

# Less is More Expensive: Income Differences in Bulk Buying

*E. Mallick Hossain*

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[Updated Version Here\\*](#)

## **Abstract**

Quantity discounts are an effective way for households to save money. My paper explores how large quantity discounts are, how bulk buying differs by income and what factors affect the bulk buying decision. Using Nielsen’s granular store-level and household-level data, I show that quantity discounts are large for a wide range of products and low-income households are less likely to buy in bulk. I estimate that low-income households could reduce their grocery expenditures by 5%, saving an aggregate of \$5.4 billion annually, if they bought in bulk like high-income households. By augmenting the Nielsen data with novel data I collected on state-level unit-price regulations and new data on warehouse club entry, I find evidence that a combination of cognitive costs, store preferences, and storage costs discourage low-income households from realizing these savings. I then estimate a discrete choice model of household purchasing behavior to quantify how bulk buying changes when cognitive costs and storage costs are reduced. Counterfactual simulations show that mandating the display of unit prices, which has only been adopted by nine states, would reduce the bulk buying gap between the highest and lowest income households by 27%.

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# 1 Introduction

Grocery purchases account for a sizable share of a household’s discretionary spending (BLS 2019). To save money, households often wait for sales, redeem coupons, or purchase generic brands (Griffith et al. 2009). Low-income groups also increase their home production and time spent shopping to further reduce their spending (Aguiar and Hurst 2005). Quantity discounts are another way for households to save money. Even though households buy more at one time, they pay lower unit prices, and reduce their overall spending.

My paper examines how common quantity discounts are, how bulk buying varies by income groups, and which factors influence the decision to buy in bulk. Most explanations for why households pay different prices for the same product relate to differences in search behavior. Prices vary based on where households shop, whether they buy on sale, or whether they use coupons (Talukdar 2008; Griffith et al. 2009; Kaplan and Menzio 2015). However, even in the absence of sales and coupons, prices for the same product can differ within a particular store because of quantity discounts.

This paper presents new findings that, despite the substantial savings available from quantity discounts, low-income households are less likely to buy in bulk than high-income households.<sup>1</sup> Kunreuther (1973) provides the first evidence of this “bulk buying gap” for eight specific products and Orhun and Palazzolo (2019) expands this finding to the whole toilet paper category. Since households purchase a wide range of products when shopping, I show that the “bulk buying gap” exists across a wide range of product categories.

I find that cognitive costs, store preferences, and storage costs contribute to this bulk buying gap. Cognitive costs can prevent households from making economical decisions and households change their purchase decisions when relevant price information is displayed prominently (Bertrand, Mullainathan, and Shafir 2006; Chetty, Looney, and Kroft 2009; Goldin and Homonoff 2013; Mani et al. 2013). Lab experiments and small field experiments find that consumers also change their buying behavior when unit prices are posted (Miyazaki, Sprott, and Manning 2000; Bogomolova and Jarratt 2016). I build on both of these facts and show that households are more likely to buy in bulk when retailers are mandated to display unit prices, reducing cognitive costs. Households may also make different purchase decisions based on the types of stores they shop at or the neighborhoods they shop in (Chung and Myers Jr 1999; Talukdar 2008; Allcott et al. 2019). I show that where a household shops, but not where a household lives, greatly affects differences in bulk buying.

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<sup>1</sup>Throughout this paper, “high-income” refers to households making over \$100,000 and “low-income” refers to households making under \$25,000.

This paper also provides a new approach to estimate storage costs cross-sectionally using differences in product “concentration.” Firms can use nonlinear prices to discriminate between households with varying storage costs and these storage costs can be estimated using household purchase histories (Hendel and Nevo 2006; Hendel, Lizzeri, and Roketskiy 2014). The intuition of their approach is the following: given households with the same demand for a product, the household with high storage costs will purchase more frequently than the household with low storage costs. The intuition of my approach is that households that buy more concentrated, smaller packages have higher storage costs than those that buy less concentrated, larger packages. Furthermore, I provide evidence that low-income households have high storage costs while high-income households have low storage costs. On balance, this means that firms extract higher rents from low-income households because they have less ability to store for future consumption.

I use a combination of household- and store-level datasets to study income heterogeneity in bulk buying, including Nielsen’s Consumer Panel data, a nationally representative panel survey of household grocery purchases, and Nielsen’s Retail Scanner data, a national panel of weekly UPC-level sales data from over 30,000 stores. I construct a new dataset of state-level per-unit pricing regulations, including a measure of regulatory stringency. I also use data on entry dates and locations of over 1,400 warehouse clubs in the United States. As a result, I have a comprehensive view of household’s possible product choices, available price information, retail environment, and resulting expenditures.

I start by documenting income differences in bulk buying and estimating how much low-income households could save from buying in bulk like high-income households. To do this, I estimate the average bulk discount for each product category based on Nielsen’s weekly store-level price and product data. Then, I estimate how much each household buys in bulk using Nielsen’s household-level purchase data. Given each product category-specific bulk discount and household-level bulk buying, I predict how much low-income households could have saved if they increased their bulk buying to match that of high-income households. I find that low-income households could reduce their grocery expenditures by 5% if they bought in bulk like high-income households, saving an aggregate of \$5.4 billion annually.

I then use two differences-in-differences models to determine how much cognitive costs and store preferences affect bulk buying. The first one leverages a novel dataset that I compiled of state regulations regarding the display of per-unit prices. I exploit the fact that thousands of households move between regulatory regimes when they move from one state to another. Before a household moves, they exhibit no trends in their bulk buying. After a move, there is a significant change in their bulk buying. I find that a household’s bulk buying is 2-3%

higher when they are in a state where unit prices are displayed.

The second differences-in-differences model examines how much store preferences, particularly warehouse clubs, affect bulk buying. The bulk buying gap narrows substantially after controlling for the types of stores households shop at and high-income households spend a larger portion of their budget at warehouse clubs. To estimate the effect of warehouse clubs on bulk buying, I examine how bulk buying changes within households before and after a warehouse club enters nearby. Warehouse club entry increases bulk buying by 5–10%, but only for middle- and high-income households.

I also assess the importance of storage costs using differences in bulk buying relative to the size of a household’s home and relative to the physical size of the product being purchased. I examine how a household’s bulk buying changes when they move to a different type of housing after controlling for other within-household changes. Bulk buying is 2.6–4.0% higher when households live in single-family homes relative to when they live in apartments, controlling for demographic changes. I also find that the bulk buying gap is smaller for products with smaller physical footprints.

Finally, I construct a discrete-choice model of toilet paper purchases to quantify the direct effect of reducing storage costs or posting unit prices on bulk buying. Households choose a product based on price, quantity, quality, and package size, which serves as a proxy for storage costs. I allow state-level unit pricing mandates to affect a household’s unit price sensitivity. From this demand model, I simulate household responses to two counterfactuals: (1) universally posting unit prices and (2) reducing storage costs.

The model predicts that posting unit prices would reduce the gap in package size purchased between high- and low-income households by 27% and reducing storage costs narrow the gap by an additional 27%. These two channels account for over 90% of the differences in gap between middle- and high-income households. If policymakers want to encourage households to better utilize quantity discounts, displaying unit prices would reduce cognitive costs, increase bulk buying, and help consumers save money.

The rest of the paper is structured as follows. Section 2 describes the data. Section 3 documents new facts of quantity discounting. Section 4 presents evidence of contributing factors to the bulk-buying gap. Section 5 introduces the model. Section 6 presents estimation results. Section 7 shows the counterfactual exercises and Section 8 concludes.

## 2 Data

In this section, I describe the datasets used for my analysis and give a brief overview of their respective features.<sup>2</sup> Nielsen’s Consumer Panel data provides information on household’s shopping and purchasing decisions. Nielsen’s Retail Scanner data provides information on weekly product assortments and prices. A new regulatory dataset I construct contains information on state-level regulations regarding the display of per-unit pricing. Finally, new warehouse club data provides information on the location and entry dates of warehouse clubs across the United States. By combining these data, I have a comprehensive view into a household’s possible product choices, available price information, retail environment, and their resulting purchase decision.

### 2.1 Nielsen Consumer Panel Data

I use the Nielsen Consumer Panel dataset from 2004–2017. This dataset is a panel of about 178,000 unique households. I observe about 40,000 households each year from 2004–2006 and about 60,000 households each year from 2007–2017. Households scan all items that they purchase, input quantities, prices, date of purchase, and store. Nielsen retains about 80% of its panel from year to year with the mean and median tenure of a household being four and three years, respectively.

I consider food, drink, and non-food grocery (e.g., paper towels, toilet paper, detergent, etc.) purchases made at grocery stores, discount stores, dollar stores, warehouse clubs, and drug stores. These outlets account for over 90% of household expenditures in these categories. I exclude alcohol, tobacco, health, and general merchandise products from my analysis since these products (e.g., cigarettes, painkillers, etc.) may have different consumption patterns than grocery products or are not suited for bulk purchases (e.g., printers, cookware, linens). I also exclude households with a student or military head of household as well as those with an annual income of less than \$5,000 and those living in mobile homes. Only about 7% of households are excluded and I use the remaining 166,000 households for my analysis. See Appendix A.1 for further details of sample construction.

Nielsen computes projection weights to ensure their sample is nationally representative. Weights are calculated to match population moments based on household size, income, age, race, ethnicity, education, occupation, and presence of children. All analyses use

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<sup>2</sup>Researcher’s own analyses derived based in part on data from The Nielsen Company (US), LLC and marketing databases provided through the Nielsen Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business.

these projection weights unless otherwise stated. Table 1 presents descriptive statistics for households in the sample.

Table 1: Nielsen Consumer Panel Summary Statistics

Variable	Mean	SD	25th Pctile	75th Pctile
Household income (\$000s)	57.13	31.17	27.5	85
Household size	2.56	1.45	1	3
Age	52.59	14.39	41.5	63
College Educated	0.39	0.49	0	1
Child present	0.33	0.47	0	1
Married	0.50	0.50	0	1
N (Household-Years)	734,724			
N (Households)	166,163			

Notes: Data are weighted for national representativeness.

## 2.2 Nielsen Scanner Data

The Nielsen Scanner data contains weekly prices and volume sold of individual products at about 35,000 stores from about 90 retail chains between 2006–2016. Only products with positive sales in a given week are recorded. I match the Retail Scanner data with the Consumer Panel data based on store identification numbers and purchase dates. By matching the two datasets, I recover the set of products available to a household and the product it chose to purchase.

## 2.3 Unit Pricing Regulations

I compile a novel dataset on state-level regulations regarding the display of unit prices. The data is based on annual regulatory updates aggregated in Handbook 130 published by the National Institute of Standards and Technology (NIST 2019). I cross-check this information with state regulatory codes and state officials to ensure accuracy. This data includes information on which states have regulations, when they were adopted, and how stringent these regulations are. More details are discussed in Section 4.1.

## 2.4 Warehouse Club Data

I also use hand-collected data on all warehouse clubs in the United States between 2004–2015 gathered by Coibion, Gorodnichenko, and Koustas (2017). This data records information on the opening dates, locations, and identity of all warehouse clubs in the United States. It was

gathered by combining information available on company websites, annual reports, and by contacting firms.

### 3 Stylized Facts

In this section, I document two new facts about the shopping landscape. First, I show that quantity discounts apply to 91% of grocery categories. Second, I document that households making over \$100,000 are about 27% more likely to buy non-food items in bulk than households making under \$25,000, compared to only 3% for food items. Combining these findings, I estimate that low-income households could reduce their grocery expenditures by 5%, saving an aggregate of \$5.4 billion annually, simply by buying in bulk at the same rate as high-income households.

#### 3.1 Quantity Discount Prevalence

Quantity discounts are a specific form of non-linear pricing in which unit prices decrease as package size increases. To establish the prevalence and magnitude of quantity discounts, I use Nielsen’s Retail Scanner data from 2016. I estimate quantity discounts using the following regression for each of the 693 product categories.<sup>3</sup>

$$\ln(P)_{ibm} = \beta \ln(Size)_{ibm} + \lambda_{bm} + \epsilon_{ibm}, \quad (1)$$

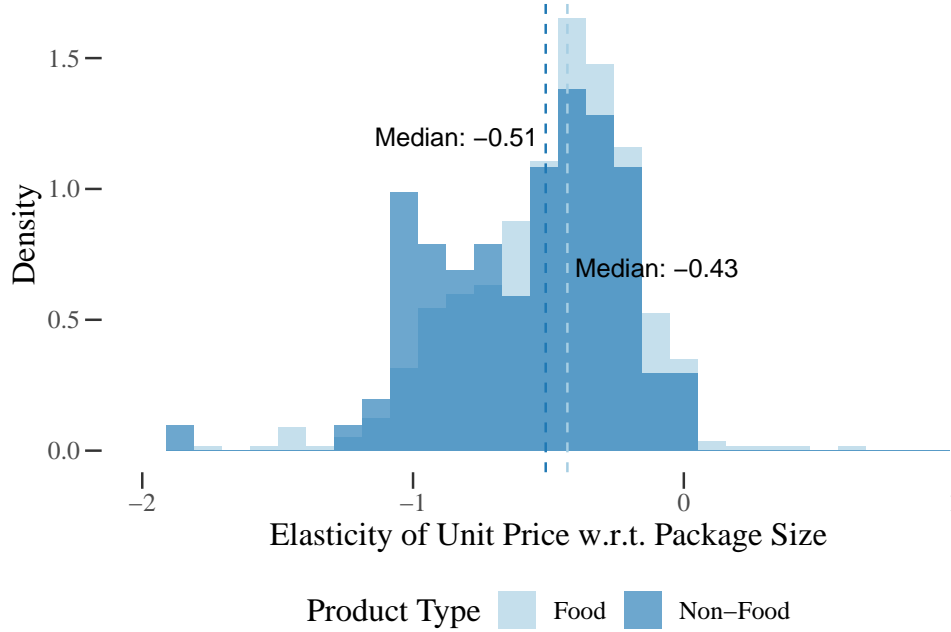
where  $P$  is the unit price (package price divided by package size) of product  $i$  from brand  $b$  purchased in market  $m$  (defined as a store-week).  $Size$  is the item’s package size, which is the number of units included in a UPC (e.g., quart, square feet, count, pound, etc.).  $\lambda$  is a brand-store-week fixed effect. Variation in unit prices across package sizes within the same brand-store-week identify  $\beta$ . If retailers offer quantity discounts, then  $\beta$  will be negative.

Figure 1 plots the distribution of  $\beta$  across product categories (statistically insignificant betas are zero). I find that 91% of all product categories have a statistically significant and negative  $\beta$  and that non-food items generally have larger discounts than food items. The median  $\beta$  is -0.51 for non-food products, which means that a 10% increase in package size is associated with a 5.1% decrease in unit price. This discount is larger than the median  $\beta$  for food items (-0.43).<sup>4</sup> The size and near-universality of quantity discounts suggest they offer substantial

<sup>3</sup>48 categories could not be estimated typically because the data did not have sufficient variation. These were generally uncommon categories like mushroom sauce, canned grapes, and canned chow mein.

<sup>4</sup>These findings are robust to outliers. Winsorizing unit prices at the 98th and 90th percentile produces almost quantitatively identical estimates.

Figure 1: Distribution of Bulk Discounts by Product Type



Notes: Using Nielsen Retail Scanner data from 2016, this figure plots the distribution of coefficients from a regression of log unit price on log package size (Equation (1)) for individual product categories. Regression controls for store-brand-week fixed effects. Histogram plots 645 product categories.

savings to households without sacrificing consumption.<sup>5</sup>

### 3.2 Bulk Purchasing

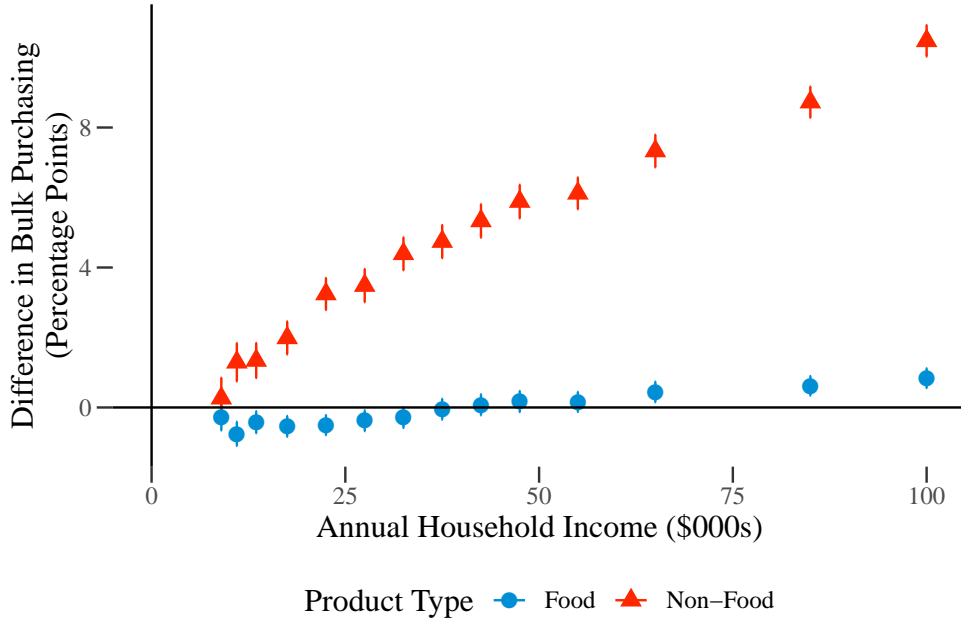
Given how common and how valuable quantity discounts are, households can use quantity discounts to save money on a wide range of products. However, since food products deteriorate while non-food products do not, bulk buying will likely differ between food and non-food products. Because of these differences, I analyze food and non-food products separately. Following the literature, I classify a product as “bulk” if it is in the top two quintiles of the size distribution for that product category (Griffith et al. 2009).<sup>6</sup> Then, for each household, I compute the expenditure-weighted share of bulk purchases of food and non-food items. Thus, for each household, I have the share of purchases that were bulk purchases. I then regress this “bulk share” on household income and other household characteristics that could affect consumption patterns and may be correlated with income, and plot the income coefficients.

<sup>5</sup>For a comparison of quantity discounts with coupons, see Appendix A.2.

<sup>6</sup>This definition avoids the risk of too narrowly defining bulk and only capturing purchases that occur solely at warehouse clubs. This broader definition helps capture large sizes that are available at grocery stores and mass merchandisers.



Figure 2: Bulk Purchasing by Household Income and Product Type



Notes: Using 2004–2017 Nielsen Consumer Panel data, this figure plots the income bin coefficients from Equation (2), which regresses the share of annual purchases that were bulk packages on household characteristics as well as market and year fixed effects. Nielsen projection weights are used to ensure national representativeness. Households making \$5–8k are the reference group. Coefficient values are reported in Appendix Tables 17 and 18.

The equation below is estimated on food and non-food purchases separately.

$$BulkShare_{imt} = \sum_q \beta^q Income_{imt} + \gamma X_{imt} + \lambda_m + \lambda_t + \epsilon_{imt}, \quad (2)$$

where *BulkShare* is household *i*'s share of bulk purchases in market *m* in year *t*.<sup>7</sup> *Income* consists of dummies for each income bin *q*. *X* consists of household characteristics (age, household composition, marital status, education, housing type, tract-level vehicle access).<sup>8</sup> Year and market fixed effects are captured by  $\lambda$ .

Figure 2 illustrates that bulk purchases compose a 10 percentage point larger share of non-food expenditures for households making over \$100,000 compared to those making \$5,000–\$8,000. As income increases, bulk purchases make up an increasing share of expenditures. For food items, there is a more muted increase of one percentage point across income groups.

The 10 percentage point gap is quite large. For the average household making between \$5,000–

<sup>7</sup>I define a market as a Designated Market Area (DMA), which are non-overlapping groups of counties originally defined by Nielsen to measure television audience share. DMA's provide a finer geographic aggregation than MSA's while capturing markets that are bigger than single counties.

<sup>8</sup>These characteristics are used consistently throughout the paper. See Appendix A.1 for details of demographic variables and how they are collected.

8,000, 39.6% of their non-food grocery spending is on bulk packages. Hence, households making over \$100,000 are 26% more likely to buy in bulk relative to the lowest-income group.

These patterns are consistent with high-income households buying in bulk, obtaining low unit prices, and consuming out of storage. Given the existence of quantity discounts, larger packages generally correspond to lower unit prices. Because low-income households are less likely to buy these storable items in bulk suggests that some obstacles may prevent them from buying and storing large packages.<sup>9</sup>

Because the bulk buying gap is largest for non-food products, the rest of this paper focuses on non-food products. These products are ideal for analyzing bulk purchasing because they isolate the key features that make bulk buying and quantity discounts attractive for households. Primarily, households can store items for future consumption. Additionally, these products generally do not have substitutes and they cannot be produced at home (e.g., toilet paper, diapers, etc.). My findings carry over to food products, but one must be careful to account for perishability, which counteracts product storability. Additionally, many food products have close substitutes (e.g., soda, juice, water, etc.) and home production (e.g., cooking meals) can substitute for many products (Aguiar and Hurst 2005, 2007).

### 3.3 Savings from Bulk Buying

In this subsection, I calculate the savings that low-income households could achieve from buying in bulk like high-income households. For each product category, I compute the average difference in package sizes by estimating the following regression:

$$\ln(AvgSize)_{imt} = \sum_q \beta^q Income_{imt} + \gamma X_{imt} + \lambda_m + \lambda_t + \epsilon_{imt}, \quad (3)$$

where *AvgSize* is the quantity-weighted average package size purchased by household *i* in market *m* in year *t*.<sup>10</sup> *Income* is an indicator for a household's income quartile. *X* controls for household characteristics. Market and year fixed effects are included through  $\lambda$ .

In this regression,  $\beta^q$  gives the average log-difference between the package size purchased by a household in income quartile *q* and the lowest-income household (making less than \$25,000). To compute savings, I multiply this average difference in package size purchased by the category-specific quantity discount estimated in Section 3.1. For example, high-income

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<sup>9</sup>This relationship persists across most categories. Appendix A.3 shows the same pattern for a few popular categories and Figure 8 illustrates the difference for all non-food categories.

<sup>10</sup>Average package size is weighted by quantity to account for the fact that an unweighted average would favor small packages.

households buy 30% larger packages of toilet paper which has a quantity discount of 0.216. Therefore, low-income households could save  $0.3 \times 0.216 = 0.0648$  or 6.5% from buying big packages like high-income households do. Aggregating across all categories where high-income households buy larger packages gives an estimated savings of 5%, or \$222, per year.<sup>11,12</sup>

Saving 5% on these common household purchases is substantial for low-income households. For the bottom quintile of the income distribution, these items account for 30% of their discretionary spending compared to 19% for the top quintile of the distribution.<sup>13</sup> If the about 24.4 million households making under \$25,000 were to obtain these savings, that would be an overall savings of \$5.4 billion annually.<sup>14</sup> For context, this is equal to 8% of the \$68 billion federal Supplemental Nutrition Assistance Program budget in 2017 (USDA 2019). These potential savings do not require low-income households to buy more over the course of the year because buying in bulk does not necessarily change how much households *consume*. It just changes how much they *buy* at one time.

## 4 Factors Affecting Bulk Buying

In this section, I provide evidence for the importance of *cognitive costs*, *store preferences*, and *storage costs* to the bulk-buying gap. To do this, I use plausibly exogenous variation and natural experiments to estimate the causal impact of unit pricing regulation and warehouse club entry on bulk purchasing. Since the biggest differences in bulk buying are for non-food grocery items, all analysis is restricted to non-food products.

### 4.1 Cognitive Costs

Cognitive costs are the first possible contributor to the bulk-buying gap. Consumers may not be aware of the quantity discount (or how valuable they are) because they do not compute unit prices when making purchases. To test this hypothesis, I utilize a novel hand-collected

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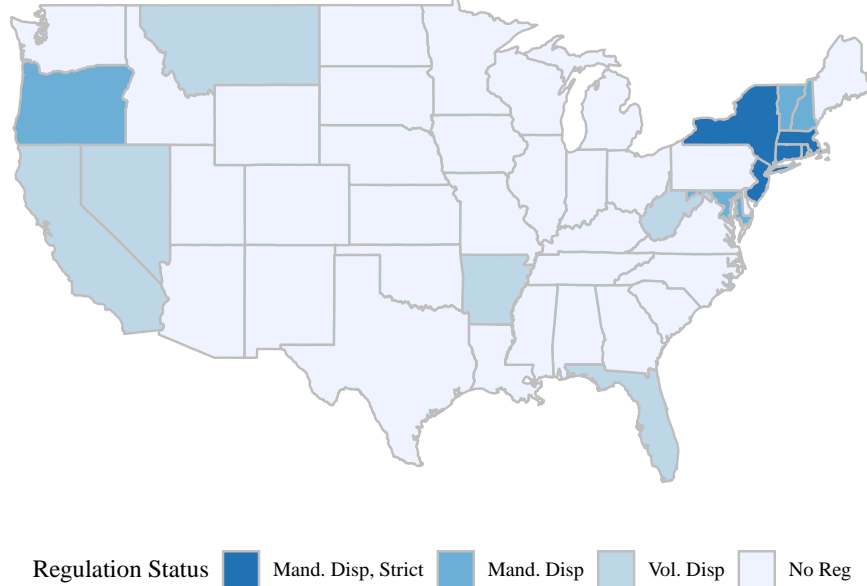
<sup>11</sup>This averages only across categories where high-income households buy larger packages. There are some categories, such as septic tank cleaners, in which high-income households buy in smaller packages. Imposing that low-income households buy the same average size across *all* categories reduces projected savings to 2.3%.

<sup>12</sup>The first-best calculations of savings would identify the product with the lowest unit price given a household's brand and store choice and compute savings based on that product. This estimate will likely be substantially higher than what I computed, so I view the estimated 5% savings as a conservative estimate of potential savings. See Appendix A.4 for calculations of savings on popular product categories.

<sup>13</sup>Discretionary spending is defined as total expenditures minus expenditures on shelter, utilities, transportation, healthcare, cash contributions, personal insurance, and pensions. Calculation is based on expenditure data on food at home and housekeeping supplies from Table 1 of the 2017 Consumer Expenditure Survey available at <https://www.bls.gov/opub/reports/consumer-expenditures/2017/home.htm>

<sup>14</sup>Household count comes from Table B19001 of the 2017 1-year American Community Survey.

Figure 3: Unit Price Regulations by State (2017)



Notes: Using data from NIST Handbook 130, this figure plots whether or not a state has regulations in place governing the display of unit prices as of August 1, 2017. "No Reg" denotes that no regulations are in effect. "Vol. Disp" denotes states where regulations apply if retailers choose to display unit prices. "Mand. Disp" denotes states where all retailers must display unit prices. "Mand. Disp, Strict" denotes states where strict display formatting requirements are in effect.

dataset of state-level unit-price regulations requiring retailers to display per-unit prices, which substantially reduce the cognitive costs of computing unit prices so households can compare products and pick the best value.

Unit price labeling dates back to the late 1960s and early 1970s. During this period, a large consumer protection movement pushed for unit prices to be posted so consumers could compare different brands and sizes of products (Miyazaki, Sprott, and Manning 2000). As a result, some states passed laws requiring retailers to display unit prices. These laws varied widely with some giving retailers discretion over how to display unit prices and other states specifying formatting requirements, such as minimum font sizes and background colors to aid readability and clarity (Rose 2000).

Using annual regulatory updates published by the National Institute of Standards and Technology (NIST), I compile a time series of state-level regulations on unit pricing (NIST 2019). For states with regulations, I cross-check NIST's designation with state regulatory codes and consulted with state officials to ensure accuracy. Figure 3 shows that, as of 2017, 16 states have regulations on the display of unit prices and 34 have no regulations.<sup>15</sup>

<sup>15</sup>Summary statistics of these groups are reported in Appendix Table 22.

If these regulations affect household decisions, then bulk buying should differ between states with and without these regulations. To test this hypothesis, I estimate the following regression:

$$BulkShare_{it} = \beta_1 Reg_{it} + \gamma X_{it} + \lambda_t + \epsilon_{it}, \quad (4)$$

where *BulkShare* is the annual share of expenditures that were bulk purchases for household *i* in year *t*. *Reg* is an indicator for whether or not unit-price regulations are in effect. *X* controls for household characteristics. I control for time fixed effects through  $\lambda$ . Standard errors are clustered by state because these regulations are at the state level.

Since 2004, no state has modified its regulations on unit prices, so the coefficient on unit pricing regulation is identified from cross-sectional variation between states that have regulations and those that do not. Columns (1) and (2) of Table 2 reveal that bulk purchasing is 3.6 percentage points higher in states with unit price regulations compared to states without unit price regulation, even after controlling for household characteristics and year fixed effects.

Table 2: Unit Price Regulations and Bulk Buying

	(1)	(2)	(3)	(4)
Regulation	0.036** (0.017)	0.036** (0.016)		
Vol. Disp			0.050* (0.027)	0.012 (0.010)
Mand. Disp			0.038*** (0.009)	0.038*** (0.009)
Mand. Disp, Strict			0.028*** (0.006)	0.027*** (0.006)
Demographics	N	Y	Y	Y
Omit California	N	N	N	Y
Observations	731,762	731,762	731,762	668,065
Adjusted R <sup>2</sup>	0.006	0.057	0.045	0.037

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Notes: Using Nielsen 2004–2017 Consumer Panel data combined with state-level regulations, this table shows the results of estimating Equation 4. The dependent variable is the annual share of bulk purchases made by households and the independent variables are either a binary indicator of the presence or absence of regulation (Columns (1) and (2)) or an ordered measure of regulatory stringency (Columns (3) and (4)). Column (4) omits California because it is the only state that has voluntary unit price, but strict requirements on how unit prices are displayed. Standard errors are clustered by state.

I then analyze these unit pricing regulations at a higher level of detail. State regulations vary across two dimensions: Posting and Formatting. Table 3 shows the breakdown of states along

these dimensions. First, states can opt to have unit price posting be voluntary (seven states) or mandatory (nine states). Second, states can specify how unit prices are formatted when they are displayed.<sup>16</sup> Formatting regulations specify features including minimum font sizes, background colors, and label positioning. With the exception of California, only states that mandate unit price posting have formatting requirements. Excluding California, regulations are naturally ordered: no regulation, voluntary posting, mandatory posting (no formatting requirements), and mandatory posting (with formatting requirements).

Table 3: Unit Price Regulations by State				
		No Formatting Rules		Strict Formatting Rules
Voluntary Posting		Arkansas	Montana	California
		Florida	Nevada	
		Hawai'i	West Virginia	
Mandatory Posting		Maryland	Vermont	Connecticut
		New Hampshire		New York
		Oregon		Massachusetts
				Rhode Island
				New Jersey

Notes: Based on state regulatory codes, the above table reports whether unit price posting is mandatory or voluntary for retailers and whether or not there are strict formatting requirements on how unit prices should be displayed (minimum font size, color, etc.).

Columns (3) and (4) continue the earlier analysis, but leverage the stringency of the regulations. Column (3) shows that mandatory posting is associated with significantly higher bulk buying, but states with voluntary requirements may have higher rates of bulk buying. However, as Table 3 shows, California is an outlier in this regulatory environment because it is the only state with the unique combination of voluntary posting and strict formatting requirements. Because of this, I exclude California and re-estimate the regression. Column (4) reveals that California is the primary driver of this effect and states with voluntary posting do not have significantly higher bulk purchasing. On the other hand, mandatory unit price posting is associated with a 2.7–3.8 percentage point increase in bulk buying. The point estimates for bulk buying in states with strict formatting requirements are lower than those in states without formatting requirements, but these estimates are not significantly different from each other. This pattern supports the intuition that standardized unit price presentation reduces cognitive costs, increases the salience of unit prices, and facilitates comparisons for consumers.

This estimation provides strong evidence of a relationship between unit pricing regulations and bulk purchasing. However, there is a risk of selection bias since these regulations were primarily adopted in the Northeast and West Coast regions of the United States. To avoid

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<sup>16</sup>All states with these regulations standardize how unit prices are to be calculated, which is what makes the voluntary states different from states without regulations.

endogeneity and provide causal evidence, I examine about 2,100 households that move between states with different regulatory regimes. To estimate the effect of unit-price regulations on these movers, I use a differences-in-differences specification:

$$BulkShare_{it} = \beta_1 Reg_{it} + \gamma X_{it} + \lambda_i + \lambda_t + \epsilon_{it}, \quad (5)$$

where the variables are the same as in Equation (4), but I control for household fixed effects and standard errors are clustered at the household level. With this specification,  $\beta_1$  is identified by changes in bulk purchases for households that move from a state with unit-price regulations to a state without unit-price regulations (or vice versa).<sup>17</sup> Since the “direction” of a household’s move may matter (i.e. whether they start in a state without regulations and move to a state with regulations or vice versa), in subsequent specifications, I will account for the direction of the move.

This specification relies on the assumption that households would have continued buying in bulk like other households that did not move. To provide evidence supporting this “common trends” assumption, I plot an event study by estimating a modified version of Equation (5):

$$Y_{it} = \sum_T \beta_1^t Yr_{it} + \gamma X_{it} + \lambda_i + \lambda_t + \epsilon_{it}, \quad (6)$$

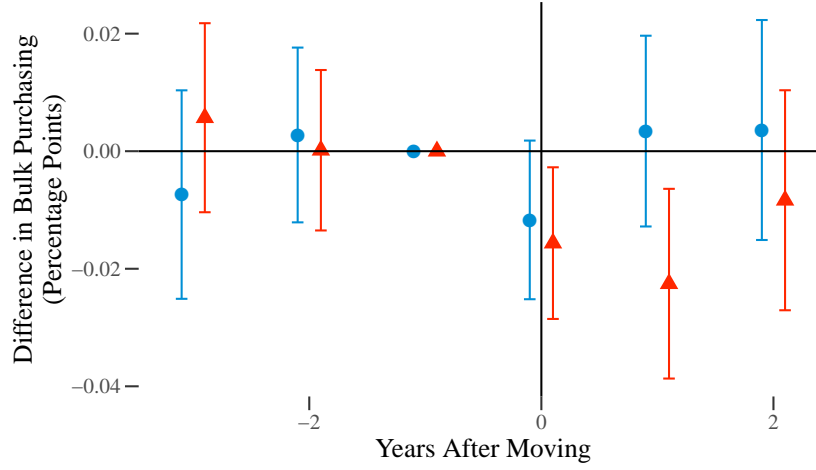
where  $Yr$  is a dummy for each year before or after a household moves to a state with a different unit pricing regime. The reference group is  $t = -1$  so all effects are relative to the year before the household moves. Figure 4 plots the annual coefficients. Figure 4 shows that there are no significant pre-trends. Furthermore, households decrease their bulk buying when they move from a state with unit-price regulations to a state without unit-price regulations. On the other hand, households that move from states without unit-price regulations to states with unit pricing regulations do not significantly change their bulk buying.

Table 4 reports the results of estimating Equation (5). Columns (1) and (2) show that moving to a state with unit price regulation increases bulk buying by about one percentage point. This specification implicitly assumes that the effect of moving to a state with unit price regulations will be the same as moving to a state without regulations (i.e. the effect is symmetric). Column (3) treats the different directions of moving differently and shows that moving to a state without unit price regulations significantly decreases bulk buying by 2.2 percentage points while moving to a state with regulations does not change bulk buying significantly.

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<sup>17</sup>Projection weights are not used because the weights are not designed for this subsample of movers.

Figure 4: Event Study of Movers and Unit Price Regulations



Law Status After Household Move    ● To Law    ▲ To No Law

Notes: Using 2004–2017 Nielsen Consumer Panel data, this figure plots the  $\beta_1^t$  coefficients and 95% confidence intervals from Equation (6), which regresses household bulk purchasing on dummies for years before and after a household moves to a state with a different unit pricing regime than the state it moves from. The regression controls for household characteristics as well as household and year fixed effects. Standard errors are clustered at the household level. "To" reports estimates for households that move from a state without unit price regulations to a state with unit price regulations. "Away" reports estimates for households that move from a state with unit price regulations to a state without regulations.

Table 4: Event Study of Movers to Different State Regulatory Regimes

	All Households		No Law To Law	Law To No Law
	(1)	(2)	(3)	(4)
Regulation	0.011*** (0.004)	0.013*** (0.004)	0.004 (0.006)	0.022*** (0.006)
Household FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Demographics	N	Y	Y	Y
Observations	731,762	731,762	723,926	723,394
Adjusted R <sup>2</sup>	0.658	0.659	0.659	0.659

Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Notes: Using 2004–2017 Nielsen Consumer Panel data and state-level regulations, this table shows estimates of Equation 5 which regresses household bulk buying on unit price regulation after controlling for household fixed effects. "Regulation" denotes the estimated effect of moving from a state without regulation to a state with regulation. Columns (3) and (4) only include one set of movers in each specification with the remaining households that do not move. Column (3) excludes households that move to states without unit price regulations to restrict identification of the regulatory effect to households moving to states with regulations. Column (4) excludes households that move to states with unit price regulations to restrict identification of the regulatory effect to households moving to states without regulations. Standard errors are clustered at the household level.



The asymmetric effect of unit pricing indicates the importance of both cognitive costs and consumer education. For households that move to states without regulation, the negative coefficient suggests that cognitive costs are discouraging households from buying in bulk. For households that move to states with regulation, they may not know how to best use the information provided and therefore consumer education may help them recognize the value of quantity discounts and buy in bulk more.

Unit pricing regulations are relatively simple to implement for both policymakers and retailers. Retailers will bear some initial setup costs of redesigning their price labels, but ongoing costs will likely be similar to current menu costs that firms bear.<sup>18</sup> Adopting unit pricing policies (like those recommended by the National Conference on Weights and Measures) would encourage bulk buying while imposing few costs. These findings support the broader assertion that increasing price transparency allows households to choose products that deliver more value.

## 4.2 Store Preferences

The second potential contributor to the bulk buying gap is *store preferences*; low-income households may not live in areas where bulk sizes are available or may not shop at stores that offer bulk sizes. In this subsection, I provide evidence that the bulk buying gap persists within neighborhoods and within store types. Then, I show that warehouse club entry increases bulk buying by 4.7–6.9%, but these increases hold only for middle- and high-income households.

### 4.2.1 Inequality Within Markets and Retail Chains

If supply factors are the primary driver of the bulk buying gap, then the gap should disappear when comparing households in the same neighborhood since they have the same set of stores to choose from. I show that the bulk buying gap still persists within ZIP codes. This remaining gap corresponds to the amount that *cannot* be explained by differences in access, at least as approximated by geography.

Even within ZIP codes, there may be other factors affecting where households shop, such as whether or not a household has a vehicle, access to public transit, or a warehouse club membership. To account for possible differences, I examine how much of the bulk buying gap persists within chains. This exercise assumes that within a chain, households have access

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<sup>18</sup>In 1975, the Government Accountability Office (then the General Accounting Office) estimated that implementation and maintenance would cost about 0.1% of sales (General Accounting Office 1975). This was estimated before the adoption of bar codes and other efficiency-improving practices of the retail sector. Implementing unit pricing now is likely to cost substantially less than those early estimates.

to the same assortment of goods (DellaVigna and Gentzkow 2019). I also examine the bulk buying gap within store types (i.e. “channel”) to account for the fact that bulk buying differences may primarily be between channels (discount versus dollar) instead of between retailers within a channel (Walmart versus Target).

I estimate within-ZIP and within-chain bulk buying gaps using a modified form of Equation 2:

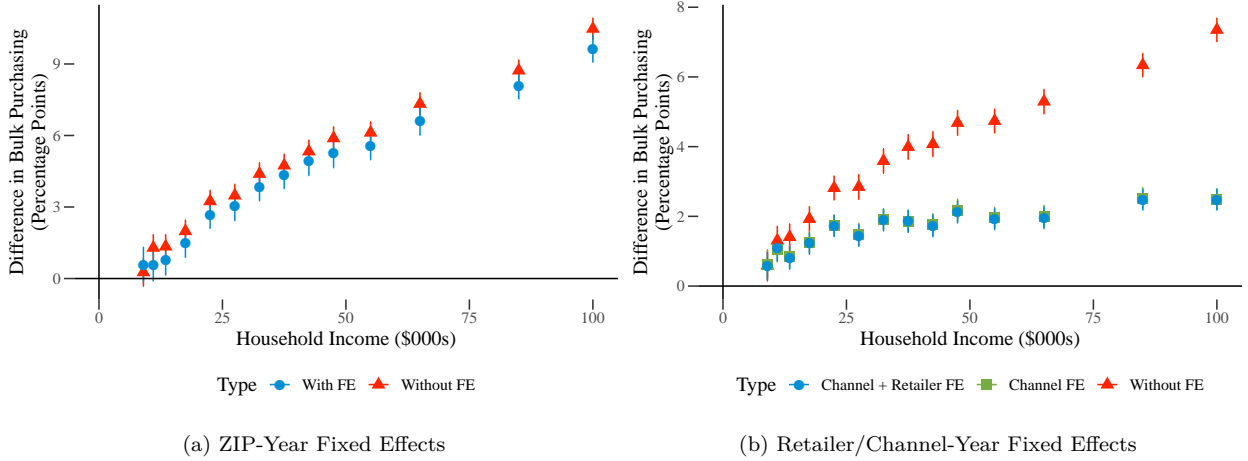
$$BulkShare_{imt} = \sum_q \beta^q Income_{imt} + \gamma X_{imt} + \lambda_{mt} + \epsilon_{imt}, \quad (7)$$

where  $Income$  is an indicator for the income bin of household  $i$  in market  $m$  in year  $t$ .  $X$  consists of household characteristics. For the analysis of bulk buying within ZIP code,  $BulkShare$  is the share of bulk purchases made by household  $i$  in ZIP code  $m$  in year  $t$  and  $\lambda_{mt}$  is a ZIP-year fixed effect. For the analysis of bulk buying within retail chains,  $BulkShare$  is the share of bulk purchases made by household  $i$  in retail chain  $m$  in year  $t$  and  $\lambda_{mt}$  is a retail chain-year fixed effect and/or a channel-year fixed effect.

Figure 5 plots the income coefficients with and without fixed effects for each regression. Adding ZIP-year fixed effects reduces the gap between the highest and lowest income groups by 9% (from 10.5 percentage points to 9.6 percentage points). Results are virtually unchanged if I use county-year fixed effects instead of ZIP-year fixed effects. Using channel-year fixed effects reduces the bulk buying gap by a more substantial 66% (from 7.4 percentage points to 2.5 percentage points). Adding retail chain-year fixed effects on top of channel-year fixed effects does not significantly affect the bulk buying gap. This implies that a large share of the bulk buying gap is related to the *types* of stores households shop at, but not the specific chain they choose within a particular store type.

Overall, within ZIP codes, the bulk buying gap between high- and low-income households persists. However, within store type (or retail chain), the bulk buying gap is substantially reduced. Two important conclusions can be drawn from these patterns. First, in an accounting sense, the type of store a household shops at accounts for two-thirds of the bulk buying gap. This is likely an overestimate given that there is endogeneity in store choice by households because many factors influence where households choose to shop. Second, the bulk buying gap *still persists* within channels and retail chains. These patterns suggest that where a household shops and what they choose within a store are much more important than where a household is located. The next section explores how store preferences are related to income and how warehouse clubs affect bulk buying.

Figure 5: Bulk Buying Within ZIP Codes or Stores



Notes: Using 2004–2017 Nielsen Consumer Panel data, this figure plots the income bin coefficients from Equation (7), which regresses the share of annual purchases that were bulk packages on household characteristics as well as either ZIP code-year, retailer-year, or channel-year fixed effects (a "channel" is a type of store). Nielsen projection weights are used to ensure national representativeness. Households making \$5–8k are the reference group. Coefficient values are reported in Table 19.

#### 4.2.2 Store Preferences by Income

The previous section shows that while the bulk buying gap persists within ZIP codes, it is narrower within store types and retail chains. In this section, I show that the biggest shopping differences between income groups are related to warehouse clubs. I then estimate the effect of warehouse club entry on bulk buying.

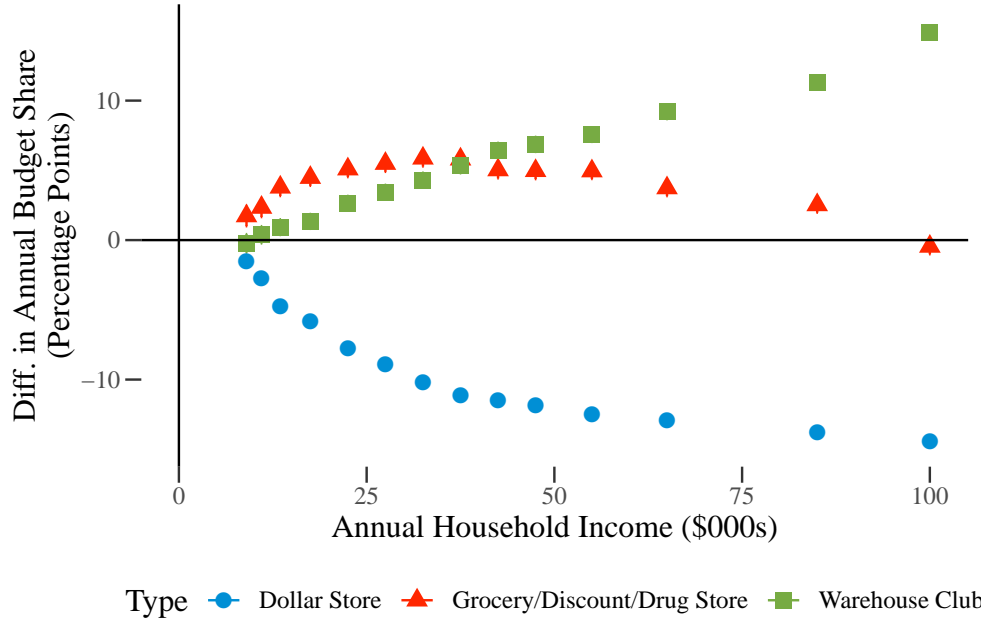
To demonstrate differences in store preference by household income, I examine the relationship between where households shop and their income using the following regression:

$$ChannelShare_{imt} = \sum_q \beta^q Income_{imt} + \gamma X_{imt} + \lambda_m + \lambda_t + \epsilon_{imt}, \quad (8)$$

where  $ChannelShare$  is the share of annual spending that household  $i$  in market  $m$  in year  $t$  made in a particular channel (grocery store, discount store, dollar store, drug store, or warehouse club).  $Income$  is an indicator for a household's income bin.  $X$  captures other household characteristics. Finally, market and year fixed effects capture differences in spending shares across markets and over time.

Figure 6 reveals that while there are small differences in the share of annual expenditures at grocery, drug, and discount stores, there are dramatic differences in whether households shop at warehouse clubs or dollar stores: households making over \$100,000 spend about 13 percentage points more of their non-food expenditures at warehouse clubs than households making under \$25,000.

Figure 6: Annual Spending By Store Type, Relative to Low-Income Households



Notes: Using 2004–2017 Nielsen Consumer Panel data, this figure plots the income bin coefficients from Equation (8), which regresses the share of annual purchases at each store type on household characteristics as well as year and market fixed effects. Nielsen projection weights are used to ensure national representativeness. Households making \$5–8k are the reference group.

Because the biggest differences are in warehouse clubs and these stores almost solely stock bulk sizes, I focus on how warehouse clubs affect bulk buying. The following analysis of warehouse clubs uses hand-collected data on over 1,400 warehouse club locations between 2004–2015.<sup>19</sup> The first possibility is that high-income households shop at warehouse clubs because they are closer. Table 5 shows that low-income households are about 15 miles away from the nearest warehouse club compared to only 8 miles away for high-income households.

Household Income	Mean	SD	25th Pctile	75th Pctile
<25k	14.79	18.98	3.26	20.53
25-50k	12.79	17.51	3.03	15.94
50-100k	10.61	15.16	2.85	12.01
>100k	7.92	12.08	2.51	8.45

Notes: Using Nielsen Consumer Panel data from 2004–2015 and warehouse location data, this table reports the distance between ZIP code centroids of warehouse locations and household locations. Nielsen projection weights are used to ensure national representativeness.

The ideal experiment would randomly assign warehouse clubs to neighborhoods and then their effect on bulk buying could easily be calculated. Even though store locations are not

<sup>19</sup>Data provided by the authors of Coibion, Gorodnichenko, and Koustas (2017) and covers BJ’s, Costco, and Sam’s Club.

randomly assigned, within a household, it is exceedingly unlikely that a warehouse club opening could be co-incident with a shift in bulk buying, so any observed changes are likely causal. Leveraging the panel structure of the Nielsen Consumer Panel, I estimate how a household’s bulk purchasing changes after a warehouse club opens using the following equation:

$$BulkShare_{imt} = \beta Entry_{imt} + \gamma X_{imt} + \lambda_{im} + \lambda_t + \epsilon_{imt}, \quad (9)$$

where *BulkShare* is the share of bulk purchases made by household *i* in market *m* in quarter *t*. *Entry* is an indicator for whether or not a warehouse club entered within 15 miles of household *i* in quarter *t*.<sup>20,21</sup> I include a household-market and year-quarter fixed effects  $\lambda$  to ensure that  $\beta$  is identified by within-household changes in bulk buying before and after a warehouse club opens instead of households that may move to areas closer to warehouse clubs. *X* controls for possible demographic changes within the household.

This specification relies on the assumption that households would have continued buying in bulk like other households that did not move. To provide evidence supporting this “common trends” assumption, I plot an event study by estimating a modified version of Equation 9, but replace the entry indicator with dummies for each quarter pre- and post-entry:

$$BulkShare_{imt} = \sum_q \beta^q Qtr_{imt} + \gamma X_{imt} + \lambda_{im} + \lambda_t + \epsilon_{imt}, \quad (10)$$

where *Qtr* is a dummy for each quarter prior to entry and after entry, with the quarter immediately before entry ( $q = -1$ ) as the reference group. Figure 7 plots the quarterly coefficients and shows that for most income groups there are no significant pre-trends. For households in the lowest income quartile, there is some evidence that those that experienced a warehouse club entry buy in bulk more often than other low-income households that do not experience an entry. After a warehouse club enters, there are significant increases in bulk buying for middle- and high-income households and these effects are persistent up to eight quarters after a warehouse club has opened.

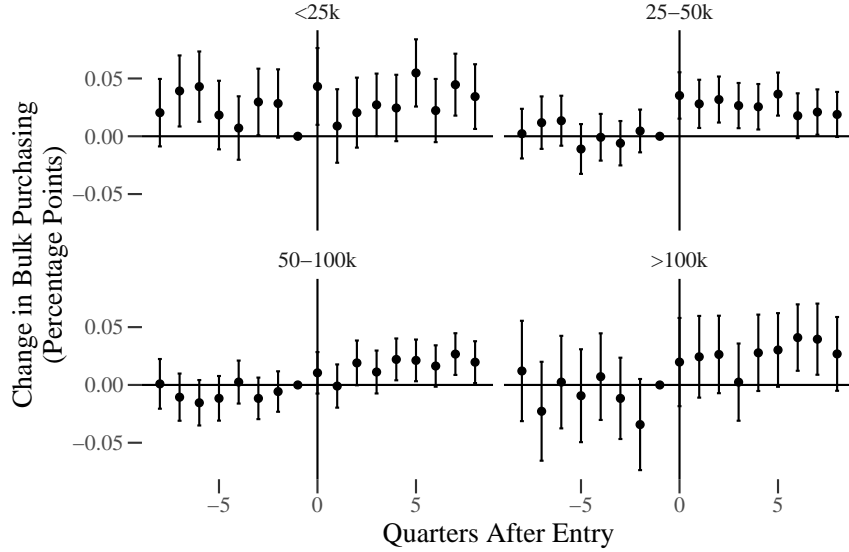
Table 6 shows the regression results. Overall, households that experienced a warehouse club entry increased their bulk purchasing by 1.7 percentage points. However, when I interact household income with warehouse club entry, the increase in bulk buying is due to changes

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<sup>20</sup>In cases where a household is located near multiple warehouse clubs, I use the earliest entry date since the first warehouse club would generate the largest supply shock.

<sup>21</sup>According to the 2017 National Household Travel Survey, the average household traveled about seven miles to buy goods, with low-income households traveling about one or two miles less than higher-income households (Federal Highway Administration 2017). Allowing for the possibility that households might travel farther to shop at a warehouse club, I use a cutoff of 15 miles. Appendix Table 23 shows that this pattern is robust to other cutoffs.

Figure 7: Event Study of Warehouse Club Entry



Notes: This figure plots the quarterly coefficients from Equation (10)—the effects of warehouse club entry on bulk purchasing of households before and after warehouse club entry—using 2004–2015 household-by-quarter Nielsen Consumer Panel data. The regression controls for household characteristics as well as household-ZIP code fixed effects. All coefficients are relative to bulk purchasing in the quarter before entry ( $q = -1$ ). Error bars denote 95% confidence intervals.

for households making over \$25,000 and is increasing in income, with households making over \$100,000 increasing their bulk buying by 3.5 percentage points. Households in the lowest quartile do not have any significant change in their bulk buying. One likely reason that low-income households do not change their bulk buying is that even after a warehouse club enters, households do not purchase a membership (fees range from \$45–\$120 depending on the chain and membership level). Other possible reasons are that low-income households do not have access to transportation that can carry items home, do not have the space to store the items, or even if they had a membership, they still would not purchase extremely large sizes available at warehouse clubs due to budget constraints.<sup>22</sup>

This analysis estimates the intent to treat effect since not all households shop at the entrant warehouse club after it opens. As a result, this is a conservative lower bound on the actual treatment effect on households that shop at warehouse clubs.<sup>23</sup> The effect is quite substantial even given how conservative it is.

<sup>22</sup>As an example, Philadelphia provides public transit access to a warehouse club. However, carrying club-sized items on a bus is infeasible for more than two or three items. A personal vehicle would be necessary.

<sup>23</sup>Even though low-income households do not change their bulk buying, other research suggests that they may be worse off because existing retailers are more likely to increase prices for storable products as a competitive response (Bauner and Wang 2019).

Table 6: Effect of Warehouse Club Entry on Bulk Buying

	(1)	(2)	(3)
Post-Entry	0.020*** (0.004)	0.020*** (0.004)	
Post-Entry : <25k			0.001 (0.008)
Post-Entry : 25-50k			0.019*** (0.006)
Post-Entry : 50-100k			0.025*** (0.005)
Post-Entry : >100k			0.035*** (0.009)
Household-ZIP FE's	Y	Y	Y
Year-Quarter FE's	Y	Y	Y
Demographic Controls	N	Y	Y
Observations	2,401,038	2,401,038	2,401,038
Adjusted R <sup>2</sup>	0.428	0.428	0.428

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Notes: This table uses 2004–2015 Nielsen Consumer Panel data at the household-quarter level. Coefficients are reported for Equation (9) which regresses households' quarterly bulk purchase shares on an indicator for warehouse club entry, household characteristics as well as household-ZIP code and year-quarter fixed effects are included. Projection weights are not used.

### 4.3 Storage Costs

Storage costs are the third contributing factor that I examine. Intuitively, households that buy in bulk need a place to store large packages, which could be in a basement, pantry, or cabinets. Households without available storage space may want to save money through quantity discounts, but choose not to because they have limited storage space.

The ideal experiment would randomly assign households to various home sizes and then observe their bulk purchasing behavior to identify storage costs. However, exogenously changing a household’s living situation is infeasible. The next best option is to test some intuitive implications of storage costs. First, while I cannot randomly assign households to different home sizes, there are many households that move while they are in the Nielsen panel. I observe whether households live in single-family homes or apartments, which generates variation in available storage space. According to the American Housing Survey, the median single-family home is about twice as large as the median apartment. Since at least 1999, new single-family homes have had a median size of 2,000-2,400 square feet while the median apartment is only 1,000-1,100 square feet and this holds true within Census regions as well. Therefore, households that move into single-family homes are likely to have more available storage space and this will increase their willingness to buy in bulk.

To test this hypothesis, I estimate how bulk buying changes when households change their housing size, by estimating Equation 11:

$$BulkShare_{it} = \beta_1 House_{it} + \gamma X_{it} + \lambda_i + \lambda_t + \epsilon_{it}, \quad (11)$$

where *House* is a dummy for whether a household *i* lives in a single-family house in year *t* (apartments are the reference group). *X* controls for changes in other household characteristics. Household and year fixed effects,  $\lambda$ , ensure that  $\beta$  is identified off of within-household changes in housing. Standard errors are clustered at the household level. Table 7 shows that bulk buying is one percentage point higher when households are in single-family homes compared to when they are in apartments.

Column (1) shows that bulk buying is 1.2 percentage points higher when a household lives in a single-family home. However, since housing changes can be due to other within-household shifts, such as marriage or having children, column (2) also controls for other within-household demographic changes. The increase in bulk buying is slightly reduced, but there is still an increase when households move into larger spaces. Finally, households may move into larger housing if they expect to earn more and this expectation of future income may also increase their bulk buying. Column (3) also includes a household’s one-year-ahead income and there



Table 7: Relationship Between Bulk Buying and Housing Changes

	(1)	(2)	(3)
Single-Family Home	0.012*** (0.002)	0.010*** (0.002)	0.010*** (0.003)
Market FE's	Y	Y	Y
Year FE's	Y	Y	Y
Demographics	N	Y	Y
Future Income	N	N	Y
Observations	731,762	731,762	566,535
Adjusted R <sup>2</sup>	0.687	0.687	0.690

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Notes: Using Nielsen 2004–2017 Consumer Panel data, this table shows the results of estimating Equation 11. The dependent variable is the annual share of bulk purchases made by households and the independent variables are housing and other household characteristics. Estimating includes household, market, and year fixed effects. "Future Income" denotes a household's income one year in the future. Standard errors are clustered by household.

is no change to the bulk buying increase after a household moves into a single-family home. This result is not causal, but it supports the intuition that when households have more storage space, they are more able to buy in bulk.

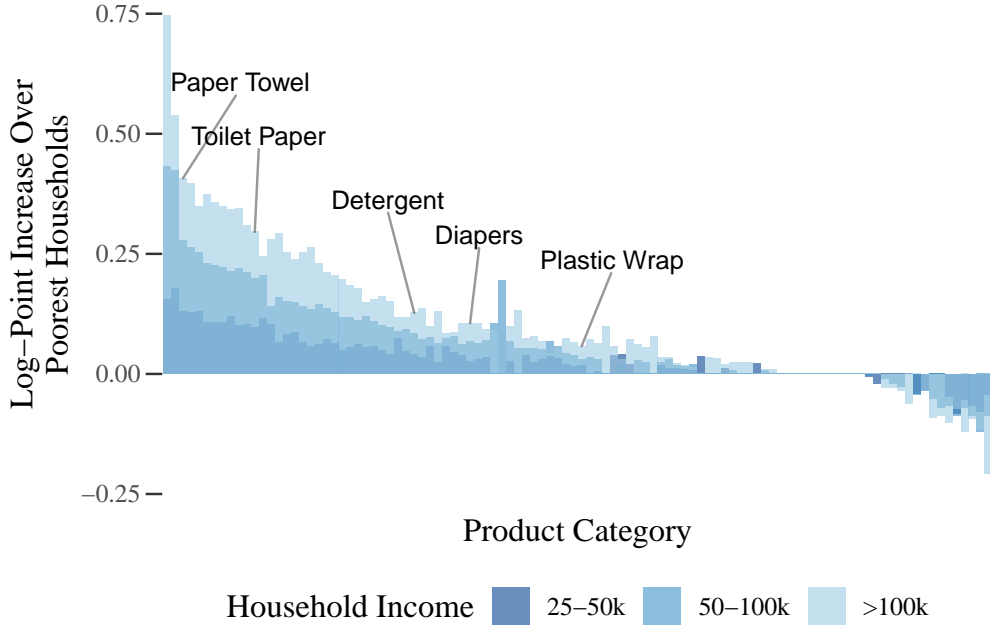
Another implication of storage costs are that products with a smaller "footprint" (physical volume) have lower storage costs. Therefore, if storage costs influence bulk buying, there should be a smaller gap in bulk buying for smaller products (like plastic wrap) relative to large, cumbersome products (like paper towels and toilet paper). To test this implication, I estimate Equation 3 (reproduced below) that relates average package sizes with household income:

$$\ln(AvgSize)_{imt} = \sum_q \beta^q Income_{imt} + \gamma X_{imt} + \lambda_m + \lambda_t + \epsilon_{imt},$$

where  $AvgSize$  is the average package size purchased by household  $i$  in market  $m$  in year  $t$ .  $Income$  consists of dummies for each income quantile  $q$ .  $X$  consists of household characteristics. Year and market fixed effects are captured by  $\lambda$ .

Figure 8 plots the income coefficients from the regression for all non-food grocery categories. I have highlighted some popular product categories. The bulk buying gap is largest for the physically biggest products such as paper towels and toilet paper while the gap is smaller for less bulky items such as liquid detergent and plastic wrap. Overall, this pattern supports the hypothesis that storage costs contribute to the bulk buying gap, but the persistence of the gap even for smaller products suggests that other factors are at play. This graph should

Figure 8: Bulk Buying Gap For Non-Food Grocery Products



Notes: Using 2004–2017 Nielsen Consumer Panel data, these figures plot the  $\beta$  coefficients from Equation (3), which regresses average package size purchased on household income. The regression controls for household characteristics as well as market and year fixed effects. Values are reported in Appendix Table 21.

also be interpreted with caution because not all products are commonly consumed across all income groups. The two largest gaps are in pool cleaning supplies and paper bags, which are more likely to be purchased by high-income households than low-income households, regardless of package size.

Overall, these results provide evidence that storage costs and bulk buying are related. When households move to larger homes (relative to apartments), they buy more in bulk. Similarly, product categories with larger physical footprints exhibit larger bulk buying gaps relative to product categories with smaller footprints. To more precisely quantify storage costs, I estimate a simple model of the consumer purchase decision.

## 5 Model

The previous analyses show that cognitive costs and storage costs affect the bulk buying decision. To decompose the contribution of each factor, I embed them into a discrete choice model of the household's purchase decision. The ideal setting would include a homogeneous good where demand is uncorrelated with income. Given substantial price, package size, and regulatory variation, differences in large and small purchases between households would identify storage costs and differences in buying between regulatory regimes would identify

cognitive costs. This setting is approximated by one where products have limited dimensions of differentiation and storage costs can be separately identified from demand.

A discrete choice model of toilet paper purchases closely approximates this ideal setting. Toilet paper is an excellent product for this analysis because it is a necessity item with easily observable dimensions of differentiation, namely price, quality, quantity, and package size. It is offered in a wide range of package sizes and stores stock numerous brands and sizes (grocery and mass merchandise stores usually stock 35–40 unique brand-sizes). The top five brands and private-label store brands account for 86% of sales. I focus on the most common package sizes, which range from 4- to 24-roll packages. I define a product as a unique brand-size combination.<sup>24</sup> Additionally, underlying toilet paper consumption is primarily a function of household composition and age, not income.<sup>25</sup> High-income households consume a similar amount as low-income households but make fewer purchases (Orhun and Palazzolo 2019). Finally, toilet paper cannot be easily substituted for another product nor can it be obtained through home production.<sup>26</sup>

The biggest identification challenge is separately identifying storage costs from underlying demand (i.e. households may buy large quantities because they have high consumption or because they have low storage costs). To separate storage costs from demand, I use variation induced by differences in product “concentration,” which I define as the yield of the product per unit volume. Product concentration breaks the direct link between volume and consumption. In the detergent category, a product’s yield is the number of washes it will supply. A concentrated detergent can wash the same number of loads but requires a smaller fluid volume than diluted detergent. Therefore, given the same number of washes, households that choose concentrated detergent must have higher storage costs than those choosing diluted detergent, assuming quality does not differ based on concentration.

The same reasoning holds true for toilet paper. Households do not demand a particular number of rolls (the primary determinant of package size), but choose how long they want their supply to last (i.e. purchase enough to last for two weeks, a month, two months, etc.).<sup>27</sup> Toilet paper comes in a variety of concentrations with “mega” rolls being more concentrated

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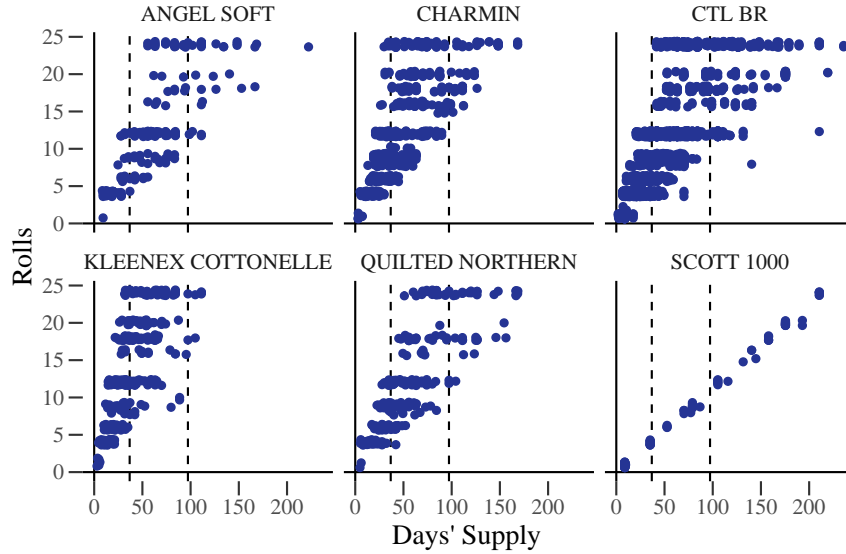
<sup>24</sup>Specifically, this is a unique brand-roll count-sheet count because packages can differ in their “concentration” due to “double,” “mega,” and “super mega” rolls.

<sup>25</sup>A 100-fold cross-validated elastic net regression of annual purchases on household characteristics rules out income as significantly predictive. See Appendix A.5 for details.

<sup>26</sup>While a bidet is a possible alternative, this is more likely a lifestyle choice instead of a situation where households switch between toilet paper and bidets. Furthermore, in the United States, 98% of households report that they use toilet paper (the remainder either said no or did not respond) (Statista 2019).

<sup>27</sup>According to a 2007 Charmin survey, the average person uses 57 sheets per day. I assume this consumption rate when computing how long a product will last (Jaffe 2007).

Figure 9: Scatter-plot of Toilet Paper Package Size and Quantity



Notes: Using 2004–2017 Nielsen Consumer Panel data, this figure plots the package sizes and quantities of the top five toilet paper brands and private-label products. The y-axis represents the number of toilet paper rolls contained in a package while the x-axis represents the number of days a product will last a single person household assuming a consumption rate of 57 two-ply sheets per day (Jaffe 2007). Noise is added vertically to better illustrate the number of products available within package sizes since roll counts are discrete. Dashed lines indicate the 25th and 75th percentiles of the average days’ supply purchased by households.

than “regular” rolls. Therefore, a household that purchases 24 “regular” rolls has the same demand for toilet paper as a household that purchases six “mega” rolls, but the former household has lower storage costs since they can store the bigger package.

To illustrate the varying concentrations of toilet paper, Figure 9 plots the distribution of quantity (measured in number of days the supply will last for a single person) against package sizes (measured in rolls) for toilet paper products in the Nielsen data. As expected, there is an increasing relationship between how long the package will last and the number of rolls in a package, but there is substantial variation within packages containing the same number of rolls. The dashed lines denote the 25th and 75th percentiles of the average days’ supply purchased by households. A wide range of package sizes fall within this range for each brand.<sup>28</sup> For example, a household demanding a 60-day supply of Charmin could purchase a package containing anywhere from 8 to 24 rolls. This overlap generates the necessary variation to separate storage costs from underlying demand.

<sup>28</sup>Scott toilet paper is an exception because it does not offer different roll types. All rolls have 1000 sheets.

## 5.1 Model Setup

I model a household's purchase decision using a static discrete choice framework. When making a purchase, households consider the price, unit price, quality, quantity, and size of each package and choose the package that maximizes their utility. These features are captured in the household  $i$ 's indirect utility function:

$$U_{ijt} = \beta_1 Price_{jt} + \beta_2 UnitPrice_{jt} + \beta_3 UnitPrice_{jt} \times Reg_i + \beta_4 \log(Days_j) + \beta_5 BigPack_j + \beta_6 BigPack_j \times House_i + \beta_7 SmallPack_j + \beta_8 SmallPack_j \times House_i + \theta_{b(j)} + \epsilon_{ijt}, \quad (12)$$

where  $Price$  is the total price of product  $j$  at time  $t$ .  $Reg$  is an indicator for whether unit price regulations are in effect.  $Days$  is the number of days the package will last (a function of the number of total sheets in the package).  $UnitPrice$  is the per-day price of the package, since the yield of a package is how many days it will last.  $BigPack$  is a dummy for the package having more than 12 rolls and  $SmallPack$  is a dummy for less than 12 rolls.<sup>29</sup>  $House$  is an indicator for whether the household lives in a single-family home, with the alternative being an apartment. Finally,  $\theta$  is a brand fixed effect. Brand fixed effects capture quality differences between products. I assume  $\epsilon$  is iid Type 1 extreme value.

This simple model incorporates the key features necessary to quantify the contribution of cognitive and storage costs to the bulk-buying gap. Preferences for package size (a measure of storage costs) are captured by  $\beta_5$ ,  $\beta_6$ ,  $\beta_7$ , and  $\beta_8$ , while the effect of displaying per-unit prices is captured by  $\beta_3$ .

The price coefficient is identified using price variation across shopping trips due to shopping at different stores or sales. The size coefficient is identified by variation in the product "concentration" as illustrated in Figure 9. That is, given their preferred days' supply (x-value), some households choose large packages and some choose small packages (y-value).

Given these assumptions and the structure of the error term, the probability that household  $i$  chooses product  $j$  on trip  $t$  has a closed form:

$$P_{ijt} = \frac{e^{\beta' x_{ijt}}}{\sum_j e^{\beta' x_{ijt}}}, \quad (13)$$

---

<sup>29</sup>Households bunch at 12-roll packages, so this allows for different package preferences around this bunching point.

As a result, the log-likelihood function can be written as:

$$LL(\beta) = \sum_t \sum_i \sum_j y_{ijt} \log(P_{ijt}), \quad (14)$$

where  $y$  indicates whether household  $i$  chose product  $j$  on shopping trip  $t$ . The preference parameters  $\beta$  can then be estimated using MLE.

## 6 Estimation Results

I estimate this model separately for each income quartile using household purchases from 2016. I observe about 45,500 toilet paper purchases across about 14,800 households at grocery and mass merchandisers. Table 8 reports model estimates.

The estimation results show that both the price and unit price coefficients are negative, implying that all else equal, households prefer lower prices. Lower income households are more price sensitive than high-income households, but higher-income households are more sensitive to unit prices. The interaction terms reveal that when unit prices are posted, all households are more sensitive to unit prices with lower income households being affected the most. This pattern supports the assertion that households respond to new price information. All households prefer to have more days' supply of toilet paper compared to less. In terms of storage costs, all households have a similar preference against large sizes and, with the exception of the highest-income households, this preference is not significantly different based on their housing type. The highest-income households that live in single-family homes have a much smaller preference against large packages than other income groups. On the other hand, all households also have a similar dislike for small packages. Under a pure storage costs story, the small packages would have been expected to have a positive sign for low-income households. However, as mentioned in the model specification section, there is bunching at 12-roll packages across households of all types, so this negative sign on the small size is likely a result of that bunching.

Figure 10 plots the distribution of price elasticities (own-price) for each brand. The majority of elasticities fall between -0.5 and -2.5 with poorer households having larger elasticities (in magnitude).<sup>30</sup>

To check the reasonableness of the estimates, I compute the willingness-to-pay measure for

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<sup>30</sup>Table 4 of Cohen (2008) reports elasticities ranging from -1.94 to -2.54 for paper towels. My estimates cover this range, but are generally much lower with a large mass between -0.5 and -1.5. Demand for toilet paper is likely less elastic than toilet paper since kitchen towels or paper napkins can substitute for paper towels. Toilet paper does not have any similar, readily available, substitutes.

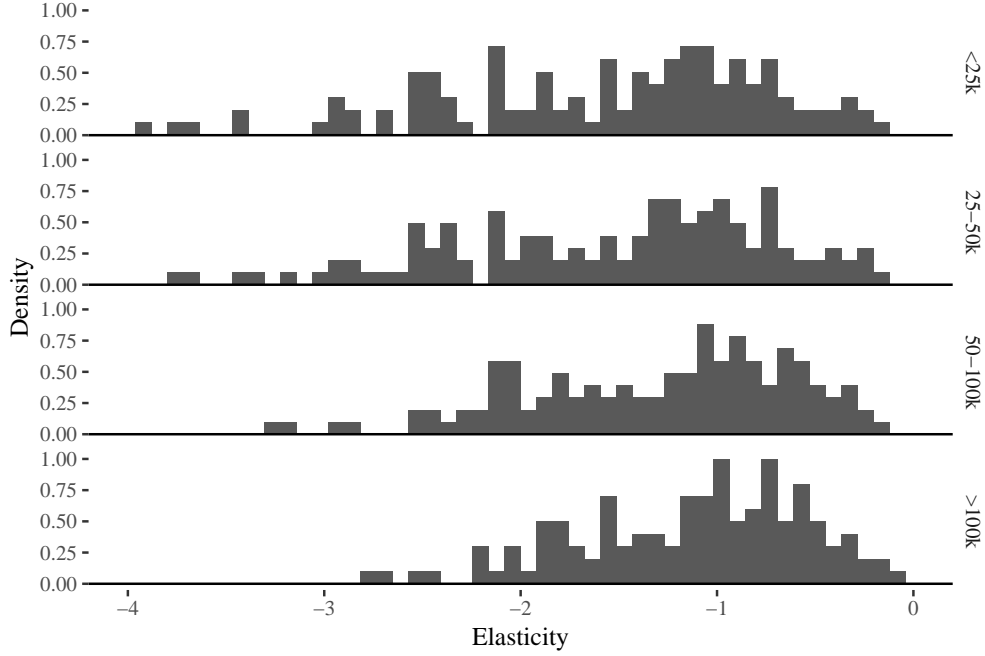
Table 8: Multinomial Logit Estimation Results (2016)

	<25k	25-50k	50-100k	>100k
	(1)	(2)	(3)	(4)
Total Price	−0.179*** (0.009)	−0.177*** (0.006)	−0.153*** (0.005)	−0.132*** (0.007)
Unit Price	−8.243*** (0.442)	−7.963*** (0.272)	−9.671*** (0.245)	−8.504*** (0.377)
. : Reg	−1.860*** (0.462)	−2.610*** (0.281)	−1.441*** (0.228)	−0.556* (0.311)
Log(Days)	0.262*** (0.051)	0.384*** (0.034)	0.265*** (0.030)	0.303*** (0.051)
Large Size	−0.569*** (0.096)	−0.620*** (0.070)	−0.391*** (0.068)	−0.576*** (0.126)
. : Home	0.147 (0.113)	0.092 (0.078)	−0.012 (0.072)	0.305** (0.129)
Small Size	−0.243*** (0.057)	−0.288*** (0.044)	−0.267*** (0.048)	−0.437*** (0.091)
. : Home	−0.228*** (0.065)	−0.127*** (0.047)	−0.226*** (0.050)	−0.100 (0.093)
Brand FE's	Y	Y	Y	Y
Observations	4,968	12,950	17,875	7,942
Log Likelihood	−15,758.520	−40,784.040	−55,809.530	−24,763.630

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Notes: Using 2016 Nielsen Consumer Panel and Retail Scanner data, this table presents MLE estimates from Equation 12. "Total Price" denotes the total price of the package while "unit price" is the price per day that the package will last (assuming constant consumption of 57 sheets per day (Jaffe 2007)). "Reg" indicates whether unit price regulations are in effect. "Large" indicates packages that are larger than 12 rolls and "small" indicates packages that are smaller than 12 rolls. A 12-roll package is the reference group. "House" indicates if the household lives in a single-family home (reference group is an apartment).

Figure 10: Distribution of Price Elasticity by Household Income



Notes: Using 2016 Nielsen Consumer Panel and Retail Scanner data, this figure plots the distribution of price elasticities resulting from the estimation of Equation 12.

each coefficient by dividing each coefficient by the price coefficient. Households are willing to pay between \$0.45 and \$0.64 for a \$0.01 reduction in the unit price of the package (price per day), which is reasonable given that a wide range of packages will last for one to two months (See Figure 9).

These results support my earlier findings that unit price regulations affect a household's bulk buying decision and that high-income households have lower storage costs. In the counterfactuals, I predict how the bulk buying gap changes in response to regulatory changes and reductions in storage costs.

## 6.1 Model Fit

Table 9 compares the overall model predictions to the actual data. The model fits the data quite well, even given its parsimony. It slightly over-predicts purchasing for most households, but this is primarily because it does not capture some products that are disproportionately popular (or unpopular) relative to what would be expected based on their characteristics. For example, a particular Charmin 6-pack has a 9–10% share for each income group, but based on its characteristics, the model only predicts a 6–7% share. Including a product fixed effect would ensure a better fit, but at the cost of reducing the interpretability and intuition of the model. I opt to maintain the parsimony and interpretability of the model and simulate



counterfactuals using this specification.

Table 9: Multinomial Logit Model Fit (Days’ Supply Purchased)

Income	Data	Model
<25k	48.64	49.06
25-50k	49.07	49.81
50-100k	51.23	52.18
>100k	53.85	53.50

Notes: Using 2016 Nielsen Consumer Panel and Retail Scanner data, this table compares the average days’ supply of toilet paper purchased in the data with the predicted purchase from the model. I assume an average daily consumption rate of 57 two-ply sheets per day (Jaffe 2007).

## 7 Counterfactuals

Using the parameter estimates from the previous section, I predict how households respond to lower storage costs and universal unit price regulation. For these counterfactual exercises, I compare all counterfactual results to a “base case” of predicted purchases given their current shopping environment. I consider two counterfactual scenarios:

1. **Unit-Price Regulation:** Unit-price regulations are adopted everywhere.
2. **Reduced Storage Costs:** All households have the same storage costs (i.e. size preferences) as high-income households.

For the unit-price regulation scenario, I set each household’s price coefficients (both total and unit prices) to the sum of their coefficient and the regulation interaction term. For households making under \$25,000, their unit price coefficient becomes  $-8.243 - 1.860 = -10.103$ . For the reduced storage cost scenario, I set all size coefficients equal to the coefficients for households making over \$100,000.

Table 10 reports the counterfactual predictions. When unit price regulations are adopted, all but the highest-income households increase their purchase quantity, with lower income groups increasing the most. As a result, the gap between the top and the bottom income quartiles closes by 27%. Equalizing storage costs closes another 27% of the gap, with all but the lowest-income households buying virtually the same amount as the highest-income households. The remaining difference is due to brand preferences, particularly because low-income households have a stronger preferences for generic brands.

These counterfactuals support the main findings from Section 4 which showed that unit price regulations increase bulk buying and that storage costs are a substantial factor preventing

Table 10: Predicted Effects on Bulk Purchasing

Income	Base	+ Unit Price Regs	+ Rich Storage
<25k	49.06	50.28	51.48
25-50k	49.81	51.63	53.25
50-100k	52.18	53.19	53.39
>100k	53.50	53.50	53.50

Notes: This table reports predicted package quantities purchased by households using model estimates of Equation (12). Units are number of days the chosen package will last assuming average daily consumption rate of 57 two-ply sheets (Jaffe 2007). The "Unit Price Regs" scenario imposes unit price regulations everywhere. The "Rich Storage" scenario imposes that all households have the same preferences for "large" packages as households making over \$100k. Scenarios are cumulative.

households from buying in bulk. Since the earlier sections examined bulk purchasing across all non-food products, I repeat the earlier analysis on mover households specifically for toilet paper purchases. I estimate a modified version of Equation 5 which replaces share of bulk purchases with log days' supply of toilet paper:

$$\text{Log}(\text{DaysSupply})_{it} = \beta_1 \text{Reg}_{it} + \beta_2 \text{SingleFamily}_{it} + \gamma X_{it} + \lambda_i + \lambda_t + \epsilon_{it}, \quad (15)$$

Table 11 shows that households increase the days' supply purchased by 3.5% when unit prices are posted and by 2.6% when they move into a single-family home. The model predictions are in line with these changes. The model predicts that purchasing increases by 1.9–3.7% (barring high-income households) when unit prices are posted and by 0–3.1% when storage costs are reduced. Overall, reducing cognitive costs and increasing the salience of unit prices helps households make better value decisions, and generate a similar boost to bulk buying as reducing storage costs.

Given the model predictions, I can also estimate how the average unit price varies in each counterfactual scenario. Table 12 reports how the average unit price paid (in cents per day) changes under each counterfactual scenario.

Household pay a lower unit price under both counterfactual scenarios. Universally displaying unit prices reduces the average unit price paid for the lowest-income households from 15.58 cents to 14.72 cents. Setting storage costs equal to those of high-income households further reduces the average unit price paid to 14.66 cents. Overall, these two policies reduce the average unit price paid by 6%. Similar reductions are achieved by all but the highest-income households. Overall, posting unit prices and reducing storage costs encourages households, especially the lowest-income households, to buy larger quantities and pay lower unit prices.

Table 11

	(1)	(2)
Regulation	0.029* (0.015)	0.035** (0.015)
Single-Family Home		0.026*** (0.006)
Household FE	Y	Y
Year FE	Y	Y
Demographics	N	Y
Observations	4,553,957	4,553,957
Adjusted R <sup>2</sup>	0.507	0.508

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Notes: Using 2004–2017 Nielsen Consumer Panel data and state-level regulations, this table shows estimates of Equation 5 which regresses household bulk buying on unit price regulation after controlling for household fixed effects and changes in household characteristics. "Regulation" denotes the estimated effect of moving from a state without regulation to a state with regulation. "Single-Family Home" indicates that household lives in a single-family home with the reference category being an apartment. Standard errors are clustered at the household level.

Table 12: Predicted Effects on Unit Prices Paid (Cents / Day)

Income	Base	+ Unit Price Regs	+ Rich Storage
<25k	15.58	14.72	14.66
25-50k	16.49	15.19	15.11
50-100k	16.79	16.13	16.12
>100k	18.30	18.30	18.30

Notes: This table reports predicted unit price (cents / day) paid by households using estimates of Equation (12). The "Unit Price Regs" scenario imposes unit price regulations everywhere. The "Rich Storage" scenario imposes that all households have the same preferences for "large" packages as households making over \$100k. Scenarios are cumulative.

## 8 Conclusion

This paper documents the new fact that low-income households are less likely to take advantage of quantity discounts relative to high-income households. This gap is especially large for storable, necessity items like toilet paper and paper towels. If low-income households bought in bulk like high-income households, they could save 5% on grocery items, saving an aggregate of \$5.4 billion annually. I provide evidence that *cognitive costs*, *store preferences*, and *storage costs* contribute to this gap.

By using state-level variation in whether or not retailers have to display unit prices, I find that displaying unit prices reduces cognitive costs and increases bulk buying. Then, I show that *where* a household shops accounts for a large portion of this disparity and that warehouse clubs increase bulk buying, but only for middle- and high-income households. Low-income households are unlikely to shop at warehouse clubs, even if they are nearby. Finally, I show that households increase bulk buying when they move to larger housing, supporting the fact that storage costs also influence the bulk buying decision.

Combining these features into a discrete choice model of toilet paper purchases, I predict how households' bulk purchasing changes if unit-price regulations are adopted universally and if storage costs are removed. I find that posting unit prices closes the bulk buying gap by 27% and reducing storage costs closes the gap an additional 27%, with middle-income groups almost completely closing the gap with high-income households. Furthermore, not only are households buying larger quantities, they are paying lower unit prices, with the lowest-income households reducing their unit prices by 6%.

This paper is one of the first to focus on consumer's take-up of quantity discounts and explore the factors that contribute to this decision. It provides evidence that *cognitive costs*, *store preferences*, and *storage costs* affect a households bulk buying decision. These differences have substantial financial consequences for the poorest households and are likely to generate systematic underestimates of consumption inequality if quantity discounts offset quality differences between products. Additionally, if the prices of large and small packages evolve differently, then households may experience substantial changes in their buying power. Future work will determine the extent to which inequality and inflation measures are underestimated because of quantity discounts.

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# A Appendix

## A.1 Data Appendix

The Nielsen Consumer Panel consists of about 40,000–60,000 US households that provide information on their shopping purchases using in-home scanners or Nielsen’s mobile app. Panelists are geographically dispersed and demographically balanced. Households are recruited based on key demographic characteristics, primarily household size, income, age, education, presence of children, race, ethnicity, and occupation. To generate national averages, Nielsen assigns each household a projection factor.

Households are recruited through direct mail and online invitations. To incentivize households to remain in the panel, Nielsen provides monthly prize drawings, sweepstakes, points, and regular communication and support to panelists. Nielsen tries to ensure that incentive methods are non-biasing and regularly tests for its correlation with retention rates. To ensure data quality, Nielsen filters out any households that are poor reporters and do not meet minimum spending thresholds based on their household size. All households in the sample meet this threshold for the full year.

Demographic variables are recorded and updated annually. For my analysis, I collapse some of the demographic variables into more aggregate categories. Household composition measures the number adults and children residing in the home. Marital status is an indicator for whether the head of household is married or not (I do not distinguish between single, divorced, or widowed). Education is an indicator for whether at least one head of household completed college. Housing variables indicate whether a household lives in a single-family home, and apartment, or a mobile home. Finally, age is the age of the head of household. In the case of two heads, I average the two ages.

To construct my analysis sample, I remove any households where the head of household is a student or a member of the military because these households likely have different living arrangements that are not representative of a typical household’s decision (i.e. on campus housing or barracks are different than traditional homes and apartments). I drop any households living in mobile homes as well because this type of housing could include a wide range of house types including RVs and manufactured homes. I also remove any households making less than \$5,000 and those that could not be geocoded based on their ZIP code.<sup>31</sup>. Finally, some households were dropped because they could not be matched to tract-level

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<sup>31</sup>I use the 2017 Census Gazetteer to assign ZIP codes to the latitude and longitude of their population-weighted centroid



car ownership data.<sup>32</sup> Table 13 reports how many households were removed based on this cleaning procedure.

Table 13: Homescan Sample Construction

Step	HH
Starting HH:	178,232
Exclude military and students:	175,102
Exclude Households under 5k:	174,106
Exclude Mobile Homes:	167,065
Drop ZIPs Not Geocoded:	166,366
Cannot Be Matched to Car Access:	166,164

Notes: Using 2004–2017 Nielsen Consumer Panel data, this table reports the number of unique households in the sample after each step of data refinement.

In the purchase data, I exclude alcohol, tobacco, pet items, health and beauty items, general merchandise, “magnet,” and “deferred” product categories from my analysis. Alcohol and tobacco are excluded because of their addictive qualities, which may induce peculiar purchase patterns. For example, a smoker may choose to only buy one pack of cigarettes with the intention of quitting even though a full carton may deliver a better value. Pet items are excluded to focus on products intended for human consumption. I exclude health and beauty items and general merchandise because these products such as trash cans, printers, eye shadow, and antacids are unlikely to be bought in bulk or have irregular consumption patterns. “Deferred” categories are categories that Nielsen has stopped tracking, so to maintain a consistent sample of products, these are excluded from my analysis. Finally, “magnet” purchases are items which do not have a UPC codes such as fresh fruits and vegetables, deli counter items, or bakery items. Because these items are only recorded for a subset of Nielsen households and are not standardized, I also exclude them from my analysis. This process leaves me with 721 unique product categories. Because this paper focuses on bulk purchases, I also exclude 28 categories that have five or fewer sizes across all possible products.<sup>33</sup> Overall, the products analyzed are common household staples including almost all food categories, basic toiletry items, and non-food essentials like toilet paper, soaps/detergents, and diapers. See Table 14 for summary statistics of the top 20 product categories by annual spending.

<sup>32</sup>Car ownership data comes from the 2009–2013 American Community Survey.

<sup>33</sup>These excluded categories are: jelled aspic salad, sour cream sauce mix, canned roast beef, canned roast beef hash, retort pouch bags, prepared sandwiches, canned rice, canned dumplings, canned bread, frozen vegetables in pastry, frozen grapefruit juice, frozen grape juice, frozen orange juice, frozen cream substitutes, canned ham patties, bathroom accessory, packaged soap, borateem, dry starch, grease relief, bathroom brushes, miscellaneous brushes, thermometers, dustpans, feather dusters, laundry baskets, sanitary belts, gift package with candy or gum.

Table 14: Summary Statistics of Top 20 Product Categories in Nielsen Homescan Data (2017)

Product	Annual Spending	SD	Avg. Price	SD	Avg. Size	SD
Soft Drinks	79.38	139.02	4.75	4.17	85.87	53.81
Diet Soft Drinks	74.82	132.79	4.73	5.07	84.18	65.06
Milk	65.65	77.02	3.11	1.79	97.79	35.00
Cereal	57.97	68.37	4.06	2.10	18.05	8.17
Toilet Paper	56.15	49.47	11.44	7.09	17.09	10.51
Yogurt	55.00	75.68	3.28	2.17	17.25	15.22
Coffee	53.97	61.69	8.60	5.74	21.84	11.05
Bread	50.03	47.09	2.88	1.52	20.54	4.64
Cookies	46.97	57.60	3.59	3.44	13.02	6.39
Fresh Meat	46.96	62.86	7.75	5.03	30.48	24.97
Frozen Pizza	44.48	60.64	5.99	3.67	20.69	12.48
Bottled Water	44.06	73.46	4.21	3.75	261.91	181.39
Fresh Fruit	42.68	64.91	4.28	2.06	1.93	1.31
Chocolate Candy	41.05	53.83	3.91	3.67	8.64	9.15
Detergent	40.17	45.29	10.05	7.85	99.52	61.23
Shredded Cheese	39.16	42.80	4.21	2.45	13.37	10.98
Bacon	37.63	45.44	6.87	4.67	17.42	11.88
Ice Cream	37.36	50.34	4.43	2.03	46.80	24.47
Potato Chips	35.99	41.71	3.04	1.89	8.87	3.81
Canned Soup	32.39	38.36	3.21	2.22	22.07	17.33

Notes: Using 2004–2017 Nielsen Consumer Panel data, this table reports summary statistics for the top 20 product categories by total spending. Annual spending is the average spending in that product category among households that purchased in that product category over the course of the year. Average price and average size are the average prices and sizes of products purchased in their corresponding category. All estimates are weighted using Nielsen’s projection weights. Prices are in nominal 2017 dollars. Sizes are reported in common units for for that category (e.g. ounces for milk).

To compare sizes across different product categories, I assign each product to its quintile in the size distribution for that product category. I assign quintiles based upon the sample quintiles of product sizes to ensure that each quintile has 20% of available products in its support. An alternative strategy would assign quintiles based on cutting the range of product sizes into equal intervals. However, in some product categories, this risks generating quintiles with sparse support when there is an especially large package available. As an example, consider eggs. Most packages contain 6, 12, or 18 eggs, but there are some products that offer up to 15-dozen eggs (180 eggs). Generating quintiles by cutting the available range into equal intervals would generate quintiles of 1-36, 37-72, 73-108, 109-144, 145-180 which would assign almost all packages to the first quintile and the fifth quintile. Using the sample quintiles generates a more even distribution ensuring better support of each quintile. For products with a narrow range of sizes that fall in multiple quintiles, I assign the product to the minimum quintile. For example, over 60% of egg products are dozens, which covers three quintiles. I assign all products with 12 or fewer eggs to the first quintile.

## A.2 Quantity Discounts and Coupon Savings

This section compares savings from quantity discounts to savings from coupons. To be conservative, I compare the savings from redeemed coupons (likely higher than the average savings of all coupons offered) to savings offered by quantity discounts (likely lower than quantity discounts actually redeemed). For each product purchased in the Consumer Panel data, households can input the value saved if they used a coupon. For each product category, I compute the average discount across all products in that category.

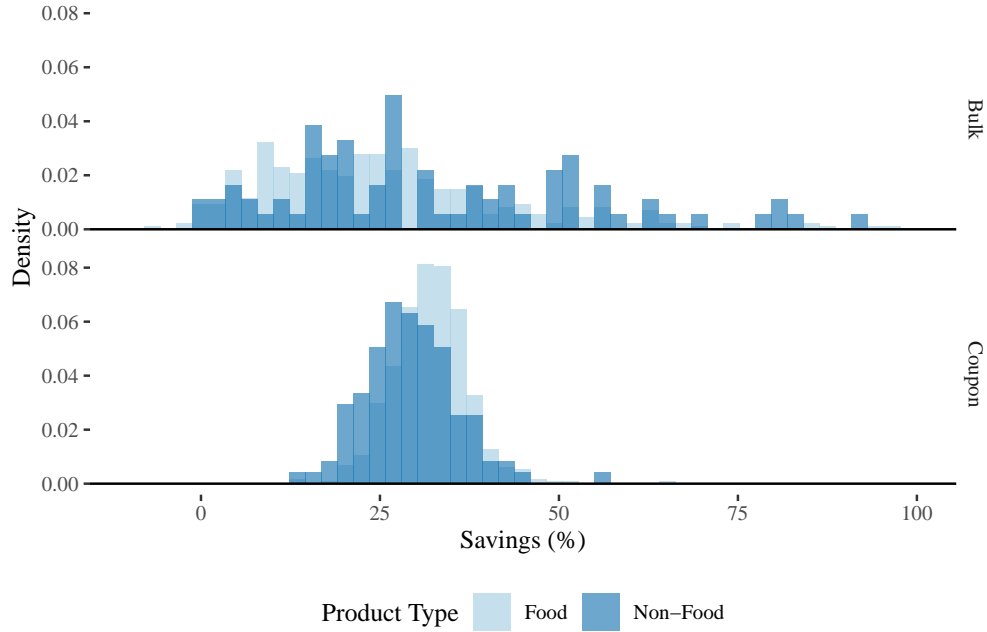
I then estimate quantity discount savings based on moving from a product in the second quintile to the fourth quintile of the size distribution. This leaves out small product sizes that may have high unit prices due to convenience (e.g., a 20-oz soda bottle at the checkout counter) and especially large sizes that may not be widely available at all stores. This range covers sizes that households are likely to consider when making their purchase decision.

Figure 11 plots the distribution of coupon savings and estimated bulk savings for food and non-food products. Coupon savings are narrowly clustered with a median savings of 31% for non-food products and 33% for food products. Bulk discounts have lower median savings for non-food and food products of 27% and 23%, respectively, but are more widely dispersed, even exceeding 50% savings for some non-food products.<sup>34</sup> Coupon savings are similar across product categories while there is substantial variation in quantity discounts with non-food

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<sup>34</sup>Smaller shifts, such as from the second to third quintile or third to fourth quintile generate smaller savings, but still preserve the long right tail primarily for non-food products.

Figure 11: Percent Savings from Coupons and Bulk Discounts



Notes: Using 2004–2017 Consumer Panel and 2016 Retail Scanner data, this figure plots the distribution of savings from coupons and quantity discounts. For each coupon redemption, the percent savings are the ratio of the coupon value to the product’s price. These savings are then averaged across all purchases in that product category. Bulk discounts are computed using coefficient estimates obtained from Equation (1) relating log unit prices to log package sizes. Bulk savings are the estimated savings obtained from moving from the second to the fourth quintile of the size distribution for each product category.

products offering higher savings.

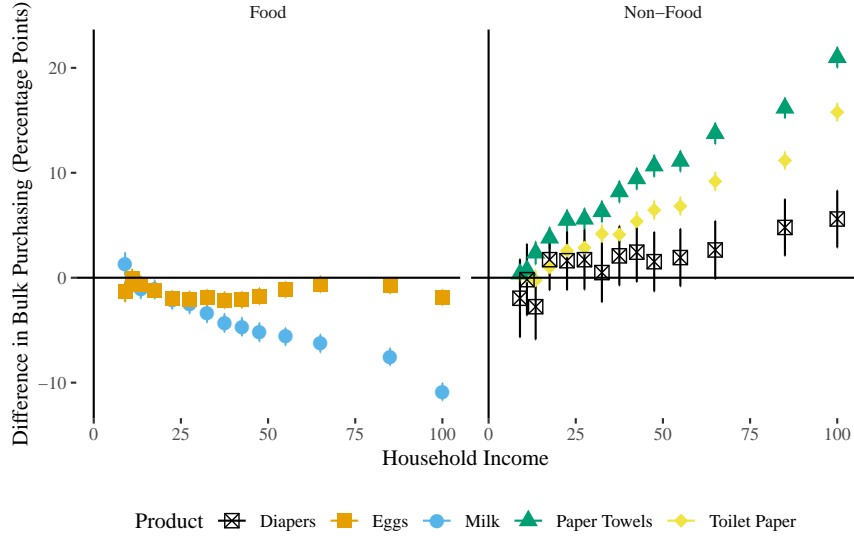
### A.3 Bulk Buying Across Popular Categories

Across popular spending categories, these gaps are particularly large in storable, non-food categories like paper towels and toilet paper, where households making over \$100,000 are more than twice as likely to buy in bulk compared to households making under \$25,000. In popular food categories like milk and eggs, there is little relationship or even a negative relationship between income and bulk buying (See Figure 12).

### A.4 Alternative Calculation of Missed Quantity Discounts

An alternative way of calculating savings from quantity discounts is to calculate first-best savings obtained from purchasing the lowest unit-priced item available, since even high-income households may not be buying at the lowest unit price. I compute this by taking the difference between the unit price paid by each household and the lowest unit price available in the store, given the household’s brand preference. I get this information through linking the Nielsen

Figure 12: Bulk Purchasing by Household Income and Product Type



Notes: Using 2004–2017 Nielsen Consumer Panel data, this figure plots the income bin coefficients from Equation (2), which regresses the share of annual purchases that were bulk packages on household characteristics as well as market and year fixed effects. This regression is estimated for milk, eggs, diapers, toilet paper, and paper towels. Nielsen projection weights are used to ensure national representativeness. Households making \$5–8k are the reference group. Standard errors are clustered at the DMA level. Coefficient values are reported in Appendix Table 20

Consumer Panel with the Nielsen Retail Scanner data.

I compute the first-best savings a household could obtain for toilet paper, diapers, milk, and eggs using the following approach. First, for each shopping trip, I compute the lowest unit price the household could have paid given its brand and store choice in that week. The difference in unit prices relative to the unit price chosen is a household’s first-best savings for that purchase. Then, to get the average savings for a household, I compute the expenditure-weighted average savings across all purchases for each household. Based on this measure, Table 15 reports average excess spending by income group, computed for a family of four.

Overall, households could save over 30% by buying in bulk and low-income households could save even more. I estimate the differences in savings between households from the following regression:

$$Y_{imt} = \sum_q \beta^q Income_{imt} + \gamma X_{imt} + \lambda_{mt} + \epsilon_{imt}, \quad (16)$$

where  $Y$  is the excess spending of household  $i$  in market  $m$  in year  $t$ .  $Income$  is the household’s income bin and  $X$  consists of household characteristics.  $\lambda$  is a market-year fixed effect. Table 16 shows that low-income households miss out on 1.7–1.8 percentage points more savings than high-income households and the excess spending is primarily in non-food categories like

Table 15: First-Best Savings by Household Income and Product

Income	Non-Perishable		Perishable	
	Toilet Paper	Diapers	Milk	Eggs
<\$25k	0.36	0.33	0.31	0.17
\$25-50k	0.35	0.33	0.30	0.17
\$50-100k	0.34	0.33	0.31	0.17
>\$100k	0.33	0.31	0.33	0.18

Notes: This table uses 2006–2016 Nielsen Retail Scanner and Consumer Panel data to compute average savings a household could achieve given its brand and store choice. Average savings for a family of four is reported above. For example, a household making <\$25k could save 36% by purchasing at the lowest unit price available.

toilet paper (36% savings) and diapers (33% savings) as opposed to food categories like milk (31% savings) and eggs (17% savings). Given the perishability of food items, these savings may not be realized if the product perishes before it can be consumed.

Table 16: Regression Results of First-Best Savings Across Household Income and Products

	Diapers	Toilet Paper	Eggs	Milk
	(1)	(2)	(3)	(4)
25-50k	−0.010** (0.005)	−0.005*** (0.001)	0.001 (0.001)	−0.002 (0.001)
50-100k	−0.015*** (0.005)	−0.013*** (0.001)	0.004*** (0.001)	0.002** (0.001)
>100k	−0.018*** (0.005)	−0.017*** (0.002)	0.018*** (0.002)	0.010*** (0.001)
Demographics	Y	Y	Y	Y
Market-Year FE	Y	Y	Y	Y
Observations	36,903	182,415	194,413	247,451
Adjusted R <sup>2</sup>	0.012	0.071	0.117	0.231

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Notes: This table uses 2006–2016 Nielsen Retail Scanner and Consumer Panel data and reports the income coefficients of Equation (16), which regresses savings on household characteristics as well as a market and year fixed effect. Units are percentage points. For example, a household making over \$100k have 2 percentage points lower excess spending than households making under \$25k. Nielsen’s projection weights are used for national representativeness.

Overall, low-income households could benefit substantially from buying in bulk and obtaining lower unit prices. Furthermore, these savings are likely to be more important for low-income households since the marginal utility of an additional dollar of savings is likely to be higher than for high-income households. This analysis also provides evidence that all households

could benefit from purchasing at the lowest unit price.

## A.5 Annual Consumption Analysis

I show that income is not predictive of a household’s toilet paper consumption rate first using basic OLS regressions. I then formalize the result using a 100-fold cross-validated elastic net regression to select the most predictive variables. If income and toilet paper consumption are related, then an OLS regression will extract the correlation.

First, I compute a household’s daily consumption by aggregating the total number of sheets purchased by a household in a given year, excluding the final purchase of the year since it may not be consumed within the year. I divide this total by the number of days between the first and last purchase of the year to get a household’s average daily consumption rate. This method avoids complications where end of the year inventory may be carried over to the following year or a household may start the year with some inventory.

Given a household’s average daily consumption rate, I estimate an OLS regression of consumption on household characteristics:

$$Y_i = \beta X_i + \epsilon_i, \quad (17)$$

where  $Y$  is household  $i$ ’s average daily consumption and  $X$  is a vector of household characteristics. Figure 13 plots the income coefficients of an OLS regression including only income covariates and the coefficients when household characteristics are included. The graph illustrates that after controlling for covariates that plausibly cause increased consumption, income is not significantly correlated with consumption.

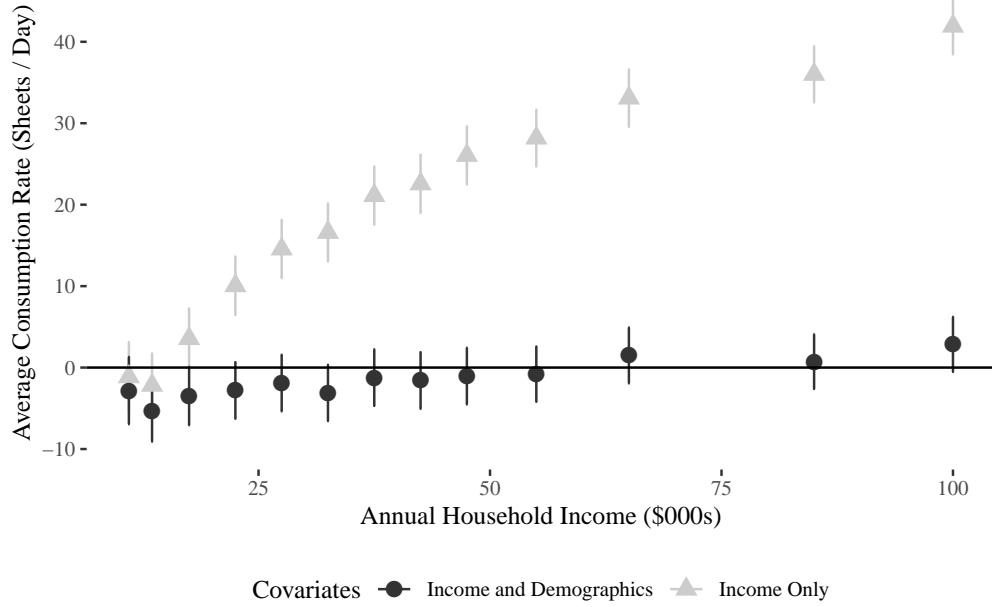
The above specification omits many other possible covariates that could be correlated with average daily consumption. When there are many possible variables that can be included, there is a risk of over-fitting. Elastic net regularization is a machine learning method that penalizes over-fitting and selects only the most predictive variables.

The elastic net solves the following minimization problem:

$$\min_{\beta} \|y - X\beta\|^2 + \lambda \left( \alpha \|\beta\|_1 + (1 - \alpha) \|\beta\|_2^2 \right), \quad (18)$$

where  $\|\cdot\|_1$  is the L1 norm and  $\|\cdot\|_2$  is the L2 norm. The OLS estimate is the  $\beta$  that solves the minimization problem with only the first term. The second term and third term provide penalties to shrink and select for the most predictive variables.

Figure 13: Average Daily Consumption by Household Income



Notes: Using 2004–2017 Nielsen Consumer Panel data, this figure plots the income bin coefficients from Equation (17), which regresses average daily household toilet paper consumption on household characteristics. Average daily consumption is computed by dividing total quantity purchased in a year by the number of days a household was active in the panel.

I set the mixing parameter  $\alpha$  to be 0.5. When covariates are correlated in groups, lasso regression ( $\alpha = 1$ ) tends to only select one and discard all other members of the group while ridge regression ( $\alpha = 0$ ) tends to shrink correlated coefficients towards each other (Zou and Hastie 2005). Because some of the possible covariates form natural groups (e.g., all income bins or all markets), I chose  $\alpha = 0.5$  since this tends to include or exclude groups together.

I estimate a 100-fold cross-validated elastic net regression to select the most predictive covariates. The resulting estimates selects many household characteristics including household composition, age, marital status, and race, but excludes almost all income and geographic coefficients.<sup>35</sup>

## A.6 Appendix Tables

<sup>35</sup>Elastic net results are available upon request.



Table 17: Correlation of Bulk Buying and Demographics (Food Products)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
8-10k	-0.005*** (0.002)	-0.004** (0.002)	-0.004** (0.002)	-0.003* (0.002)	-0.002 (0.002)	-0.002 (0.002)	-0.002 (0.002)	-0.004** (0.002)	-0.003 (0.002)
10-12k	-0.004** (0.002)	-0.005*** (0.002)	-0.004** (0.002)	-0.006*** (0.002)	-0.006*** (0.002)	-0.006*** (0.002)	-0.006*** (0.002)	-0.008*** (0.002)	-0.008*** (0.002)
12-15k	-0.0001 (0.002)	-0.002 (0.002)	-0.001 (0.002)	-0.002 (0.002)	-0.004** (0.002)	-0.005*** (0.002)	-0.005*** (0.002)	-0.005*** (0.002)	-0.004*** (0.002)
15-20k	0.001 (0.002)	-0.003* (0.002)	-0.002 (0.002)	-0.004*** (0.002)	-0.006*** (0.002)	-0.006*** (0.002)	-0.006*** (0.002)	-0.006*** (0.001)	-0.005*** (0.001)
20-25k	0.007*** (0.002)	0.0003 (0.002)	0.001 (0.002)	-0.002 (0.001)	-0.005*** (0.001)	-0.006*** (0.001)	-0.005*** (0.001)	-0.006*** (0.001)	-0.005*** (0.001)
25-30k	0.013*** (0.002)	0.004*** (0.002)	0.004*** (0.002)	-0.0002 (0.002)	-0.004*** (0.002)	-0.005*** (0.002)	-0.004*** (0.002)	-0.004*** (0.002)	-0.004** (0.001)
30-35k	0.016*** (0.002)	0.005*** (0.002)	0.005*** (0.002)	0.0004 (0.002)	-0.004** (0.002)	-0.004*** (0.002)	-0.003** (0.002)	-0.004** (0.001)	-0.003* (0.001)
35-40k	0.021*** (0.002)	0.008*** (0.002)	0.008*** (0.002)	0.003** (0.002)	-0.002 (0.002)	-0.002 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.0005 (0.002)
40-45k	0.024*** (0.002)	0.010*** (0.002)	0.009*** (0.002)	0.004*** (0.002)	-0.001 (0.002)	-0.001 (0.002)	0.0002 (0.002)	0.0002 (0.002)	0.001 (0.002)
45-50k	0.028*** (0.002)	0.011*** (0.002)	0.011*** (0.002)	0.005*** (0.002)	-0.0001 (0.002)	-0.0003 (0.002)	0.001 (0.002)	0.001 (0.002)	0.002 (0.002)
50-60k	0.029*** (0.001)	0.011*** (0.001)	0.010*** (0.001)	0.005*** (0.001)	-0.001 (0.001)	-0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.002 (0.001)
60-70k	0.035*** (0.002)	0.015*** (0.002)	0.014*** (0.002)	0.008*** (0.002)	0.002 (0.002)	0.001 (0.001)	0.003** (0.002)	0.004** (0.001)	0.004*** (0.001)
70-100k	0.038*** (0.001)	0.015*** (0.001)	0.015*** (0.001)	0.009*** (0.001)	0.002 (0.001)	0.002 (0.001)	0.005*** (0.001)	0.005*** (0.001)	0.006*** (0.001)
>100k	0.041*** (0.001)	0.015*** (0.001)	0.015*** (0.001)	0.010*** (0.001)	0.002 (0.001)	0.003* (0.001)	0.006*** (0.001)	0.007*** (0.001)	0.008*** (0.001)
Married		0.043*** (0.0004)	0.042*** (0.0004)	0.022*** (0.0004)	0.018*** (0.0004)	0.016*** (0.0004)	0.016*** (0.0004)	0.017*** (0.0004)	0.018*** (0.0004)
Age			-0.0002*** (0.00001)	0.0002*** (0.00001)	0.00005*** (0.00001)	0.0001*** (0.00001)	0.00003** (0.00001)	0.0001*** (0.00001)	0.0001*** (0.00001)
Adults				0.017*** (0.0002)	0.016*** (0.0002)	0.017*** (0.0002)	0.016*** (0.0002)	0.015*** (0.0002)	0.015*** (0.0002)
Children				0.016*** (0.0002)	0.015*** (0.0002)	0.015*** (0.0002)	0.015*** (0.0002)	0.014*** (0.0002)	0.014*** (0.0002)
Single-Family Home					0.033*** (0.0004)	0.026*** (0.0004)	0.026*** (0.0004)	0.025*** (0.0004)	0.025*** (0.0004)
College						(0.002)	-0.006*** (0.0004)	-0.006*** (0.0004)	-0.006*** (0.0004)
Market FE's	N	N	N	N	N	N	N	Y	Y
Year FE's	N	N	N	N	N	N	N	N	Y
Observations	733,894	733,894	733,894	733,894	733,894	733,894	733,894	733,894	733,894
Adjusted R <sup>2</sup>	0.011	0.030	0.030	0.050	0.058	0.062	0.062	0.101	0.102

Note:

\*p&lt;0.1; \*\*p&lt;0.05; \*\*\*p&lt;0.01

Source: Author calulations from Nielsen Consumer Panel.

Table 18: Correlation of Bulk Buying and Demographics (Non-Food Products)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
8-10k	0.008** (0.003)	0.008*** (0.003)	0.008*** (0.003)	0.008*** (0.003)	0.009*** (0.003)	0.009*** (0.003)	0.009*** (0.003)	0.006 (0.007)	0.002 (0.007)
10-12k	0.023*** (0.003)	0.022*** (0.003)	0.022*** (0.003)	0.021*** (0.003)	0.020*** (0.003)	0.020*** (0.003)	0.020*** (0.003)	0.016* (0.008)	0.013 (0.008)
12-15k	0.023*** (0.003)	0.021*** (0.003)	0.021*** (0.003)	0.019*** (0.003)	0.018*** (0.003)	0.018*** (0.003)	0.017*** (0.003)	0.016** (0.007)	0.013** (0.007)
15-20k	0.033*** (0.002)	0.030*** (0.002)	0.029*** (0.002)	0.028*** (0.002)	0.026*** (0.002)	0.026*** (0.002)	0.025*** (0.002)	0.022*** (0.007)	0.019*** (0.007)
20-25k	0.052*** (0.002)	0.046*** (0.002)	0.046*** (0.002)	0.044*** (0.002)	0.041*** (0.002)	0.041*** (0.002)	0.039*** (0.002)	0.035*** (0.006)	0.032*** (0.006)
25-30k	0.057*** (0.002)	0.049*** (0.002)	0.049*** (0.002)	0.046*** (0.002)	0.042*** (0.002)	0.042*** (0.002)	0.041*** (0.002)	0.036*** (0.006)	0.034*** (0.006)
30-35k	0.069*** (0.002)	0.061*** (0.002)	0.061*** (0.002)	0.057*** (0.002)	0.053*** (0.002)	0.053*** (0.002)	0.051*** (0.002)	0.045*** (0.005)	0.042*** (0.006)
35-40k	0.076*** (0.002)	0.065*** (0.002)	0.065*** (0.002)	0.061*** (0.002)	0.057*** (0.002)	0.057*** (0.002)	0.054*** (0.002)	0.048*** (0.006)	0.046*** (0.006)
40-45k	0.084*** (0.002)	0.072*** (0.002)	0.073*** (0.002)	0.068*** (0.002)	0.064*** (0.002)	0.064*** (0.002)	0.060*** (0.002)	0.054*** (0.006)	0.052*** (0.006)
45-50k	0.095*** (0.002)	0.081*** (0.002)	0.081*** (0.002)	0.077*** (0.002)	0.072*** (0.002)	0.072*** (0.002)	0.068*** (0.002)	0.060*** (0.006)	0.057*** (0.006)
50-60k	0.099*** (0.002)	0.084*** (0.002)	0.085*** (0.002)	0.080*** (0.002)	0.075*** (0.002)	0.075*** (0.002)	0.070*** (0.002)	0.062*** (0.005)	0.059*** (0.005)
60-70k	0.117*** (0.002)	0.101*** (0.002)	0.101*** (0.002)	0.096*** (0.002)	0.091*** (0.002)	0.091*** (0.002)	0.085*** (0.002)	0.075*** (0.006)	0.071*** (0.006)
70-100k	0.136*** (0.002)	0.118*** (0.002)	0.118*** (0.002)	0.113*** (0.002)	0.107*** (0.002)	0.107*** (0.002)	0.099*** (0.002)	0.088*** (0.006)	0.085*** (0.006)
>100k	0.172*** (0.002)	0.151*** (0.002)	0.151*** (0.002)	0.146*** (0.002)	0.139*** (0.002)	0.140*** (0.002)	0.128*** (0.002)	0.111*** (0.006)	0.102*** (0.006)
Married		0.035*** (0.001)	0.035*** (0.001)	0.024*** (0.001)	0.020*** (0.001)	0.020*** (0.001)	0.021*** (0.001)	0.026*** (0.002)	0.025*** (0.002)
Age			0.0001*** (0.00002)	0.0003*** (0.00002)	0.0002*** (0.00002)	0.0002*** (0.00002)	0.0003*** (0.00002)	0.0002*** (0.0001)	0.0002** (0.0001)
Men				0.016*** (0.0004)	0.015*** (0.0004)	0.015*** (0.0004)	0.016*** (0.0004)	0.013*** (0.002)	0.014*** (0.002)
Women				0.003*** (0.0004)	0.002*** (0.0004)	0.002*** (0.0004)	0.004*** (0.0004)	0.001 (0.001)	0.001 (0.001)
Children				0.008*** (0.0003)	0.007*** (0.0003)	0.007*** (0.0003)	0.007*** (0.0003)	0.005*** (0.001)	0.005*** (0.001)
Single-Family Home					0.027*** (0.001)	0.026*** (0.001)	0.027*** (0.001)	0.038*** (0.003)	0.039*** (0.003)
College							0.020*** (0.001)	0.018*** (0.002)	0.017*** (0.002)
Market FE's	N	N	N	N	N	N	N	Y	Y
Year FE's	N	N	N	N	N	N	N	N	Y
Observations	731,762	731,762	731,762	731,762	731,762	731,762	731,762	731,762	731,762
Adjusted R <sup>2</sup>	0.049	0.054	0.054	0.056	0.058	0.058	0.060	0.087	0.094

Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Source: Author calculations from Nielsen Consumer Panel. Columns (7) and (8) cluster standard errors at the market level

Table 19: Bulk Buying Within ZIP Codes, Store Types, or Retail Chains by Income

	ZIP Code		Channel/Retailer Type		
	(1)	(2)	(3)	(4)	(5)
8-10k	0.003 (0.003)	0.006 (0.004)	0.006*** (0.002)	0.006*** (0.002)	0.006*** (0.002)
10-12k	0.013*** (0.003)	0.006* (0.003)	0.013*** (0.002)	0.011*** (0.002)	0.011*** (0.002)
12-15k	0.013*** (0.003)	0.008** (0.003)	0.014*** (0.002)	0.008*** (0.002)	0.008*** (0.002)
15-20k	0.020*** (0.002)	0.015*** (0.003)	0.019*** (0.002)	0.013*** (0.002)	0.012*** (0.002)
20-25k	0.032*** (0.002)	0.027*** (0.003)	0.028*** (0.002)	0.017*** (0.002)	0.017*** (0.002)
25-30k	0.035*** (0.002)	0.030*** (0.003)	0.028*** (0.002)	0.015*** (0.002)	0.014*** (0.002)
30-35k	0.044*** (0.002)	0.038*** (0.003)	0.036*** (0.002)	0.019*** (0.002)	0.019*** (0.002)
35-40k	0.047*** (0.002)	0.044*** (0.003)	0.040*** (0.002)	0.019*** (0.002)	0.019*** (0.002)
40-45k	0.053*** (0.002)	0.049*** (0.003)	0.041*** (0.002)	0.018*** (0.002)	0.017*** (0.002)
45-50k	0.059*** (0.002)	0.052*** (0.003)	0.047*** (0.002)	0.022*** (0.002)	0.021*** (0.002)
50-60k	0.061*** (0.002)	0.056*** (0.003)	0.047*** (0.002)	0.020*** (0.002)	0.019*** (0.002)
60-70k	0.073*** (0.002)	0.066*** (0.003)	0.053*** (0.002)	0.020*** (0.002)	0.020*** (0.002)
70-100k	0.087*** (0.002)	0.081*** (0.003)	0.063*** (0.002)	0.025*** (0.002)	0.025*** (0.001)
>100k	0.105*** (0.002)	0.096*** (0.003)	0.074*** (0.002)	0.025*** (0.002)	0.025*** (0.002)
Demographics	Y	Y	Y	Y	Y
ZIP-Year FE	N	Y	N	N	N
Channel-Year FE	N	N	N	Y	Y
Chain-Year FE	N	N	N	N	Y
Observations	731,762	731,762	3,799,404	3,799,404	3,799,404
Adjusted R <sup>2</sup>	0.093	0.270	0.013	0.223	0.241

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Notes: Using 2004–2017 Nielsen Consumer Panel data, this table displays the regression coefficients from estimating Equation eq:discountingBehaviorFE which regresses a household's annual share of bulk purchases of non-food products on household characteristics (household composition, age, marital status, and education) and includes a DMA and year fixed effect (Columns 1, 3, 5). Columns 2, 4, and 6 also include a ZIP code-year, store type-year, or retail chain-year fixed effect.

Table 20

	Toilet Paper	Paper Towels	Diapers	Eggs	Milk
	(1)	(2)	(3)	(4)	(5)
8-10k	0.003 (0.006)	0.004 (0.007)	-0.020 (0.019)	-0.013*** (0.005)	0.013** (0.006)
10-12k	0.002 (0.005)	0.007 (0.006)	-0.002 (0.017)	-0.001 (0.005)	-0.005 (0.005)
12-15k	-0.002 (0.005)	0.024*** (0.006)	-0.028* (0.016)	-0.007 (0.004)	-0.011** (0.005)
15-20k	0.010** (0.005)	0.038*** (0.005)	0.017 (0.015)	-0.012*** (0.004)	-0.011** (0.004)
20-25k	0.026*** (0.004)	0.055*** (0.005)	0.016 (0.014)	-0.020*** (0.004)	-0.021*** (0.004)
25-30k	0.029*** (0.005)	0.056*** (0.005)	0.017 (0.015)	-0.021*** (0.004)	-0.025*** (0.004)
30-35k	0.042*** (0.005)	0.063*** (0.005)	0.005 (0.014)	-0.019*** (0.004)	-0.034*** (0.004)
35-40k	0.041*** (0.005)	0.082*** (0.005)	0.021 (0.014)	-0.021*** (0.004)	-0.043*** (0.004)
40-45k	0.054*** (0.005)	0.094*** (0.005)	0.024* (0.014)	-0.021*** (0.004)	-0.047*** (0.004)
45-50k	0.065*** (0.005)	0.107*** (0.005)	0.015 (0.014)	-0.018*** (0.004)	-0.052*** (0.005)
50-60k	0.068*** (0.004)	0.111*** (0.005)	0.019 (0.014)	-0.011*** (0.004)	-0.056*** (0.004)
60-70k	0.092*** (0.004)	0.138*** (0.005)	0.026* (0.014)	-0.006 (0.004)	-0.063*** (0.004)
70-100k	0.112*** (0.004)	0.162*** (0.005)	0.048*** (0.014)	-0.008** (0.004)	-0.075*** (0.004)
>100k	0.158*** (0.004)	0.210*** (0.005)	0.056*** (0.014)	-0.019*** (0.004)	-0.109*** (0.004)
Married	0.045*** (0.001)	0.040*** (0.001)	0.027*** (0.003)	0.028*** (0.001)	0.062*** (0.001)
Age	-0.0003*** (0.00004)	0.002*** (0.00004)	-0.003*** (0.0001)	-0.001*** (0.00003)	-0.002*** (0.00004)
Adults	0.016*** (0.001)	0.010*** (0.001)	0.009*** (0.002)	0.055*** (0.001)	0.065*** (0.001)
Children	0.010*** (0.001)	0.001 (0.001)	-0.014*** (0.001)	0.040*** (0.0005)	0.088*** (0.001)
Single-Family Home	0.068*** (0.001)	0.085*** (0.002)	-0.004 (0.004)	0.024*** (0.001)	0.056*** (0.001)
College	0.029*** (0.001)	0.019*** (0.001)	0.045*** (0.003)	-0.047*** (0.001)	-0.029*** (0.001)
Market FE's	Y	Y	Y	Y	Y
Year FE's	Y	Y	Y	Y	Y
Observations	671,131	597,542	111,945	683,671	683,567
Adjusted R <sup>2</sup>	0.094	0.084	0.041	0.137	0.171

Note:

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Notes: Using Nielsen Consumer Panel data from 2004–2017, this table reports the coefficients plotted in Figure 12. Standard errors are clustered at the market level.

Table 21: Package Size Differences by Income (Non-Food Products)

Category	25-50k	50-100k	>100k
POOL AND SPA CHEMICALS AND TREATMENT	0.155	0.432	0.746
BAGS - PAPER	0.177	0.423	0.538
PAPER TOWELS	0.131	0.278	0.407
BAGS - TALL KITCHEN	0.128	0.263	0.397
ALUMINUM FOIL	0.107	0.230	0.373
BAGS - TRASH/TRASH COMPACTOR	0.108	0.225	0.358
SOAP - BAR	0.131	0.253	0.349
BAGS - LAWN AND LEAF	0.108	0.222	0.349
FABRIC SOFTENERS-DRY	0.102	0.220	0.345
CLOTH-POLISHING/CLEANING	0.120	0.213	0.343
DISPOSABLE CUPS	0.102	0.210	0.310
TOILET TISSUE	0.096	0.199	0.296
BAGS - FREEZER	0.065	0.160	0.293
FIREPLACE LOGS	0.104	0.141	0.279
FACIAL TISSUE	0.057	0.134	0.264
TOILET BOWL - CLEANERS	0.066	0.140	0.252
WATER CONDITIONERS FILTERS AND UNITS	0.083	0.151	0.252
DETERGENTS-PACKAGED	0.116	0.204	0.246
FABRIC WASHES - SPECIAL	0.087	0.148	0.238
BAGS - SANDWICH	0.061	0.144	0.230
BAGS - FOOD STORAGE	0.072	0.136	0.210
CHARCOAL	0.063	0.129	0.204
DISHWASHER RINSING AIDS	0.049	0.118	0.196
SANITARY NAPKINS	0.054	0.118	0.184
CLEANERS - DISINFECTANTS	0.060	0.111	0.177
FABRIC SOFTENERS-LIQUID	0.049	0.101	0.161
CLEANERS - BATHROOM	0.057	0.109	0.155
TAMPONS	0.040	0.098	0.151
RUG CLEANERS	0.055	0.120	0.149
CHARCOAL/WOOD LIGHTERS	0.035	0.072	0.135
LAUNDRY AND IRONING ACCESSORIES	0	0.054	0.132
DRAIN PIPE OPENERS	0.023	0.064	0.131
DETERGENTS - HEAVY DUTY - LIQUID	0.040	0.085	0.127
AUTOMATIC DISHWASHER COMPOUNDS	0.047	0.094	0.117
MOTH PREVENTATIVES	0.074	0.089	0.117
DISPOSABLE DIAPERS	0.027	0.068	0.106
SOAP - SPECIALTY	0.039	0.062	0.105
MILDEW REMOVERS AND PREVENTATIVES	0.031	0.063	0.105
CLEANERS - POWDERS	0	0	0.100
DETERGENT BOOSTERS	0.057	0.077	0.100
DISPOSABLE DISHES	0.027	0.067	0.099
RUG AND ROOM DEODORIZERS	0.035	0.070	0.093
DYE AND DYE REMOVER	0	0.106	0.090
BAGS - OVEN	0.044	0.078	0.086
SOAP - LIQUID	0.058	0.074	0.085
CLEANERS - WINDOW	0.024	0.054	0.079
BATH ADDITIVES - DRY	0	0	0.077
DETERGENTS - LIGHT DUTY	0.020	0.042	0.073
ABRASIVE CLEANSERS-LIQUID	0.039	0.054	0.073
PAPER NAPKINS	0	0.034	0.072
POLISHES	0.019	0	0.072
DISINFECTANTS	0.030	0.052	0.067
STARCH - AEROSOL AND SPRAY	0.016	0.039	0.066
FURNITURE POLISH	0.006	0.031	0.064
CLEANERS-METAL	0	0.029	0.061
PLASTIC WRAP	0.018	0.030	0.058
UPHOLSTERY CLEANERS	0.039	0	0.056
RUST REMOVERS	0.032	0.057	0.055
AIR/SPECIALTY FRESHNERS - AEROSOL SPRAY AND PUMP	0	0.023	0.055
SPOT AND STAIN REMOVERS	0.037	0.067	0.043
AMMONIA	0.012	0.030	0.035
AIR/SPECIALTY FRESHENERS - SOLID	0.018	0.023	0.035
SODA STRAWS	0	0	0.034
FLOOR CARE - WAXES	0	0	0.032
BLEACH - DRY	0.040	0.023	0.030
HAND CLEANERS AND HAND SANITIZERS	0	0	0.024
CLEANERS - NON-DISINFECTANT	0	0.006	0.024
FLOOR CARE-CLEANERS	0	0	0.023
OVEN CLEANERS	0.012	0.017	0.022
WATER FILTRATION STORAGE CONTAINER	0.011	0	0.020
WAX PAPER	0.009	0.015	0.017
ABRASIVE CLEANSERS-POWDERED	0.008	0.020	0.013
SALT-WATER SOFTENING	0	0	0.009
BROOMS/ MOPS AND WAX APPLICATORS	0	0.007	0.008
BATH OIL - LIQUIDS	0	0.194	0
BLEACH - LIQUID/GEL	0	0	0
BLUINGS	0	0	0
BRUSHES-KITCHEN AND SCRUB	-0.005	-0.004	0
CLEANERS-HUMIDIFIERS/VAPORIZERS	0	0	0
CLEANERS.PASTE AND JELLY	0	0	0
DISPOSABLE LIDS	0	0	0
FABRIC FINISHERS	0	0	0
FABRIC PROTECTORS	0	0	0
FOOD WRAP - REMAINING	0	0	0
HEAT-CANNED	0	0	0
HOUSEHOLD AREA ALLERGEN CONTROL	0	0	0
MATCHES	0	0	0
SCOURING PADS	-0.041	-0.042	0
STARCH - LIQUID	0.036	0	0
TOILET BOWL - DEODORIZERS	-0.019	0	0
WATER SOFTENERS AND CONDITIONERS	0.023	0	0
COFFEE AND TEA FILTERS - DISPOSABLE	0	-0.009	-0.028
BAGS - WASTE	0	-0.020	-0.029
SPONGES AND SQUEEGEES - HOUSEHOLD	-0.033	-0.035	-0.032
LAUNDRY TREATMENT AIDS	0	-0.027	-0.034
CLOTHESPINs	0	0	-0.062
FABRIC SOFTENERS-AEROSOL	-0.083	-0.087	-0.072
LAUNDRY BAR SOAP	0	-0.071	-0.087
WOOD CHIPS-COOKING	0	-0.052	-0.090
PRE-MOISTENED TOWELETtes	-0.065	-0.086	-0.093
BAKING CUPS AND LINERS	-0.048	-0.066	-0.100
AIR/SPECIALTY FRESHENERS - REMAINING	-0.079	-0.121	-0.113
BATH ADDITIVES - LIQUID	-0.053	-0.070	-0.121
CLEANERS-SEPTIC TANK	-0.043	-0.088	-0.206
BATH OIL - DRY	0	0	-1.258

Table 22: Nielsen Consumer Panel Summary Statistics for States With and Without Unit Price Regulation

Variable	Without Regs		With Regs	
	Mean	SD	Mean	SD
Household income (\$000s)	55.65	30.75	59.60	31.70
Household size	2.53	1.43	2.61	1.49
Age	52.34	14.37	53.02	14.43
College Educated	0.37	0.48	0.41	0.49
Child present	0.33	0.47	0.32	0.47
Married	0.52	0.50	0.49	0.50
N (Household-Years)	488,461		246,263	

Notes: Unweighted means and standard deviations are reported.

Table 23: Robustness Test: Warehouse Club Entry on Bulk Buying (Different Radii)

	5 Mi	10 Mi	15 Mi	20 Mi
	(1)	(2)	(3)	(4)
Post-Entry	−0.005 (0.006)	−0.007 (0.007)	0.001 (0.008)	0.005 (0.008)
Post-Entry : 25-50k	0.012*** (0.005)	0.012** (0.006)	0.019*** (0.006)	0.014** (0.005)
Post-Entry : 50-100k	0.014*** (0.004)	0.022*** (0.005)	0.025*** (0.005)	0.023*** (0.006)
Post-Entry : >100k	0.017*** (0.006)	0.030*** (0.008)	0.035*** (0.009)	0.043*** (0.010)
Household-ZIP FE's	Y	Y	Y	Y
Year-Qtr FE's	Y	Y	Y	Y
Demographic Controls	Y	Y	Y	Y
Observations	2,400,344	2,401,665	2,401,038	2,400,924
Adjusted R <sup>2</sup>	0.428	0.428	0.428	0.428

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Notes: This table uses 2004–2015 Nielsen Consumer Panel data at the household-quarter level. Coefficients are reported for Equation (9) which regresses households' quarterly bulk purchase shares on an indicator for warehouse club entry, an indicator for whether the household shops at a warehouse club, and an interaction term as well as household characteristics. Different distance cutoffs defining an "entry" are used for each regression. Household-ZIP code and year-quarter fixed effects are included. Projection weights are not used.