houde, 2012). The direct effect is the effect of downsizing on the purchase volume of downsized products, while competitive effect is the effect of downsizing on the purchase volume of competing non–downsized products. To measure these disaggregate average effects we estimate the following equation:

$$\begin{aligned} \ln v_{ijt} = {} & \alpha_0 + D_t + G_j + \gamma_0 D_t \times G_j \times S_{jt} + \gamma_1 D_t \times G_j \times (1 - S_{jt}) + \ln Z_{jt} \\ & + \lambda_i + \lambda_j + \lambda_t + \varepsilon_{ijt}, \end{aligned} \tag{3}$$

where S_{jt} takes on a value of one for the downsized products during the post–downsizing period. The direct and competitive effects of package downsizing are captured by the regression coefficients γ_0 and γ_1, respectively.

In our estimation we control for the potential endogeneity of product prices by using prices of products in other cities as instruments (Hausman 1996).

5 Data

We use Nielsen homescan data on tuna and PB purchases in the 25 major Nielsen scantrack markets over a period of 7 years, 2004–2010. The data set comprises information on price and quantity of products, product characteristics, promotion, and timing of purchase for each grocery store transaction made by a large panel of U.S. households . Nielsen selects participating households based on their demographic information to construct a nationally representative sample. Each participating household is provided with a scanner to record their purchases. The dataset includes households who record a purchase of any product in at least 10 out of 12 months of the year. We conduct our analysis on a subset of households who made at least one purchase in both the pre– and post–downsizing periods. We define the first month of post–downsizing period in a city as the month that we observe the first purchase of a downsized product in that city.

To perform our difference-in-difference analysis we assign each of the tuna and PB products to either the treatment or control group. We define a product as follows. First we identify the major brands in each of the product categories. In tuna and PB markets there are 6 and 13 major brands[1], respectively. Then, we identify the container types and the major package size categories in each of the container types. For example, tuna brands are offered in can and envelope containers, comprising approximately 94 percent and 6 percent of total market volume, respectively. Similarly, PB brands are offered in plastic, glass, and can containers comprising approximately 87 percent, 11 percent, and 2 percent of the total market volume. We identify size categories in each of the container types and then define products as brand–container–size combinations. If a size category of a brand is downsized then our definition of a product would encompass both the old and the new size; because the new size of a downsized product essentially replaces the old size. For example, based on our definition, 6 oz. and 5 oz. package sizes of a tuna brand are considered to be the same product. Finally, we identify products which have at least 0.1 percent share of the total market volume or at least 0.1 percent of the total purchase occasions and assign a product number. The products that are less than 0.1 percent threshold are lumped in either major sizes of “all other store brands” or “all other national brands”. Also, we exclude infrequently sold

[1]Each of the major brands have at least 0.5 percent of the total market volume in their respective product category.

products such as the products that are sold only in one city. Categorized this way, the tuna sample includes 27 products that comprise over 98 percent of the total market volume, and the PB sample includes 56 products comprising over 97 percent of the total market volume. We summarize the details of the product definitions and present the treatment and control groups in the Appendix.

We calculate the price variable at the product level as the average per-unit price paid for product j in month t. Similarly, we construct a promotion variable at the product level as the share of purchases of product j made with some form of discounting, *e.g.*, coupons or store discounts, in month t. For example, $prom_{jt} = 0.75$ denotes that 75 percent of the purchases of product j in time t were made with a discount, while the remaining 25 percent were made at the shelf price. The key variable of interest is the household purchase volume contracted as the average purchase volume of household i of product j in month t.

Table 3 presents summary statistics on treatment and control groups before and after downsizing. The upper (lower) panel corresponds to the tuna (PB) sample. We observe 17,011 (14,996) households in the tuna (PB) sample who on average made a purchase approximately 19 (19) times during the study period, for a total of 315,592 (282,747) purchase occasions over all households. The sample size, i.e., the number of purchase occasions, is different between the treatment and control groups for both product categories.

The average price is higher in the post-downsizing period for all groups, whereas the discount frequency remains almost the same. On average the tuna products in the control group are more expensive than the products in the treatment group. The opposite is true for the PB products, that is, on average PB products in the treatment group are more expensive than the products in the control group. In both product categories, the control products are more heavily promoted than the treated products.

The average purchase volume of tuna has decreased by approximately 1.9 oz. and 0.5 oz. in the post-downsizing period for treatment and control groups, respectively. That is, the average difference-in-difference in the purchase volume of tuna is about 1.3 oz. a month. The purchase volume statistics of PB products show a different pattern. The average purchase volume of PB for the treatment

group has remained almost the same in the post-downsizing period, whereas it has increased for the control group by approximately 5.3 oz. That is, the average difference-in-difference in the purchase volume of PB is about 5.3 oz. a month. While these differences imply that purchase volume decreased after downsizing, it should be noted that we are not controlling for any confounding factors that could be happening at the same time as the downsizing event.

Table 3: Summary statistics on treatment and control groups

Shelf-Stable Tuna	Treatment Group		Control Group	
Number of Products	22		5	
Number of Purchase Occasions	298,694		16,898	
	Before	After	Before	After
Average Price ($)	0.1623	0.1973	0.205	0.2227
	(0.0999)	(0.1134)	(0.0634)	(0.0669)
Average Discount Frequency	0.5607	0.5655	0.8069	0.809
	(0.4903)	(0.4906)	(0.3913)	(0.3893)
Average Purchase Volume (APM)	25.0222	23.1587	22.6676	22.168
	(27.6547)	(25.0254)	(20.2088)	(16.0056)
(Post–APM) - (Pre–APM)	−1.8635		−0.4996	
DD	−1.3639			
Number of households	17,011			
Peanut Butter	**Treatment Group**		**Control Group**	
Number of Products	41		15	
Number of Purchase occasions	236,171		46,576	
	Before	After	Before	After
Average Price	0.1051	0.1213	0.0897	0.1011
	(0.0363)	(0.0405)	(0.0198)	(0.0227)
Average Discount frequency	0.5844	0.5816	0.8374	0.8165
	(0.4886)	(0.4892)	(0.3652)	(0.3834)
Purchase Volume	28.6341	28.6351	68.1928	73.5375
	(23.6404)	(25.2142)	(34.2491)	(36.2067)
(Post–APM) - (Pre–APM)	0.001		5.3447	
DD	−5.3437			
Number of households	14,996			

Notes: "Before (After)" denotes the Pre(Post)-Downsizing period. "Average purchase volume" is the average of monthly per-household purchase volume expressed in ounces. DD corresponds to the average difference-in-difference for the treated and control products. Standard deviations are in parentheses.

Before we turn to the results of our analysis, we investigate the key identifying assumption of the difference-in-difference approach. That is, the purchase volume trends for the treatment and control groups would have been the same in the absence of package downsizing. This assumption necessitates that we observe a common trend in the pre-downsizing period for the treatment and control groups. Figure 3 shows the trends of the monthly per-household average purchase volume for the treatment and control groups in both the tuna and PB categories. The two vertical lines in each graph denote the start of the post-downsizing in the 1st city and the last city, respectively. We note that the evolution of trends are very similar during the pre-downsizing period in both product categories. This observation provides a strong support for the common trend assumption.

The evolution of purchase volume trends after the downsizing period are different. In the case of tuna it appears that downsizing coincides with a stark decrease in purchase volume for the treatment group, while control group exhibits a slight decrease. In the case of PB it appears that there is an increase for the control group while the treatment group remains stable. This could be due to an increase in the overall category demand for peanut butter in the post-downsizing period.

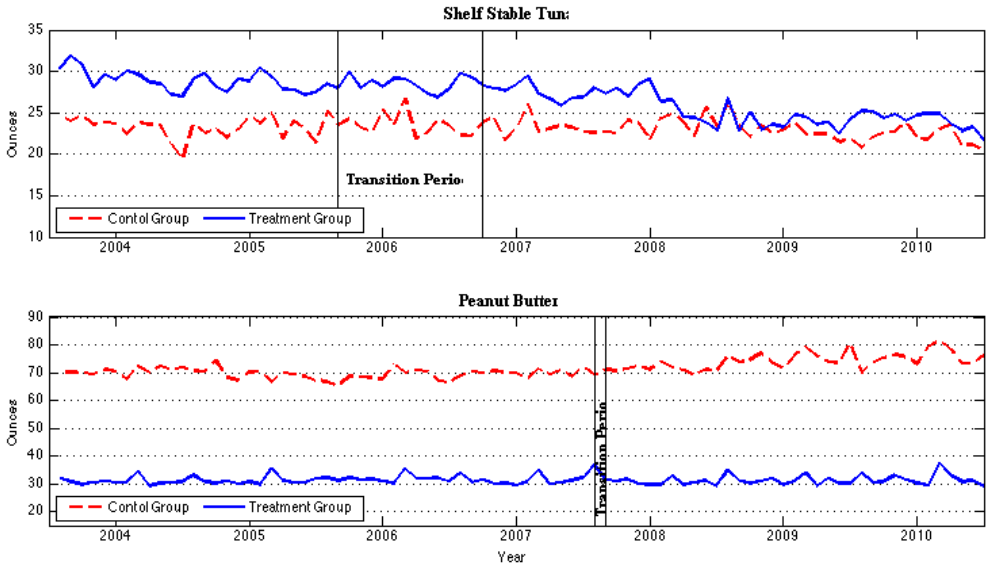

Figure 3: Evolution of the monthly per household purchase volume of shelf stable tuna and peanut butter by treatment and control groups

6 Results

We estimate equations 2 and 3 by OLS, controlling for household, product and time (quarter) specific fixed-effects. Using the tuna sample, table 4 presents the estimates of equations 2 and 3 in the upper and the lower panels, respectively. The first column presents the estimates of the pure difference-in-difference model without controlling for any potentially confounding factors. We estimate that, on average, package downsizing reduces purchase volume of tuna by 8.3 percent. The lower panel presents the disaggregate direct and competitive effects.The direct effect is the effect of downsizing on downsized products, whereas the competitive effect is the effect of downsizing on non-downsized competing products. Both effects are significant and have the expected signs. Accordingly, the direct effect of downsizing is negative 9.3 percent while the competitive effect is 15.7 percent. However, the R^2 of both models are less than 1% and, as discussed above, these estimates could be biased.

When we include price and discount variables, and control for household fixed–effects, the R^2 increases above 9% and we estimate that the average effect of downsizing is 1.9 percent. The price and discount effects are significant and have the expected signs. The disaggregate estimates are negative 3.1 percent and positive 33.5 percent for the direct and competitive effects, respectively. To control for the unobserved product-specific factors we include product fixed effects. The R^2 in the upper panel of column 3 implies that the product fixed effects explain an additional 5 percent of the variation in purchase volume. The average effect of downsizing is negative 4 percent. The disaggregate results imply that most of this effect is due to households' reduced purchase volume of downsized products. That is, the direct effect is negative 4.3 percent, while the competitive effect is insignificant. In model 4, presented in the 4^{th} column, we include time fixed effects and their interaction variables with the product fixed effects. The interaction variables control for unobserved factors that might have changed quarter by quarter for each product. Comparing these results to model 3, the estimates of average downsizing effects and the R^2 are almost the same. That is, on average package downsizing reduced the purchase volume of treated products by about 4.2 percent, and most of this effect is attributed to the direct effect.

Table 4: Difference-in-Difference Estimates of the Shelf-Stable Tuna Sample

Dependent variable: (log) monthly per–household purchase volume by products				
	M1	M2	M3	M4
Downsizing	-0.0830^{***}	-0.0196^{*}	-0.0404^{***}	-0.0415^{***}
	(0.0137)	(0.0118)	(0.0115)	(0.0115)
log(price)		-0.6388^{***}	-0.4833^{***}	-0.4649^{***}
		(0.0077)	(0.0117)	(0.0120)
Discount		0.0964^{***}	0.0600^{***}	0.0510^{***}
		(0.0086)	(0.0080)	(0.0081)
Constant	2.9499^{***}	1.9121^{***}	2.1002^{***}	2.0937^{***}
	(0.0129)	(0.0170)	(0.0443)	(0.0608)
R^2	0.0044	0.0921	0.1435	0.1441
	M1'	M2'	M3'	M4'
Downsizing x	-0.0937^{***}	-0.0316^{***}	-0.0426^{***}	-0.0437^{***}
Direct	(0.0138)	(0.0118)	(0.0115)	(0.0115)
Downsizing x	0.1573^{***}	0.3349^{***}	0.0122	0.0122
Competitive	(0.0281)	(0.0191)	(0.0218)	(0.0219)
log(price)		-0.6631^{***}	-0.4802^{***}	-0.4617^{***}
		(0.0077)	(0.0117)	(0.0120)
Discount		0.1347^{***}	0.0600^{***}	0.0510^{***}
		(0.0082)	(0.0080)	(0.0081)
Constant	2.9499^{***}	1.8655^{***}	2.1055^{***}	2.0994^{***}
	(0.0129)	(0.0170)	(0.0443)	(0.0607)
R^2	0.0065	0.1027	0.1435	0.1441
Household	No	Yes	Yes	Yes
Product	No	No	Yes	Yes
Product x Quarter	No	No	No	Yes
Observations	315,592			

Note: The variable Downsizing correspond to the interaction term Post-Downsizing × Treatment. The variable Downsizing × Direct (Downsizing × Competitive) correspond to the interaction term Post-Downsizing × Treatment× Downsized Products during Post-Downsizing (Post-Downsizing × Treatment× (1 - Downsized Products during Post-Downsizing)). The lower order terms of interactions are not reported but are included in all specifications. Clustered standard errors at the household level are reported in parentheses. *,**,*** indicate significance at the 10%, 5%, 1% level, respectively.

Table 5 presents the estimates of equations 2 and 3 using the peanut butter sample. We follow the same estimation strategy as in the case of the tuna sample and include the fixed–effects sequentially. The pure difference–in–difference estimates show that the average impact of downsizing on purchase volume is negative 6.1 percent. The estimated disaggregate effects are counterintuitive due to the significant negative sign on the competitive effect. When we include the price and discount variables, and control for household fixed–effects, the R^2 increases by approximately 2 percent and the estimated

average effect of downsizing reduces to negative 4.1 percent. When we include product fixed effects the R^2 increases by approximately 7 percent and the estimated average effect of downsizing reduces to negative 1.9 percent. The disaggregate estimates in this case show that most of the average downsizing effect can be attributed to the direct effect, while the the competitive effect is insignificant. Finally, when we include time fixed–effects and their interaction variables with the product fixed–effects, the estimates of average downsizing effects and the R^2 remain almost the same.We estimate that the average effect of downsizing on the purchase volume of treated PB products is about 2 percent, and that most of this effect is attributed to the direct effect.

Table 5: Difference-in-Difference Estimates of the Peanut Butter Sample

Dependent variable: (log) monthly per–household purchase volume by products				
	M1	M2	M3	M4
Downsizing	-0.0612^{***}	-0.0410^{***}	-0.0194^{***}	-0.0202^{***}
	(0.0070)	(0.0056)	(0.0051)	(0.0051)
Price		-0.3479^{***}	-0.3025^{***}	-0.2904^{***}
		(0.0089)	(0.0123)	(0.0127)
Discount		0.0412^{***}	0.1249^{***}	0.1250^{***}
		(0.0051)	(0.0044)	(0.0044)
Constant	4.1284^{***}	3.1618^{***}	3.4935^{***}	3.5334^{***}
	(0.0062)	(0.0218)	(0.0444)	(0.0525)
R^2	0.3592	0.3773	0.4485	0.4491
	M1'	M2'	M3'	M4'
Downsizing x	-0.0556^{***}	-0.0908^{***}	-0.0631^{***}	-0.0641^{***}
Direct	(0.0074)	(0.0064)	(0.0064)	(0.0064)
Downsizing x	-0.0740^{***}	-0.0193^{***}	-0.0007	-0.0015
Competitive	(0.0083)	(0.0058)	(0.0052)	(0.0052)
Price		-0.3438^{***}	-0.2964^{***}	-0.2832^{***}
		(0.0088)	(0.0123)	(0.0127)
Discount		0.0582^{***}	0.1302^{***}	0.1304^{***}
		(0.0051)	(0.0044)	(0.0044)
Constant	4.1284^{***}	3.1697^{***}	3.5064^{***}	3.5487^{***}
	(0.0062)	(0.0217)	(0.0444)	(0.0526)
R^2	0.3593	0.3779	0.4489	0.4494
Household	No	Yes	Yes	Yes
Product	No	No	Yes	Yes
Product x Quarter	No	No	No	Yes
Observations	282,747			

Note: The variable Downsizing corresponds to the interaction term Post-Downsizing × Treatment. The variable Downsizing × Direct (Downsizing × Competitive) corresponds to the interaction term Post-Downsizing × Treatment× Downsized Products during Post-Downsizing period (Post-Downsizing × Treatment× (1 - Downsized Products during Post-Downsizing period)). The lower order terms of interactions are not reported but are included in all specifications. Clustered standard errors at the household level are reported in parentheses. *,**,*** indicate significance at the 10%, 5%, 1% level, respectively.

7 Conclusion

Our study contributes to the literature on the effects of packaging on consumer food purchase and consumption behavior. We examine the impact food package size on food-at-home consumption using Nielsen Homescan household panel data. We exploit food manufacturer package downsizing strategy to track shifts in household purchase volume before and after package size changes.

In our analysis we focus on purchases of shelf-stable tuna and peanut butter products in 25 major cities between 2004 and 2010. We design a difference-in-difference analysis to compare the changes in purchase volume of products that are affected by package downsizing to the changes in purchase volume of products that are not affected by package downsizing. In subsequent analysis, we separate the average effect of package downsizing into a direct and a competitive effect. The direct effect is the effect of downsizing on the purchase volume of downsized products, while the competitive effect is the effect of downsizing on the purchase volume of competing non-downsized products. We use household, product and time (quarter) specific fixed-effects to control for unobserved confounding fixed factors.

Our main finding is that smaller package size significantly reduced household purchase volume in both product categories. Specifically, we find that, on average, package downsizing reduced the purchase volume of tuna products that are affected by downsizing by 4.2 percent. This negative impact is expected since a regular tuna product is not designed to be used intermittently. Consumers will find it difficult to maintain the same serving size of tuna after downsizing. However, considering that the degree of downsizing of tuna products was approximately 17 percent (i.e., from 6 oz. to 5 oz.) the estimate of the average treatment effect implies that consumers might have switched away from downsized products and/or increased purchase frequency. The disaggregate results show that most of the average effect is due to the impact of downsizing on purchase volume of downsized tuna products, while the impact on purchase volume of close competitors is found to be insignificant.

As for peanut butter, we find that, on average, the purchase volume of peanut butter products that are affected by downsizing decreased by 2 percent. The lower impact of downsizing on peanut butter compared tuna can be due to i) lower degree of downsizing, approximately 9 percent (i.e., form 18 oz.

to 16.3 oz), ii) lower share of downsized products in the treatment group, or iii) the intermittent consumption which may lead to increased purchase frequency. Similarly, most of the average effect is again due to the impact of downsizing on purchase volume of downsized PB products. The impact on purchase volume of close competitors is found to be insignificant.

The negative impacts of package downsizing on purchase volume of both product categories imply that package size is positively correlated with food-at-home consumption. This finding is consistent with the results of the experimental studies showing that larger package sizes lead to higher usage volume compared with smaller package sizes.

References

Allain, M. L., C. Chambolle, S. Turolla, and S. B. Villas-Boas. 2013. The Impact of Retail Mergers on Food Prices: Evidence from France.

Çakır, M., and J.V. Balagtas. 2013. Consumer Response to Package Downsizing: Evidence from the Chicago Bulk Ice Cream Market. *Journal of Retailing*, Available online 1 August 2013 http://dx.doi.org/10.1016/j.jretai.2013.06.002

Chan T., C. Narasimhan and Q. Zhang. 2008. Decomposing Promotional Effects with a Dynamic Structural Model of Flexible Consumption. *Journal of Marketing Research* 45 (4), 487–498.

Chandon, P. 2013. How Package Design and Packaged-based Marketing Claims Lead to Overeating. *Applied Economic Perspectives and Policy*. 35 (1), 7–31.

Chandon, P., and N. Ordabayeva.2009. Supersize in One Dimension, Downsize in Three Dimensions: Effects of Spatial Dimensionality on Size Perceptions and Preferences. *Journal of Marketing Research*. 46 (6), 739–53.

Chandon, P., and B. Wansink. 2007. Is Obesity Caused by Calorie Underestimation? A Psychophysical Model of Meal Size Estimation. *Journal of Marketing Research*. 44 (1), 84–99.

Cohen, A. 2008. Package Size and Price Discrimination in the Paper Towel Market. *International Journal of Industrial Organization*. 26 (2), 502–16.

Ello-Martin, J. A., J. A. Ledikwe, and B. J. Rolls. 2005. The Influence of Food Portion Size and Energy Density on Energy Intake: Implications for Weight Management. *American Journal of Clinical Nutrition*. 82 (1), 236S–241S.

Hausman, J. 1996. Valuation of New Goods Under Perfect and Imperfect Competition. in *The Economics of New Goods*, Studies in Income and Wealth Vol. 58, ed. by T. Bresnehan and R. Gordon. Chicago: National Bureau of Economic Research.

Houde, J. F. 2012. Spatial Differentiation and Vertical Mergers in Retail Markets for Gasoline. *American Economic Review*. 102 (5), 2147–2182.

Krishna, A. 2006. Interaction of Senses: The Effect of Vision Versus Touch on the Elongation Bias. *Journal of Consumer Research*. 32 (4), 557–66.

Neslin, S. A., and H. J. Van Heerde. 2008. Promotion Dynamics. *Foundations and Trends in Marketing*. 3 (4), 177–268.

Raghubir, P. and A. Krishna. 1999. Vital Dimensions in Volume Perception: Can the Eye Fool the Stomach? *Journal of Marketing Research*. 36 (3), 313–26.

Rolls, B. J., E. L. Morris, and L. S. Roe. 2002. Portion Size of Food Affects Energy Intake in Normal-Weight and Overweight Men and Women. *American Journal of Clinical Nutrition*. 76 (6), 1207–1213.

Rolls, B. J., L. S. Roe., T. V. E. Kral, J. S. Meengs, and D. E. Wall. 2004. Increasing the Portion Size of a Packaged Snack Increases Energy Intake in Men and Women. *Appetite*. 42 (1), 63–69.

Salop, S. C. 1977. The Noisy Monopolist: Imperfect Information, Price Dispersion and Price Discrimination. *Review of Economic Studies*. 44 (138), 2393–406.

Stigler, G. J. 1961. The Economics of Information. *The Journal of Political Economy*. 69 (3), 213–25.

Young, L. R., and M. Nestle. 2002. The Contribution of Expanding Portion Sizes to the US Obesity Epidemic. *American Journal of Public Health* 92 (2), 246–249.

Wansink, B. 1996. Can package size accelerate usage volume? *Journal of Marketing* 60 (3), 1–14.

Wansink, B., J. E. Painter, and J. North. 2005. Bottomless Bowls: Why Visual Cues of Portion Size May Influence Intake.*Obesity Research*. 13(1), 93–100.

Appendix

SHELF-STABLE TUNA PRODUCT DEFINITIONS AND TREATMENT AND CONTROL GROUPS

Treatment Group			Control Group		
Product No	Brand	Package Size	Product No	Brand	Package Size
Product 1	National Brand 1	3	Product 3	National Brand 1	12
Product 2	**National Brand 1**	**5 and 6**	Product 7	National Brand 2	12
Product 4	National Brand 2	3	Product 11	National Brand 3	12
Product 5	**National Brand 2**	**5 and 6**	Product 19	All other SB	12
Product 6	National Brand 2	7	Product 14	Store Brand 2	12
Product 8	National Brand 3	3			
Product 9	**National Brand 3**	**5 and 6**			
Product 10	National Brand 3	7			
Product 12	**Store Brand 1**	**5 and 6**			
Product 13	**Store Brand 2**	**5 and 6 and 6.5**			
Product 15	**Store Brand 3**	**5 and 6 and 6.5**			
Product 16	All other SB	3			
Product 17	**All other SB**	**5 and 6 and 6.5**			
Product 18	All other SB	7			
Product 20	All other NB	5 and 6			
Product 21	**National Brand 1 (envelope)**	**2.6 and 3**			
Product 22	**National Brand 1 (envelope)**	**4.5 and 5**			
Product 23	**National Brand 1 (envelope)**	**6.4 and 7.06**			
Product 24	**National Brand 2 (envelope)**	**2.5 and 3**			
Product 25	National Brand 2 (envelope)	7.06			
Product 26	**National Brand 3 (envelope)**	**2.5 and 3**			
Product 27	National Brand 3 (envelope)	7.1			

Note: Downsized products are listed in bold.

PEANUT BUTTER PRODUCT DEFINITIONS AND TREATMENT AND CONTROL GROUPS

Treatment Group			Control Group		
Product No	Brand	Package Size	Product No	Brand	Package Size
Product 1	National Brand 1	12	Product 4	National Brand 1	40
Product 2	National Brand 1	18	Product 5	National Brand 1	48
Product 3	National Brand 1	28	Product 10	National Brand 4	40
Product 6	National Brand 2	17.3	Product 11	National Brand 4	48
Product 7	**National Brand 4**	**16.3 and 18**	Product 12	National Brand 4	64
Product 8	National Brand 4	28	Product 19	National Brand 7	56
Product 9	National Brand 4	36.4	Product 28	Store Brand 1	40
Product 13	**National Brand 5**	**15 and 16.3**	Product 32	Store Brand 2	40
Product 14	National Brand 5	26.5	Product 33	Store Brand 2	64
Product 15	National Brand 6	16.1	Product 38	All other SB	40
Product 16	**National Brand 7**	**16.3 and 18**	Product 39	All other SB	64
Product 17	National Brand 7	28	Product 54	All other SB (glass)	40
Product 18	National Brand 7	40	Product 55	National Brand 1 (can)	64
Product 20	**National Brand 8**	**16.3 and 17.6**	Product 56	National Brand 4 (can)	96
Product 21	National Brand 9	16			
Product 22	National Brand 9	26			
Product 23	All other NB	14			
Product 24	All other NB	16			
Product 25	All other NB	18			
Product 26	Store Brand 1	18			
Product 27	Store Brand 1	28			
Product 29	Store Brand 2	17			
Product 30	Store Brand 2	18			
Product 31	Store Brand 2	28			
Product 34	Store Brand 3	18			
Product 35	All other SB	16			
Product 36	All other SB	18			
Product 37	All other SB	28			
Product 40	National Brand 10 (glass)	16			
Product 41	National Brand 10 (glass)	18			
Product 42	National Brand 10 (glass)	26			

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Treatment Group			Control Group		
Product No	Brand	Package Size	Product No	Brand	Package Size
Product 43	National Brand 3 (glass)	16			
Product 44	National Brand 3 (glass)	26			
Product 45	National Brand 3 (glass)	36			
Product 46	All other NB (glass)	16			
Product 47	All other NB (glass)	18			
Product 48	All other NB (glass)	26			
Product 49	Store Brand 1 (glass)	16			
Product 50	Store Brand 1 (glass)	28			
Product 51	All other SB (glass)	16			
Product 52	All other SB (glass)	18			
Product 53	All other SB (glass)	28			

Note: Downsized products are listed in bold.