An Empirical Investigation of the Impact of Gasoline Prices on Grocery Shopping Behavior

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ABSTRACT

The authors empirically examine the effect of gas prices on grocery shopping behavior using IRI panel data from 2006–2008, which track panelists’ purchases of almost 300 product categories across multiple retail formats. They quantify the impact on consumers’ total spending and examine the potential avenues for savings – shifting from one retail format to another; shifting from national brands to private label, regular price to promotional products, and higher to lower price tiers. They find a substantial negative effect on shopping frequency and purchase volume, and shifts away from grocery and to supercenter formats. Importantly, there is a greater shift from regular priced national brands towards promoted ones than towards private label, and, among national brand purchasers, bottom tier brands lose share, mid tier brands gain, and top tier brand share is relatively unaffected. The analysis also controls for general economic conditions and shows that gas prices have a much bigger impact on grocery shopping behavior than broad economic factors.

Key words: grocery expenditure, gas price effect, macro-economic factors, retail format choice, promotions, private label.
Macro-economic conditions clearly influence consumers’ attitudes, shopping behavior, and consumption. Although these conditions are not controllable by manufacturers and retailers, understanding how they affect consumers and how consumers respond to them is critical in guiding effective managerial actions. This issue currently occupies front and center stage as the world economy tries to emerge from the most severe economic crisis in decades.

There is a small but rich body of literature in marketing on the impact of macro-economic factors. One stream of research describes how firms change advertising, innovation, and other “pro-active” marketing activities during a recession and assesses the effectiveness of these actions (Deleersnyder et al. 2009; Frankenberger and Graham 2003; Srinivasan, Rangaswamy, and Lilien 2005). Another stream studies the effect of business cycles and consumer confidence on sales of durable goods (Allenby, Jen, and Leone 1996; Deleersnyder et al. 2004; Kumar, Leone, and Gaskins 1995) and private labels (Lamey et al. 2007). Both streams of research are typically conducted at an aggregate level, with industry, firm or product category level sales data. But, change in consumer behavior is at the root of why these macroeconomic variables affect sales and firm performance. It is therefore important to conduct a more disaggregate analysis (Deleersnyder et al. 2004) and understand how consumers react to changes in macro-economic factors (Grewal, Levy and Kumar 2009).

An underlying theme in the literature is the notion, proposed by Katona (1975) that consumer response to macro-economic factors is a function of not just their ability to buy (as measured by current and expected future income), but also of their willingness to buy (as measured by attitudes, sentiment, etc.). Conventional wisdom has it that macro-economic factors and consumer sentiment have an impact on durable goods sales because purchases of such products are discretionary and can be postponed when willingness to buy is low, whereas non-
durable products such as groceries are less affected because they cannot be postponed (Deleersnyder et al. 2004; Lamey et al. 2007).

The focus of our research is on a macro-economic factor that is qualitatively different from business cycles and consumer sentiment and that has been very prominent in recent years – the price of gasoline. Since 2006, the price of a gallon of regular gasoline has varied widely, from lows just over $2.00 to highs over $4.00. Gasoline demand is fairly inelastic (Brons et al. 2008; Greening et al. 1995), so expenditure on gas goes up hand-in-hand with its price. A U.S. household earning a median income spent 11.5% of that income on gas in July 2008, up from 4.6% five years before that (Wall Street Journal 2008). When the price of gas increases sharply, consumers have less disposable income, feel significant financial hardship, become more price conscious, and find ways to reduce spending in other areas (Du and Kamakura 2008; Gallup News Service 2006). Consistent with this, Hamilton (2008) notes in his recent review of oil and the economy that the key mechanism whereby energy price shocks affect the economy is through a disruption in spending on goods and services other than energy.

Thus, the impact of gas price on consumers’ shopping behavior derives not just from psychological willingness to buy but also from the immediate economic ability to buy. Grocery products individually cost little relative to overall income. However, after housing and transportation, they form the largest percentage of the U.S. household’s annual expenditures. For instance, expenditure on food at home for the average household was 5.6% of total income after taxes in 2007, exceeding other expense categories like apparel, entertainment, and healthcare (Consumer Expenditure Survey 2007, hereafter CES). Further, grocery shopping is done frequently, generally more than once a week, so there is plenty of opportunity to make adjustments in purchases. Therefore, expenditures on grocery products provide a substantial and
flexible means to adjust spending in response to unexpected changes in discretionary income. In sum, grocery products may be relatively immune to general economic conditions and business cycles but such is not likely to be the case with rising gas prices.

However, there is little systematic research on the impact of gas prices on consumers’ shopping behavior. One exception is the work by Gicheva, Hastings and Villas-Boas (2010) who find from CES data that expenditures on food-away-from home decrease by 56% and expenditures on food purchased at grocery stores increase slightly with a 100% increase in gas price. Gicheva et al. (2010) also use sales data in four food categories from a California grocery chain to show that consumers substitute away from regular shelf-price products and towards promotional items in order to save money on overall grocery expenditures.

The objective of our research is to provide a comprehensive analysis of the impact of gas price on consumers’ grocery shopping behavior. Consumers can alter how much they purchase, how often they purchase, and how much they spend on their purchases which in turn is a function of what they buy and where they buy it. We not only quantify the impact on households’ shopping frequency, total purchase volume and spending, but we also examine which avenues they use to save money on grocery shopping – shifting from one retail format to another, from national brands to private labels, from regular priced products to promotional purchases and from higher priced national brands to lower priced ones. Such an analysis is important not only for researchers and policy makers but also for manufacturers and retailers who must determine the best way to respond to, and perhaps pre-empt, changes in shopping behavior as we enter an era of “peak oil” and sustained volatility in energy prices. And, as we will discuss in the next section, the answers are certainly not obvious.
We conduct our analysis using a household panel dataset provided by Information Resources Inc. (IRI). The dataset captures grocery shopping information across multiple retail formats of approximately 1000 panelists from a major U.S. metropolitan area. The data are from January 2006 to October 2008 and span panelists’ purchases of almost 300 product categories. We supplement these data with gas prices in the same metropolitan area obtained from the Department of Energy Information Administration website. Some unique features of these data make them especially useful for our research. First, we cover not just a few product categories but the vast majority of CPG products purchased by consumers. Second, we cover not only the traditional grocery and drug store channels but also regular and supercenter stores of mass merchants (including Wal-Mart), and warehouse clubs. Third, there was substantial variation in gas prices during the period of our data. Fourth, we control for general economic conditions so as to isolate and contrast the impact of gas price.

We organize the remainder of this article as follows. In the next section, we present the conceptual framework for our model and analysis, drawing on relevant literature wherever possible. Next, we discuss our data and methodology. Following this, we present our empirical results, and, finally, the implications of our findings for researchers and managers.

**Conceptual Development**

**Overview**

Figure 1 depicts the framework that guides our expectations and analysis. Gas prices affect consumers’ budget constraint because an increase in gas price directly reduces the income available for other purchases, given the relative inability to reduce gas consumption in the short term. The budget constraint requires consumers to reduce their total spending. They can do this by lowering their purchase volume (consumption) and/or by reducing the cost of their purchases.
Cost can be reduced by shifting to less expensive retail formats, private label products or national brands on promotion, and/or lower price tier national brands (Griffith et al. 2009). In addition, of course, consumers can adjust the number of shopping trips they make.

[Insert Figure 1 About Here]

However, consumers’ shopping utility is not just a function of the quantity of products purchased and their monetary cost. Although the monetary cost may be most salient in the face of gas price induced budget constraints, consumers also experience other costs and benefits of shopping, such as the opportunity cost of time spent in travel and search (Bell, Ho and Tang 1998; Blattberg, Buesing, Peacock and Sen 1978; Marmorstein, Grewal and Fishe 1992), other utilitarian benefits of quality and decision simplicity, and psychosocial benefits of self-expression and entertainment (Ailawadi, Neslin and Gedenk 2001; Chandon, Wansink and Laurent 2000; Urbany, Dickson and Kalapurakal 1996). Figure 1 includes the major elements of total utility identified in prior research but represents them as costs for exposition simplicity.

As gas prices increase and tighten the consumers’ budget constraint, there is pressure to cut monetary costs by looking for lower prices. However, the reduction in monetary costs must be traded off against possible increases in the other costs. Travel costs refer to the distance and how frequently the consumer must travel for shopping; quality costs are driven by whether the consumer is downgrading to a less preferred brand; search costs are driven by how easy it is to find preferred products and deals; decision costs refer to how easy it is to decide what to buy; holding costs are driven by whether shopping has to be done in bulk; and psychosocial costs refer to how much enjoyment the shopping activity provides.

We do not directly observe all these costs but they provide an important conceptual basis for our work (see Geyskens, Gielens and Dekimpe 2002 and Narasimhan, Neslin and Sen 1996
for similar conceptual development in other contexts). In the following discussion, we consider the trade-offs among these costs in developing expectations about how gas price affects consumers’ overall shopping as well as the allocation of their purchases to different formats, promotions, and brands. Note that we control for general economic conditions through the GDP growth variable, which is a widely accepted measure of economic health.\(^1\) Our expectation, based on prior research and conventional wisdom, is that the impact of this variable will be weaker than that of gas price.

**Effect of Gas Price on Overall Shopping**

*Total purchase volume:* The lower disposable income resulting from higher gas price puts pressure on consumers to buy and consume less. Of course, since consumers are also trying to save money by eating in more than in restaurants (Gicheva et al. 2010), and spending more time at home (New York Times 2008), there is a positive substitution effect for food products. Across all grocery products however, we expect a negative effect of gas prices on total purchase volume.

*Total dollar spending:* Total spending is composed of purchase volume and the cost of those purchases. To the extent that consumers reduce purchase volume, spending should decrease too. Consumers should also try to reduce the cost of their purchases, especially in light of the fact that retail prices tend to go up as energy costs rise. The avenues by which the cost of purchases may be reduced are examined below.

*Shopping trips:* The most direct effect of higher gas price should be to reduce travel costs as much as possible. This implies a reduction in number of shopping trips. On the other hand, however, consumers with low search costs can shop frequently to make better use of promotions,

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\(^1\) We obtained similar results with the Conference Board’s Composite Index of Coincident Indicators which combines four individual factors – payroll employment, personal income, industrial production, and manufacturing and trade sales.
thus saving money (Gauri, Sudhir and Talukdar 2008; Putrevu and Ratchford 1997; Urbany, Dickson and Kalapurakal 1996). Gauri, Sudhir and Talukdar (2008) find that households can obtain savings of up to 68% if they engage in either temporal (over time) or spatial (across stores) search, and can increase those savings to 76% if they search across both stores and time. Further, consumers must trade off the reduced travel cost against the psychosocial value from shopping and the fact that they must incur higher inventory holding cost if they shop less frequently. Thus, looking down the column of “No. of Trips” in Figure 1, we cannot predict whether gas prices will have a negative or positive effect on the number of shopping trips for the average household.

**Avenues for Reducing Shopping Expenditure**

*Effect of Gas Price on Retail Format Choice:* Average price levels are lower in mass, supercenter, and warehouse club formats than in drug and grocery stores, and there is considerable, though not complete, overlap in the product categories carried by different formats, making it feasible for consumers to shift their spending from one format to another (Luchs, Inman and Shankar 2007). Monetary costs should therefore drive consumers to shift to the former formats from drug and grocery stores. However, consumers must trade-off this benefit against other costs. Mass, supercenter, and warehouse club stores are not as densely located as drug and grocery stores and their assortment is not as deep as grocery stores, thus increasing travel and search costs. Apart from membership fees, warehouse clubs also require consumers to buy in bulk, increasing their inventory holding costs. On the other hand, supercenters and warehouse clubs offer one-stop shopping which can reduce the number of shopping trips and hence travel costs.\(^2\) With special displays and frequently changing layouts especially in

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\(^2\) We distinguish between traditional mass stores that have less square-footage and carry a smaller assortment of categories, and the larger supercenter format whose assortment is broader and includes perishable food products.
peripheral parts of drug and grocery stores, and "treasure hunts" for frequently changing assortment in some warehouse clubs, these formats may offer more entertainment and exploration appeal than mass and supercenter formats.

Prior research has shown that all these costs are relevant to format choice. For instance, Bell, Ho and Tang (1998) show that consumers consider the sum of fixed (e.g., traveling to and from the store) and variable (product prices and quantities in the basket) costs of shopping in making their store choice. Similarly, Bhatnagar and Ratchford (2004) argue that format choice is a function of consumers’ costs of travel, inventory holding etc. The net impact of gas price on format choice can be assessed by looking down the column titled “format share” in Figure 1. Given the countervailing effects of the different costs, the net impact of gas price on the share of each format is clearly an empirical question.³

**Effect of Gas Price on Brand and Promotion Choice:** National brands are sold at retail prices that are 20%-30% higher than private labels (Ailawadi and Harlam 2004) and penetration of private label has increased substantially in the past decade with most retailers offering private label products in a wide range of categories (Kumar and Steenkamp 2007). This makes shifting from national brands to private labels an easy way for households to save money on their grocery shopping. Value conscious consumers can also save money by searching out promotions and both private labels and promotions reduce decision costs by making it easy for the consumer to decide what to buy (Ailawadi, Neslin and Gedenk 2001; Chandon, Wansink and Laurent 2000).

However, the temporal and spatial search for promotions and the pressure to stock-up on deals increase travel, search, and inventory holding costs while private labels do not increase

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³ Consumers could also shop more at convenience stores because they are conveniently located, often together with a gas station. We don’t include this format in our analysis, however, because it accounts for less than 1% of total spending in our data.
these costs since they are priced lower every day. On the other hand, despite the emergence of “premium” private labels, U.S. consumers generally perceive a quality cost in downgrading to private label whereas they may be able to buy preferred brands on promotion. Also, promotions offer psychosocial benefits while private label does not. Overall, therefore, we expect a negative effect of gas price on regular priced national brand share and a positive effect on private label and promotional purchases of national brands. Whether the positive impact is greater for promotions or private label, however, is an empirical question.

Effect of Gas Price on National Brand Price Tier Share: Despite private label’s price advantage, national brands still have a unit market share of over 75% across CPG categories (PLMA 2009), supporting Sethuraman’s (2000) finding that consumers are willing to pay a significant premium for national brands even if private label is of equivalent quality. Consumers can save money by switching from high to mid and low price tier national brands even if they are not willing to switch to private label. This suggests a positive effect of gas price on lower tier share and a negative effect on top tier share.

However, consumers incur a quality cost in switching away from higher tier national brands to low tier ones. Those to whom monetary savings are important and quality cost is not, are likely to switch to private label, leaving the more quality conscious consumers to buy national brands. The literature on asymmetric price and context effects shows that consumers of low tier national brands are more likely to switch to private label while higher tier national brands are more insulated (Blattberg and Wisniewski 1989; Geyskens, Gielens and Gijsbrecht 2009; Pauwels and Srinivasan 2004; Sethuraman et al. 1999). Thus, despite the conventional wisdom that top tier brands hurt when times are tight, we cannot predict the effect of gas price on bottom, mid, and top tier shares among national brand purchasers.
Role of Demographic Variables

Although economic costs are likely to be more salient than psychosocial ones in the face of a significant budget constraint, it is reasonable to expect heterogeneity in how consumers make trade-offs between the various costs in Figure 1. Two over-arching consumer characteristics that determine these costs and consequent shopping behaviors have been identified in the literature – financial constraints and time constraints (Ailawadi, Neslin and Gedenk 2001; Blattberg et al. 1978; Fox, Montgomery and Lodish 2004; Luchs, Inman and Shankar 2007; Marmorstein, Grewal and Fishe 1992; Urbany, Dickson and Kalapurakal 1996). Financially constrained consumers are more likely to emphasize monetary and travel costs and time constrained consumers are more likely to emphasize travel, search, and decision costs. In order to preserve parsimony and strong theoretical grounding, we select three key demographic variables that are directly relevant to financial and time constraints – household income, presence of kids, and presence of at least one household head who does not work outside the home. Income drives financial constraints while the latter two variables drive time constraints.4

These three demographic variables are expected to have main effects on the various aspects of purchase behavior that we study in this paper and may also moderate the impact of gas price. For instance, lower income households are more likely to engage in the savings behaviors discussed above (e.g., smaller supermarket and drug store shares, greater private label and promotion shares, smaller top tier national brand share) and they may also be more sensitive to gas price increases. In contrast, time constrained households may be less likely to engage in search and more attracted to one-stop shopping (i.e., lower promotion share, higher supercenter share). We follow Ailawadi, Neslin and Gedenk (2001) and Fox, Montgomery and Lodish

4 Of course, these demographics are also related to other characteristics. For instance, households with kids have greater needs, and those who do not work outside the home are more likely to be older and retired.
(2004) in including demographics to account for heterogeneity but do not develop explicit hypotheses about their effects.

Data

We obtained an IRI panel data set from a major metropolitan area for this study. The data capture household-level shopping and spending of 1389 panelists across stores and formats, including all items bought in 297 categories tracked by IRI. Purchases are tracked over 147 weeks between 2006 and 2008. For each household, we also obtained information on key demographic variables including household income, household size, age, and employment status. Finally, we obtained gasoline prices in the metropolitan area over the same period from the Department of Energy Information Administration website, and quarterly GDP growth rate figures from the Bureau of Economic Analysis website. Figure 2 depicts both gas price and GDP growth during the period of our data.

[Insert Figure 2 and Table 1 About Here]

Descriptive statistics are provided in Table 1. Our unit of analysis is a household and month (e.g., Fox, Montgomery and Lodish 2004). The average household spends $270 per month across 9.31 shopping trips. Note that total purchase volume is also measured in dollars. This is because the vastly different units across categories (e.g., pounds, gallons, square feet, etc.) cannot be aggregated in a meaningful way. We use an average category price per unit volume to aggregate purchase volume so the resultant variable is in dollar units. However, variations in this variable occur only due to volume changes, not price changes so we can assess the impact of gas price on purchase volume by modeling variation in this variable. Table 1 also summarizes marketing mix differences across formats and how households allocate their purchases across formats, brands, and promotions.
Method

In line with Figure 1, we specify and estimate models for four sets of shopping decisions. The first set relates to overall shopping and includes three dependent variables, number of shopping trips, purchase volume, and total expenditure per month. The second set relates to how consumers allocate their total purchase volume across five different retail formats, the third set relates to the share of regular versus promotional national brands and private label in their total purchase volume, and the fourth set relates to their share of top, mid, and bottom price tier national brands.

Each model contains three groups of explanatory variables. The first group accounts for heterogeneity in preferences among households using demographic variables and the household’s value of the dependent variable during a two-month initialization period (Briesch, Chintagunta and Fox 2009; Bucklin, Gupta and Han 1995). The second group includes the macro-economic variables of central interest to our research -- gasoline price and GDP growth rate. We allow for heterogeneity in response to these variables by interacting them with the demographic variables.

The final group contains the control variables that also drive households’ shopping – distance travelled for shopping and the key retailer marketing mix variables, i.e., net price, assortment size, and percentage of assortment devoted to private label. The variables in this group are computed at different levels of aggregation as appropriate for each set of models, using household-specific weights obtained from an initialization period. Detailed definitions of the variables for each set of models are provided in the appendix.

Since retailers may adjust their marketing mix based on local demand shocks and gas price, we control for potential endogeneity in the three marketing mix variables by using their
values from markets other than the focal market as instruments (see Nevo 2001 and Chintagunta, Kadiyali and Vilcassim 2006 for examples of similar instruments).

**Total Trips, Purchase Volume, and Dollar Spending**

Model specifications for the three total monthly shopping variables are provided below. All three equations are specified in log-log form because households vary widely in the magnitudes of these dependent variables and this specification provides coefficients in percentage rather than absolute terms. The only variables not in log form are the two dummy variables (AtHome and Kids) and the GDP variable which can take on negative values.

\[
(1) \quad \ln(\text{Numtrps}_{ht}) = \beta_1 \ln(\text{Inc}_{ht}) + \beta_2 \ln(\text{Price}_{ht}) + \beta_3 \ln(\text{Dis}_{ht}) + \beta_4 \ln(\text{GDP}_{ht}) + \epsilon
\]

\[
(2) \quad \ln(\text{Dolspnd}_{ht}) = \beta_1 \ln(\text{Inc}_{ht}) + \beta_2 \ln(\text{Price}_{ht}) + \beta_3 \ln(\text{Dis}_{ht}) + \beta_4 \ln(\text{GDP}_{ht}) + \epsilon
\]

\[
(3) \quad \ln(\text{Purvol}_{ht}) = \beta_1 \ln(\text{Inc}_{ht}) + \beta_2 \ln(\text{Price}_{ht}) + \beta_3 \ln(\text{Dis}_{ht}) + \beta_4 \ln(\text{GDP}_{ht}) + \epsilon
\]

where:

\[
\text{Numtrps}_{ht} = \text{Number of shopping trips made by household } h \text{ in month } t
\]

\[
\text{Dolspnd}_{ht} = \text{Total grocery spending in dollars by household } h \text{ in month } t
\]

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5 The fit of the log-log specification was as good as or better than the linear specification, particularly in holdout sample comparisons.
Purvol_{ht} = Total purchase volume by household \( h \) in month \( t \) measured in constant dollars

Numtrps_{h0} = Average number of trips per month by household \( h \) in initialization period

Purvol_{h0} = Average purchase volume per month by household \( h \) in initialization period

Dolspnd_{h0} = Average dollar spending per month by household \( h \) in initialization period

Inc_{h} = Annual income of household \( h \)

AtHome_{h} = 1 if at least one household head is at home (not working), 0 otherwise

Kids_{h} = 1 if household \( h \) has kid(s) less than 18 years of age at home, \( 0 \) otherwise

GPrice_{t} = Average price per gallon of regular gas in month \( t \)

GDP_{t} = Annualized real GDP growth rate in the quarter of month \( t \)

Dist_{h} = Distance traveled by household \( h \) for shopping

NPrice_{ht} = Net price facing household \( h \) in month \( t \)

AssrtSize_{ht} = Assortment size facing household \( h \) in month \( t \)

PctPL = Percent of assortment size facing household \( h \) in month \( t \) that is private label

**Share Allocation Models**

The share models are of the following form:

\[
\ln(\text{Share}_{jht}) = \beta_0 \ln(\text{Share}_{jht}) + \beta_1 \ln(\text{Inc}_{h}) + \beta_2 \text{AtHome}_{h} + \beta_3 \text{Kids}_{h} + \beta_4 \ln(\text{GPrice}_{t}) + \beta_5 \ln(\text{Dist}_{h}) + \beta_6 \ln(\text{NPrice}_{jht}) + \beta_7 \ln(\text{AssrtSize}_{jht}) + \beta_8 \ln(\text{PctPL}_{jht}) + \epsilon_{jht}
\]

where the subscript \( j \) refers to the \( j^{th} \) alternative within each set (one of five retail formats; regular or promotional national brand or private label; one of three national brand price tiers), and distance and the marketing mix variables for an alternative are computed relative to the weighted average across all alternatives in the set to account for cross-effects in a parsimonious way. National brands are categorized as bottom, mid or top tier depending on whether their
average retail price is in the lowest, middle or top third of the national brand price distribution. All other variables are as defined previously.

Format shares have a significant number of zero values in our data since not all households shop at all five formats every month. Therefore, we use a two-tiered model in which a probit governs the zero-non-zero format choice and a regression of log share determines the magnitude of non-zero format share (Wooldridge 2002, page 536; Ailawadi and Harlam 2009). Since the percentages of zero values for the brand/promotion and national brand tier shares are small (generally between 0.5% and 5% of the observations), a two-tiered model is not needed for these models.

Consistent with the overall shopping models, we use a log-log formulation. The independent variables in all share models are as shown in equation (3). Note that the relative marketing mix variables are defined appropriately in each case, i.e., relative to the weighted average of all formats for the format share models, relative to the weighted average of national brands and private label for the brand/promo share models, and relative to the weighted average of the three price tiers for the national brand tier share models. Also, the Rel.PctPL variable is only included in the format share models since it is not relevant in the others, and the distance variable is relative only for format share models since it does not vary across alternatives for the other share models.

**Results**

We wish to note some overarching points before reporting specific results. First, we account for potential endogeneity of marketing mix variables in all the models, using instrumental variables as noted earlier. The first stage regressions confirm that the instruments are strong – the $R^2$'s are generally in the range of 0.40 to 0.80 and the F-statistics far exceed cut-
offs recommended in the econometrics literature. Second, gas price, GDP growth, and income are mean-centered so we can interpret the coefficients of the gas price and GDP growth variables as their respective effects on the dependent variable for households with no head “at home”, no kids, and average income. Third, we checked for multicollinearity and did not find it to be a concern. Table 2 shows the correlation matrix for variables in the overall shopping models. The highest correlation among independent variables is between AssrtSize and PctPL. Correlations of main variables with their interactions are substantial, as expected, but none are high enough to be of concern. We also checked Variance Inflation Factors and none of them are above 5.

[Insert Table 2 About Here]

Fourth, we perform three F-tests for the role of demographics in each model, to test the joint significance of their main effects, interactions with gas price, and interactions with GDP growth respectively. We include these effects only when the corresponding F-tests are significant. Fifth, the initialization period values of dependent variables that capture unobserved heterogeneity are highly significant and positive in all the models, thus confirming that preferences are relatively stable.

[Insert Table 3 About Here]

**Effect of Gas Price on Shopping Behavior**

*Overall Shopping*: Table 3 presents the estimates of our overall shopping models. Looking across the columns at the coefficient for gas price, we find that monthly number of shopping trips, expenditure, and purchase volume all decrease significantly as gas price goes up. The coefficient can be interpreted as an elasticity -- for a 100% increase in gas price, the average household reduces these three variables by approximately 20%, 6%, and 14% respectively.

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6 We also tested for interactions of gas price with distance and net price. Since these interactions were significant and negative only in the shopping trip model, we do not include them here.
Retail Format Shares: The results of the format share models are summarized in Table 4. Since grocery format share is 0 for less than 3% of the observations, it is not meaningful to estimate a probit visit model for that format. For all other formats, we report both probit and log share model results.

As gas price increases, consumers shift towards one-stop shopping formats – they visit drug and mass stores less often, and supercenters more often. High income households are particularly likely to shift away from mass stores and towards supercenters. Since the probit model coefficients cannot be directly interpreted as effects on visit probability, we use them to compute the change in predicted visit probability when gas price increases by 100% from $2.00 to $4.00 per gallon and all other model variables are held at their means. We find that the predicted visit probability decreases from 53.8% to 49% for drug stores, and from 58.8% to 54% for mass stores, while increasing from 13.9% to 18.5% for supercenters.

The impact of gas price on the share of spending at each format, given that the format is visited, is also consistent with consolidation of shopping to offset travel costs. As gas price increases, households visit drug and mass formats less often, but when they do visit these formats, the share of their total spending at these formats goes up -- by 38.2% and 21.8% respectively. Households with kids reduce their share of spending at grocery stores by 8.7% and, not only do they shop much more often at supercenters, but when they do, they increase their share of spending there by 50%. Higher income households also increase their share of spending at supercenters conditional on a visit.

In order to compute the net effect of gas price on the unconditional share of each format, we compute both the predicted visit probability and the predicted conditional share at a gas price.
of $2.00, holding all other model variables at their means. The product of the two provides the predicted unconditional share at a gas price of $2.00. By doing the same thing at a gas price of $4.00, we can compute the change in predicted unconditional share of each format when gas price increases by 100% from $2.00 to $4.00. As a percentage of the average share of the format (Table 1), these changes are -3.6%, +10%, +5%, and +24.9% for grocery, drug, mass, and supercenter formats respectively.\footnote{Note that, in share points, the 3.6% decrease in grocery share is larger than the 24.9% increase in supercenter share, given the much larger average share of the grocery format.}

[Insert Table 5 About Here]

*Brand and Promotion Shares:* The first three columns of Table 5 show estimates of the national brand/private label/promotion share models. Consistent with our expectations, an increase in gas price decreases the share of regular priced national brands. For the average income, no-head-at-home household, when gas price increases by 100%, the share of regular priced national brands decreases by 11.9%, the share of promoted national brands increases by 28.8%, and there is no significant change in private label share. The fact that private label does not make gains in this group may be partly because households shift from grocery stores, which have higher private label assortments, to supercenters, which have lower private label assortments (see Table 1). We do see an almost 10% increase (0.128-0.031=0.097) in private label share among households with at least one head at home, that constitute 48% of the panel. Such households shop more at drug stores and drug stores have a fairly large private label assortment (see Table 1). Also, such households are more private label prone anyway (see the main effect of “AtHome” on private label share in Table 5), and higher gas prices seem to reinforce that saving behavior.
Surprisingly, high income households are more likely than others to shift away from regular priced national brands to promotional purchases. This is contrary to what we would expect based on their financial constraints, but it is important to note that low income households already have lower shares of regular priced national brands and higher shares of promotional national brands and private labels (see the main effect of income), so, when gas prices increase, high income households have more room to shift.

National Brand Tier Shares: The last three columns of Table 5 show estimates of the national brand tier share models. As we expected, higher gas prices increase the share of middle tier national brands. Further, they do not affect the share of top tier brands and they actually decrease the share of bottom-tier brands. For a 100% increase in gas price, bottom tier share of the average household’s national brand purchases decreases by 9.6%, while mid tier share increases by 5.7%.

Heterogeneity in Gas Price Effect Across Demographic Groups: Interactions of demographic variables with gas price are not significant for the most part, showing that the gas price effect is not dramatically different across demographic groups. When there is a difference, it is generally due to the presence of kids and household income. The effect of kids is largely consistent with the notion that such households have higher requirements but are more constrained by time. Therefore, the negative effect of gas price on shopping trips is more pronounced for households with kids. Such households also switch more than others to supercenters, attracted by one-stop shopping.

The effect of income is largely consistent with fewer financial constraints. High income households can afford to make larger dollar outlays so they shop less frequently, spend more, spend more at warehouse clubs, and are more likely to shift to supercenters when gas price
increases. They are also more likely to shift away from regular priced national brands to promotional ones as gas price increases, but as we noted previously, they have more “room to switch” since they buy more regular priced and fewer promotional national brands overall. They are also heavier buyers of top tier national brands so it makes sense that they take advantage of promotions on those top brands to reduce their cost.  

8  

Effects of Other Variables on Shopping Behavior  

GDP Growth Rate: The overall shopping results in Table 3 show that the GDP growth coefficient is not significant for shopping frequency and it is negative for expenditure and purchase volume. The negative sign is surprising but may reflect a small substitution effect as consumers travel and eat out more when economic conditions are good, and thus buy less for home consumption. Recall that this variable is not in log form, so the coefficient is the % change in the dependent variable for a unit increase in GDP growth. For a one percentage point increase in GDP growth, the decreases in expenditure and purchase volume are very small -- 0.9% and 0.5% respectively. In elasticity terms, a 100% increase in GDP growth from its average of 1.29% (see Table 1) is associated with 1.1% and 0.65% decreases in expenditure and volume. 

In line with our expectations, the impact of this variable is substantially smaller than the impact of gas price across all the other models too. Indeed, there are only a few significant effects in Tables 4 and 5. As GDP growth rises, households increase their share of purchases at grocery stores and reduce shares at other formats, especially supercenters. Consistent with economic theory, as GDP growth increases, households slightly increase their share of regular priced and top tier national brands.

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8 Our key results are robust and remain substantively unchanged with a linear formulation. Two differences worth noting are that, in the linear formulation, the small gas price effect on total spending turns insignificant, and the insignificant gas price effect on warehouse club visit probability turns into a small, but significant, positive effect.
Control Variables: The effects of the control variables, when significant, are generally intuitive. We begin with the impact of distance. It has a negative effect on shopping frequency and spending (Table 3) -- households consolidate their shopping into fewer trips when they have to travel farther and they conserve spending to offset higher travel costs. Table 4 confirms that the farther the relative distance to a format, the less likely a household is to visit that format (Ailawadi, Pauwels and Steenkamp 2008; Fox, Montgomery and Lodish 2004). Distance also induces some shopping consolidation in that the further the drug or mass format is, the greater the share of spending in those formats conditional on a visit. The supercenter format suffers because of its locational disadvantage in that households that are further away not only visit it less often but also spend less there. Finally, Table 5 shows a negative effect of distance on private label share and a positive effect on promotional national brand share. Consumers also reduce mid and top tier brand shares and increase bottom tier brand shares when they have to travel farther to shop. This may be to offset driving cost, but it could also be because the retail formats that are farthest away (warehouse clubs) have a lower than average top tier assortment and a higher than average bottom tier assortment (Table 1).

The effect of net price is not always negative. Net price has the expected negative effect on shopping trips, purchase volume, and expenditure. With a couple of exceptions, it also has the expected negative effect in the format share models though it is not always significant. This is consistent with the mixed effect of price in prior research (e.g., Fox, Montgomery and Lodish 2004). The positive effect for regular national brand and private label shares is consistent with previous findings that the price differential between private labels and national brands may be too big and private labels can benefit from reducing the differential (Ailawadi, Pauwels and Steenkamp 2008; Hoch and Banerji 1993).
Finally, the impact of assortment is interesting. It is negative for shopping frequency—presumably consumers need fewer shopping trips to find what they need when assortment is large. Both spending and purchase volume increase with the variety of choices offered by a bigger assortment. Also, we find that the more private label is emphasized in the total assortment, the more frequently households shop and the lower is their purchase volume and spending. Consistent with prior research (e.g., Ailawadi, Pauwels and Steenkamp 2008), this suggests that emphasizing private label too much is not good for retailers.

As expected, the relative size of a format’s assortment generally increases its share, one exception being the mass format. As grocery and drug stores increase their emphasis on private label, households lower their visits and share of spending there, but the opposite is true for mass stores. This is consistent with different expectations and objectives in shopping trips made to different formats (Fox and Sethuraman 2006). Consumers want variety at the local grocery and drug stores and lower priced private labels when they visit a mass store. Table 5 shows that assortment size has the expected positive effect for bottom and top tier national brands and for private labels, but surprisingly, it has a negative effect for regular and promoted national brand share. The latter is consistent with prior findings that sales actually improve when retailers prune assortment strategically (Broniarczyk, Hoyer and McAlister 1998).

Demographic Variables: The main effects of demographics on shopping behavior are largely in line with intuition. Table 3 shows that income has a negative effect on number of shopping trips and a positive effect on spending. Both effects make sense as the financial constraints of low income households encourage them to search more and therefore make more trips, and of course, high income households can afford to spend more according to basic economic theory. Table 4 shows that high income households make fewer visits to drug and
mass stores and also have lower shares in these formats conditional on a visit. They also visit supercenters and warehouse clubs more often, and have higher warehouse club share conditional on a visit, perhaps because they can afford the budget outlay that is required for bulk shopping. Finally, Table 5 shows that, consistent with basic economic theory, high income households have higher shares of regular priced national brands and middle and top tier national brands, and lower shares of promotional and bottom tier national brands as well as private labels.

Households with at least one non-working household head make slightly more trips, consistent with fewer time constraints, and their volume and spending are also slightly greater (Table 3). They spend less at grocery and mass stores and more at drug stores (Table 4). This may have less to do with their time constraints (or lack thereof) and more to do with the probability that they are older and/or retired, a prime target market for drug stores. They buy fewer regular priced national brands, but, surprisingly, they buy more private label, not more promotional national brands despite their fewer time constraints. This may be related to their preference for drug stores which carry a higher percentage of private label products than supercenters and warehouse clubs (Table 1).

The impact of kids is generally intuitive. Households with kids make fewer shopping trips, presumably because of time constraints, but their total expenditure and purchase volume are higher because of the greater needs of large families. They visit and spend less at drug stores which is consistent with the older, female target market of drug store chains. In contrast, they spend more at grocery, mass, and supercenter formats. They are time constrained and they need to save money on their large shopping baskets, so they prefer formats that balance convenience (grocery) with affordability (mass and supercenter). Also in line with intuition, time constrained households with kids buy more private label and fewer national brands on promotion.
Discussion

Macro-economic conditions have major effects on consumer behavior and therefore on firm performance. Our research provides a comprehensive disaggregate analysis of how and how much consumers change their grocery shopping behavior in response to a macro-economic variable that is growing in importance, i.e., gas price. In quantifying the effect of gas price, we control for general macro-economic conditions as reflected in the GDP growth rate. On one hand, our work complements aggregate research on the impact of macro-factors and, on the other hand, it builds on the large body of research on consumer grocery shopping behavior, which examines a host of variables like price, promotions, assortment, and competitive factors, but generally does not incorporate macro-economic factors.

Gas Price Effect

We summarize the estimated average magnitude of the gas price effect on each component of shopping behavior in Figure 3. For easy interpretation, the magnitudes are in terms of elasticities, i.e., the percentage change in a component of shopping behavior for the average household, attributable to a 100% increase in gas price, e.g., from $2.00 per gallon to $4.00 per gallon. The one-sentence summary of the effect of gas price is as follows: Households consume less and consolidate their shopping as rising gas prices take a bigger bite out of their wallet, but they preserve their preference for high quality brands, looking for them on promotion to save money. We highlight below the aspects of these results that are surprising and/or contrary to conventional wisdom and discuss their implications.

[Insert Figure 3 About Here]

The fact that an increase in gas price reduces shopping frequency and purchase volume may not appear surprising, but it is important for at least two reasons. First, while prior research
has established a strong effect of macro-economic factors such as recessions and lower consumer confidence on sales of durable goods, CPG products are deemed more habitual and necessary, less conducive to purchase postponement, and hence less vulnerable (Deleersnyder et al. 2004; Katona 1975). Second, there is evidence that consumers travel less and eat at home more as gas prices go up, so there is a positive substitution effect that should increase food purchases. Indeed, Gicheva, Hastings and Villas-Boas (2010) report a positive effect of gas price on expenditure in four food categories. Despite these phenomena, we document a substantial reduction especially in overall purchase volume when we include a comprehensive array of grocery products and control for other variables. Apart from the general decrease in purchase volume, which hurts manufacturers and retailers alike, manufacturers of impulse products may be especially hurt by lower shopping frequency as impulse purchase opportunities decrease. Also, consumers will stockpile so manufacturers and retailers should offer frequent promotions to generate shopping trips and increase the opportunities for consumers to choose their offering.

The impact of gas prices on where consumers shop is generally intuitive – they consolidate their shopping. Supercenters, the quintessential one-stop shopping format, benefit at the expense of traditional grocery stores, driven largely by households with kids. Although consumers visit drug and mass stores less, they buy a bigger share of their requirements there when they do visit, and the net impact is slightly positive. Manufacturers must consider the shift in consumer choice as they negotiate prices and trade deals with the different formats. They may need to offer more promotional funds to the traditional formats to keep them competitive while engaging the supercenter channel with different, possibly larger size SKUs that higher income and larger households are willing to buy.
Consistent with economic theory, higher gas prices make households shift away from regular to promotional priced national brands. The shift towards private label is much smaller. Indeed, there is no significant impact on private label share except among households with one head at home. This is a surprising finding given the attention in the business press to private label growth, and its implications are important. Retailers should realize that continuing to further emphasize private label at the expense of national brands, unless it is accompanied by credible quality improvements and strong marketing and differentiation (Ailawadi, Pauwels and Steenkamp 2008), may not grow share even in tight times. Promotions are an effective retention tool as gas prices increase so balancing a robust private label with attractive promotions on national brands is more likely to be effective. And, manufacturers should realize that hunkering down in tough times by cutting promotions and allowing prices to rise will lead to share losses (see also the work by Deleersnyder et al. 2004 on price increases in tough times). Further, given prior research on the asymmetry of consumer shifts (Lamey et al. 2007), consumers lost in tough times may not return when financial constraints are eased.

Equally important is our finding that higher gas prices do not hurt the share of top tier brands among those who continue to purchase national brands. Indeed, it is the share of bottom tier brands that drops while mid tier brands gain. This is contrary to the conventional wisdom that top tier brands suffer when times are tough but it is consistent with research on context effects – private labels are much more likely to take share away from bottom tier brands than from top tier ones. Thus, manufacturers should tread carefully in introducing lower-prices extensions of their high equity brands. Unless they can significantly cut costs and preserve margins at the substantially lower price needed to combat private labels, they may find that the lower tier introductions are not effective in retaining customers and may end up hurting their
overall brand equity. It will be interesting to monitor the performance of “basic” versions of national brands that are being introduced by companies such as P&G (Wall Street Journal 2009).

In summary, the most direct way in which consumers can offset higher gas prices is by using less gas, but the economics literature has shown quite convincingly that gasoline demand is fairly inelastic. Our results show that travel cost plays a role in consumer shopping shifts but it is far from the sole determinant. On one hand, shopping frequency decreases substantially as gas price increases. And, distance is an important control variable in our models which generally shows the expected negative sign. Further, the one-stop shopping supercenter format increases share as gas price goes up. On the other hand, supercenters are generally farther away. And, consumers buy more on promotion as gas price goes up, despite the need to search at different times and in different stores. Also, sensitivity to distance does not get stronger with gas price increases, except in the shopping trip model. Overall, therefore, our results underscore the importance of considering not just monetary cost but the full spectrum of other economic costs and, to a smaller extent, the psychosocial aspects of shopping in understanding consumer shopping response to macro-economic factors like gas price.

**Limitations**

Before concluding, we note some limitations of our work that we hope can be addressed by future researchers. First, we estimate the impact of gas price on each component of shopping behavior separately. It is likely however, that the consumers’ shopping decisions are interdependent or follow a hierarchical structure, e.g., they first decide on their budget and where to shop and then decide what to buy. We leave it future research to test more integrated models.

Second, although we do allow for heterogeneity in the gas price effect across key demographic groups, there may be heterogeneity in response among consumers that is not
captured by these demographic variables. For instance, consumers with different psychographic and shopping profiles may react differently. Generating such profiles and studying differences in their response is a fruitful direction for additional research.

Third, although we control for economic conditions with the well-accepted GDP growth variable and also found similar results with the Conference Board Composite Index of Coincident Indicators, other macro-economic variables may affect shopping behavior and should be examined in future research, especially when the data span longer periods of time. Similarly, we account for key marketing mix variables, but other retail factors such as service and convenience (Ailawadi and Keller 2004; Berry, Seiders and Grewal 2002; Gauri, Trivedi and Grewal 2008) influence consumers’ format and store choice. To the extent that these factors are stable, we control for them through the heterogeneity variable. However, future research should examine whether the influence of these factors changes with the macro-economic environment.

**Conclusion**

In conclusion, the significant effect of gas price that we document in this paper makes it important to incorporate this factor explicitly into consumer shopping behavior models when it exhibits substantial variance. We also contrast the effects of gas price and general economic health on grocery shopping and find that the former is much stronger. Of course, our study looks at the short term impact, but it is important to understand whether these changes persist over the longer term, and whether they reverse when gas price goes down again. Further, it is important to understand the extent to which shopping behavior changes are driven by psychological factors versus the direct budgetary constraints imposed by higher gas prices. Gas prices and general economic conditions are likely to have very different effects on consumer sentiment and attitudes which in turn affect consumers’ psychological willingness to buy. Finally, gas price is one
important macro-economic variable outside the control of managers that we have shown
influences consumer shopping. There are other macro-economic variables, home values and tax
rates to name just a couple, that may also affect consumers’ willingness and/or ability to buy.

We hope our work stimulates further research in this important domain.
REFERENCES


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Correlations Between Shopping Model Variables

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Note: All variables are in log form except GDP and dummy variables
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Overall Shopping Model Estimates

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Note: Coefficient estimates are reported with t-statistics in parentheses.  
*** p<.01, ** p<.05, * p<.10
### TABLE 4
Format Share Model

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Note: All shares are shares of total purchase volume.

Coefficient estimates are reported with t-statistics in parentheses; *** p<.01, ** p<.05, * p<.10
### TABLE 5

**Brand, Promotion, and Tier Share Models**

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**Note:** All shares are shares of purchase volume.

Coefficient estimates are reported with t-statistics in parentheses; *** p<.01, ** p<.05, * p<.10.
FIGURE 1
Guiding Framework

Shopping Costs

- **Monetary Cost**
  - Price

- **Travel Cost**
  - Distance
  - Frequency

- **Quality Cost**
  - Downgrade

- **Search Cost**
  - Assortment
  - Deals

- **Decision Cost**
  - Brand choice

- **Holding Cost**
  - Stockpiling

- **Psychosocial Cost**
  - Variety
  - Entertainment

Avenues for Reducing Cost of Purchases

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<td></td>
<td>• Drug, Grocery, Mass, Supercenter (+)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trips (+)</td>
<td>• Mass, Supercenter (-)</td>
<td>• Reg NB, PL (-)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Drug, Grocery, Club (+)</td>
<td>• Promo NB (+)</td>
<td></td>
</tr>
</tbody>
</table>
FIGURE 2
Gas Prices and GDP Growth Rates

Mean (Std. dev.) of Gas Price: $3.07 ($0.58)
Mean (Std. dev.) of GDP Growth: 1.19% (2.29%)
FIGURE 3
Summary of Average Gas Price Effect

100% increase in gas price from $2.00 to $4.00

- 20% decrease in monthly shopping trips
- 14% decrease in monthly purchase volume
- 6% decrease in monthly expenditure

Format Shares
- 3.6% decrease in grocery format share, driven by households with kids
- 10% increase in drug format share, despite lower visit probability
- 5% increase in mass format share, despite lower visit probability
- 24.9% increase in supercenter format share, driven especially by households with kids
- No significant change in warehouse club format share

Brand/Promotion Shares
- 12% decrease in regular price national brand share
- 29% increase in promotional national brand share
- 3% increase in private label share, driven by households with one or more head at home

National Brand Tier Shares
- 10% decrease in share of bottom tier brands
- 6% increase in share of mid tier brands
- No significant change in share of top tier brands

Note: Percentage changes in shares are from the average share of each option. In share points, therefore, the 3.6% decrease in grocery share is larger than the 24.9% increase in supercenter share, given the much larger average share of the grocery format.
Appendix: Variable Definitions

**Note:** All variables are aggregated from the category to format and market level using household-specific category and format shares in the initialization period as weights.\(^9\) The first two months are used as the initialization period.

**I. Variables for Format Share Models**

a) **Distance\(_hj\):** Distance to retail format \(j\) for household \(h\), calculated as
\[
\text{Distance}_{hj} = \frac{\text{dist}_{hjn}}{\text{ts}_{hjnt0}},
\]
where \(\text{dist}_{hjn}\) is the distance from the closest store of retailer \(n\) in format \(j\) to household \(h\), and \(\text{ts}_{hjnt0}\) is the share of retailer \(n\) in retail format \(j\) for household \(h\) in initialization period.

b) **RelDist\(_hj\):** Distance to format \(j\) for household \(h\) relative to weighted average distance to all formats, calculated as
\[
\text{RelDist}_{hj} = \frac{\text{Distance}_{hj}}{\sum_{j'} \text{Distance}_{hj'}},
\]
where \(\text{Distance}_{hj'}\) is the distance to format \(j'\) for household \(h\) in initialization period.

c) **NPrice\(_hjt\):** Net price of category \(c\) in format \(j\) in month \(t\), calculated as
\[
\text{NPrice}_{hjt} = \frac{\text{Nprice}_{jtc}}{\text{cs}_{hnt0c}},
\]
where \(\text{Nprice}_{jtc}\) is net price of category \(c\) in format \(j\) in month \(t\) and \(\text{cs}_{hnt0c}\) is share of total spending by household \(h\) in initialization period on category \(c\).

d) **RelNPrice\(_hjt\):** Net price of format \(j\) in month \(t\) for household \(h\), relative to weighted average net price of all formats, calculated as
\[
\text{RelNPrice}_{hjt} = \frac{\text{NPrice}_{hjt}}{\sum_{j'} \text{NPrice}_{hjt'}},
\]
where \(\text{NPrice}_{hjt'}\) is net price of format \(j'\) in month \(t\) for household \(h\).

e) **AssrtSize\(_hjt\):** Assortment size of format \(j\) for household \(h\) in month \(t\), calculated as
\[
\text{AssrtSize}_{hjt} = \frac{\text{AssrtSize}_{jtc}}{\text{cs}_{hnt0c}},
\]
where \(\text{AssrtSize}_{jtc}\) is the number of distinct SKUs of category \(c\) in the quarter of month \(t\) in retail format \(j\).

\(^9\) The exception is net price of a category, which is aggregated up from SKU and brand levels using market shares in the initialization period as weights.
f) \( \text{RelAssrtSize}_{hj} \): Assortment size of format \( j \) for household \( h \) relative to weighted average

assortment size of all formats, calculated as

\[
\text{RelAssrtSize}_{hj} = \frac{\text{Assortment size of format } j \text{ for household } h}{\text{Weighted average assortment size of all formats}}
\]

g) \( \text{PctPL}_{hj} \): Percentage private label in assortment of format \( j \) for household \( h \) in quarter of

month \( t \), calculated as

\[
\text{PctPL}_{hj} = \frac{\text{Private label assortment}}{\text{Total assortment}}
\]

\( \text{h) RelPctPL}_{hj} \): Percentage private label in assortment size of format \( j \) for household \( h \) relative to

weighted average percentage private label in all formats, calculated as

\[
\text{RelPctPL}_{hj} = \frac{\text{Private label assortment size}}{\text{Total assortment size}}
\]

II. Variables for Brand/Promotion Share Models

a) \( \text{Distance}_h \): Average distance to stores for household \( h \), calculated

\[
\text{Distance}_h = \frac{\text{Distance}_h}{\text{Total trips}}
\]

\( \text{fs}_{hj0} \) is as defined previously and \( \text{fs}_{hj0} \) is the share of

total trips to retail format \( j \) by household \( h \) in initialization period.

b) \( \text{NPrice}_{khct} \): \( \text{NPrice}_{khct} = \frac{\text{Price}_{khct}}{\text{Total price}} \), where \( \text{NPrice}_{khct} \) is net price of brand

type \( k \) in category \( c \) in month \( t \) and \( \text{cs}_{hct0} \) is as defined previously. Note \( k=1 \) is national brands

and \( k=2 \) is private label.

c) \( \text{RelNPrice}_{khct} \): \( \text{RelNPrice}_{khct} = \frac{\text{RelPrice}_{khct}}{\text{Total price}} \), where \( \text{ts}_{khct0} \) is household \( h \)’s share

of brand type \( k \) in initialization period.

d) \( \text{AssrtSize}_{khct} \): Assortment size of brand type \( k \) for household \( h \) in month \( t \), calculated as

\[
\text{AssrtSize}_{khct} = \frac{\text{Number of distinct SKUs}}{\text{Total assortment size}}
\]

\( \text{AssrtSize}_{khct} \) is the number of distinct SKUs of brand

type \( k \) in category \( c \) in the quarter of month \( t \).
e) $\text{RelAssrtSize}_{hti}$: Assortment size of brand type $k$ for household $h$ relative to weighted average assortment size of both brand types, calculated as

$$\text{RelAssrtSize}_{hti} = \frac{\text{AssrtSize}_{hti}}{\text{AssrtSize}_{h0}}$$

III. Variables for National Brand Tier Share Models

Same as above, except that $k=1$, 2, and 3 respectively for bottom, mid and top tier national brands.

IV. Variables for Overall Shopping Models

$\text{Distance}_h$: As defined previously.

$\text{NPrice}_{ht} = 15$.

$\text{AssrtSize}_{ht} = 15$.

$\text{PctPL}_{ht} = 15$.

where $\text{NPrice}_{ht}$, $\text{AssrtSize}_{ht}$, $\text{PctPL}_{ht}$, and $f_{ht0}$ are as defined in the format share models.

$\text{Purchase Volume}_{ht}$: Total purchase volume by household $h$ in month $t$ calculated as

$$\text{Purchase Volume}_{ht} = \frac{q_{htc}}{N\text{Price}_{t0c}}$$

where $q_{htc}$ is total equivalent units of category $c$ purchased by household $h$ in month $t$ and $N\text{Price}_{t0c}$ is net price of category $c$ in initialization period.