Distributional Impacts of the Changing Retail Landscape

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Abstract

Countering the prevailing narrative of a "retail apocalypse," we demonstrate expansion of the general merchandise sector from 2010 to 2019 period, driven predominantly by the growth of dollar and discount department stores. Using geolocation data from millions of smartphones, we estimate preferences for specific, identified chains across income groups and geographies. We introduce a novel instrument to address endogeneity of the distance between consumers and retail establishments. We estimate that welfare per trip to general merchandise stores has not substantially declined over time. While consumers have been made worse off from the decline in smaller regional chains, they have benefited from entry of national chains locating closer to their residences.

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1 Introduction

The last decade has seen a transformation of the U.S. retail landscape, with the press energetically asserting that exits of large retail chains constitute a "retail apocalypse."[1] This raises the possibility that some households are now facing substantially diminished access to retail opportunities. While much has been written about the transition from manufacturing jobs to new economy jobs having "left behind" a cohort of dislocated workers, there has been less focus on how the transition from traditional brick and mortar retail to the current physical/online retail mix may have left behind a cohort of dislocated shoppers.

This concern is particularly salient given the uneven take up of e-commerce. While e-commerce has transformed the way many consumers acquire general merchandise goods, this transformation has not been felt equally by all strata of U.S. consumers. For example, Dolfen et al. [2022] estimate that, for households with annual incomes above $50,000, online shopping accounts for about 9.7 percent of spending but only about 3.4 percent of spending for lower-income households. These findings suggest that lower-income households may remain relatively more reliant on brick and mortar retailers as a source of household goods. Moreover, changing local retail opportunities may create "retail deserts" that impact the consumption and/or travel burden of some shoppers, particularly those who do not actively participate in the online economy.

This paper begins by documenting new facts on the changing retail landscape in the general merchandise sector during the 2010-2019 period. Despite claims of a retail apocalypse, we show that the number of general merchandise stores has actually increased over the decade and that the increase has been concentrated among large national chains. In particular, this growth has been driven by the near-doubling of dollar store outlets such as Dollar General, Family Dollar, and Dollar Tree. In addition, we find substantial growth among discount department stores and a concurrent decline of traditional department stores and regional and independent retailers.

We use smartphone geolocation data for over four million smartphone devices in

[1] For example, see Peterson [2017], Townsend et al. [2017], and Thompson [2017].

metropolitan areas. We document the differential visit patterns to different chains by consumers of different incomes. We show that the income composition of visitors varies across general merchandise chains; for example, the lowest-income consumers represent a higher share of visitors to Dollar General and Family Dollar than other general merchandise chains. This difference in visit propensity could be attributed to differences in consumer preferences and/or proximity to chains across consumer incomes.

We use our smartphone data to estimate a model of consumer shopping behavior that allows us to disentangle preference effects from proximity effects and we quantify the welfare impact of the change in the general merchandise sector over the 2010-2019 period.

While our smartphone data provide no information on the purchases made at each store visit, we can infer consumer tastes for different chains based on differential willingness to travel. We estimate an income- and spatial-specific taste for each retailer which encompasses the product assortment, prices, and store amenities offered by each chain. The cost of each retailer visit is characterized by consumers' distance to the visited store and distance costs may be mitigated by trip chaining, which we model in a reduced-form way using the retailer's store density characteristics. Intuitively, if a retailer is in close proximity to many other stores, e.g., within a mall, it may be more attractive for a consumer to visit that retail location.

One challenge in estimating location-choice models is the potential endogeneity of the distance between consumers and choices—in this case, stores. Despite the growing understanding of the importance of consumption-based spatial sorting[2] most empirical work using travel costs as an indicator of preferences does not address this endogeneity. Stores presumably locate themselves strategically based on consumer preferences, balancing accessibility to agglomerations of consumers who they expect to like those stores with harvesting the willingness to travel of their most loyal customers. These location strategies potentially lead to unobserved consumer characteristics being correlated with distance, thus potentially biasing our estimates of distance parameters and the taste for individual stores. This form of endogeneity may be relevant in the literature more broadly—for

[2]See, for example, Almagro and Domínguez-Iino [2022], Diamond and Gaubert [2022], and Couture et al. [2019]

example, in school or hospital choice.

We introduce a novel ring instrument to control for endogenous distances and show that this instrument has substantial influence on our estimates. The instruments are constructed using spatial demographic data and therefore, can be adapted to a variety of settings using publicly available data. More precisely, we use the idea of preference externalities Waldfogel [1999], as furthered by Fan [2013], to construct instruments based on the density of consumers of different income types in rings around the central business district (CBD). Consumer densities affect the attractiveness of siting a particular store and therefore, the choice set and the distances consumers face for shopping. We also discuss alternative spatial demographic instruments and compare our findings.

To our knowledge, smartphone data have not been used to estimate models of shopping behavior, with the exception of Cook [2022]. Smartphone data have several advantages. First, smartphone data have been shown to be broadly representative of US demographic groups [e.g., Chen and Pope, 2020, Couture et al., 2022], making them optimal for a study that focuses on the inter-income differences. Relatedly, one alternative data source is credit card data, but low- and high- income consumers differ substantially in their propensity to make cash versus credit card transactions [Foster et al., 2020]. Finally, in contrast to consumer panel and credit card datasets, smartphone data have no data use restrictions that forbid the disclosure of the identities of specific retailers. We are thus able to identify whether any specific retailer contributes disproportionately to consumer welfare.

Our preference estimates show both similarities and differences in the preferences of higher- and lower-income consumers across chains, with some sharp differences apparent even within a category. For example, while Target and Walmart may seem to be similar supercenters, low-income consumers value access to Walmart substantially more than access to Target while high-income consumers view them quite similarly. Both low- and high-income consumers value Dollar Tree more than Dollar General. Intuitively, high-income individuals have higher relative preference for chains such as Nordstrom, Saks Fifth Avenue, and Bloomindale's, than low-income individuals. Our findings underscore the value of having data that allow for the disclosure of chain identities.

Combining our demand estimates with historical data on retail locations provided by Data Axle (formerly ReferenceUSA) , we estimate the welfare accruing to consumers of different incomes from the change in general merchandise retail chains over the last decade. The welfare calculation allow us to decompose the welfare changes due to consumer migration, national chain entry and exit, and the entry and exit of small regional chains. Our results suggest that, if all consumers remained at their 2010 locations, the lowest income consumers benefited slightly more than other income groups from the changes in general merchandise opportunities over the decade. The welfare gain attributable to the expansion of discount department stores, supercenters, and dollar stores outweigh the welfare losses attributable to the exit of smaller regional chains and traditional department stores. Given recent findings that welfare improvements from access to online retail have been substantially concentrated in higher-income consumers, our welfare results alleviate some concerns of widening income consumption inequality in the era of ecommerce. The positive impacts of the changing retail environment are counteracted by migration, as both the lowest and highest income consumers tended to move farther from retail opportunities over the course of the decade.

Our paper proceeds as follows. Section 2 briefly describes background information and the prior literature. Section 3 describes our data sources. Section 4 provides model-free evidence documenting that substantial exit and entry of brick and mortar retailers over the last decade have changed the US brick and mortar retail landscape. Section 4 also documents that consumers of different incomes differ substantially in their propensity to visit different retailers. Section 5 describes our model of consumer shopping choices. Section 6 and 7 discuss our estimation and welfare results. Section 8 concludes.

2 Literature and Background

Our work is closely related to the study of preference externalities, a term first coined by Waldfogel [1999]. Presumably, if a chain exits, that is because insufficient consumers value its presence enough to induce the chain to pay the fixed costs of remaining in business. However, consumers can be worse off when their preferences differ from those of others in

their community [George and Waldfogel, 2003, Waldfogel, 2008]. In particular, one could be concerned that the migration of higher-income consumers to ecommerce leads to the exit of stores that lower-income consumers would still substantially value.

Our findings also complement recent work on the growth of ecommerce. Dolfen et al. [2022] estimate the gains from ecommerce and show that they are substantially higher for richer households. This finding stems in large part from their estimates of the difference in take-up of ecommerce; they find that households earning less than $50,000 spend 3.4% of their consumption spending online versus 9.7% for higher income consumers. Estimates from their model also suggest that online competition led to a modest contraction of brick and mortar stores; they estimate a 3 percent decrease in the number of physical retail stores due to online competition.

Although Dolfen et al. [2022] estimates a causal impact of ecommerce on physical store locations, the question of how changing proximity to retail opportunities impacts different demographic groups differently has previously been studied most extensively in the area of food, grocery stores and "food deserts." Allcott et al. [2019] estimate a model of food demand and obtain counterfactuals suggesting that exposing low-income households to the same products and prices available to high-income households reduces nutritional inequality by only about 10 percent, while the remaining 90 percent is driven by differences in demand. The role of the expansion of small-format dollar stores on the locational choices and sales of other retailers has been examined by Caoui et al. [2022] and Chenarides et al. [2021]. Both estimate the impacts of dollar stores on grocery stores and access to food. Cao [2022] examines the welfare impact of dollar stores, demonstrating that a substantial fraction of dollar store sales derive from low-priced private label goods, creating welfare gains for low-income households. Both Cao [2022] and Chevalier et al. [2022] show that dollar stores tend to choose locations close to low income consumers.

Perhaps the paper closest to ours is Cook [2022]. The author uses smartphone geolocation data to examine the willingness of above-median income and below-median income consumers to travel to a variety of amenities including restaurants, shops, services, and entertainment places. The focus is on measuring the extent to which the preferences of above- and below-median income are correlated. The author shows that

preferences are somewhat heterogeneous but that the income sorting of locations is limited; neighborhoods that are amenity-rich have amenities favored by both income types and neighborhoods that are amenity-poor lack amenities desired by both income types. Cook [2022] does not estimate a demand system accounting for location endogeneity. Similar to our findings, the author finds that Walmart is a universally high-value amenity in the domain of general merchandise stores. Cook [2022] and our work both relate to a literature estimating how households at different income levels value the retail opportunities in different cities and neighborhoods. In particular, our work complements Diamond and Moretti [2021] who compare the cost of living across commuting zones, accounting for differences in expenditure weights between households at different income levels.

Relative to these papers, we focus specifically on the role of general merchandise retailers, and on the impact of the change in the landscape over the 2009-2019 period. General merchandise retailers (tracked as NAICS code 452) consist of traditional department stores like Nordstrom or Sears, discount department stores like Five Below or TJ Maxx, supercenters like Walmart, warehouse clubs like Costco, and dollar stores like Dollar General and Dollar Tree. Intuitively, the goods sold at such stores are likely substitutes for the types of goods shipped by ecommerce retailers like Amazon. Thus, our paper complements the existing literature by shedding light on the welfare of consumers, especially low-income consumers, who don't fully embrace ecommerce.

While there is a growing literature estimating the process by which consumers and retail amenities co-locate (see for example Almagro and Domínguez-Iino [2022]), the resulting endogeneity of the distance from consumers to retail stores has not, to our knowledge, been widely incorporated into demand system estimation. This distance endogeneity is potentially a concern whether or not prices and price endogeneity are also being considered and could impact demand systems that incorporate distance to other entities such as hospitals or transportation. [3]

[3]Bayer et al. [2007] proposes a method to extract preferences for schools while addressing the endogeneity of neighborhood sorting; however, the jurisdictional boundary discontinuities exploited there are less likely to be helpful in modeling retail location choices.

3 Data

Our primary data are smartphone geolocation data for over 4 million devices for 2019 provided by PlaceIQ. PlaceIQ, a location data and analytics firm, aggregates location data from users who have opted into geolocation in different smartphone applications. The raw pings from smartphones are joined with a map of establishments, which are characterized by two-dimensional polygons. A timestamped set of pings in a polygon within a short period of time are characterized as a visit by the smartphone owner to the establishment corresponding to the polygon. We focus on visits to polygons that PlaceIQ identifies as containing a general merchandise store. These stores are found within the NAICS classification 452. To avoid misclassifying visits to polygons containing both general merchandise establishments as well as a device's home location or workplace, we drop all device-weeks in which a device visits general merchandise establishments more than ten times in the week.

Smartphone geolocation data have strengths and weaknesses for this kind of analysis. Previous studies of how shopping behavior varies with demographics typically rely on either microdata from a selected consumer panel [e.g., Cao, 2022, Caoui et al., 2022] or on consumer credit and debit card data [e.g., Dolfen et al., 2022, Relihan, 2022].[4] These studies provide important results on shopping behavior. However, Canilang et al. [2020] and Dolfen et al. [2022] show that the consumer propensity to own credit cards is lower for low-income consumers than high-income consumers. Futhermmore, credit card usage varies by age, income, and transaction type (see Foster et al. [2020]. For example, the 2019 Survey of Consumer Payment Choices shows that, in a typical month, consumers with income less than $40,000 per year made 8 credit card transactions, 17 cash transactions and 18 debit card transactions. In contrast, consumers with income greater than $75,000 made 26 credit card transactions, 13 cash transactions, and 28 debit card transactions. The survey also reports that 30 percent of in-person retail purchase transactions were made with cash. Another advantage of smartphone data derives from retailer idenity.

[4]Dolfen et al. [2022] use data from credit and debit purchases excluding PIN-enabled debit card purchases. Relihan [2022] uses data from credit and debit purchases for JP Morgan Chase customers and finds them to skew somewhat more male and higher-income than the census at large.

The providers of payment card, government, and shopper panel datasets typically forbid the disclosure of identifiable information, such as the identities of specific retailers. This forecloses identifying which specific retailers influence consumer shopping behavior and hence, contribute disproportionately to welfare. In contrast, our smartphone data have no such data use restrictions. Moreover, smartphone data has been shown to be broadly representative of US demographic groups [e.g., Chen and Pope, 2020, Couture et al., 2022]. To our knowledge, smartphone data have not been used to estimate models of shopping behavior, with the exception of Cook [2022]. Like credit card data, smartphone data do not provide information on what specific items consumers purchased or at what prices. Unlike credit card and consumer panel data, smartphone data also do not provide the overall transaction size. This motivates our decision to use these data to estimate consumers' taste for retail chains in terms of willingness to travel.

We further restrict our attention to devices originating in the twenty largest Core-Based Statistical Areas, excluding New York, Los Angeles, San Francisco, and Seattle.[5] The sample CBSAs together comprise over 25 percent of US population, about 31 percent of urban population in the US. For a subset of devices, PlaceIQ provides income estimates based on the building in which the device resides. Since we are mainly interested in the impact of the changes in retail opportunities along the income dimension, we assign individual devices to income quartiles calculated using the PlaceIQ data and national Census income quartile cutoffs. Couture et al. [2022] discuss the representativeness and reliability of the PlaceIQ data.

While the PlaceIQ data provides rich detail on individual visit decisions, there are several limitations and challenges inherent in geolocation data that we need to deal with in our estimation and welfare quantification. First, these smartphone data have only become available in recent years; we cannot examine historical shopping behavior. We combine these data with another data source, Data Axle Reference Solutions, to examine changes in retail opportunities over time as well as the ensuing consumer welfare changes.

Data Axle, formerly known as Infogroup Reference USA, provides identity and outlet

[5] We exclude New York and Los Angeles for computational reasons and San Francisco and Seattle because over half the population has top-coded income

locations for multi-unit retail stores. We focus on general merchandise stores including department stores, discount stores, and dollar stores that report more than five employees at an individual outlet. These data have the benefit of being available historically. We check the reliability of this data source by comparing the county-level store counts derived from Data Axle for NAICS code 452 with the corresponding store counts from the US Census Bureau's County Business Patterns (CBP) data. County Business Patterns provides county-level establishment counts by NAICs code but does not identify particular establishment names. The county-level store counts from Data Axle are extremely similar to those from CBP.

Table 1: Summary Statistics for the Data Sample

Variable	Mean	25th Pctile.	Median	75th Pctile.
per device, week				
Number of visits to inside chains	3.01	1.00	2.00	4.00
Number of visits to fringe stores	1.61	1.00	1.00	2.00
per device				
Number of inside chains in choice set	16.67	15.00	18.00	20.00
Number of fringe stores in choice set	11.73	4.00	9.00	16.00
Number of weeks observed	9.43	2.00	6.00	14.00
Number of outlets of inside chains	114.51	51.00	104.00	165.00
Number of stores visited per trip	1.78	1.00	1.00	2.00
Number of unique chains	166			
Number of outlets	13,847			
Number of devices	6,002,510			
Total number of visits	184.282 mil.			

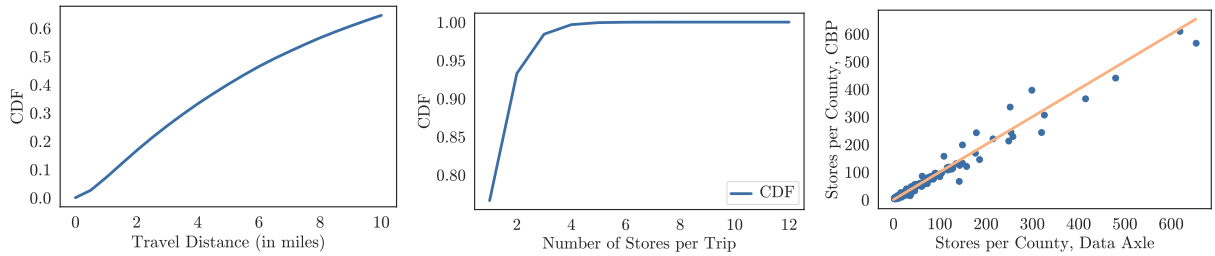
Note: Summary statistics for the 2019 cell phone data.

Second, the PlaceIQ data do not identify the names of all general merchandise stores, especially smaller or independent chains. In our estimation, we treat all of these unidentified chains as "fringe" options. We include unnamed chains and smaller named chains in the fringe group and only estimate chain-specific preferences preferences for the largest national chains. The list of national chains for which we estimate individual specific preferences are listed in Table 2. These national chains account for over 63 percent and over 82

percent of establishments in the general merchandise sector in 2010 and 2019 respectively. They also represent over 89 percent of visits to general merchandise stores in 2019 in our smartphone data sample.

While in principle a consumer can visit any store at any distance and combine multiple store visits into a trip, most trips consist of a visit to a single store close to home. The left panel of Figure 1 shows the distribution of visits by the distance between a consumer's home location and the general merchandise establishment the consumer visits. We find that 65% of store visits are within 10 miles of an individual's residence. In our estimation, for tractability, we confine each device's choice set to the set of general merchandise stores within 10 miles of the device's home location. The middle panel of Figure 1 shows the distribution of number of general merchandise stores visited per trip, verifying that the majority of trips are to a single store. In our estimation, we will make an adjustment for the potential for "trip chaining" using the proximity of a given store to other stores.

Figure 1: Trip Statistics and Store Counts



Note: Panels (a) and (b) use the universe of shopping trips to General Merchandise stores in the CBSAs we study over the study period. The left panel shows the CDF of distance traveled for each trip while the middle panel shows the number of stores in NAICS 452 visited per trip. Panel (c) shows concordance between Data Axle store counts and store counts in County Business Patterns (CBP) in 2019.

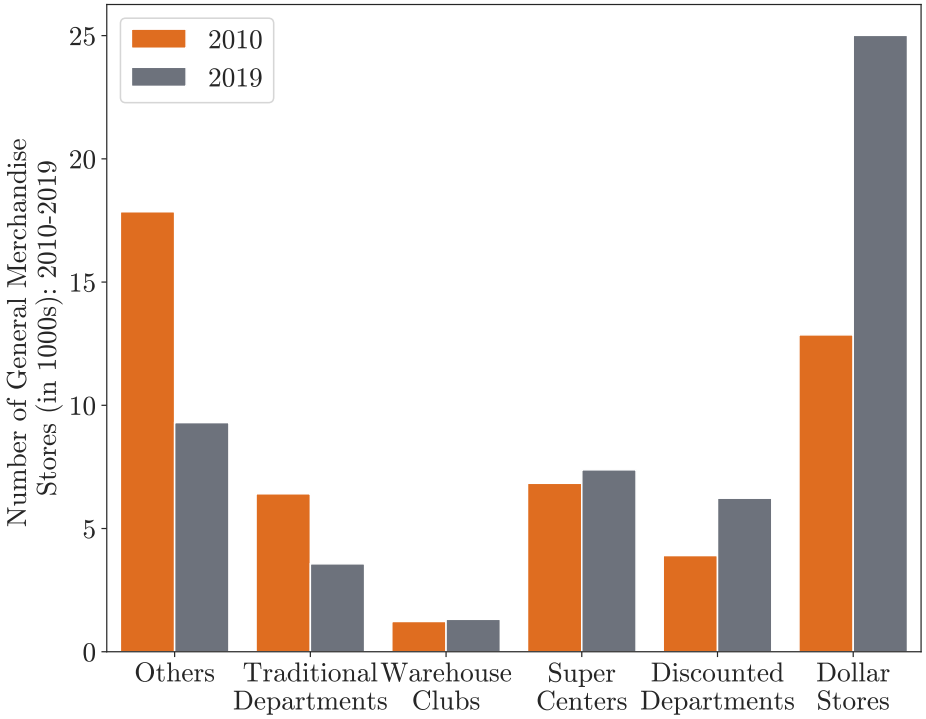
We use the PlaceIQ data to estimate consumer preferences. In order to undertake our welfare exercise and also to construct our instrument, we use population and demographic data for 2010 and 2019 obtained from the U.S. Census.

4 Evidence on the changing retail landscape

We begin by providing some new facts about the evolution of the general merchandise store category over the 2010 to 2019 period and the shopping patterns of consumers by

their demographics. Figure 2 shows the count of general merchandise stores (NAICS: 452) across the U.S. for 2010 and 2019 using data from Data Axle. To better understand the changing retail landscape, we group the "inside good" general merchandise stores into six types: Traditional Department Stores, Warehouse Clubs, Supercenters, discount department Stores, Dollar Stores, and Others. The chains categorized are the 25 chains enumerated in Table 2 plus Kmart and SteinMart. Kmart and SteinMart have very low visit counts in our smartphone data in 2019 making it difficult to extract specific preferences for them. Given their historical importance we include them in our locational analysis. [6]

Figure 2: Number of General Merchandise Stores in the U.S. in 2010 and 2019



Note: The figure reports the number of general merchandise (NAICS 452) stores with more than 5 employees listed in Data Axle reference Solutions in the U.S. in 2010 and 2019 by category. "Traditional Departments" includes Bloomingdales, Dillard's, JCPenney, Kohl's, Kmart, Macy's, Neiman Marcus, Nordstrom, Saks Fifth Avenue, Sears, and SteinMart; "Warehouse Clubs" includes BJ's Wholesale Club, Costco, and Sam's Club; "Super Centers" includes Target, Walmart, and Big Lots; "discount departments" includes Burlington Coat Factory, Marshalls, Ross Dress For Less, TJ Maxx, Citi Trends, and Five Below; "Dollar Stores" includes Dollar General, Dollar Tree, Family Dollar, and 99 Cents Only; and "Others" includes general merchandise stores that are not associated with the aforementioned national chains.

In contrast to the press around the "retail apocalypse," the total number of general

[6]SteinMart went bankrupt and closed all of its stores in 2020 and Kmart closed nearly all of its US stores in 2019 to 2020.

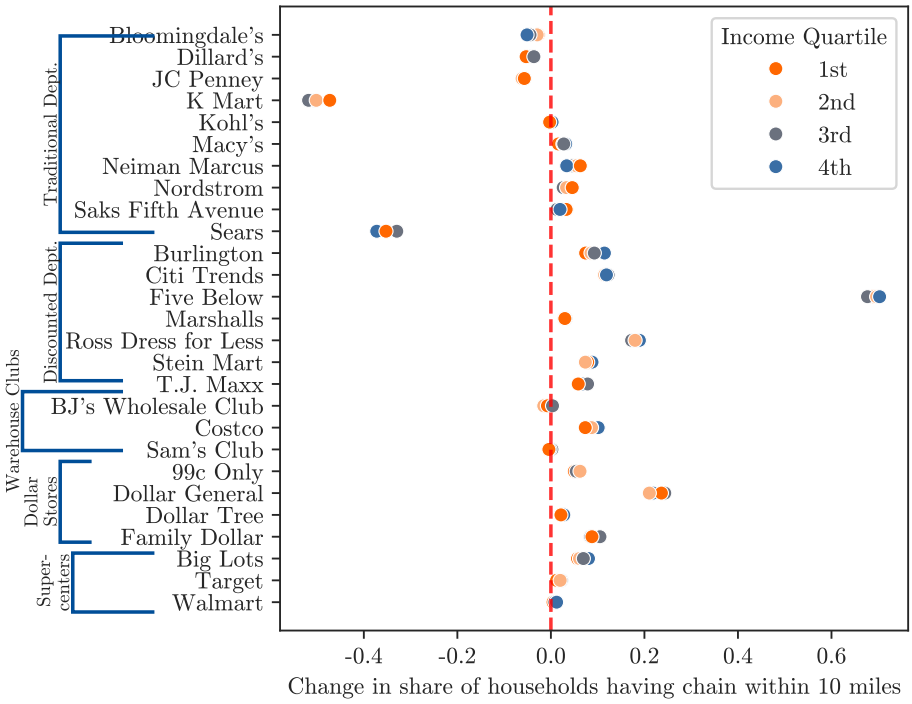
merchandise chain stores increased substantially between 2010 and 2019. The increase is mainly driven by dollar stores and, to a lesser extent, supercenters and discount department stores. The number of dollar stores—including Dollar General, Dollar Tree, and Family Dollar—more than doubled over the decade and, by 2019, was nearly equal to the total count of other general merchandise stores. During the same period, however, traditional department stores and regional chains have been on the decline.

The changing retail landscape of general merchandise stores can potentially generate differential impacts on households of different income groups. To illustrate this, we provide evidence on the differential changes in households' access to general merchandise chains by household incomes. Figure 3 plots, for each income quartile, the change in the share of households with access to each general merchandise chain from 2010 to 2019, where access is defined as having a store within 10 miles. Figure 4 shows the change in the average distance to the closest store of each general merchandise chain over the same period.

The expansion of dollar stores has increased their proximity of these stores to households of all income levels. In 2019, more households had access to dollar stores within 10 miles of their census tracts of residence and the average household needed to travel fewer miles to visit dollar stores. The degree of the improved access varies by household incomes and dollar store chains. The share of households within ten miles of a Dollar General increased by over 20 percent for all income groups. The travel distance to the closest Dollar General and 99 Cents Only stores decreased more for lower-income households while the accessibility of Dollar Tree stores improved more for higher-income households. In addition, households' access to discount department store chains, especially Five Below, improved on both the intensive and extensive margins. The share of households with access to Five Below stores increased by more than 60 percentage points and the closest Five Below stores were located more than two miles closer for the average households. Among supercenter chains, Big Lots expanded more on the extensive margin and among higher-income households while Walmart and Target expanded more on the intensive margin and Target expansion is more concentrated among higher-income households.

The differential changes in households' access to general merchandise chains may

Figure 3: Share of households withing 10 miles of General Merchandise Stores in 2010 and 2019 By Household Income Groups



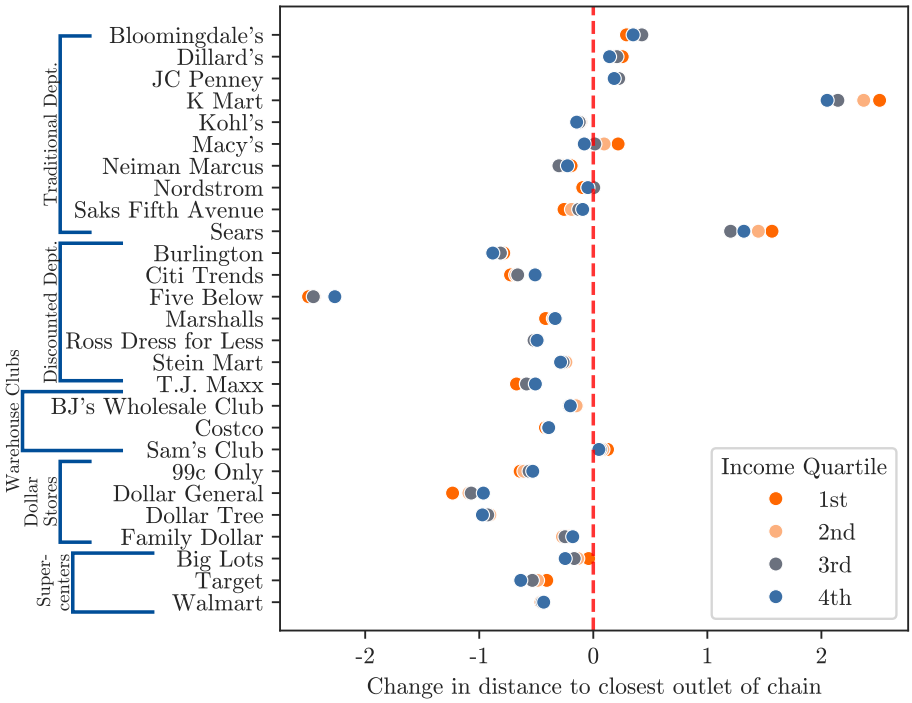
Note: This figure uses U.S. Census data on household residences and income combined with Data Axle data on store locations. The figure shows the mean number of general merchandise stores within 10 miles of a household by income quartile for 2010 and 2019. The upper panel includes all general merchandise stores including dollar stores while the lower panel excludes dollar stores from the store count.

be potentially correlated with the shopping choices of households of different incomes. We examine the shopping patterns of households of different income levels in 2019 over general merchandise chains.[7] Figure 5 plots the income distribution of individuals who visited each general merchandise chain in 2019. Because the income distribution of our CBSAs are similar to the national distribution but our cell phone data skew toward higher income, we normalize the plot so that each income quartile represents 25% of visits.[8] Dollar stores are among the chains that have the largest share of visitors from the lowest income quartile. Among discount department store chains, Cititrends stands out from other chains. The majority of visits to Cititrends are from the two lowest income quartiles,

[7]We are not able to document the changes in households' shopping patterns from 2010 to 2019 because the PlaceIQ smartphone location data is not available for 2010

[8]More precisely, let $s_{i,j}$ be the percentage of visits of income quartile i visiting chain j. In the data, $\sum_i s_{i,j} = 1 \forall j$, but $\sum_j s_{i,j} / \sum_i \sum_j s_{i,j} \neq .25 \ \forall i$. In the figure, we re-weight $s_{i,j}$ by first calculating $\tilde{s}_{i,j} = s_{i,j} / \sum_j s_{i,j}$ for each i, and then re-scaling the distribution for each j, i.e., $\hat{s}_{i,j} = \tilde{s}_{i,j} / \sum_i \tilde{s}_{i,j}$.

Figure 4: Household Proximity to General Merchandise Stores in 2010 and 2019 By Household Income Groups



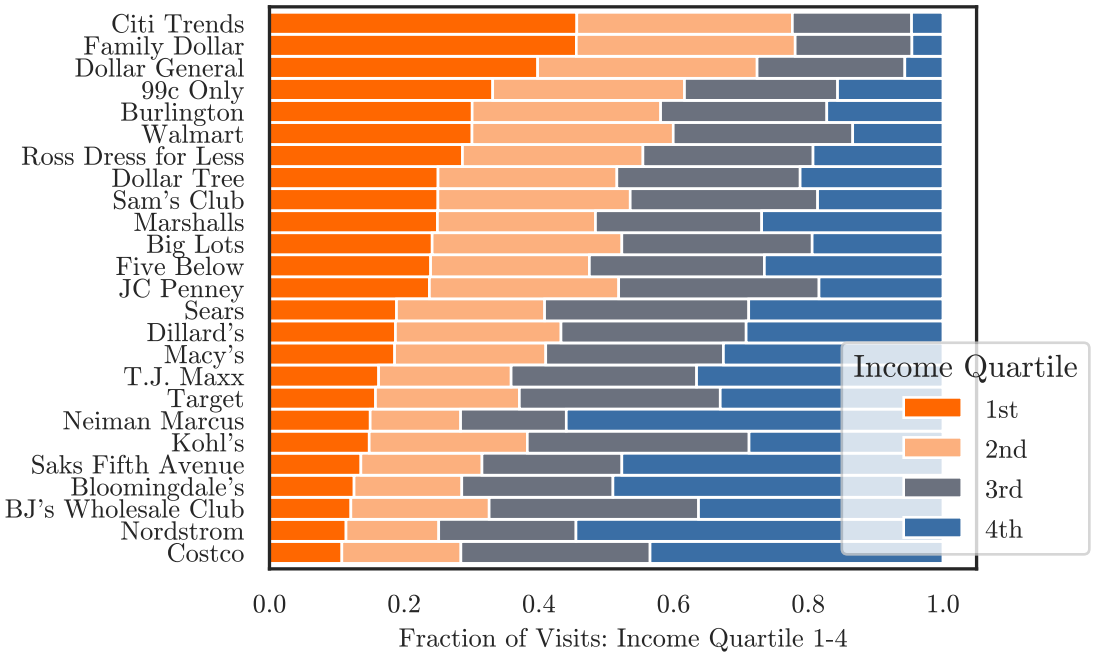
Note: This figure uses U.S. Census data on household residences and income combined with Data Axle data on store locations. The figure shows the mean number of general merchandise stores within 10 miles of a household by income quartile for 2010 and 2019. The upper panel includes all general merchandise stores including dollar stores while the lower panel excludes dollar stores from the store count.

while other discount department store chains see at least 60% of visits coming from the two highest income quartiles and around 40% from the highest income quartile.[9] Supercenters are more frequented by higher-income individuals with the income distribution of Walmart being the most even and Target most skewed. These differences in chain visits across income quartiles potentially reflect a mix of both proximity and preferences. For example, Target and Dollar Tree, both of which expanded more among higher-income households between 2010 and 2019, may cater more to the tastes of higher-income consumers. On the other hand, Walmart may opt to provide product prices and variety with appeal to the general population along with its strategy of even expansion across income quartiles. We estimate the separate roles of preferences and proximity in the rest of the

[9]According to its 2022 10-K filing, Cititrends is a "value retailer of apparel, accessories and home trends for way less spend, primarily for African American and Latinx families in the United States" and stores are located "at the crossroads of low to moderate income households."

paper.

Figure 5: Household Shopping Patterns By Household Income Groups



Note: The figure uses PlaceIQ data to show the share of 2019 visitors to each chain represented by members of each household income quartile. Chains are ordered from highest to lowest share of income quartile one visitors.

5 A model of consumer shopping choices

We model consumer store-choice decisions using a discrete choice framework and study the trade-offs from visiting physical stores. We abstract from the decision to shop online. We present the model for a representative CBSA in order to minimize the number of indices required. However, we note that all parameters in the model are CBSA-specific.

Let i denote a consumer and $y(i)$ her income. We assign $y(i)$ to be the quartile of national household income based on the residence-level income information observed in the AIQ data. All parameters also vary by income quartile, as we show below. We define j to be a representative store for a specific chain and abstract from the choice among stores that are part of the same chain. This approach greatly simplifies the choice set without introducing substantial measurement error as 90% of consumer visits to a chain store are

to the closest location of that chain.

A consumer's choice set, J_i, contains all stores located within 10 miles of consumer i's residence. The 10-mile range covers about 67% of consumer trips and keeps data processing tractable. We partition a consumer's choice set into two sets, denoted by J_i^c and J_i^f. The first set contains a set of brick and mortar stores of identified retail chains. The second set denotes fringe (e.g. regional and smaller chain) stores.

A consumer's indirect utility of visiting chain j is given by

$$u_{i,j} = \begin{cases} v_{i,j}\left(\mathbf{x}_{i,j}, dist_{i,j}; \boldsymbol{\beta}_{y(i)}\right) + \xi_{i,j} + \varepsilon_{i,j} & j \in J_i^c \\ \Gamma(J_i^f) + \varepsilon_{i,0} & j \in J_i^f \end{cases}, \tag{5.1}$$

where $v_{i,j}(\cdot)$ is a function of chain covariates x_j and straight line distance from i to chain j, $dist_{i,j}$. The terms $\xi_{i,j}$ and $\varepsilon_{i,j}$ are unobserved preferences. The function $v_{i,j}(\cdot)$ characterizes chain quality and distance costs, which we assume is linear and of the form

$$v_{i,j} = \beta_{y(i),j} + \beta_{y(i)}^{d1} dist_{i,j} + \beta_{y(i)}^{d2} density_{i,j}. \tag{5.2}$$

The parameter $\beta_{y(i),j}$ is a chain-income fixed effect that captures the average utility consumer i of income $y(i)$ derives from visiting any store of chain j. It is offset by consumer's shopping cost, which also varies by income grouping.

Consumer's shopping cost has two elements. The first element captures the travel cost consumers incur and increases in distance, $dist_{i,j}$. Because we collapse all stores of a given chain to a single option, we measure distance as the trip-weighted mean distance between consumer i and stores of chain j. If a consumer never visits a specific chain, we use the trip-weighted mean distance to the specified chain among consumers living in the same zip code.

The additional element in our shopping cost specification is $density_{i,j}$, which we include to account for trip chaining. Trip chaining occurs when a consumer visits multiple retail outlets on a single trip, reducing the effective distance traveled to a store.[10] Trip chaining

[10] A complete analysis of trip chaining is quite complex and is the focus of ongoing research in the geolocation data field (see, for example, Cook [2022]).

may be particularly likely to occur when stores are co-located—for example, within a mall. To account for the possibility that consumers experience a lower effective travel cost when stores are co-located, we control for density. Like distance, density is measured for each consumer-chain pair. If there is a single location of chain j within 10 miles of consumer i, we define $density_{i,j}$ as the natural log of one plus the number of other general merchandise stores within 0.1 miles of that location of chain j. When there is more than one outlet of chain j within 10 miles of consumer i, we take the trip-weighted average of this log proximate store count across each of the outlets of chain j within 10 miles of consumer i's residence. For an isolated store, the density measure, $density_{i,j}$, is zero.

We assume that the deterministic utility of choosing a fringe store is equal to

$$\Gamma(J_i^f) = \omega_{y(i)} \log\left(\left|J_i^f\right| + 1\right), \tag{5.3}$$

where $\omega_{y(i)}$ captures the income-specific taste for fringe stores, and $\left|J_i^f\right|$ is the total number of fringe stores available in consumer i's location. This functional form allows utility to increase proportionally with the number of the fringe stores available to consumer i residing at her location. Our implementation is similar to Ackerberg and Rysman [2005] who consider crowding in product space by including a notion of congestion.

Unlike prior work that involves location-choice models, we allow for the possibility that the unobservable chain preferences ($\xi_{i,j}$s) are potentially correlated with distance. We assume that the second set of unobservables ($\varepsilon_{i,j}$s), are independently and identically distributed and follow a type-1 extreme value distribution. We assume a single unobservable ($\varepsilon_{i,0}$) is associated with choosing a store in the fringe (J_i^f).

We address potential endogeneity between distance and ξ, or the co-location of stores and consumers, using instrumental variables and a control function approach following Petrin and Train [2010]. The control function is

$$dist_{i,j} = \Pi\left(\mathbf{z}_{i,j}, \mathbf{x}_{i,j}; \boldsymbol{\delta}\right) + \mu_{i,j},$$

where $\mathbf{z}$ are instruments that are relevant for distance, but do not enter consumers' utility

functions, and μ and ξ are jointly normal over j. We assume that Π is linear in parameters, i.e., $\Pi := [\mathbf{z}_{i,j}, \mathbf{x}_{i,j}]^T \boldsymbol{\delta}$. With our assumptions on the unobservables, we can rewrite utility of choosing a non-fringe chain as

$$u_{i,j} = v_{i,j}\left(\mathbf{x}_{i,j}, dist_{i,j}; \boldsymbol{\beta}_{y(i)}\right) + \rho\mu_{i,j} + \sigma_j \eta_{i,j} + \varepsilon_{i,j},$$

where η are standard normal distributions. Integrating over the unobservables, we obtain individual choice probabilities of the mixed-logit model, i.e.,

$$\begin{aligned} s_{i,j} &= \int \mathrm{I}\left[u_{i,j} > u_{i,j'} \ \forall j' \in J_i\right] dF(\eta)\, dF(\varepsilon) \\ &= \int \frac{\exp\left(v_{i,j} + \mu_{i,j}\rho + \sigma_j \eta_{i,j}\right)}{\exp\left(\Gamma(J_i^f)\right) + \sum_{j' \in J_i^c} \exp\left(v_{i,j'} + \mu_{i,j'}\rho + \sigma_j \eta_{i,j}\right)} dF(\eta_1 \mid \sigma_1) \times \ldots \times dF\left(\eta_{J_i} \mid \sigma_{J_i}\right). \end{aligned} \tag{5.4}$$

We place some additional restrictions on the distributions $F(\cdot)$ in the next subsection.

5.1 Estimation

We estimate our model using a two-step approach. Due to the size of the data, we split estimation by CBSA-income quartile.

In the first step, we estimate the control functions using OLS and compute their residuals as

$$\widehat{\mu}_{i,j} = dist_{i,j} - \Pi\left(\mathbf{z}_{i,j}, \mathbf{x}_{i,j}; \widehat{\boldsymbol{\delta}}\right).$$

We plug in these residuals into Equation 5.4. Because Equation 5.4 does not have a closed-form solution, we use Monte Carlo integration to numerically compute its values.

In the second step, we estimate the parameters, $\boldsymbol{\theta} := (\boldsymbol{\beta}, \rho, \boldsymbol{\sigma})$, via simulated maximum likelihood. Specifically, given a set of devices (I) for a particular CBSA-income quartile group, we define $N_{i,j}$ to be the total number of visits i makes to option j. We can aggregate visits because the model does not have time-varying parameters, which is reasonable given that devices are only tracked for a few months on average. The log-likelihood for

the data is[11]

$$\max_{\theta} \frac{1}{R} \sum_{r \in R} \sum_{i,j} \left(N_{i,j} \cdot \log \left(s_{i,j}^{(r)}(\theta \,;\, \mathbf{x}_{i,j}, \mathbf{dist}_{i,j}, \widehat{\mu}) \right) \right).$$

Due to the richness and size of the data, we make a simplification on the distributions $F(\cdot)$ by grouping chains and imposing the same variance for chains in the same group. This greatly reduces the number of random coefficients estimated. The mapping of chains into groupings is shown in Figure 3. Specifically, we estimate random coefficients for the groupings: warehouse stores, traditional stores, discount stores, supercenters, and dollar stores for each CBSA-income quartile. In total, we estimate four preference coefficients (distance, density, fringe, and control function), (up to) 26 chain preferences, and five random coefficients for each CBSA-income quartile. We compute standard errors using bootstrap, sampling devices with replacement.

We also estimate a variant of our model where distance is assumed to be exogenous for comparison. When distance is exogenous, we remove the control function and estimate the model using a single step, retaining ξ as random effects and estimating the variances using the same chain groupings.

5.2 Identification

Our data describe the choices of consumers of different income types in different locations. The disutility from distance is identified by measuring the propensity of individuals within an income quartile to visit more proximate vs more distant stores. Conditional on the disutility of distance, we infer a given income quartile's willingness-to-travel to a given chain relative to another by the relative frequency with which that group visits stores from each chain. Intuitively, if we observe a consumer driving past a Walmart to visit a Target, it must be because that consumer values the Target more.

As discussed above, we use a control function approach to instrument for distance. We do this because it is conceivable that the match quality between consumers and a given chain may vary by some unobserved consumer characteristics and that a profit-

[11] We select $R = 100$ Halton draws per consumer-chain to compute choice probabilities that enter the likelihood function.

maximizing chain will choose store locations strategically based on the spatial distribution of these consumer characteristics.[12]

The potential bias introduced by endogenous distance is more complex than the familiar price endogeneity. The standard price endogeneity problem involves unobservable quality ξ_j (common to all customers) being correlated with prices (which are also common to all customers). In our setting, individual-specific match quality may be correlated with individual-specific distance, that is, that the model errors $\xi_{i,j}$ will be correlated with distance $dist_{i,j}$.

To be concrete about the concern, consider a store location decision. Suppose there is a subgroup of consumers who particularly value a store and this is observable to the store executives but not the econometrician. A store may systematically locate its outlets to be accessible to those consumers who particularly value it. Were one to infer a distance disutility and taste for the store ignoring this, consumers would appear to be very unwilling to travel; distance disutilities would appear large and consumers would not appear to value the store very much because mostly only those living close to it would visit it. [13]

On the other hand, a profit-maximizing store may locate a little farther from loyal types who are willing to travel to it in order to be more proximate to a group of consumers who are more indifferent. Similarly, a store may not bear the expense of building an outlet in a location full of consumers who are willing to travel to reach it. Were one to estimate consumer tastes ignoring this endogeneity, consumers would appear less sensitive to distance than they indeed are, biasing the estimates of distance disutility parameters towards zero.[14]

[12]This endogeneity problem is also conceivably a concern for other settings where distances are taken as exogenous such as models of transportation or school choice or models in which distance to, for example, hospitals with various characteristics are used as an instrument for (for example) health outcomes.

[13]Similarly, consider a policymaker locating transportation infrastructure. The social planner may locate train or bus routes near people who particularly like public transportation; people who particularly like public transportation will choose to live near this infrastructure. Inference regarding tastes for the infrastructure and distance disutilities could be biased.

[14]Note that these latter intuitions are closest to the price endogeneity problem. If consumers have high willingness to pay due to an unobserved demand shock, the producer will raise price to appropriate some of the consumer surplus. If a consumer has a high willingness to travel due to an unobserved match with the store, the producer can appropriate some of the consumer surplus by building fewer costly locations.

Modeling the full location choice function of each store would be challenging. Given that our concern is the endogeneity of the distances between consumers and stores, we pursue an instrument for distance that exploits plausible supply shifters for stores.

Our instrument strategy is inspired by the Waldfogel-style instruments introduced by Fan [2013]. Recall that we have individual level data and our preference model allows consumers of different incomes to have different disutilities of distance and tastes for stores. The density of consumers of these different income types would be expected to influence the attractiveness of siting a particular store.

Any location in a two-dimensional space can be characterized by its polar coordinates (r,φ), where r is the distance from the origin point and φ is the angle, or, location along the circle traced out by r. In US cities, distance from the city center is a primary determinant of land values and commuting times. Relative to neighborhood sorting within a distance ring from the city center, distance from the central business district is driven by arguably exogenous factors. Thus, our first set of instruments for consumer densities takes the city center as the origin point and uses only information about the consumer's location r to construct the density measures but not the consumer's φ. The main threat to our identification strategy occurs if consumers' unobservable tastes for different stores is correlated with their tastes for co-locating at the same distance from the city center as others in their income quartile. [15]

We model the distance of an individual i from their nearest establishment of each chain c ($dist_{ij}$) as a chain-specific linear function of the share of the CBSA's residents in income quartile inc that reside the same or closer distance to the city center as individual i ($share_{\ell(i),q}$), the aggregate population residing the same or closer to the city center as individual i ($Pop_{\ell(i)}$), and their interaction. That is, $dist_{ij}$ is modeled as $dist_{\ell,j}$ where ℓ is the consumer's location.

$$dist_{\ell,j} = \gamma_j + \sum_{inc} \beta^{(1)}_{inc,j} share_{\ell,inc} + \beta^{(2)}_{inc,j} \ln Pop_{\ell} + \sum_{inc} \beta^{(3)}_{inc,j} \ln Pop_{\ell} share_{\ell,inc} + \varepsilon_{\ell,j} \tag{5.5}$$

[15] Our instrument strategy is robust to a consumer's unobservable tastes for different stores being correlated with taste for colocating with others in their same income quartile along a given distance ring.

The fact that we model the predicted distance as a chain-specific function is important as it will capture important differences across chains in their location policy functions. The unobservable, potentially endogenous, component of the distance policy function is $\varepsilon_{\ell,j}$. We estimate (5.5) using OLS. To implement the control function approach, we then include the estimated endogenous component, $\hat{\varepsilon}_{\ell(i),j}$ in our maximum likelihood estimation.

In the Appendix, we show results for an alternative instrument strategies. Our preferred instrumenting strategy, as described above, predicts between the consumer i and a store j using information on the income and population shares of consumers who live the same distance or closer to the city center as consumer i. In the Appendix, we alternatively use the income shares and population shares of consumers living within a 5 mile radius of consumer i. This instrument has a stronger first stage than our preferred instrument, but is arguably more vulnerable to the criticism that assortive living by consumers violates the exclusion restriction. Overall results using this alternative instrument are shown to be quite similar. In the Appendix, we also explore the possibility that both the density of fringe stores and distance are endogeneous, and use our instruments to predict both. These results are also quite similar to the ones we present below.

6 Results

Due to the large number of parameters estimated, we summarize our results. In Table 2, we report income quartile-level estimates, aggregated over CBSAs using income quartile-specific population counts. In Table 2 the results using our preferred model. That is, we use the control function approach to address the endogeneity of distance using the population and income shares for consumers in distance rings around the CBD as instruments, as described above. We also, in Table 3 report results that ignore distance endogeneity. We report the parameter estimates for each income quartile and CBSA in Appendix (Table C). In the Appendix we also report results using several alternative instrumenting strategies.

Table 2: Summary of Demand Estimates, Distance Endogenous (CBD)

Income Quartile		Income Quartile 1	Income Quartile 2	Income Quartile 3	Income Quartile 4
Parameter					
Distance	β^{d1}	-0.392	-0.438	-0.424	-0.447
Density	β^{d2}	0.396	0.267	0.217	0.130
Fringe	ω	1.024	1.001	1.046	1.191
Control Function	ρ	0.151	0.210	0.187	0.176
Chain Preferences					
BJ's Wholesale Club		-0.886	0.677	0.328	0.429
Costco		0.499	1.618	1.734	2.268
Sam's Club		-1.191	-1.331	0.830	0.521
Bloomingdale's		-2.861	-1.470	-1.163	-0.778
Dillard's		-4.945	-2.247	-2.049	-1.095
JC Penney		-2.004	-1.435	-0.896	-1.883
Kohl's		-2.583	-0.877	-0.479	-0.512
Macy's		-1.714	-0.962	-0.425	-0.277
Neiman Marcus		-3.806	-2.987	-2.117	-1.671
Nordstrom		-3.085	-2.116	-1.197	-0.610
Saks Fifth Avenue		-3.500	-2.635	-1.939	-1.962
Sears		-4.931	-3.998	-3.057	-3.449
Burlington		1.280	1.194	1.378	1.476
Citi Trends		1.562	1.291	1.020	0.255
Five Below		-0.984	-1.054	-0.601	-0.315
Marshalls		0.838	0.725	1.181	1.530
Ross Dress for Less		1.648	1.493	1.632	2.160
T.J. Maxx		0.630	0.855	1.353	1.534
Big Lots		-1.023	-0.101	0.009	0.066
Target		1.619	2.256	2.636	3.308
Walmart		3.717	3.843	3.700	3.413
99c Only		2.502	2.298	1.343	0.622
Dollar General		1.488	1.449	1.075	-0.061
Dollar Tree		2.665	2.800	2.643	2.440
Family Dollar		1.956	1.934	1.370	0.376
Random Coefficients	σ_k				
Warehouse Stores		2.255	1.652	1.841	2.055
Traditional Stores		3.015	2.650	2.293	2.653
Discount Stores		0.801	0.993	0.677	0.537
Supercenters		1.684	1.182	0.954	0.739
Dollar Stores		0.649	0.430	0.550	1.112
Summary					
Number of Visits		3,373,332	17,252,522	24,288,153	25,870,321
Number of Devices		272,736	1,203,022	1,586,662	1,675,981
Avg. First Stage R^2		36.5%	28.7%	25.1%	26.8%
Avg. First Stage F-stat		1363.6	4090.4	4210.7	5026.5

Demand estimation parameters, summary over all CBSAs. Each column represents an income quartile, with 1 being the lowest income group. This version of the model treats distance as exogenous and uses the income and population densities of consumers living in rings around the CBD as instruments as described in the text.

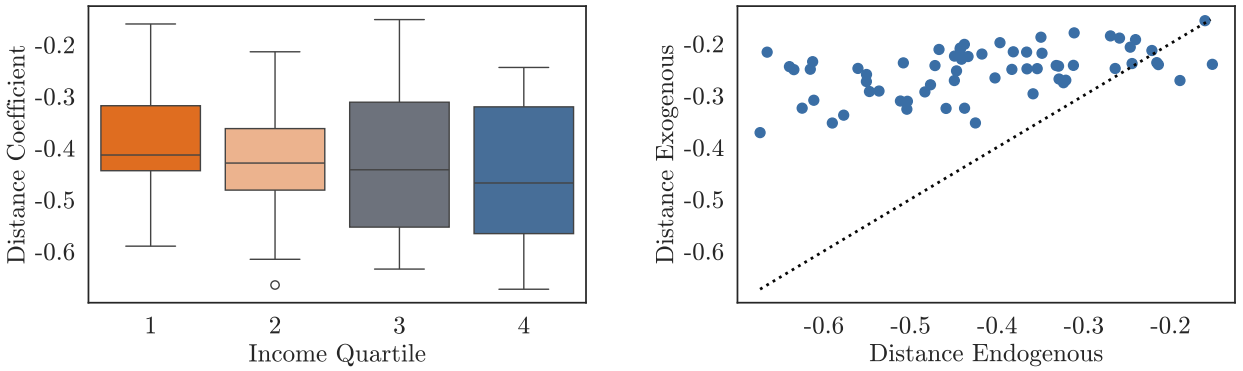
Table 3: Summary of Demand Estimates, Distance Exogenous

Income Quartile		Income Quartile 1	Income Quartile 2	Income Quartile 3	Income Quartile 4
Parameter					
Distance	β^{d1}	-0.253	-0.241	-0.246	-0.280
Density	β^{d2}	0.401	0.283	0.228	0.146
Fringe	ω	0.971	0.937	0.963	1.090
Control Function	ρ	–	–	–	–
Chain Preferences					
BJ's Wholesale Club		-0.850	0.100	-0.396	-0.707
Costco		0.146	0.864	1.123	1.349
Sam's Club		-1.564	-1.751	0.250	-0.423
Bloomingdale's		-3.445	-2.699	-2.155	-1.574
Dillard's		-5.593	-3.363	-2.887	-1.558
JC Penney		-2.591	-2.438	-1.748	-2.511
Kohl's		-3.107	-1.661	-1.203	-0.982
Macy's		-2.333	-1.929	-1.322	-0.946
Neiman Marcus		-4.541	-4.192	-3.155	-2.268
Nordstrom		-3.774	-3.220	-2.180	-1.286
Saks Fifth Avenue		-4.204	-3.810	-3.224	-2.532
Sears		-5.440	-4.958	-3.984	-4.096
Burlington		0.490	0.401	0.433	0.391
Citi Trends		0.973	0.305	-0.081	-0.986
Five Below		-1.769	-1.784	-1.462	-1.348
Marshalls		0.091	0.033	0.267	0.509
Ross Dress for Less		0.921	0.706	0.799	1.174
T.J. Maxx		-0.142	0.095	0.447	0.548
Big Lots		-1.803	-1.325	-1.141	-1.086
Target		0.882	1.171	1.659	2.435
Walmart		3.069	2.949	2.831	2.530
99c Only		1.537	1.236	0.788	-0.204
Dollar General		0.778	0.421	0.034	-1.379
Dollar Tree		2.016	1.930	1.809	1.480
Family Dollar		1.343	1.007	0.360	-1.023
Random Coefficients	σ_k				
Warehouse Stores		1.760	1.249	1.445	1.966
Traditional Stores		2.777	2.448	2.124	2.249
Discount Stores		0.697	0.801	0.568	0.448
Supercenters		1.690	1.276	1.034	0.707
Dollar Stores		0.690	0.538	0.623	1.198
Summary					
Number of Visits		3,373,332	17,252,522	24,288,153	25,870,321
Number of Devices		272,736	1,203,022	1,586,662	1,675,981

Demand estimation parameters, summary over all CBSAs. Each column represents an income quartile, with 1 being the lowest income group. This version of the model treats distance as exogenous.

Focusing on Table 2, we first highlight that the average first-stage F-stat and R^2 suggest that our instruments are strong and explain significant variation in the observed distances. Directionally, our estimates show that consumers have a disutility of travel to stores. The similarity of the travel disutility estimates across income groups may be surprising.

Figure 6: Distance coefficients



However, we note that our travel disutility estimates encompass both the time cost of travel and the actual cost of travel. While the opportunity cost of time per hour is likely higher for the higher-income consumers, they are also presumably more likely to live in multi-vehicle households and can readily use private vehicles to shop. Thus, while their cost per hour may be higher, the actual time involved in reaching a store a fixed distance away might be lower. These countervailing factors may offset one another, reducing the difference in the disutility of traveling across income groups.

Comparing the income quartile-CBSA travel disutility parameters in Table 2 and estimates from the exogenous distance specification in Table 3 demonstrates that the disutility from distance is revealed to be greater (more negative) when we account for endogenous proximity. This result, that consumers appear to view distance as more costly when controlling for endogeneity of distance echoes the familiar results regarding price endogeneity.

Consistent with our hypothesis about trip chaining, the estimates on the log density parameter are positive, meaning that consumers prefer stores that are co-located with other stores over stand-alone stores, ceteris paribus. A low-income consumer is willing to travel 1 mile further to visit a store that has 1 neighboring store than they would to visit a stand-alone store of the same chain.

To examine the tastes for the various chains and the differences in tastes across consumer incomes, for each CBSA, we use the parameter estimates to calculate a mile-

normalized taste measure for each pair of chains and income quartiles:

$$\tilde{\beta}_{y(i),j} = \int \frac{\beta_{y(i),j} + \beta^{d2}_{y(i)} \text{median}\left(density_{\cdot,j}\right) + \sigma_j \eta_{i,j} - \omega_{y(i)} \text{median}\left(\Gamma(J^f_{\cdot})\right)}{\left|\beta^{d1}_{y(i)}\right|} dF\left(\eta \,|\, \sigma\right) \tag{6.1}$$

$$= \frac{\beta_{y(i),j} + \beta^{d2}_{y(i)} \text{median}\left(density_{\cdot,j}\right) - \omega_{y(i)} \text{median}\left(\Gamma(J^f_{\cdot})\right)}{\left|\beta^{d1}_{y(i)}\right|} \tag{6.2}$$

This taste measure uses the CBSA-specific median store density surrounding stores of each chain (i.e. $mn(density_{r(j)})$) to adjust for the differences in travel cost across chains, which arise from the varying degree of store co-location across chains. It is calculated relative to the fringe store set of the median size (i.e. $med(|J^f_\ell|)$) in each CBSA and can be interpreted as the number of additional miles a consumer in income quartile y would be willing to travel to visit a store of chain $r(j)$ rather than patronize the fringe store opportunities.

Figure 7 graphically illustrates these normalized taste parameter estimates for the 27 identified chains, averaged across CBSAs. We plot the taste parameters for consumers in the lowest-income quartile on the x-axis against those for consumers in the highest-income quartile on the y-axis. The positive correlation exhibited in Figure 7 shows that the preference ranking over general merchandise chains is similar between low- and high-income consumers. For example, Walmart is the most preferred chains for both lowest- and highest-income consumers and traditional department store chains are among the least preferred chains by consumers. The overall low taste for the chains relative to the fringe opportunities our specification's amalgamating the fringe opportunities; each trip to the fringe represents a consumer's trip to their most preferred option within the fringe and the fringe is likely more tailored to local tastes than the national chains.

While there is an overall positive correlation, the deviation of consumers' taste parameters from the 45-degree line highlights the differing degree of dispersion of consumers' taste over chains across consumer incomes. For example, while higher-income consumers are nearly indifferent between Walmart and Target, we can see that Walmart is by far preferred for lower-income people.

Unsurprisingly, the dollar stores and Cititrends sit below the 45-degree line; they

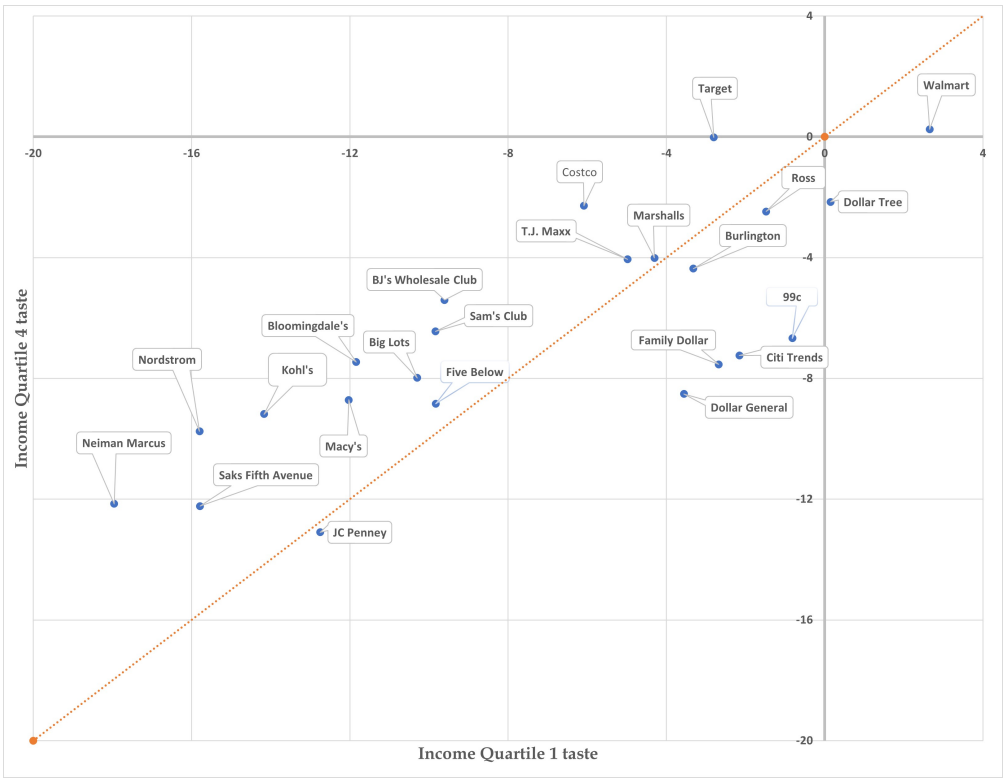


Figure 7: Distance normalized chain taste parameters

are more valuable to low-income consumers relative to the fringe chains than for high-income consumers, a finding consistent with Cao [2022]. Department stores such as Dillards, Nordstrom, Bloomingdales, and Macy's tend to be relatively more favored by higher-income consumers. There are stark differences within categories of stores that the casual observer might view to be close substitutes. For example, our estimates suggest that Dollar General, Family Dollar, and Dollar Tree are quite different, with Dollar Tree being relatively more valued by higher income consumers than Dollar General and Family Dollar.

While Walmart is the most-preferred chain, its sister chain Sam's Club are viewed by both lower-income and higher-income consumers as less preferred to rival warehouse clubs Costco and BJ's. Our estimates suggest that preferences for all of the warehouse clubs skew toward higher income consumers.

Our estimates allow us to quantify the relative utility that the income groups receive from the different chains. Specifically, using the estimates in the graph, the horizontal

distance between two points defines the additional distance a consumer in Income Quartile 1 would be willing to travel to visit an outlet of the right-hand chain relative to the left-hand chain. The vertical distance reflects the same marginal willingness-to-travel of a consumer in Income Quartiles 4.

For example, our estimates suggest that, given the disutility for distance and the tastes for each chain, a consumer in the lowest income quartile would be close to indifferent between having a Dollar General co-located with the consumer (at a distance of zero) and having a Walmart located 6 miles away. For a Walmart any closer than 6 miles, the consumer is estimated to prefer the Walmart to the co-located Dollar General.

7 Welfare estimates of the changing retail landscape

Using the estimates for consumer preferences derived from the model allowing for endogenous distances, we turn to assessing the welfare impact of the changing retail landscape over the 2010-2019 period for consumers of different incomes.

To do this, we combine the estimated consumer preferences with data on store locations and consumer locations in 2010 and 2019. Recall that we do not have smartphone data for 2010. Thus, to calculate the distance between a consumer and a chain, and to do so consistently for both 2010 and 2019, we use data from DataAxle on store locations for 2010 and 2019. We use data from the Census to calculate the number of consumers in each income quartile in each census tract of our CBSAs. For both 2010 and 2019, we assume that each consumer resides at the centroid of his/her census tract of residence. The changes in the general merchandise sector affect consumer welfare through store entry and exit from each consumer's choice set and through changes in the distance cost paid to visit individual stores.

We measure, for each consumer, the change in consumer welfare associated with the changing retail landscape as the change in the inclusive value over the consumer's choice set; that is, for consumer i,

$$\Delta CS_i = \frac{\ln\left(\sum_{j \in J_{i,2019}} \exp(v_{i,j,2019})\right) - \ln\left(\sum_{j \in J_{i,2010}} \exp(v_{i,j,2010})\right)}{\beta^{d1}_{y(i)}} \times c \tag{7.1}$$

where $v_{i,j,t}$, defined in equation 5.2, is the deterministic indirect utility consumer i derives from chain j and is calculated using the estimated consumer preference estimates combined with the distances between consumers and stores of the chain in 2010 and 2019.

The first term of Equation 7.1 expresses the change in consumer surplus in mileage equivalents. To express welfare changes in dollars, we follow Dolfen et al. [2022] and calculate a travel cost that is derived from evidence in the literature and includes both a time and direct cost of travel. During the period we study, the travel cost estimate is c = \$3.36 per mile round-trip.

The calculated welfare change captures both the extensive and intensive changes of a consumer's choice set characterized in Figure 3. The units of the welfare changes are in dollars of surplus per trip. Thus, for example, if consumers were visiting all of the same stores in 2010 and 2019 but traveling less far for them, we would observe a welfare increase. If they were making the same number of trips and traveling the same distances but more-preferred stores had replaced less-preferred ones, we would also observe a welfare increase.

Since consumers live in different locations with different choice sets, we aggregate the welfare measure across consumers and present in Table 4 the average consumer welfare change associated with the changing retail landscape for each income quartile.

Table 4: Welfare Change from 2010-2019 by Income Quartile

Income Quartile	1	2	3	4
ΔW, Actual	-0.532	0.283	-0.232	-0.709
ΔW, No Moves	-0.225	-0.172	-0.490	-0.812
ΔW, No Δ Fringe	0.624	1.179	0.956	0.669
ΔW, No Δ Fringe nor Moves	0.964	0.705	0.781	0.603

Aggregate welfare per trip by Income quartile is reported. The first row represents our overall estimates and the subsequent rows provide counterfactuals with different assumptions.

The first row of Table 4 presents the overall welfare change per trip by income quartile.

It takes as its inputs the locations of all general merchandise stores and all consumers in 2010 and the locations of all general merchandise stores and all consumers in 2019. By this measure, three of the four income quartiles have slightly lower welfare in 2019 vs. 2010. We report these in dollars per trip, however, we could also interpret them in mile equivalents. For example, the first row suggests that the lowest-income consumers are receiving roughly 53 cents lower welfare per trip in 2019 vs. 2010. Alternatively, welfare is as if low income consumers have to travel 0.16 miles farther to reach equivalent retail opportunities to 2010.

The second row repeats the exercise but holds all consumers in their 2010 locations. This metric presents slightly different results and suggests a very small decrease in welfare for the lowest income quartile. To reconcile these results, it suggests that, over the decade, lower income consumers on average moved slightly farther from retail opportunities. That is, about half of the 0.16 farther travel required in 2019 was due to population movements as opposed to the changes in store locations.

The third and fourth rows limit our attention only to the 25 named chains rather than the smaller fringe stores. The decade overall saw, on average, a reduction in the counts of smaller fringe stores. When considering only the 25 named national chains, welfare per trip is estimated to have grown over the decade for all consumer groups. This result stands at odds with the conventional view of a retail apocalypse.

To further understand the pattern of consumers' welfare changes across incomes, we measure the welfare contribution of the change of each individual type of general merchandise store during the 2010-2019 period.

For each general merchandise chain, its impact on consumer welfare is measured as the average against two baselines. The first baseline consists of a consumer's choice set in 2010 and we calculate the consumer welfare change that derives from the 2010-2019 physical location changes of a chain, holding everything else in the consumer's choice set fixed at 2010 level. To put it formally, for chain j, its welfare impact on consumer i

measured against the consumer's 2010 choice set is

$$\Delta CS_{ij}^{b=2010} = \frac{\ln\Big(\sum_{j' \in J'_{i,2010}} \exp(\nu_{i,j',2010}) + \exp(\nu_{i,j,2019})\Big) - \ln\Big(\sum_{j' \in J_{i,2010}} \exp(\nu_{i,j',2010})\Big)}{\beta_{y(i)}^{d1}} \times c \quad (7.2)$$

where $J'_{i,2010} = J_{i,2010} \backslash J_{i,j,2010}$ is consumer i's choice set in 2010 excluding chain j.

Second, we set the baseline to be a consumer's choice set in 2019 and return the physical locations of a chain back to its 2010 level. We then calculate the consumer welfare change, absent the 2010-2019 changes of a chain, against the baseline of a consumer's 2019 choice set as follows:

$$\Delta CS_{ij}^{b=2019} = \frac{\ln\Big(\sum_{j' \in J_{i,2019}} \exp(\nu_{i,j',2019})\Big) - \ln\Big(\sum_{j' \in J'_{i,2019}} \exp(\nu_{i,j',2019}) + \exp(\nu_{i,j,2010})\Big)}{\beta_{y(i)}^{d1}} \times c \quad (7.3)$$

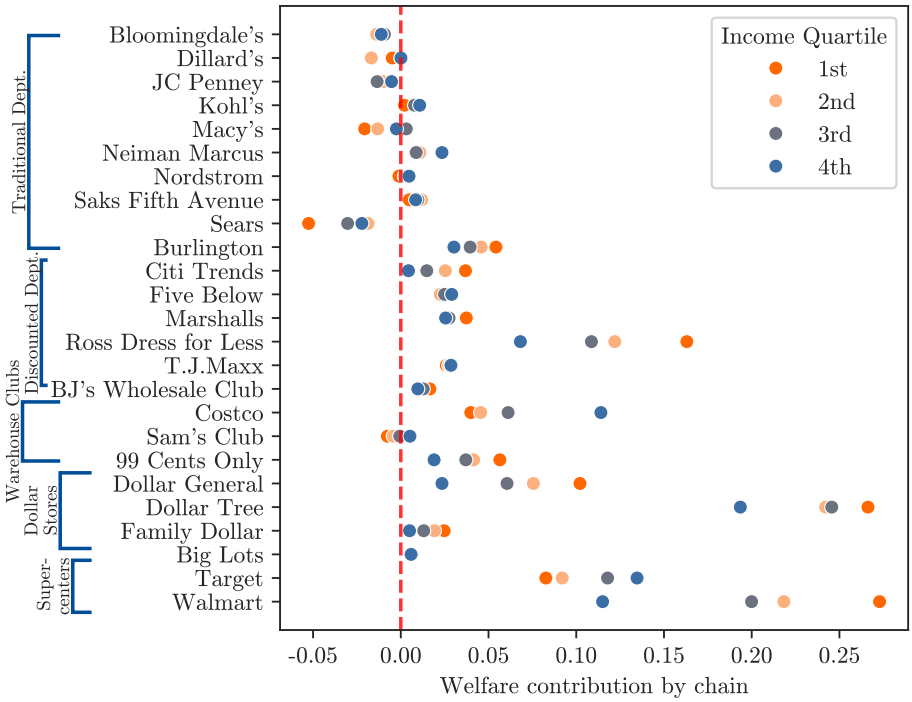
where, similarly, $J'_{i,2019} = J_{i,2019} \backslash J_{i,j,2019}$ is consumer i's choice set in 2019 excluding chain j.

These two methods, which are akin to a Laspeyres and a Paasche-type index, generate similar estimates of consumer welfare changes. We take the average of these two measures as our measure of an individual chain's impact on consumer welfare. We calculate this for each income quartile for each chain.

These overall welfare change drivers are presented in Figure 8.

Consider some examples from these figures. First, we see a modest positive welfare contribution from Five Below, slightly larger for high income consumers. This combines a large expansion shown in Figures 4 and 3 and a relatively modest welfare contribution per trip (although income quartile 4 consumers value it more than income quartile 1 consumers). In contrast, Ross Dress for Less had a more modest expansion, with a roughly 20 percent increase in the share of households with acccess for all income quartiles, but has a large low-income taste parameter and thus its expansion makes an overall large welfare contribution low-income consumers. The large expansions of Dollar General and Dollar Tree over the decade combined with the relatively high preference for them among low-income consumers lead to a substantial welfare contribution from their expansion for low-income consumers. The impact for Dollar Tree is driven almost entirely by proximity, Dollar Trees were already ubiquitous in the choice set in 2010.

Figure 8: Welfare change drivers: chain-level contributions



In contrast, the change in the number of consumers with access to Walmart was almost zero and the improvement in proximity for consumers with Walmart in the choice set was less than a half mile for all income groups. Nonetheless, due to the strong taste for Walmart among low-income consumers, net welfare gains from Walmart expansion were estimated to be the highest contributors to the welfare gains of low-income consumers of all chains.

Taken together with Table 4, the results suggest that the expansion of discount chains, particularly the dollar stores and Walmart, improved welfare for lower-income consumers that approximately compensated for the decline in traditional department stores and the smaller regional chains.

8 Conclusion

We introduce a novel instrument for the endogeneous distance between consumers and stores. Echoing the familiar bias in estimating the price elasticity of demand, we show that

accounting for distance endogeneity leads us to estimate consumers to be more sensitive to distance than we find not accounting for distance endogeneity.

While other researchers have shown the gains from ecommerce have accrued differentially to higher income groups, we demonstrate a substantial countervailing improvement in retail opportunities catering to lower income individuals. Looking forward, the near-saturation of dollar store retailers may limit the potential welfare gains achievable by their continued expansion in the future. Our results also suggest that regulations that restrict the siting of large big-box supercenters, particularly Walmart, could have disproportionate negative impacts on low-income consumers.

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Appendix – For Online Publication

A Additional Tables and Figures

Table A.1: Chains in each type of general merchandise stores

	Chain
Traditional Department	Bloomingdale's, Dillard's, JC Penney Macy's, Neiman Marcus, Nordstrom Saks Fifth Avenue, Kohl's, Sears
Discount Department	Citi Trends, Five Below, Burlington, Marshalls, Ross Dress for Less, T.J. Maxx
Warehouse Club	BJ's Wholesale Club, Costco, Sam's Club
Dollar Store	99c Only, Dollar General, Dollar Tree, Family Dollar
Supercenters	Big Lots, Target, Walmart
Others	Soma, Meijer, Dollar Plus, Von Maur, Boscov's, 99 Ranch Market, Christmas Tree Shops, etc.

Table A.2: Summary Statistics for the Data Sample, by Income Quartile

Variable	1st	2nd	3rd	4th
per device, week				
Number of visits to inside chains	1.99	1.97	1.91	1.81
Number of visits to fringe stores	1.73	1.75	1.77	1.82
per device				
Number of inside chains in choice set	16.20	16.20	16.01	16.82
Number of fringe stores in choice set	13.14	12.48	11.74	12.54
Number of weeks observed	7.21	8.24	9.11	9.61
Number of outlets of inside chains	99.06	88.08	74.94	70.41
Number of stores visited per trip	1.30	1.31	1.33	1.36
Number of unique chains	67	67	67	67
Number of outlets	10,980	11,209	11,202	11,066
Number of devices	273,326	1,205,344	1,589,830	1,678,993
Total number of visits	4.559 mil.	23.144 mil.	33.42 mil.	36.886 mil.

TBD

B Alternate and Detailed Instrument Results

Table B.1: Summary of Demand Estimates, Distance Endogenous (5 mile)

Income Quartile		Income Quartile 1	Income Quartile 2	Income Quartile 3	Income Quartile 4
Parameter					
Distance	β^{d1}	-0.404	-0.393	-0.359	-0.388
Density	β^{d2}	0.379	0.261	0.217	0.120
Fringe	ω	1.022	0.978	1.028	1.161
Control Function	ρ	0.184	0.184	0.133	0.128
Chain Preferences					
BJ's Wholesale Club		-0.660	0.649	0.284	0.182
Costco		0.484	1.459	1.785	1.933
Sam's Club		-1.206	-1.373	0.916	0.144
Bloomingdale's		-2.592	-1.724	-1.421	-0.765
Dillard's		-4.991	-2.889	-2.391	-0.787
JC Penney		-1.909	-1.856	-1.187	-1.872
Kohl's		-2.525	-1.264	-0.775	-0.475
Macy's		-1.656	-1.364	-0.750	-0.297
Neiman Marcus		-3.731	-3.487	-2.529	-1.691
Nordstrom		-3.011	-2.595	-1.576	-0.614
Saks Fifth Avenue		-3.436	-3.246	-2.584	-2.098
Sears		-4.884	-4.468	-3.412	-3.477
Burlington		1.470	1.532	1.172	1.163
Citi Trends		1.698	1.090	0.644	-0.130
Five Below		-0.778	-0.610	-0.756	-0.607
Marshalls		1.039	1.180	1.012	1.237
Ross Dress for Less		1.776	1.737	1.420	1.853
T.J. Maxx		0.840	1.109	1.139	1.255
Big Lots		-0.874	-0.159	-0.283	-0.205
Target		1.738	2.185	2.387	3.094
Walmart		3.764	3.661	3.422	3.168
99c Only		2.206	1.888	1.271	0.393
Dollar General		1.526	1.277	0.650	-0.530
Dollar Tree		2.730	2.615	2.350	2.166
Family Dollar		1.987	1.740	0.997	-0.048
Random Coefficients	σ_k				
Warehouse Stores		2.246	1.444	1.427	2.100
Traditional Stores		2.972	2.718	2.272	2.395
Discount Stores		0.689	0.497	0.552	0.438
Supercenters		1.611	0.966	0.856	0.594
Dollar Stores		0.612	0.331	0.609	1.080
Summary					
Number of Visits		3,373,332	17,252,522	24,288,153	25,870,321
Number of Devices		272,736	1,203,022	1,586,662	1,675,981
Avg. First Stage R^2		47.3%	40.4%	36.7%	37.9%
Avg. First Stage F-stat		1323.1	4285.4	4588.8	5296.3

Demand estimation parameters, summary over all CBSAs. Each column represents an income quartile, with 1 being the lowest income group. This version of the model treats distance as exogenous.

Table B.2: Summary of Demand Estimates, Dist. & Fringe Endogenous (CBD)

Income Quartile		Income Quartile 1	Income Quartile 2	Income Quartile 3	Income Quartile 4
Parameter					
Distance	β^{d1}	-0.404	-0.431	-0.419	-0.482
Density	β^{d2}	0.322	0.225	0.180	0.115
Fringe	ω	0.974	1.010	1.026	1.276
Control Function	ρ_1	0.160	0.202	0.181	0.205
Control Function	ρ_2	-0.512	-0.239	-0.134	0.198
Chain Preferences					
BJ's Wholesale Club		-0.810	0.696	-0.293	-0.264
Costco		0.336	1.416	1.647	2.495
Sam's Club		-1.248	-0.471	0.728	0.653
Bloomingdale's		-3.021	-1.409	-1.386	-0.904
Dillard's		-4.849	-1.903	-1.662	-1.312
JC Penney		-2.228	-1.459	-0.996	-2.333
Kohl's		-2.826	-0.923	-0.564	-0.675
Macy's		-1.964	-1.049	-0.512	-0.383
Neiman Marcus		-4.092	-3.124	-2.237	-1.880
Nordstrom		-3.352	-2.186	-1.297	-0.762
Saks Fifth Avenue		-3.851	-2.812	-2.179	-2.378
Sears		-5.169	-4.198	-3.259	-3.899
Burlington		1.267	1.256	1.274	1.580
Citi Trends		1.536	1.349	0.793	0.419
Five Below		-0.952	-0.943	-0.673	-0.165
Marshalls		0.847	0.798	1.097	1.647
Ross Dress for Less		1.725	1.674	1.712	2.455
T.J. Maxx		0.644	0.929	1.279	1.682
Big Lots		-1.093	-0.069	-0.013	0.384
Target		1.543	2.291	2.606	3.589
Walmart		3.664	3.884	3.683	3.700
99c Only		2.375	2.169	1.785	2.191
Dollar General		1.504	1.597	1.129	0.416
Dollar Tree		2.674	2.882	2.663	2.801
Family Dollar		1.943	2.021	1.395	0.823
Random Coefficients	σ_k				
Warehouse Stores		2.285	1.809	1.889	2.302
Traditional Stores		3.134	2.706	2.352	3.034
Discount Stores		0.763	0.915	0.730	0.704
Supercenters		1.822	1.231	0.968	0.880
Dollar Stores		0.635	0.399	0.551	1.169
Summary					
Number of Visits		3,373,332	17,252,522	24,288,153	25,870,321
Number of Devices		272,736	1,203,022	1,586,662	1,675,981
Avg. First Stage R^2		35.8%	28.0%	24.0%	25.6%
Avg. First Stage F-stat		1329.5	3976.0	3997.5	4792.7

Demand estimation parameters, summary over all CBSAs. Each column represents an income quartile, with 1 being the lowest income group. This version of the model treats distance as exogenous.

Table B.3: Summary of Demand Estimates, Dist. & Fringe Endogenous (5 mi.)

Income Quartile		Income Quartile 1	Income Quartile 2	Income Quartile 3	Income Quartile 4
Parameter					
Distance	β^{d1}	-0.417	-0.415	-0.405	-0.447
Density	β^{d2}	0.401	0.282	0.243	0.150
Fringe	ω	1.064	1.050	1.200	1.435
Control Function	ρ_1	0.196	0.207	0.176	0.184
Control Function	ρ_2	0.074	0.163	0.397	0.636
Chain Preferences					
BJ's Wholesale Club		-0.549	0.772	0.670	0.851
Costco		0.538	1.668	2.192	2.881
Sam's Club		-1.207	-0.314	1.264	1.043
Bloomingdale's		-2.521	-1.196	-0.919	0.019
Dillard's		-5.013	-2.690	-1.900	-0.193
JC Penney		-1.917	-1.401	-0.821	-1.279
Kohl's		-2.560	-0.952	-0.461	0.233
Macy's		-1.642	-1.053	-0.356	0.450
Neiman Marcus		-3.702	-2.964	-2.022	-0.745
Nordstrom		-3.008	-2.152	-1.121	0.126
Saks Fifth Avenue		-3.461	-2.853	-2.167	-1.301
Sears		-4.872	-4.117	-2.955	-2.657
Burlington		1.537	1.741	1.725	2.081
Citi Trends		1.857	1.354	1.271	1.000
Five Below		-0.722	-0.425	-0.242	0.279
Marshalls		1.074	1.360	1.530	2.119
Ross Dress for Less		1.854	1.963	1.979	2.802
T.J. Maxx		0.893	1.315	1.663	2.109
Big Lots		-0.772	0.135	0.242	0.526
Target		1.859	2.456	2.886	3.800
Walmart		3.880	3.886	3.924	3.886
99c Only		2.284	2.060	1.637	1.056
Dollar General		1.626	1.417	1.004	0.028
Dollar Tree		2.821	2.765	2.711	2.796
Family Dollar		2.070	1.879	1.363	0.596
Random Coefficients	σ_k				
Warehouse Stores		2.357	1.564	1.716	2.107
Traditional Stores		3.082	2.630	2.472	2.451
Discount Stores		0.749	0.556	0.601	0.431
Supercenters		1.625	0.921	0.909	0.782
Dollar Stores		0.639	0.441	0.816	1.293
Summary					
Number of Visits		3,373,332	17,252,522	24,288,153	25,870,321
Number of Devices		272,736	1,203,022	1,586,662	1,675,981
Avg. First Stage R^2		46.9%	39.8%	36.2%	37.6%
Avg. First Stage F-stat		1305.0	4213.4	4540.4	5279.3

Demand estimation parameters, summary over all CBSAs. Each column represents an income quartile, with 1 being the lowest income group. This version of the model treats distance as exogenous.

C CBSA-Specific Parameter Estimates

Table C.1: Atlanta-Sandy Springs-Alpharetta, GA Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.443	(–)	-0.666	(–)	-0.635	(–)	-0.612	(–)
Density	β^{d2}	0.101	(–)	0.192	(–)	0.162	(–)	-0.131	(–)
Fringe	ω	0.990	(–)	1.123	(–)	1.292	(–)	1.161	(–)
Control Function	ρ	0.235	(–)	0.453	(–)	0.394	(–)	0.322	(–)
Chain Preferences									
BJ's Wholesale Club		-0.789	(–)	0.182	(–)	-0.075	(–)	-2.339	(–)
Costco		-0.289	(–)	1.454	(–)	0.895	(–)	1.018	(–)
Sam's Club		0.335	(–)	1.763	(–)	0.989	(–)	-1.115	(–)
Bloomingdale's		-3.637	(–)	-1.993	(–)	-2.342	(–)	-3.049	(–)
Dillard's		-3.649	(–)	-2.187	(–)	-2.741	(–)	-1.270	(–)
JC Penney		-2.281	(–)	-2.027	(–)	-2.289	(–)	-1.376	(–)
Kohl's		-2.664	(–)	-2.558	(–)	-2.476	(–)	-0.749	(–)
Macy's		-2.998	(–)	-3.875	(–)	-2.909	(–)	-0.401	(–)
Neiman Marcus		-3.387	(–)	-2.729	(–)	-1.976	(–)	-1.313	(–)
Nordstrom		-2.565	(–)	-4.396	(–)	-2.382	(–)	-0.707	(–)
Saks Fifth Avenue		-1.431	(–)	-0.507	(–)	-0.422	(–)	0.699	(–)
Sears		-8.595	(–)	-8.893	(–)	-7.682	(–)	-6.673	(–)
Burlington		-0.373	(–)	0.870	(–)	0.912	(–)	0.949	(–)
Citi Trends		0.139	(–)	1.269	(–)	1.260	(–)	1.734	(–)
Five Below		-3.200	(–)	-2.355	(–)	-1.783	(–)	-1.754	(–)
Marshalls		-1.169	(–)	0.185	(–)	0.883	(–)	1.950	(–)
Ross Dress for Less		-0.280	(–)	0.966	(–)	1.238	(–)	1.920	(–)
T.J. Maxx		-1.923	(–)	-0.599	(–)	0.444	(–)	1.228	(–)
Big Lots		-2.074	(–)	-0.180	(–)	0.194	(–)	0.827	(–)
Target		0.395	(–)	1.978	(–)	2.409	(–)	3.284	(–)
Walmart		3.774	(–)	4.757	(–)	4.563	(–)	3.854	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		2.026	(–)	2.899	(–)	2.787	(–)	1.678	(–)
Dollar Tree		2.582	(–)	3.642	(–)	3.672	(–)	3.380	(–)
Family Dollar		2.006	(–)	2.869	(–)	2.768	(–)	1.825	(–)
Random Coefficients	σ_k								
Warehouse Stores		3.380	(–)	4.179	(–)	4.177	(–)	3.334	(–)
Traditional Stores		2.346	(–)	2.248	(–)	2.348	(–)	1.404	(–)
Discount Stores		0.017	(–)	0.044	(–)	0.258	(–)	0.000	(–)
Supercenters		2.670	(–)	2.747	(–)	2.576	(–)	1.828	(–)
Dollar Stores		2.769	(–)	2.711	(–)	3.182	(–)	3.957	(–)
Summary									
Log Likelihood		-401258.5		-3110628.7		-5526431.4		-4265115.2	
Number of Visits		206,074		1,556,413		2,745,526		2,197,857	
Number of Devices		19,446		119,793		184,787		140,089	
First Stage R^2		40.7%		27.7%		22.5%		27.2%	
First Stage F-stat		1560.4		5149.4		6012.5		6207.3	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.2: Boston-Cambridge-Newton, MA-NH Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.425	(–)	-0.366	(–)	-0.329	(–)	-0.484	(–)
Density	β^{d2}	0.540	(–)	0.115	(–)	0.179	(–)	0.174	(–)
Fringe	ω	1.310	(–)	1.113	(–)	1.104	(–)	1.005	(–)
Control Function	ρ	0.098	(–)	0.132	(–)	0.093	(–)	0.214	(–)
Chain Preferences									
BJ's Wholesale Club		0.995	(–)	2.028	(–)	1.219	(–)	2.836	(–)
Costco		-1.142	(–)	1.465	(–)	0.454	(–)	3.236	(–)
Sam's Club		-30.628	(–)	-46.390	(–)	-5.309	(–)	-3.816	(–)
Bloomingdale's		0.456	(–)	-0.678	(–)	-0.313	(–)	-0.443	(–)
Dillard's		–	–	–	–	–	–	–	–
JC Penney		0.217	(–)	-0.690	(–)	0.137	(–)	-1.981	(–)
Kohl's		-0.710	(–)	-1.073	(–)	0.176	(–)	-1.144	(–)
Macy's		1.403	(–)	-0.268	(–)	0.432	(–)	-1.005	(–)
Neiman Marcus		0.479	(–)	-0.939	(–)	0.181	(–)	-1.763	(–)
Nordstrom		-0.731	(–)	-2.001	(–)	-0.723	(–)	-1.392	(–)
Saks Fifth Avenue		-0.605	(–)	-1.413	(–)	-0.668	(–)	-2.535	(–)
Sears		0.436	(–)	-1.636	(–)	-0.480	(–)	-3.444	(–)
Burlington		2.540	(–)	1.837	(–)	1.253	(–)	1.793	(–)
Citi Trends		1.651	(–)	1.078	(–)	0.549	(–)	0.612	(–)
Five Below		0.938	(–)	0.999	(–)	0.974	(–)	2.509	(–)
Marshalls		3.245	(–)	2.314	(–)	2.078	(–)	2.399	(–)
Ross Dress for Less		–	–	–	–	–	–	–	–
T.J. Maxx		2.673	(–)	1.488	(–)	1.501	(–)	2.405	(–)
Big Lots		0.612	(–)	1.139	(–)	1.094	(–)	1.200	(–)
Target		3.352	(–)	2.895	(–)	2.925	(–)	3.459	(–)
Walmart		4.433	(–)	3.583	(–)	3.397	(–)	3.359	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		1.388	(–)	1.143	(–)	0.917	(–)	1.428	(–)
Dollar Tree		2.910	(–)	2.662	(–)	2.510	(–)	2.958	(–)
Family Dollar		2.134	(–)	2.344	(–)	1.964	(–)	1.690	(–)
Random Coefficients	σ_k								
Warehouse Stores		2.398	(–)	2.663	(–)	2.023	(–)	3.370	(–)
Traditional Stores		0.883	(–)	0.195	(–)	0.000	(–)	0.000	(–)
Discount Stores		1.306	(–)	0.000	(–)	0.251	(–)	0.000	(–)
Supercenters		0.000	(–)	0.379	(–)	0.466	(–)	0.327	(–)
Dollar Stores		3.204	(–)	1.173	(–)	1.975	(–)	0.000	(–)
Summary									
Log Likelihood		-55427.3		-380161.0		-1061840.9		-2962592.2	
Number of Visits		26,463		179,556		495,135		1,317,420	
Number of Devices		2,840		17,045		44,764		122,299	
First Stage R^2		45.9%		27.7%		23.6%		23.2%	
First Stage F-stat		340.4		779.7		1596.8		4684.0	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.3: Chicago-Naperville-Elgin, IL-IN-WI Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.403	(–)	-0.383	(–)	-0.447	(–)	-0.459	(–)
Density	β^{d2}	0.233	(–)	0.010	(–)	-0.030	(–)	-0.297	(–)
Fringe	ω	0.573	(–)	0.602	(–)	0.716	(–)	0.852	(–)
Control Function	ρ	0.146	(–)	0.139	(–)	0.199	(–)	0.139	(–)
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		0.440	(–)	1.664	(–)	1.672	(–)	0.586	(–)
Sam's Club		0.173	(–)	1.290	(–)	1.074	(–)	-0.573	(–)
Bloomingdale's		-3.171	(–)	-2.722	(–)	-3.788	(–)	-5.245	(–)
Dillard's		–	–	–	–	–	–	–	–
JC Penney		-1.805	(–)	-1.973	(–)	-3.588	(–)	-4.763	(–)
Kohl's		-2.000	(–)	-1.821	(–)	-2.235	(–)	-3.010	(–)
Macy's		-3.540	(–)	-3.151	(–)	-1.711	(–)	-3.223	(–)
Neiman Marcus		-3.081	(–)	-4.722	(–)	-5.620	(–)	-6.614	(–)
Nordstrom		-2.889	(–)	-3.092	(–)	-3.839	(–)	-4.264	(–)
Saks Fifth Avenue		-6.033	(–)	-6.815	(–)	-7.347	(–)	-6.273	(–)
Sears		-4.869	(–)	-5.355	(–)	-4.165	(–)	-6.336	(–)
Burlington		1.388	(–)	0.889	(–)	1.006	(–)	0.988	(–)
Citi Trends		1.175	(–)	0.855	(–)	1.095	(–)	0.583	(–)
Five Below		-1.034	(–)	-1.505	(–)	-1.258	(–)	-1.543	(–)
Marshalls		0.530	(–)	0.235	(–)	0.468	(–)	0.371	(–)
Ross Dress for Less		1.726	(–)	1.375	(–)	1.517	(–)	1.667	(–)
T.J. Maxx		0.692	(–)	0.590	(–)	1.264	(–)	1.755	(–)
Big Lots		-2.288	(–)	-1.045	(–)	-0.970	(–)	-1.495	(–)
Target		1.037	(–)	1.935	(–)	2.405	(–)	2.562	(–)
Walmart		2.562	(–)	2.734	(–)	2.853	(–)	2.452	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		0.789	(–)	0.519	(–)	0.756	(–)	-0.371	(–)
Dollar Tree		2.066	(–)	1.715	(–)	1.938	(–)	1.530	(–)
Family Dollar		1.682	(–)	1.251	(–)	1.160	(–)	-0.129	(–)
Random Coefficients	σ_k								
Warehouse Stores		2.752	(–)	2.765	(–)	3.338	(–)	4.077	(–)
Traditional Stores		1.763	(–)	0.237	(–)	0.094	(–)	0.000	(–)
Discount Stores		0.081	(–)	0.061	(–)	0.000	(–)	1.185	(–)
Supercenters		0.000	(–)	0.263	(–)	0.000	(–)	0.000	(–)
Dollar Stores		1.837	(–)	0.576	(–)	1.388	(–)	2.685	(–)
Summary									
Log Likelihood		-1079771.2		-4294117.0		-5588573.9		-4892304.7	
Number of Visits		475,655		1,943,835		2,587,516		2,412,041	
Number of Devices		35,733		133,881		167,383		144,017	
First Stage R^2		34.7%		23.8%		21.4%		26.7%	
First Stage F-stat		2929.0		6135.5		6625.5		8214.1	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.4: Dallas-Fort Worth-Arlington, TX Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.350	(–)	-0.418	(–)	-0.221	(–)	-0.477	(–)
Density	β^{d2}	0.700	(–)	0.600	(–)	0.594	(–)	0.322	(–)
Fringe	ω	0.965	(–)	1.081	(–)	1.019	(–)	1.326	(–)
Control Function	ρ	0.178	(–)	0.208	(–)	0.009	(–)	0.214	(–)
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		1.212	(–)	1.733	(–)	1.583	(–)	3.417	(–)
Sam's Club		2.044	(–)	1.824	(–)	1.332	(–)	2.516	(–)
Bloomingdale's		-6.360	(–)	-4.598	(–)	-4.002	(–)	0.974	(–)
Dillard's		-4.786	(–)	-2.967	(–)	-1.334	(–)	2.870	(–)
JC Penney		-3.234	(–)	-3.586	(–)	-1.601	(–)	2.198	(–)
Kohl's		-3.897	(–)	-1.084	(–)	-1.413	(–)	2.654	(–)
Macy's		-2.603	(–)	-1.997	(–)	-0.809	(–)	2.949	(–)
Neiman Marcus		-3.133	(–)	-2.065	(–)	-0.717	(–)	4.327	(–)
Nordstrom		-3.798	(–)	-2.622	(–)	-1.352	(–)	3.470	(–)
Saks Fifth Avenue		–	–	–	–	–	–	–	–
Sears		-7.882	(–)	-5.977	(–)	-4.826	(–)	-1.969	(–)
Burlington		1.271	(–)	1.851	(–)	0.401	(–)	2.274	(–)
Citi Trends		1.640	(–)	1.945	(–)	0.140	(–)	1.411	(–)
Five Below		-0.847	(–)	-0.192	(–)	-1.614	(–)	0.002	(–)
Marshalls		1.314	(–)	1.829	(–)	0.514	(–)	2.441	(–)
Ross Dress for Less		1.741	(–)	2.224	(–)	0.985	(–)	2.587	(–)
T.J. Maxx		1.070	(–)	1.786	(–)	0.663	(–)	2.758	(–)
Big Lots		0.337	(–)	0.300	(–)	-0.827	(–)	0.296	(–)
Target		2.526	(–)	2.792	(–)	1.952	(–)	3.827	(–)
Walmart		4.298	(–)	4.535	(–)	3.525	(–)	4.361	(–)
99c Only		1.315	(–)	1.379	(–)	-0.143	(–)	0.034	(–)
Dollar General		1.826	(–)	1.880	(–)	0.896	(–)	0.423	(–)
Dollar Tree		2.178	(–)	2.528	(–)	1.688	(–)	2.242	(–)
Family Dollar		2.077	(–)	2.345	(–)	0.971	(–)	0.930	(–)
Random Coefficients	σ_k								
Warehouse Stores		3.536	(–)	3.226	(–)	2.117	(–)	0.014	(–)
Traditional Stores		0.000	(–)	0.931	(–)	0.920	(–)	1.016	(–)
Discount Stores		0.000	(–)	0.529	(–)	0.000	(–)	1.569	(–)
Supercenters		0.000	(–)	0.000	(–)	0.230	(–)	0.206	(–)
Dollar Stores		1.409	(–)	1.876	(–)	1.257	(–)	1.672	(–)
Summary									
Log Likelihood		-1091326.6		-5702980.3		-6422163.9		-5004096.9	
Number of Visits		573,282		2,885,216		3,285,559		2,647,950	
Number of Devices		44,028		192,053		204,502		161,604	
First Stage R^2		33.3%		27.9%		23.2%		27.6%	
First Stage F-stat		2909.1		10295.6		8148.8		7692.9	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.5: Denver-Aurora-Lakewood, CO Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.590	(–)	-0.536	(–)	-0.551	(–)	-0.674	(–)
Density	β^{d2}	1.258	(–)	1.490	(–)	1.314	(–)	1.502	(–)
Fringe	ω	1.513	(–)	1.132	(–)	1.499	(–)	2.184	(–)
Control Function	ρ	0.277	(–)	0.308	(–)	0.309	(–)	0.332	(–)
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		2.527	(–)	-1.293	(–)	0.505	(–)	7.089	(–)
Sam's Club		2.672	(–)	-2.008	(–)	-0.490	(–)	4.387	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		3.243	(–)	3.490	(–)	3.804	(–)	2.889	(–)
JC Penney		3.440	(–)	3.884	(–)	4.173	(–)	2.502	(–)
Kohl's		3.538	(–)	3.980	(–)	4.274	(–)	3.971	(–)
Macy's		2.639	(–)	3.230	(–)	3.098	(–)	3.151	(–)
Neiman Marcus		0.206	(–)	-1.056	(–)	-0.286	(–)	0.388	(–)
Nordstrom		3.721	(–)	4.143	(–)	4.583	(–)	4.723	(–)
Saks Fifth Avenue		–	–	–	–	–	–	–	–
Sears		-0.928	(–)	-0.332	(–)	1.183	(–)	-0.611	(–)
Burlington		4.212	(–)	4.053	(–)	5.080	(–)	7.424	(–)
Citi Trends		–	–	–	–	–	–	–	–
Five Below		0.486	(–)	0.640	(–)	1.536	(–)	4.376	(–)
Marshalls		3.151	(–)	3.945	(–)	5.273	(–)	6.707	(–)
Ross Dress for Less		4.328	(–)	4.139	(–)	5.287	(–)	6.758	(–)
T.J. Maxx		2.819	(–)	3.630	(–)	4.872	(–)	6.763	(–)
Big Lots		0.569	(–)	1.958	(–)	2.645	(–)	3.515	(–)
Target		3.840	(–)	4.639	(–)	5.724	(–)	7.703	(–)
Walmart		6.931	(–)	6.340	(–)	7.395	(–)	8.144	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		3.901	(–)	1.615	(–)	2.707	(–)	0.609	(–)
Dollar Tree		5.775	(–)	4.445	(–)	6.042	(–)	4.345	(–)
Family Dollar		6.151	(–)	4.011	(–)	5.606	(–)	1.920	(–)
Random Coefficients	σ_k								
Warehouse Stores		1.826	(–)	0.000	(–)	1.566	(–)	3.270	(–)
Traditional Stores		3.511	(–)	1.326	(–)	1.648	(–)	1.900	(–)
Discount Stores		0.835	(–)	0.961	(–)	0.000	(–)	3.522	(–)
Supercenters		2.110	(–)	0.000	(–)	0.000	(–)	0.000	(–)
Dollar Stores		3.963	(–)	6.000	(–)	6.000	(–)	3.310	(–)
Summary									
Log Likelihood		-74823.4		-412651.4		-994466.1		-2399283.5	
Number of Visits		36,267		196,048		467,369		1,117,353	
Number of Devices		3,462		18,103		40,955		84,608	
First Stage R^2		39.0%		37.6%		31.9%		29.7%	
First Stage F-stat		375.0		1740.4		2882.3		5156.1	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.6: Detroit-Warren-Dearborn, MI Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.216	(–)	-0.354	(–)	-0.577	(–)	-0.359	(–)
Density	β^{d2}	-0.144	(–)	-0.063	(–)	0.091	(–)	0.462	(–)
Fringe	ω	0.696	(–)	0.831	(–)	1.446	(–)	1.554	(–)
Control Function	ρ	-0.025	(–)	0.116	(–)	0.253	(–)	0.067	(–)
Chain Preferences									
BJ's Wholesale Club		-5.559	(–)	-1.718	(–)	-0.062	(–)	-0.288	(–)
Costco		-2.223	(–)	-0.098	(–)	2.621	(–)	3.269	(–)
Sam's Club		-1.998	(–)	-0.188	(–)	1.711	(–)	2.118	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		–	–	–	–	–	–	–	–
JC Penney		-1.357	(–)	-0.300	(–)	-0.433	(–)	-2.515	(–)
Kohl's		-1.339	(–)	-0.111	(–)	0.189	(–)	-0.471	(–)
Macy's		-1.888	(–)	-0.636	(–)	-1.117	(–)	0.312	(–)
Neiman Marcus		-4.019	(–)	-2.199	(–)	-3.332	(–)	-3.352	(–)
Nordstrom		-1.581	(–)	-0.521	(–)	-1.174	(–)	-0.573	(–)
Saks Fifth Avenue		-2.832	(–)	-1.297	(–)	-1.611	(–)	-0.686	(–)
Sears		-3.299	(–)	-2.188	(–)	-4.048	(–)	-3.339	(–)
Burlington		0.646	(–)	1.511	(–)	4.007	(–)	2.829	(–)
Citi Trends		0.058	(–)	0.750	(–)	2.805	(–)	0.636	(–)
Five Below		-1.241	(–)	-0.580	(–)	1.179	(–)	-0.495	(–)
Marshalls		-0.075	(–)	0.705	(–)	2.762	(–)	1.295	(–)
Ross Dress for Less		–	–	–	–	–	–	–	–
T.J. Maxx		-0.473	(–)	0.441	(–)	2.876	(–)	2.278	(–)
Big Lots		-4.406	(–)	-1.195	(–)	-0.983	(–)	-4.738	(–)
Target		-1.559	(–)	1.342	(–)	3.015	(–)	2.292	(–)
Walmart		0.501	(–)	2.233	(–)	3.407	(–)	0.839	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		-0.896	(–)	-0.045	(–)	-0.855	(–)	-5.722	(–)
Dollar Tree		0.899	(–)	1.553	(–)	1.897	(–)	0.459	(–)
Family Dollar		0.003	(–)	0.654	(–)	-0.340	(–)	-2.572	(–)
Random Coefficients	σ_k								
Warehouse Stores		1.946	(–)	1.865	(–)	3.470	(–)	3.402	(–)
Traditional Stores		3.009	(–)	1.337	(–)	2.251	(–)	3.281	(–)
Discount Stores		1.445	(–)	1.130	(–)	2.929	(–)	3.648	(–)
Supercenters		0.000	(–)	0.000	(–)	0.000	(–)	0.387	(–)
Dollar Stores		2.894	(–)	2.290	(–)	2.886	(–)	2.056	(–)
Summary									
Log Likelihood		-482531.0		-2343578.5		-2961738.6		-1942404.8	
Number of Visits		223,012		1,114,272		1,465,891		964,818	
Number of Devices		17,553		79,162		93,973		61,556	
First Stage R^2		41.9%		32.5%		26.7%		28.3%	
First Stage F-stat		1938.6		5528.0		4727.9		3563.6	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.7: Houston-The Woodlands-Sugar Land, TX Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.449	(–)	-0.472	(–)	-0.450	(–)	-0.323	(–)
Density	β^{d2}	0.864	(–)	0.626	(–)	0.396	(–)	0.097	(–)
Fringe	ω	1.131	(–)	0.988	(–)	0.802	(–)	0.898	(–)
Control Function	ρ	0.236	(–)	0.237	(–)	0.185	(–)	0.051	(–)
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		-2.021	(–)	-0.194	(–)	0.086	(–)	-0.540	(–)
Sam's Club		-0.567	(–)	0.882	(–)	-0.157	(–)	-2.256	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		-7.327	(–)	-6.771	(–)	-4.793	(–)	-5.792	(–)
JC Penney		-7.463	(–)	-6.526	(–)	-4.670	(–)	-9.459	(–)
Kohl's		-11.551	(–)	-6.410	(–)	-4.970	(–)	-4.831	(–)
Macy's		-4.447	(–)	-4.385	(–)	-4.136	(–)	-4.703	(–)
Neiman Marcus		-7.187	(–)	-7.201	(–)	-4.023	(–)	-4.081	(–)
Nordstrom		-10.784	(–)	-8.860	(–)	-4.511	(–)	-6.390	(–)
Saks Fifth Avenue		-6.672	(–)	-5.632	(–)	-2.858	(–)	-3.991	(–)
Sears		-11.967	(–)	-8.592	(–)	-5.617	(–)	-6.930	(–)
Burlington		2.940	(–)	2.196	(–)	1.737	(–)	0.987	(–)
Citi Trends		1.577	(–)	0.773	(–)	0.393	(–)	-1.352	(–)
Five Below		1.245	(–)	0.714	(–)	1.056	(–)	0.539	(–)
Marshalls		2.563	(–)	1.919	(–)	1.884	(–)	1.319	(–)
Ross Dress for Less		2.654	(–)	2.271	(–)	2.243	(–)	1.786	(–)
T.J. Maxx		1.779	(–)	1.181	(–)	1.052	(–)	0.443	(–)
Big Lots		-1.492	(–)	-0.999	(–)	-1.254	(–)	-1.519	(–)
Target		1.218	(–)	1.524	(–)	1.270	(–)	1.832	(–)
Walmart		4.805	(–)	4.091	(–)	3.207	(–)	2.390	(–)
99c Only		1.936	(–)	1.468	(–)	0.597	(–)	-1.516	(–)
Dollar General		2.236	(–)	1.622	(–)	0.699	(–)	-1.727	(–)
Dollar Tree		3.098	(–)	2.820	(–)	2.148	(–)	0.953	(–)
Family Dollar		2.583	(–)	2.000	(–)	1.060	(–)	-1.219	(–)
Random Coefficients	σ_k								
Warehouse Stores		6.000	(–)	6.000	(–)	4.209	(–)	4.547	(–)
Traditional Stores		2.485	(–)	2.026	(–)	1.579	(–)	0.000	(–)
Discount Stores		0.000	(–)	0.183	(–)	0.000	(–)	1.414	(–)
Supercenters		0.607	(–)	1.056	(–)	0.000	(–)	0.000	(–)
Dollar Stores		4.135	(–)	3.161	(–)	2.910	(–)	3.160	(–)
Summary									
Log Likelihood		-1446453.5		-5443076.2		-5435607.4		-4079090.6	
Number of Visits		679,228		2,455,553		2,418,533		1,794,429	
Number of Devices		52,128		159,872		145,811		111,412	
First Stage R^2		36.2%		27.8%		19.1%		28.5%	
First Stage F-stat		4105.3		9143.6		5147.6		6920.4	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.8: Miami-Fort Lauderdale-Pompano Beach, FL Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.438	(–)	-0.512	(–)	-0.547	(–)	-0.551	(–)
Density	β^{d2}	0.621	(–)	0.316	(–)	0.018	(–)	-0.128	(–)
Fringe	ω	0.952	(–)	0.755	(–)	0.771	(–)	0.698	(–)
Control Function	ρ	0.126	(–)	0.222	(–)	0.271	(–)	0.283	(–)
Chain Preferences									
BJ's Wholesale Club		1.298	(–)	1.559	(–)	2.169	(–)	1.659	(–)
Costco		1.251	(–)	1.806	(–)	2.656	(–)	2.532	(–)
Sam's Club		1.009	(–)	1.211	(–)	1.928	(–)	1.633	(–)
Bloomingdale's		-5.774	(–)	-0.751	(–)	1.229	(–)	0.863	(–)
Dillard's		-13.431	(–)	-1.147	(–)	-2.205	(–)	-3.306	(–)
JC Penney		-6.797	(–)	-4.729	(–)	-0.140	(–)	-1.652	(–)
Kohl's		-10.653	(–)	-2.805	(–)	-1.347	(–)	-2.285	(–)
Macy's		-7.570	(–)	-2.097	(–)	-0.039	(–)	-1.000	(–)
Neiman Marcus		-12.295	(–)	-5.127	(–)	-1.145	(–)	-1.637	(–)
Nordstrom		-12.904	(–)	-5.085	(–)	-2.096	(–)	-1.659	(–)
Saks Fifth Avenue		-6.580	(–)	-1.697	(–)	0.035	(–)	-0.599	(–)
Sears		-5.898	(–)	-4.566	(–)	-2.105	(–)	-3.095	(–)
Burlington		2.290	(–)	1.248	(–)	1.226	(–)	1.434	(–)
Citi Trends		1.685	(–)	1.308	(–)	1.378	(–)	1.754	(–)
Five Below		-0.529	(–)	-1.457	(–)	-1.467	(–)	-0.166	(–)
Marshalls		1.402	(–)	0.672	(–)	0.498	(–)	1.562	(–)
Ross Dress for Less		2.453	(–)	1.672	(–)	2.045	(–)	2.625	(–)
T.J. Maxx		1.725	(–)	0.823	(–)	0.957	(–)	2.063	(–)
Big Lots		-3.435	(–)	-3.271	(–)	-1.129	(–)	0.013	(–)
Target		-1.760	(–)	-1.539	(–)	0.633	(–)	1.970	(–)
Walmart		2.062	(–)	1.692	(–)	2.244	(–)	2.286	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		-0.613	(–)	-0.686	(–)	-0.215	(–)	-0.639	(–)
Dollar Tree		2.149	(–)	2.445	(–)	2.617	(–)	2.478	(–)
Family Dollar		1.109	(–)	1.446	(–)	1.284	(–)	0.854	(–)
Random Coefficients	σ_k								
Warehouse Stores		6.000	(–)	3.259	(–)	2.374	(–)	2.749	(–)
Traditional Stores		3.529	(–)	3.365	(–)	2.246	(–)	1.011	(–)
Discount Stores		2.210	(–)	1.612	(–)	1.609	(–)	1.310	(–)
Supercenters		0.313	(–)	1.342	(–)	1.535	(–)	0.000	(–)
Dollar Stores		1.244	(–)	0.887	(–)	0.000	(–)	0.000	(–)
Summary									
Log Likelihood		-562769.2		-3297557.9		-4828026.5		-6702240.1	
Number of Visits		244,367		1,409,738		2,044,688		2,905,826	
Number of Devices		16,699		79,858		108,791		150,626	
First Stage R^2		38.2%		29.7%		27.4%		24.0%	
First Stage F-stat		1752.9		5717.0		6719.7		7502.1	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.9: Minneapolis-St. Paul-Bloomington, MN-WI Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.311	(–)	-0.397	(–)	-0.348	(–)	-0.504	(–)
Density	β^{d2}	0.053	(–)	-0.076	(–)	-0.129	(–)	-0.349	(–)
Fringe	ω	2.043	(–)	2.102	(–)	2.036	(–)	2.622	(–)
Control Function	ρ	0.155	(–)	0.217	(–)	0.139	(–)	0.198	(–)
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		5.283	(–)	6.181	(–)	5.392	(–)	6.393	(–)
Sam's Club		5.663	(–)	6.367	(–)	5.073	(–)	5.176	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		–	–	–	–	–	–	–	–
JC Penney		3.409	(–)	4.258	(–)	2.407	(–)	-2.013	(–)
Kohl's		3.947	(–)	4.516	(–)	3.175	(–)	0.312	(–)
Macy's		4.385	(–)	5.170	(–)	3.518	(–)	0.715	(–)
Neiman Marcus		–	–	–	–	–	–	–	–
Nordstrom		4.382	(–)	4.339	(–)	2.636	(–)	0.679	(–)
Saks Fifth Avenue		1.220	(–)	2.682	(–)	0.211	(–)	-5.151	(–)
Sears		–	–	–	–	–	–	–	–
Burlington		4.856	(–)	5.123	(–)	3.952	(–)	-3.219	(–)
Citi Trends		5.231	(–)	5.571	(–)	4.286	(–)	-6.489	(–)
Five Below		3.415	(–)	3.967	(–)	3.393	(–)	-4.035	(–)
Marshalls		4.683	(–)	4.907	(–)	3.844	(–)	-4.243	(–)
Ross Dress for Less		–	–	–	–	–	–	–	–
T.J. Maxx		3.516	(–)	4.313	(–)	3.705	(–)	-10.844	(–)
Big Lots		2.244	(–)	3.626	(–)	2.304	(–)	1.534	(–)
Target		6.723	(–)	7.105	(–)	6.463	(–)	7.663	(–)
Walmart		6.971	(–)	7.366	(–)	6.334	(–)	6.611	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		3.722	(–)	3.873	(–)	2.965	(–)	-0.005	(–)
Dollar Tree		5.423	(–)	5.662	(–)	4.713	(–)	4.314	(–)
Family Dollar		3.651	(–)	4.314	(–)	3.209	(–)	1.116	(–)
Random Coefficients	σ_k								
Warehouse Stores		1.433	(–)	1.406	(–)	1.995	(–)	5.018	(–)
Traditional Stores		0.000	(–)	0.000	(–)	0.041	(–)	1.855	(–)
Discount Stores		1.289	(–)	1.251	(–)	1.078	(–)	2.990	(–)
Supercenters		0.049	(–)	0.628	(–)	0.792	(–)	6.000	(–)
Dollar Stores		0.000	(–)	0.000	(–)	0.960	(–)	2.490	(–)
Summary									
Log Likelihood		-130783.1		-1134068.6		-1936974.0		-1837538.7	
Number of Visits		67,339		592,812		1,078,205		1,023,360	
Number of Devices		6,100		45,938		81,302		66,587	
First Stage R^2		32.7%		26.9%		26.7%		28.9%	
First Stage F-stat		442.3		2322.2		3641.8		3522.1	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.10: Philadelphia-Camden-Wilmington, PA-NJ-DE-MD Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.321	(–)	-0.329	(–)	-0.332	(–)	-0.264	(–)
Density	β^{d2}	0.419	(–)	0.253	(–)	0.210	(–)	0.322	(–)
Fringe	ω	0.535	(–)	0.671	(–)	0.709	(–)	0.728	(–)
Control Function	ρ	0.053	(–)	0.063	(–)	0.094	(–)	0.017	(–)
Chain Preferences									
BJ's Wholesale Club		-1.217	(–)	0.787	(–)	0.986	(–)	0.375	(–)
Costco		-1.192	(–)	0.844	(–)	1.355	(–)	1.120	(–)
Sam's Club		-0.705	(–)	1.040	(–)	1.065	(–)	0.209	(–)
Bloomingdale's		-2.624	(–)	-2.281	(–)	-0.862	(–)	-0.288	(–)
Dillard's		–	–	–	–	–	–	–	–
JC Penney		-2.637	(–)	-2.673	(–)	-0.283	(–)	-0.366	(–)
Kohl's		-2.596	(–)	-1.931	(–)	0.135	(–)	0.463	(–)
Macy's		-2.392	(–)	-2.057	(–)	-0.098	(–)	0.563	(–)
Neiman Marcus		-4.516	(–)	-5.070	(–)	-2.314	(–)	-1.515	(–)
Nordstrom		-3.481	(–)	-4.211	(–)	-0.968	(–)	0.202	(–)
Saks Fifth Avenue		-6.172	(–)	-5.598	(–)	-3.150	(–)	-2.113	(–)
Sears		-2.028	(–)	-2.194	(–)	0.187	(–)	0.282	(–)
Burlington		0.111	(–)	0.661	(–)	0.531	(–)	-0.012	(–)
Citi Trends		-0.120	(–)	-0.189	(–)	-0.625	(–)	-1.641	(–)
Five Below		-1.073	(–)	-1.011	(–)	-1.075	(–)	-1.304	(–)
Marshalls		0.610	(–)	0.718	(–)	0.717	(–)	0.319	(–)
Ross Dress for Less		0.178	(–)	0.557	(–)	0.459	(–)	-0.518	(–)
T.J. Maxx		0.219	(–)	0.639	(–)	0.941	(–)	1.017	(–)
Big Lots		-4.856	(–)	-1.882	(–)	-0.402	(–)	-1.583	(–)
Target		-1.728	(–)	-0.101	(–)	1.708	(–)	1.488	(–)
Walmart		0.648	(–)	1.575	(–)	2.228	(–)	1.317	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		0.183	(–)	0.228	(–)	0.168	(–)	-0.614	(–)
Dollar Tree		1.697	(–)	1.997	(–)	2.048	(–)	1.570	(–)
Family Dollar		0.816	(–)	0.685	(–)	0.150	(–)	-1.080	(–)
Random Coefficients	σ_k								
Warehouse Stores		2.278	(–)	2.564	(–)	1.209	(–)	0.164	(–)
Traditional Stores		2.954	(–)	1.978	(–)	0.059	(–)	0.028	(–)
Discount Stores		0.143	(–)	0.000	(–)	0.121	(–)	0.016	(–)
Supercenters		0.352	(–)	0.000	(–)	0.053	(–)	0.002	(–)
Dollar Stores		2.042	(–)	0.000	(–)	0.000	(–)	0.755	(–)
Summary									
Log Likelihood		-284775.7		-2188412.4		-3894999.6		-3771112.7	
Number of Visits		131,718		1,041,849		1,876,252		1,851,163	
Number of Devices		9,018		58,454		103,116		106,305	
First Stage R^2		35.8%		23.3%		19.3%		18.1%	
First Stage F-stat		753.6		2556.6		3424.3		3267.3	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.11: Phoenix-Mesa-Chandler, AZ Metro Area — Endogeous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.434	(–)	-0.443	(–)	-0.246	(–)	-0.366	(–)
Density	β^{d2}	-0.049	(–)	0.088	(–)	-0.073	(–)	-0.281	(–)
Fringe	ω	1.291	(–)	1.254	(–)	1.263	(–)	1.488	(–)
Control Function	ρ	0.223	(–)	0.241	(–)	0.043	(–)	0.161	(–)
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		4.003	(–)	4.617	(–)	3.914	(–)	5.062	(–)
Sam's Club		3.774	(–)	3.772	(–)	2.786	(–)	3.534	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		1.675	(–)	1.781	(–)	2.307	(–)	2.777	(–)
JC Penney		2.393	(–)	2.403	(–)	2.713	(–)	2.385	(–)
Kohl's		2.097	(–)	1.904	(–)	3.166	(–)	2.960	(–)
Macy's		3.117	(–)	2.900	(–)	2.788	(–)	3.542	(–)
Neiman Marcus		-0.308	(–)	-0.905	(–)	0.092	(–)	2.102	(–)
Nordstrom		1.450	(–)	1.520	(–)	1.950	(–)	3.406	(–)
Saks Fifth Avenue		-0.941	(–)	-0.145	(–)	0.819	(–)	1.187	(–)
Sears		-0.686	(–)	-0.060	(–)	0.052	(–)	-0.072	(–)
Burlington		-6.449	(–)	-6.298	(–)	-1.382	(–)	2.299	(–)
Citi Trends		–	–	–	–	–	–	–	–
Five Below		-9.323	(–)	-9.390	(–)	-3.523	(–)	1.354	(–)
Marshalls		-8.651	(–)	-8.482	(–)	-1.732	(–)	3.252	(–)
Ross Dress for Less		0.063	(–)	-1.002	(–)	1.307	(–)	4.418	(–)
T.J. Maxx		-8.047	(–)	-5.032	(–)	-0.264	(–)	3.346	(–)
Big Lots		1.821	(–)	0.937	(–)	1.051	(–)	2.465	(–)
Target		4.179	(–)	3.342	(–)	3.467	(–)	5.088	(–)
Walmart		6.185	(–)	5.737	(–)	5.053	(–)	5.619	(–)
99c Only		4.257	(–)	3.911	(–)	3.067	(–)	3.506	(–)
Dollar General		2.914	(–)	2.483	(–)	1.229	(–)	1.375	(–)
Dollar Tree		4.320	(–)	4.251	(–)	3.780	(–)	4.530	(–)
Family Dollar		3.721	(–)	3.346	(–)	1.872	(–)	1.636	(–)
Random Coefficients	σ_k								
Warehouse Stores		1.730	(–)	1.740	(–)	0.256	(–)	1.360	(–)
Traditional Stores		1.322	(–)	1.777	(–)	1.291	(–)	0.000	(–)
Discount Stores		0.000	(–)	0.000	(–)	0.000	(–)	0.000	(–)
Supercenters		6.000	(–)	6.000	(–)	2.924	(–)	0.000	(–)
Dollar Stores		1.466	(–)	1.252	(–)	1.275	(–)	1.407	(–)
Summary									
Log Likelihood		-267596.8		-1477641.3		-1942575.9		-1402777.3	
Number of Visits		140,346		757,408		988,918		773,189	
Number of Devices		14,199		66,004		86,464		79,035	
First Stage R^2		43.4%		40.6%		31.9%		31.9%	
First Stage F-stat		1435.5		5723.4		4602.8		3255.2	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.12: Riverside-San Bernardino-Ontario, CA Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.508	(–)	-0.467	(–)	-0.438	(–)	-0.269	(–)
Density	β^{d2}	0.062	(–)	0.077	(–)	0.129	(–)	0.140	(–)
Fringe	ω	1.828	(–)	1.586	(–)	1.506	(–)	0.968	(–)
Control Function	ρ	0.279	(–)	0.265	(–)	0.246	(–)	0.090	(–)
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		3.474	(–)	4.147	(–)	3.938	(–)	2.833	(–)
Sam's Club		2.267	(–)	3.244	(–)	3.321	(–)	2.270	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		–	–	–	–	–	–	–	–
JC Penney		1.331	(–)	1.398	(–)	3.509	(–)	0.829	(–)
Kohl's		2.746	(–)	1.990	(–)	3.907	(–)	1.573	(–)
Macy's		1.549	(–)	0.987	(–)	3.667	(–)	1.385	(–)
Neiman Marcus		-0.101	(–)	-0.056	(–)	1.686	(–)	-1.010	(–)
Nordstrom		2.894	(–)	1.848	(–)	4.170	(–)	1.441	(–)
Saks Fifth Avenue		-0.965	(–)	-1.566	(–)	1.338	(–)	0.418	(–)
Sears		0.174	(–)	-1.204	(–)	1.854	(–)	-0.282	(–)
Burlington		4.226	(–)	1.637	(–)	1.691	(–)	0.187	(–)
Citi Trends		3.546	(–)	-0.149	(–)	0.205	(–)	-1.006	(–)
Five Below		2.647	(–)	-1.014	(–)	-0.344	(–)	-1.623	(–)
Marshalls		3.721	(–)	0.445	(–)	1.527	(–)	1.079	(–)
Ross Dress for Less		3.957	(–)	1.568	(–)	1.744	(–)	0.363	(–)
T.J. Maxx		3.563	(–)	1.165	(–)	1.062	(–)	0.512	(–)
Big Lots		3.316	(–)	2.759	(–)	2.439	(–)	-0.136	(–)
Target		5.834	(–)	5.266	(–)	4.926	(–)	2.749	(–)
Walmart		6.784	(–)	5.981	(–)	5.447	(–)	2.914	(–)
99c Only		5.313	(–)	4.455	(–)	3.581	(–)	1.429	(–)
Dollar General		4.007	(–)	3.065	(–)	2.072	(–)	-0.786	(–)
Dollar Tree		5.189	(–)	4.417	(–)	3.730	(–)	1.839	(–)
Family Dollar		4.005	(–)	2.962	(–)	2.000	(–)	-0.363	(–)
Random Coefficients	σ_k								
Warehouse Stores		2.547	(–)	2.611	(–)	0.000	(–)	0.228	(–)
Traditional Stores		0.000	(–)	0.000	(–)	0.184	(–)	0.005	(–)
Discount Stores		0.000	(–)	0.000	(–)	0.925	(–)	0.000	(–)
Supercenters		1.152	(–)	2.588	(–)	2.222	(–)	1.166	(–)
Dollar Stores		2.754	(–)	2.041	(–)	1.964	(–)	0.021	(–)
Summary									
Log Likelihood		-203424.1		-1394470.6		-2600265.1		-3944797.9	
Number of Visits		97,509		640,540		1,162,102		1,742,213	
Number of Devices		9,631		52,460		84,668		107,543	
First Stage R^2		22.5%		23.1%		22.7%		25.0%	
First Stage F-stat		342.1		2064.1		3409.1		5211.5	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.13: St. Louis, MO-IL Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.381	(–)	-0.441	(–)	-0.561	(–)	-0.640	(–)
Density	β^{d2}	-0.355	(–)	-0.357	(–)	-0.340	(–)	-0.744	(–)
Fringe	ω	1.929	(–)	1.837	(–)	1.750	(–)	1.630	(–)
Control Function	ρ	0.185	(–)	0.227	(–)	0.323	(–)	0.413	(–)
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		1.258	(–)	0.265	(–)	2.444	(–)	-1.797	(–)
Sam's Club		2.113	(–)	1.840	(–)	3.024	(–)	-1.034	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		-0.743	(–)	-1.240	(–)	-3.746	(–)	-0.514	(–)
JC Penney		0.455	(–)	0.203	(–)	-3.810	(–)	-1.600	(–)
Kohl's		0.355	(–)	0.592	(–)	-1.944	(–)	-0.341	(–)
Macy's		0.735	(–)	0.219	(–)	-4.024	(–)	0.805	(–)
Neiman Marcus		-2.078	(–)	-3.794	(–)	-7.041	(–)	-2.685	(–)
Nordstrom		0.059	(–)	-0.113	(–)	-3.678	(–)	0.935	(–)
Saks Fifth Avenue		-2.696	(–)	-3.929	(–)	-6.934	(–)	-2.714	(–)
Sears		-5.324	(–)	-3.185	(–)	-6.829	(–)	-3.809	(–)
Burlington		3.109	(–)	3.025	(–)	2.976	(–)	2.527	(–)
Citi Trends		2.088	(–)	2.035	(–)	1.446	(–)	0.921	(–)
Five Below		1.475	(–)	1.555	(–)	1.883	(–)	1.212	(–)
Marshalls		2.080	(–)	1.870	(–)	2.106	(–)	2.051	(–)
Ross Dress for Less		3.580	(–)	3.817	(–)	4.073	(–)	3.772	(–)
T.J. Maxx		3.662	(–)	3.912	(–)	4.293	(–)	4.229	(–)
Big Lots		2.565	(–)	2.386	(–)	2.250	(–)	2.070	(–)
Target		4.441	(–)	4.693	(–)	5.002	(–)	5.052	(–)
Walmart		5.804	(–)	5.749	(–)	5.704	(–)	5.289	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		3.554	(–)	3.473	(–)	2.759	(–)	3.217	(–)
Dollar Tree		4.147	(–)	4.241	(–)	4.007	(–)	5.113	(–)
Family Dollar		3.879	(–)	3.750	(–)	2.701	(–)	3.447	(–)
Random Coefficients	σ_k								
Warehouse Stores		2.838	(–)	3.209	(–)	5.375	(–)	3.542	(–)
Traditional Stores		0.036	(–)	0.032	(–)	0.000	(–)	0.059	(–)
Discount Stores		0.139	(–)	0.003	(–)	1.407	(–)	0.000	(–)
Supercenters		0.515	(–)	0.000	(–)	0.000	(–)	0.568	(–)
Dollar Stores		2.455	(–)	3.262	(–)	2.646	(–)	6.000	(–)
Summary									
Log Likelihood		-388002.6		-1669986.9		-2059383.1		-1279624.0	
Number of Visits		210,351		912,786		1,053,107		601,577	
Number of Devices		19,553		70,630		70,753		36,985	
First Stage R^2		38.2%		28.7%		26.8%		38.0%	
First Stage F-stat		1456.8		3373.5		3196.2		3307.2	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.14: San Diego-Chula Vista-Carlsbad, CA Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.160	(–)	-0.240	(–)	-0.259	(–)	-0.312	(–)
Density	β^{d2}	0.497	(–)	0.084	(–)	0.195	(–)	0.223	(–)
Fringe	ω	0.091	(–)	0.357	(–)	0.359	(–)	0.749	(–)
Control Function	ρ	0.005	(–)	0.069	(–)	0.085	(–)	0.059	(–)
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		-0.919	(–)	0.419	(–)	1.067	(–)	1.327	(–)
Sam's Club		-3.428	(–)	-1.771	(–)	-1.305	(–)	-2.623	(–)
Bloomingdale's		-0.090	(–)	1.247	(–)	1.327	(–)	1.149	(–)
Dillard's		–	–	–	–	–	–	–	–
JC Penney		-1.349	(–)	0.014	(–)	0.075	(–)	-0.948	(–)
Kohl's		-1.450	(–)	-0.123	(–)	-0.029	(–)	-0.658	(–)
Macy's		-1.406	(–)	0.251	(–)	0.284	(–)	-0.956	(–)
Neiman Marcus		-3.543	(–)	-1.404	(–)	-1.527	(–)	-2.571	(–)
Nordstrom		-1.962	(–)	-0.417	(–)	-0.379	(–)	-0.402	(–)
Saks Fifth Avenue		-4.619	(–)	-3.527	(–)	-2.236	(–)	-2.534	(–)
Sears		-4.675	(–)	-1.751	(–)	-2.443	(–)	-3.840	(–)
Burlington		-1.501	(–)	-0.593	(–)	-0.406	(–)	0.326	(–)
Citi Trends		–	–	–	–	–	–	–	–
Five Below		-5.587	(–)	-3.933	(–)	-4.040	(–)	-3.210	(–)
Marshalls		-1.718	(–)	-0.431	(–)	-0.191	(–)	1.278	(–)
Ross Dress for Less		-0.456	(–)	0.592	(–)	0.925	(–)	1.632	(–)
T.J. Maxx		-2.233	(–)	-0.747	(–)	-0.482	(–)	0.869	(–)
Big Lots		-2.155	(–)	-1.668	(–)	-1.960	(–)	-0.251	(–)
Target		0.184	(–)	1.256	(–)	1.024	(–)	2.562	(–)
Walmart		1.174	(–)	1.985	(–)	1.695	(–)	2.771	(–)
99c Only		-0.087	(–)	0.771	(–)	0.616	(–)	1.104	(–)
Dollar General		–	–	–	–	–	–	–	–
Dollar Tree		0.208	(–)	1.121	(–)	1.122	(–)	1.859	(–)
Family Dollar		-3.079	(–)	-2.583	(–)	-2.670	(–)	-2.448	(–)
Random Coefficients	σ_k								
Warehouse Stores		0.026	(–)	0.000	(–)	0.000	(–)	2.269	(–)
Traditional Stores		0.000	(–)	1.189	(–)	1.830	(–)	0.852	(–)
Discount Stores		0.005	(–)	0.053	(–)	0.047	(–)	0.000	(–)
Supercenters		0.103	(–)	0.694	(–)	0.000	(–)	0.000	(–)
Dollar Stores		1.668	(–)	1.618	(–)	1.407	(–)	3.020	(–)
Summary									
Log Likelihood		-104409.9		-432699.5		-885826.0		-3102845.9	
Number of Visits		45,926		188,858		384,237		1,387,395	
Number of Devices		3,812		13,352		25,579		95,325	
First Stage R^2		39.1%		37.7%		39.4%		26.5%	
First Stage F-stat		402.6		1334.9		2659.7		5122.6	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.15: Tampa-St. Petersburg-Clearwater, FL Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.189	(–)	-0.214	(–)	-0.152	(–)	-0.244	(–)
Density	β^{d2}	0.830	(–)	0.745	(–)	0.842	(–)	0.737	(–)
Fringe	ω	1.124	(–)	1.289	(–)	1.346	(–)	1.617	(–)
Control Function	ρ	-0.089	(–)	-0.028	(–)	-0.093	(–)	0.006	(–)
Chain Preferences									
BJ's Wholesale Club		0.823	(–)	1.384	(–)	1.209	(–)	2.239	(–)
Costco		1.118	(–)	1.779	(–)	1.716	(–)	3.264	(–)
Sam's Club		1.838	(–)	2.380	(–)	2.121	(–)	2.850	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		-7.419	(–)	-5.234	(–)	-6.645	(–)	-5.544	(–)
JC Penney		-9.721	(–)	-5.320	(–)	-7.290	(–)	-9.696	(–)
Kohl's		-8.932	(–)	-2.764	(–)	-3.806	(–)	-4.128	(–)
Macy's		-8.909	(–)	-3.599	(–)	-4.959	(–)	-4.927	(–)
Neiman Marcus		-14.333	(–)	-7.050	(–)	-8.901	(–)	-7.886	(–)
Nordstrom		-13.332	(–)	-6.525	(–)	-8.022	(–)	-5.841	(–)
Saks Fifth Avenue		–	–	–	–	–	–	–	–
Sears		-11.474	(–)	-7.169	(–)	-9.400	(–)	-10.038	(–)
Burlington		0.749	(–)	1.284	(–)	0.827	(–)	1.582	(–)
Citi Trends		0.519	(–)	0.490	(–)	-0.664	(–)	-0.251	(–)
Five Below		-2.672	(–)	-2.196	(–)	-2.373	(–)	-2.001	(–)
Marshalls		0.524	(–)	1.006	(–)	0.805	(–)	1.654	(–)
Ross Dress for Less		0.817	(–)	1.351	(–)	1.120	(–)	2.082	(–)
T.J. Maxx		0.217	(–)	0.642	(–)	0.465	(–)	1.930	(–)
Big Lots		-2.094	(–)	-0.771	(–)	-0.696	(–)	1.511	(–)
Target		-0.113	(–)	1.148	(–)	1.554	(–)	3.346	(–)
Walmart		3.194	(–)	3.551	(–)	3.172	(–)	3.752	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		-0.371	(–)	-0.002	(–)	-0.579	(–)	-1.143	(–)
Dollar Tree		0.174	(–)	1.364	(–)	1.073	(–)	1.465	(–)
Family Dollar		-0.762	(–)	-0.014	(–)	-0.691	(–)	-0.681	(–)
Random Coefficients	σ_k								
Warehouse Stores		5.697	(–)	3.637	(–)	4.196	(–)	4.952	(–)
Traditional Stores		2.244	(–)	1.662	(–)	1.379	(–)	0.000	(–)
Discount Stores		3.080	(–)	2.329	(–)	2.238	(–)	2.407	(–)
Supercenters		0.011	(–)	0.000	(–)	0.000	(–)	0.000	(–)
Dollar Stores		0.214	(–)	0.000	(–)	0.000	(–)	0.000	(–)
Summary									
Log Likelihood		-313631.2		-2090327.4		-2885820.8		-1834120.3	
Number of Visits		156,850		1,007,931		1,368,475		861,670	
Number of Devices		13,136		67,325		81,097		48,563	
First Stage R^2		29.3%		21.1%		20.4%		27.6%	
First Stage F-stat		714.5		2441.8		2900.4		2782.7	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.16: Washington-Arlington-Alexandria, DC-VA-MD-WV Metro Area — Endogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.504	(–)	-0.616	(–)	-0.613	(–)	-0.625	(–)
Density	β^{d2}	0.518	(–)	0.302	(–)	0.247	(–)	0.622	(–)
Fringe	ω	0.685	(–)	0.519	(–)	0.516	(–)	1.202	(–)
Control Function	ρ	0.210	(–)	0.395	(–)	0.398	(–)	0.317	(–)
Chain Preferences									
BJ's Wholesale Club		-1.865	(–)	0.433	(–)	-2.608	(–)	-0.390	(–)
Costco		-1.088	(–)	1.206	(–)	-0.312	(–)	1.862	(–)
Sam's Club		-2.299	(–)	0.580	(–)	-1.991	(–)	-0.908	(–)
Bloomingdale's		1.047	(–)	2.656	(–)	2.694	(–)	2.771	(–)
Dillard's		–	–	–	–	–	–	–	–
JC Penney		-0.484	(–)	0.847	(–)	0.810	(–)	0.480	(–)
Kohl's		0.829	(–)	1.354	(–)	1.201	(–)	0.899	(–)
Macy's		1.165	(–)	1.845	(–)	1.704	(–)	1.375	(–)
Neiman Marcus		0.548	(–)	1.915	(–)	1.842	(–)	1.928	(–)
Nordstrom		0.406	(–)	1.433	(–)	0.944	(–)	1.481	(–)
Saks Fifth Avenue		-1.434	(–)	0.485	(–)	0.617	(–)	1.067	(–)
Sears		-3.053	(–)	-0.934	(–)	-0.914	(–)	-0.529	(–)
Burlington		1.722	(–)	1.743	(–)	1.583	(–)	2.972	(–)
Citi Trends		2.612	(–)	2.412	(–)	2.160	(–)	3.388	(–)
Five Below		-0.424	(–)	-0.073	(–)	0.084	(–)	1.691	(–)
Marshalls		1.995	(–)	1.512	(–)	0.937	(–)	2.475	(–)
Ross Dress for Less		1.709	(–)	1.321	(–)	1.001	(–)	2.260	(–)
T.J. Maxx		1.851	(–)	1.799	(–)	1.668	(–)	3.038	(–)
Big Lots		-0.447	(–)	0.637	(–)	0.344	(–)	1.750	(–)
Target		1.818	(–)	2.399	(–)	2.277	(–)	3.270	(–)
Walmart		3.001	(–)	3.299	(–)	3.115	(–)	3.428	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		0.537	(–)	1.723	(–)	1.557	(–)	2.087	(–)
Dollar Tree		1.973	(–)	2.322	(–)	2.188	(–)	3.077	(–)
Family Dollar		2.049	(–)	2.203	(–)	1.897	(–)	1.968	(–)
Random Coefficients	σ_k								
Warehouse Stores		1.294	(–)	0.000	(–)	0.000	(–)	1.885	(–)
Traditional Stores		1.684	(–)	0.020	(–)	0.005	(–)	1.508	(–)
Discount Stores		1.388	(–)	0.000	(–)	0.018	(–)	1.069	(–)
Supercenters		0.000	(–)	0.114	(–)	0.000	(–)	0.039	(–)
Dollar Stores		3.331	(–)	1.724	(–)	3.252	(–)	3.293	(–)
Summary									
Log Likelihood		-129496.1		-814318.6		-1884275.3		-4708289.3	
Number of Visits		58,945		369,707		866,640		2,272,060	
Number of Devices		5,398		29,092		62,717		159,427	
First Stage R^2		33.0%		23.8%		18.2%		16.8%	
First Stage F-stat		359.4		1139.9		1676.2		4015.3	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.17: Atlanta-Sandy Springs-Alpharetta, GA Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.211	(–)	-0.217	(–)	-0.250	(–)	-0.309	(–)
Density	β^{d2}	0.153	(–)	0.239	(–)	0.167	(–)	-0.128	(–)
Fringe	ω	0.907	(–)	0.865	(–)	1.046	(–)	0.967	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		0.306	(–)	0.270	(–)	-1.562	(–)	-3.733	(–)
Costco		0.847	(–)	0.958	(–)	-0.714	(–)	-0.526	(–)
Sam's Club		1.422	(–)	1.271	(–)	-0.581	(–)	-2.439	(–)
Bloomingdale's		-3.958	(–)	-3.759	(–)	-3.776	(–)	-3.717	(–)
Dillard's		-3.662	(–)	-3.287	(–)	-3.782	(–)	-2.305	(–)
JC Penney		-2.492	(–)	-3.184	(–)	-3.338	(–)	-2.603	(–)
Kohl's		-2.552	(–)	-2.899	(–)	-3.089	(–)	-1.758	(–)
Macy's		-2.877	(–)	-3.939	(–)	-3.846	(–)	-1.548	(–)
Neiman Marcus		-4.179	(–)	-4.567	(–)	-3.809	(–)	-2.456	(–)
Nordstrom		-3.084	(–)	-4.954	(–)	-3.556	(–)	-1.883	(–)
Saks Fifth Avenue		-2.112	(–)	-2.392	(–)	-2.323	(–)	-0.642	(–)
Sears		-8.217	(–)	-8.407	(–)	-8.403	(–)	-8.080	(–)
Burlington		-1.017	(–)	-0.991	(–)	-1.172	(–)	-1.051	(–)
Citi Trends		-0.261	(–)	-0.541	(–)	-0.821	(–)	-0.480	(–)
Five Below		-3.971	(–)	-3.941	(–)	-3.619	(–)	-3.589	(–)
Marshalls		-1.856	(–)	-1.768	(–)	-1.249	(–)	0.113	(–)
Ross Dress for Less		-0.844	(–)	-0.877	(–)	-0.816	(–)	0.021	(–)
T.J. Maxx		-2.250	(–)	-2.057	(–)	-1.524	(–)	-0.540	(–)
Big Lots		-4.009	(–)	-3.432	(–)	-2.225	(–)	-1.420	(–)
Target		-1.317	(–)	-1.008	(–)	-0.014	(–)	1.485	(–)
Walmart		2.642	(–)	2.430	(–)	2.542	(–)	2.168	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		1.108	(–)	0.871	(–)	0.852	(–)	-0.060	(–)
Dollar Tree		1.545	(–)	1.390	(–)	1.648	(–)	1.793	(–)
Family Dollar		1.070	(–)	0.678	(–)	0.546	(–)	-0.415	(–)
Random Coefficients	σ_k								
Warehouse Stores		2.601	(–)	2.887	(–)	3.246	(–)	2.772	(–)
Traditional Stores		2.569	(–)	2.399	(–)	2.318	(–)	1.492	(–)
Discount Stores		0.000	(–)	0.000	(–)	0.334	(–)	0.000	(–)
Supercenters		2.079	(–)	1.996	(–)	2.215	(–)	1.701	(–)
Dollar Stores		0.000	(–)	0.000	(–)	2.520	(–)	3.505	(–)
Summary									
Log Likelihood		-401751.7		-3119015.3		-5535683.5		-4273042.4	
Number of Visits		206,074		1,556,413		2,745,526		2,197,857	
Number of Devices		19,446		119,793		184,787		140,089	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.18: Boston-Cambridge-Newton, MA-NH Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.353	(–)	-0.249	(–)	-0.244	(–)	-0.293	(–)
Density	β^{d2}	0.756	(–)	0.262	(–)	0.264	(–)	0.299	(–)
Fringe	ω	1.295	(–)	1.097	(–)	1.081	(–)	0.918	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		0.333	(–)	0.865	(–)	0.459	(–)	0.782	(–)
Costco		-1.897	(–)	0.084	(–)	-0.445	(–)	0.712	(–)
Sam's Club		-31.636	(–)	-42.713	(–)	-6.290	(–)	-6.563	(–)
Bloomingdale's		-0.043	(–)	-1.417	(–)	-0.898	(–)	-1.051	(–)
Dillard's		–	–	–	–	–	–	–	–
JC Penney		-0.322	(–)	-1.420	(–)	-0.375	(–)	-2.324	(–)
Kohl's		-1.205	(–)	-1.708	(–)	-0.288	(–)	-1.510	(–)
Macy's		0.937	(–)	-1.019	(–)	-0.101	(–)	-1.437	(–)
Neiman Marcus		0.175	(–)	-1.563	(–)	-0.323	(–)	-2.121	(–)
Nordstrom		-1.483	(–)	-2.898	(–)	-1.319	(–)	-1.814	(–)
Saks Fifth Avenue		-1.143	(–)	-2.173	(–)	-1.243	(–)	-2.845	(–)
Sears		-0.139	(–)	-2.453	(–)	-1.063	(–)	-3.608	(–)
Burlington		1.936	(–)	1.102	(–)	0.750	(–)	0.483	(–)
Citi Trends		1.238	(–)	0.579	(–)	0.128	(–)	-0.779	(–)
Five Below		0.383	(–)	0.314	(–)	0.482	(–)	1.176	(–)
Marshalls		2.907	(–)	1.748	(–)	1.642	(–)	1.335	(–)
Ross Dress for Less		–	–	–	–	–	–	–	–
T.J. Maxx		2.296	(–)	0.923	(–)	1.088	(–)	1.359	(–)
Big Lots		0.145	(–)	0.507	(–)	0.602	(–)	-0.089	(–)
Target		3.057	(–)	2.330	(–)	2.495	(–)	2.384	(–)
Walmart		4.083	(–)	3.100	(–)	3.014	(–)	2.276	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		0.830	(–)	0.447	(–)	0.406	(–)	0.048	(–)
Dollar Tree		2.572	(–)	2.217	(–)	2.168	(–)	2.004	(–)
Family Dollar		1.794	(–)	1.877	(–)	1.581	(–)	0.504	(–)
Random Coefficients	σ_k								
Warehouse Stores		2.432	(–)	2.679	(–)	2.023	(–)	2.851	(–)
Traditional Stores		0.777	(–)	0.221	(–)	0.000	(–)	0.067	(–)
Discount Stores		1.335	(–)	0.000	(–)	0.233	(–)	0.000	(–)
Supercenters		0.000	(–)	0.370	(–)	0.398	(–)	0.177	(–)
Dollar Stores		3.361	(–)	1.783	(–)	2.263	(–)	1.781	(–)
Summary									
Log Likelihood		-55484.1		-380563.1		-1062238.9		-2968357.1	
Number of Visits		26,463		179,556		495,135		1,317,420	
Number of Devices		2,840		17,045		44,764		122,299	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.19: Chicago-Naperville-Elgin, IL-IN-WI Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.266	(–)	-0.250	(–)	-0.253	(–)	-0.325	(–)
Density	β^{d2}	0.233	(–)	0.015	(–)	0.008	(–)	-0.254	(–)
Fringe	ω	0.509	(–)	0.550	(–)	0.623	(–)	0.796	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		-0.795	(–)	0.673	(–)	0.536	(–)	-0.131	(–)
Sam's Club		-0.971	(–)	0.353	(–)	-0.113	(–)	-1.444	(–)
Bloomingdale's		-4.012	(–)	-3.561	(–)	-4.342	(–)	-6.052	(–)
Dillard's		–	–	–	–	–	–	–	–
JC Penney		-2.492	(–)	-2.633	(–)	-3.755	(–)	-5.513	(–)
Kohl's		-2.562	(–)	-2.300	(–)	-2.405	(–)	-3.558	(–)
Macy's		-4.156	(–)	-3.809	(–)	-2.322	(–)	-4.017	(–)
Neiman Marcus		-3.979	(–)	-5.516	(–)	-6.020	(–)	-7.429	(–)
Nordstrom		-3.651	(–)	-3.831	(–)	-4.140	(–)	-5.024	(–)
Saks Fifth Avenue		-6.825	(–)	-7.492	(–)	-7.547	(–)	-7.117	(–)
Sears		-5.557	(–)	-6.005	(–)	-4.700	(–)	-7.217	(–)
Burlington		0.578	(–)	0.166	(–)	-0.116	(–)	0.156	(–)
Citi Trends		0.479	(–)	0.132	(–)	-0.212	(–)	-0.504	(–)
Five Below		-1.958	(–)	-2.264	(–)	-2.356	(–)	-2.298	(–)
Marshalls		-0.284	(–)	-0.501	(–)	-0.713	(–)	-0.457	(–)
Ross Dress for Less		0.971	(–)	0.695	(–)	0.463	(–)	0.921	(–)
T.J. Maxx		-0.206	(–)	-0.189	(–)	0.120	(–)	0.988	(–)
Big Lots		-3.364	(–)	-1.816	(–)	-2.188	(–)	-2.376	(–)
Target		0.141	(–)	1.291	(–)	1.503	(–)	1.989	(–)
Walmart		1.856	(–)	2.171	(–)	1.997	(–)	1.839	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		0.244	(–)	-0.070	(–)	-0.330	(–)	-1.589	(–)
Dollar Tree		1.487	(–)	1.182	(–)	1.065	(–)	0.708	(–)
Family Dollar		1.141	(–)	0.644	(–)	0.009	(–)	-1.376	(–)
Random Coefficients	σ_k								
Warehouse Stores		2.593	(–)	2.643	(–)	2.837	(–)	4.024	(–)
Traditional Stores		1.877	(–)	0.224	(–)	0.076	(–)	0.000	(–)
Discount Stores		0.040	(–)	0.059	(–)	0.000	(–)	1.431	(–)
Supercenters		0.000	(–)	0.247	(–)	0.000	(–)	0.000	(–)
Dollar Stores		2.050	(–)	0.809	(–)	1.341	(–)	2.672	(–)
Summary									
Log Likelihood		-1080269.9		-4295809.8		-5592125.7		-4893062.0	
Number of Visits		475,655		1,943,835		2,587,516		2,412,041	
Number of Devices		35,733		133,881		167,383		144,017	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.20: Dallas-Fort Worth-Arlington, TX Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.188	(–)	-0.220	(–)	-0.213	(–)	-0.280	(–)
Density	β^{d2}	0.765	(–)	0.635	(–)	0.595	(–)	0.302	(–)
Fringe	ω	0.910	(–)	0.997	(–)	1.015	(–)	1.171	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		0.154	(–)	0.445	(–)	1.523	(–)	2.120	(–)
Sam's Club		1.187	(–)	0.744	(–)	1.280	(–)	1.413	(–)
Bloomingdale's		-6.839	(–)	-6.158	(–)	-4.059	(–)	-0.460	(–)
Dillard's		-4.861	(–)	-4.406	(–)	-1.383	(–)	1.411	(–)
JC Penney		-3.449	(–)	-4.962	(–)	-1.648	(–)	0.829	(–)
Kohl's		-4.069	(–)	-2.322	(–)	-1.454	(–)	1.477	(–)
Macy's		-3.154	(–)	-3.398	(–)	-0.860	(–)	1.518	(–)
Neiman Marcus		-3.416	(–)	-3.734	(–)	-0.773	(–)	2.951	(–)
Nordstrom		-4.330	(–)	-4.266	(–)	-1.410	(–)	1.957	(–)
Saks Fifth Avenue		–	–	–	–	–	–	–	–
Sears		-7.765	(–)	-7.612	(–)	-4.883	(–)	-3.514	(–)
Burlington		0.171	(–)	0.588	(–)	0.349	(–)	0.843	(–)
Citi Trends		0.721	(–)	0.743	(–)	0.083	(–)	-0.322	(–)
Five Below		-1.944	(–)	-1.447	(–)	-1.664	(–)	-1.298	(–)
Marshalls		0.297	(–)	0.539	(–)	0.460	(–)	1.090	(–)
Ross Dress for Less		0.819	(–)	1.136	(–)	0.940	(–)	1.326	(–)
T.J. Maxx		-0.072	(–)	0.505	(–)	0.612	(–)	1.470	(–)
Big Lots		-0.829	(–)	-0.804	(–)	-0.878	(–)	-1.175	(–)
Target		1.387	(–)	1.703	(–)	1.906	(–)	2.656	(–)
Walmart		3.613	(–)	3.712	(–)	3.491	(–)	3.329	(–)
99c Only		0.350	(–)	0.191	(–)	-0.197	(–)	-1.405	(–)
Dollar General		1.211	(–)	1.070	(–)	0.861	(–)	-0.794	(–)
Dollar Tree		1.432	(–)	1.600	(–)	1.649	(–)	1.156	(–)
Family Dollar		1.452	(–)	1.448	(–)	0.926	(–)	-0.541	(–)
Random Coefficients	σ_k								
Warehouse Stores		3.125	(–)	3.268	(–)	2.115	(–)	0.046	(–)
Traditional Stores		0.633	(–)	0.982	(–)	0.927	(–)	1.160	(–)
Discount Stores		0.000	(–)	0.606	(–)	0.000	(–)	1.546	(–)
Supercenters		0.000	(–)	0.000	(–)	0.230	(–)	0.202	(–)
Dollar Stores		1.292	(–)	1.824	(–)	1.262	(–)	1.542	(–)
Summary									
Log Likelihood		-1092126.9		-5707368.8		-6422172.2		-5009349.2	
Number of Visits		573,282		2,885,216		3,285,559		2,647,950	
Number of Devices		44,028		192,053		204,502		161,604	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.21: Denver-Aurora-Lakewood, CO Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.353	(–)	-0.292	(–)	-0.273	(–)	-0.372	(–)
Density	β^{d2}	1.144	(–)	1.415	(–)	1.123	(–)	1.714	(–)
Fringe	ω	1.306	(–)	1.136	(–)	1.504	(–)	2.047	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		1.436	(–)	0.019	(–)	4.209	(–)	4.899	(–)
Sam's Club		1.606	(–)	-0.392	(–)	3.458	(–)	1.932	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		1.060	(–)	1.928	(–)	3.481	(–)	0.833	(–)
JC Penney		1.646	(–)	2.788	(–)	3.929	(–)	0.683	(–)
Kohl's		1.640	(–)	2.873	(–)	4.319	(–)	2.443	(–)
Macy's		0.644	(–)	1.912	(–)	3.403	(–)	1.184	(–)
Neiman Marcus		-1.514	(–)	-2.312	(–)	-0.262	(–)	-1.681	(–)
Nordstrom		1.840	(–)	2.756	(–)	4.120	(–)	2.525	(–)
Saks Fifth Avenue		–	–	–	–	–	–	–	–
Sears		-3.087	(–)	-1.798	(–)	0.003	(–)	-2.538	(–)
Burlington		2.312	(–)	2.681	(–)	3.689	(–)	5.474	(–)
Citi Trends		–	–	–	–	–	–	–	–
Five Below		-1.083	(–)	-0.578	(–)	0.318	(–)	1.928	(–)
Marshalls		1.329	(–)	2.572	(–)	3.933	(–)	4.587	(–)
Ross Dress for Less		2.885	(–)	3.217	(–)	4.308	(–)	4.880	(–)
T.J. Maxx		1.306	(–)	2.337	(–)	3.567	(–)	4.921	(–)
Big Lots		-0.785	(–)	-1.132	(–)	-0.253	(–)	1.145	(–)
Target		2.674	(–)	2.818	(–)	4.045	(–)	6.125	(–)
Walmart		5.627	(–)	5.513	(–)	6.428	(–)	6.447	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		1.527	(–)	-0.393	(–)	-0.084	(–)	-4.892	(–)
Dollar Tree		4.035	(–)	3.161	(–)	4.311	(–)	0.384	(–)
Family Dollar		4.308	(–)	2.443	(–)	3.241	(–)	-4.860	(–)
Random Coefficients	σ_k								
Warehouse Stores		1.850	(–)	0.000	(–)	0.000	(–)	3.213	(–)
Traditional Stores		3.155	(–)	2.446	(–)	2.561	(–)	2.132	(–)
Discount Stores		1.314	(–)	1.754	(–)	1.807	(–)	5.036	(–)
Supercenters		1.943	(–)	0.000	(–)	0.020	(–)	0.000	(–)
Dollar Stores		3.473	(–)	4.433	(–)	2.322	(–)	3.703	(–)
Summary									
Log Likelihood		-75010.5		-413717.0		-995830.1		-2401855.8	
Number of Visits		36,267		196,048		467,369		1,117,353	
Number of Devices		3,462		18,103		40,955		84,608	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.22: Detroit-Warren-Dearborn, MI Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.237	(–)	-0.248	(–)	-0.338	(–)	-0.297	(–)
Density	β^{d2}	-0.155	(–)	-0.021	(–)	0.167	(–)	0.460	(–)
Fringe	ω	0.710	(–)	0.737	(–)	1.151	(–)	1.485	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		-5.475	(–)	-2.430	(–)	-2.163	(–)	-0.916	(–)
Costco		-2.128	(–)	-0.719	(–)	0.730	(–)	2.768	(–)
Sam's Club		-1.910	(–)	-0.789	(–)	-0.186	(–)	1.571	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		–	–	–	–	–	–	–	–
JC Penney		-1.218	(–)	-1.008	(–)	-2.352	(–)	-3.071	(–)
Kohl's		-1.206	(–)	-0.765	(–)	-1.543	(–)	-0.918	(–)
Macy's		-1.738	(–)	-1.431	(–)	-3.311	(–)	-0.222	(–)
Neiman Marcus		-3.836	(–)	-3.101	(–)	-5.726	(–)	-3.917	(–)
Nordstrom		-1.402	(–)	-1.419	(–)	-3.548	(–)	-1.134	(–)
Saks Fifth Avenue		-2.645	(–)	-2.228	(–)	-4.007	(–)	-1.224	(–)
Sears		-3.130	(–)	-3.035	(–)	-6.312	(–)	-3.931	(–)
Burlington		0.801	(–)	0.709	(–)	2.000	(–)	2.268	(–)
Citi Trends		0.198	(–)	-0.047	(–)	0.596	(–)	0.022	(–)
Five Below		-1.094	(–)	-1.326	(–)	-0.640	(–)	-0.945	(–)
Marshalls		0.084	(–)	-0.104	(–)	0.811	(–)	0.813	(–)
Ross Dress for Less		–	–	–	–	–	–	–	–
T.J. Maxx		-0.327	(–)	-0.314	(–)	0.988	(–)	1.827	(–)
Big Lots		-4.183	(–)	-2.002	(–)	-3.122	(–)	-5.560	(–)
Target		-1.350	(–)	0.531	(–)	1.078	(–)	1.768	(–)
Walmart		0.680	(–)	1.463	(–)	1.545	(–)	0.241	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		-0.740	(–)	-0.763	(–)	-2.309	(–)	-6.125	(–)
Dollar Tree		1.036	(–)	0.868	(–)	0.472	(–)	0.108	(–)
Family Dollar		0.144	(–)	-0.085	(–)	-1.877	(–)	-3.027	(–)
Random Coefficients	σ_k								
Warehouse Stores		1.958	(–)	1.803	(–)	3.465	(–)	3.425	(–)
Traditional Stores		2.958	(–)	1.443	(–)	2.424	(–)	3.411	(–)
Discount Stores		1.401	(–)	1.262	(–)	2.810	(–)	3.608	(–)
Supercenters		0.000	(–)	0.000	(–)	0.000	(–)	0.396	(–)
Dollar Stores		2.928	(–)	2.181	(–)	2.834	(–)	2.076	(–)
Summary									
Log Likelihood		-482539.1		-2344356.2		-2963835.7		-1942483.9	
Number of Visits		223,012		1,114,272		1,465,891		964,818	
Number of Devices		17,553		79,162		93,973		61,556	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.23: Houston-The Woodlands-Sugar Land, TX Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.224	(–)	-0.242	(–)	-0.271	(–)	-0.276	(–)
Density	β^{d2}	0.852	(–)	0.620	(–)	0.410	(–)	0.094	(–)
Fringe	ω	1.036	(–)	0.901	(–)	0.721	(–)	0.866	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		-1.842	(–)	-1.037	(–)	-0.785	(–)	-0.853	(–)
Sam's Club		-0.618	(–)	0.049	(–)	-0.992	(–)	-2.578	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		-9.197	(–)	-8.399	(–)	-6.082	(–)	-6.222	(–)
JC Penney		-9.233	(–)	-7.938	(–)	-5.802	(–)	-9.920	(–)
Kohl's		-13.268	(–)	-7.694	(–)	-5.980	(–)	-5.186	(–)
Macy's		-6.128	(–)	-5.994	(–)	-5.424	(–)	-5.119	(–)
Neiman Marcus		-9.227	(–)	-9.186	(–)	-5.419	(–)	-4.475	(–)
Nordstrom		-12.539	(–)	-10.593	(–)	-5.869	(–)	-6.831	(–)
Saks Fifth Avenue		-8.671	(–)	-7.567	(–)	-4.204	(–)	-4.397	(–)
Sears		-13.573	(–)	-10.348	(–)	-6.885	(–)	-7.383	(–)
Burlington		1.474	(–)	0.806	(–)	0.595	(–)	0.663	(–)
Citi Trends		0.349	(–)	-0.480	(–)	-0.831	(–)	-1.740	(–)
Five Below		-0.137	(–)	-0.559	(–)	-0.036	(–)	0.233	(–)
Marshalls		1.075	(–)	0.584	(–)	0.787	(–)	1.009	(–)
Ross Dress for Less		1.402	(–)	1.081	(–)	1.254	(–)	1.501	(–)
T.J. Maxx		0.298	(–)	-0.183	(–)	0.028	(–)	0.183	(–)
Big Lots		-2.098	(–)	-1.973	(–)	-2.290	(–)	-1.818	(–)
Target		0.338	(–)	0.538	(–)	0.380	(–)	1.599	(–)
Walmart		3.783	(–)	3.177	(–)	2.484	(–)	2.177	(–)
99c Only		0.751	(–)	0.254	(–)	-0.515	(–)	-1.892	(–)
Dollar General		1.357	(–)	0.684	(–)	-0.142	(–)	-2.050	(–)
Dollar Tree		1.973	(–)	1.745	(–)	1.314	(–)	0.676	(–)
Family Dollar		1.700	(–)	1.045	(–)	0.093	(–)	-1.600	(–)
Random Coefficients	σ_k								
Warehouse Stores		6.000	(–)	6.000	(–)	4.243	(–)	4.599	(–)
Traditional Stores		2.046	(–)	1.811	(–)	1.606	(–)	0.000	(–)
Discount Stores		0.000	(–)	0.246	(–)	0.000	(–)	1.444	(–)
Supercenters		0.637	(–)	1.010	(–)	0.000	(–)	0.000	(–)
Dollar Stores		3.125	(–)	2.707	(–)	2.725	(–)	3.172	(–)
Summary									
Log Likelihood		-1448178.8		-5448682.8		-5438003.2		-4079268.7	
Number of Visits		679,228		2,455,553		2,418,533		1,794,429	
Number of Devices		52,128		159,872		145,811		111,412	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.24: Miami-Fort Lauderdale-Pompano Beach, FL Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.325	(–)	-0.311	(–)	-0.292	(–)	-0.260	(–)
Density	β^{d2}	0.668	(–)	0.403	(–)	0.062	(–)	-0.288	(–)
Fringe	ω	0.893	(–)	0.682	(–)	0.559	(–)	0.336	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		0.812	(–)	0.586	(–)	0.532	(–)	-0.455	(–)
Costco		0.792	(–)	0.796	(–)	0.846	(–)	0.303	(–)
Sam's Club		0.436	(–)	0.060	(–)	0.026	(–)	-0.943	(–)
Bloomingdale's		-6.688	(–)	-2.724	(–)	-1.061	(–)	0.641	(–)
Dillard's		-14.310	(–)	-2.698	(–)	-4.474	(–)	-1.748	(–)
JC Penney		-7.626	(–)	-6.747	(–)	-2.092	(–)	-1.223	(–)
Kohl's		-11.453	(–)	-4.513	(–)	-3.294	(–)	-1.352	(–)
Macy's		-8.396	(–)	-3.840	(–)	-1.967	(–)	-0.336	(–)
Neiman Marcus		-13.250	(–)	-7.408	(–)	-3.453	(–)	-1.241	(–)
Nordstrom		-13.674	(–)	-7.191	(–)	-4.285	(–)	-0.793	(–)
Saks Fifth Avenue		-7.459	(–)	-3.596	(–)	-2.305	(–)	-0.426	(–)
Sears		-6.315	(–)	-6.167	(–)	-3.971	(–)	-2.634	(–)
Burlington		1.614	(–)	0.074	(–)	-0.041	(–)	-0.728	(–)
Citi Trends		0.994	(–)	0.063	(–)	-0.084	(–)	-0.813	(–)
Five Below		-1.294	(–)	-2.741	(–)	-2.501	(–)	-2.210	(–)
Marshalls		0.779	(–)	-0.423	(–)	-0.648	(–)	-0.427	(–)
Ross Dress for Less		1.828	(–)	0.607	(–)	0.799	(–)	0.648	(–)
T.J. Maxx		1.008	(–)	-0.457	(–)	-0.340	(–)	0.075	(–)
Big Lots		-4.235	(–)	-5.228	(–)	-3.116	(–)	-1.835	(–)
Target		-2.479	(–)	-3.339	(–)	-1.250	(–)	0.404	(–)
Walmart		1.487	(–)	0.599	(–)	0.712	(–)	0.750	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		-1.200	(–)	-2.005	(–)	-1.838	(–)	-2.468	(–)
Dollar Tree		1.607	(–)	1.496	(–)	1.249	(–)	0.966	(–)
Family Dollar		0.614	(–)	0.405	(–)	-0.224	(–)	-1.052	(–)
Random Coefficients	σ_k								
Warehouse Stores		6.000	(–)	3.517	(–)	2.455	(–)	0.145	(–)
Traditional Stores		3.581	(–)	3.824	(–)	2.480	(–)	0.458	(–)
Discount Stores		2.226	(–)	1.841	(–)	1.655	(–)	0.764	(–)
Supercenters		0.256	(–)	1.414	(–)	1.188	(–)	0.089	(–)
Dollar Stores		0.967	(–)	0.633	(–)	0.000	(–)	0.000	(–)
Summary									
Log Likelihood		-563014.4		-3299835.4		-4834164.3		-6712973.4	
Number of Visits		244,367		1,409,738		2,044,688		2,905,826	
Number of Devices		16,699		79,858		108,791		150,626	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.25: Minneapolis-St. Paul-Bloomington, MN-WI Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.179	(–)	-0.198	(–)	-0.219	(–)	-0.327	(–)
Density	β^{d2}	0.008	(–)	-0.039	(–)	-0.132	(–)	-0.334	(–)
Fringe	ω	2.041	(–)	2.096	(–)	1.976	(–)	2.579	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		4.571	(–)	5.140	(–)	4.840	(–)	5.160	(–)
Sam's Club		4.904	(–)	5.305	(–)	4.525	(–)	4.041	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		–	–	–	–	–	–	–	–
JC Penney		2.404	(–)	2.978	(–)	1.070	(–)	-3.783	(–)
Kohl's		3.099	(–)	3.544	(–)	2.129	(–)	-1.028	(–)
Macy's		3.371	(–)	3.896	(–)	2.262	(–)	-1.056	(–)
Neiman Marcus		–	–	–	–	–	–	–	–
Nordstrom		3.512	(–)	3.050	(–)	1.182	(–)	-1.039	(–)
Saks Fifth Avenue		0.175	(–)	1.239	(–)	-1.464	(–)	-7.376	(–)
Sears		–	–	–	–	–	–	–	–
Burlington		4.158	(–)	4.206	(–)	3.222	(–)	-4.236	(–)
Citi Trends		4.683	(–)	4.646	(–)	3.452	(–)	-7.742	(–)
Five Below		2.675	(–)	2.985	(–)	2.652	(–)	-5.093	(–)
Marshalls		4.027	(–)	3.955	(–)	3.064	(–)	-5.305	(–)
Ross Dress for Less		–	–	–	–	–	–	–	–
T.J. Maxx		2.901	(–)	3.478	(–)	2.968	(–)	-11.936	(–)
Big Lots		1.523	(–)	2.630	(–)	1.474	(–)	0.138	(–)
Target		6.261	(–)	6.412	(–)	5.898	(–)	6.945	(–)
Walmart		6.370	(–)	6.532	(–)	5.690	(–)	5.709	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		2.955	(–)	2.895	(–)	2.308	(–)	-1.188	(–)
Dollar Tree		4.855	(–)	4.956	(–)	4.210	(–)	3.613	(–)
Family Dollar		2.866	(–)	3.314	(–)	2.488	(–)	-0.011	(–)
Random Coefficients	σ_k								
Warehouse Stores		1.586	(–)	1.446	(–)	2.239	(–)	5.317	(–)
Traditional Stores		0.000	(–)	0.000	(–)	0.000	(–)	1.952	(–)
Discount Stores		1.438	(–)	1.309	(–)	0.987	(–)	2.951	(–)
Supercenters		0.000	(–)	0.454	(–)	0.700	(–)	6.000	(–)
Dollar Stores		0.000	(–)	0.000	(–)	0.375	(–)	2.631	(–)
Summary									
Log Likelihood		-131004.9		-1136413.0		-1938178.0		-1838228.8	
Number of Visits		67,339		592,812		1,078,205		1,023,360	
Number of Devices		6,100		45,938		81,302		66,587	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.26: Philadelphia-Camden-Wilmington, PA-NJ-DE-MD Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.271	(–)	-0.268	(–)	-0.242	(–)	-0.248	(–)
Density	β^{d2}	0.424	(–)	0.264	(–)	0.227	(–)	0.319	(–)
Fringe	ω	0.498	(–)	0.635	(–)	0.647	(–)	0.716	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		-1.287	(–)	0.375	(–)	0.359	(–)	0.260	(–)
Costco		-1.275	(–)	0.404	(–)	0.678	(–)	0.998	(–)
Sam's Club		-0.826	(–)	0.624	(–)	0.450	(–)	0.087	(–)
Bloomingdale's		-2.922	(–)	-2.690	(–)	-1.622	(–)	-0.420	(–)
Dillard's		–	–	–	–	–	–	–	–
JC Penney		-2.955	(–)	-2.964	(–)	-0.935	(–)	-0.497	(–)
Kohl's		-2.852	(–)	-2.190	(–)	-0.400	(–)	0.359	(–)
Macy's		-2.651	(–)	-2.352	(–)	-0.705	(–)	0.442	(–)
Neiman Marcus		-4.771	(–)	-5.328	(–)	-2.965	(–)	-1.642	(–)
Nordstrom		-3.782	(–)	-4.494	(–)	-1.648	(–)	0.064	(–)
Saks Fifth Avenue		-6.486	(–)	-6.000	(–)	-3.902	(–)	-2.248	(–)
Sears		-2.378	(–)	-2.534	(–)	-0.478	(–)	0.152	(–)
Burlington		-0.239	(–)	0.259	(–)	-0.078	(–)	-0.130	(–)
Citi Trends		-0.457	(–)	-0.612	(–)	-1.338	(–)	-1.781	(–)
Five Below		-1.426	(–)	-1.418	(–)	-1.671	(–)	-1.412	(–)
Marshalls		0.249	(–)	0.320	(–)	0.122	(–)	0.209	(–)
Ross Dress for Less		-0.168	(–)	0.164	(–)	-0.153	(–)	-0.635	(–)
T.J. Maxx		-0.130	(–)	0.224	(–)	0.318	(–)	0.906	(–)
Big Lots		-5.133	(–)	-2.343	(–)	-1.096	(–)	-1.704	(–)
Target		-1.995	(–)	-0.502	(–)	1.097	(–)	1.385	(–)
Walmart		0.381	(–)	1.221	(–)	1.690	(–)	1.214	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		-0.077	(–)	-0.098	(–)	-0.379	(–)	-0.729	(–)
Dollar Tree		1.412	(–)	1.688	(–)	1.565	(–)	1.473	(–)
Family Dollar		0.562	(–)	0.366	(–)	-0.408	(–)	-1.208	(–)
Random Coefficients	σ_k								
Warehouse Stores		2.217	(–)	2.484	(–)	1.174	(–)	0.165	(–)
Traditional Stores		2.904	(–)	2.014	(–)	0.367	(–)	0.028	(–)
Discount Stores		0.145	(–)	0.000	(–)	0.110	(–)	0.015	(–)
Supercenters		0.299	(–)	0.000	(–)	0.041	(–)	0.002	(–)
Dollar Stores		1.806	(–)	0.000	(–)	0.000	(–)	0.752	(–)
Summary									
Log Likelihood		-284801.9		-2188582.0		-3895675.2		-3771133.4	
Number of Visits		131,718		1,041,849		1,876,252		1,851,163	
Number of Devices		9,018		58,454		103,116		106,305	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.27: Phoenix-Mesa-Chandler, AZ Metro Area — Endogeous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.225	(–)	-0.209	(–)	-0.207	(–)	-0.216	(–)
Density	β^{d2}	-0.036	(–)	0.029	(–)	-0.081	(–)	-0.308	(–)
Fringe	ω	1.173	(–)	1.115	(–)	1.241	(–)	1.282	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		3.509	(–)	3.617	(–)	3.656	(–)	3.908	(–)
Sam's Club		3.107	(–)	2.884	(–)	2.509	(–)	2.377	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		1.693	(–)	1.504	(–)	2.037	(–)	1.265	(–)
JC Penney		2.173	(–)	2.077	(–)	2.456	(–)	0.998	(–)
Kohl's		2.385	(–)	2.454	(–)	2.942	(–)	1.664	(–)
Macy's		2.477	(–)	2.054	(–)	2.507	(–)	2.055	(–)
Neiman Marcus		-0.478	(–)	-0.959	(–)	-0.237	(–)	0.550	(–)
Nordstrom		1.126	(–)	1.007	(–)	1.664	(–)	1.935	(–)
Saks Fifth Avenue		-0.728	(–)	-0.562	(–)	0.504	(–)	-0.221	(–)
Sears		-0.832	(–)	-0.651	(–)	-0.222	(–)	-1.754	(–)
Burlington		-7.906	(–)	-2.879	(–)	-1.495	(–)	0.937	(–)
Citi Trends		–	–	–	–	–	–	–	–
Five Below		-10.793	(–)	-5.787	(–)	-3.644	(–)	-0.013	(–)
Marshalls		-10.012	(–)	-4.074	(–)	-1.845	(–)	1.938	(–)
Ross Dress for Less		-1.250	(–)	0.483	(–)	1.172	(–)	3.155	(–)
T.J. Maxx		-9.812	(–)	-1.831	(–)	-0.369	(–)	2.046	(–)
Big Lots		0.837	(–)	-0.053	(–)	0.824	(–)	1.212	(–)
Target		3.095	(–)	2.201	(–)	3.250	(–)	3.935	(–)
Walmart		5.179	(–)	4.653	(–)	4.872	(–)	4.498	(–)
99c Only		3.113	(–)	2.724	(–)	2.870	(–)	2.241	(–)
Dollar General		1.825	(–)	1.160	(–)	0.976	(–)	-0.108	(–)
Dollar Tree		3.257	(–)	3.166	(–)	3.597	(–)	3.384	(–)
Family Dollar		2.807	(–)	2.151	(–)	1.619	(–)	0.105	(–)
Random Coefficients	σ_k								
Warehouse Stores		0.180	(–)	0.000	(–)	0.260	(–)	1.391	(–)
Traditional Stores		1.185	(–)	1.660	(–)	1.308	(–)	0.000	(–)
Discount Stores		0.000	(–)	0.000	(–)	0.000	(–)	0.000	(–)
Supercenters		6.000	(–)	3.624	(–)	2.848	(–)	0.000	(–)
Dollar Stores		0.000	(–)	0.341	(–)	1.296	(–)	1.203	(–)
Summary									
Log Likelihood		-268004.4		-1479487.8		-1942665.0		-1403764.5	
Number of Visits		140,346		757,408		988,918		773,189	
Number of Devices		14,199		66,004		86,464		79,035	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.28: Riverside-San Bernardino-Ontario, CA Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.237	(–)	-0.211	(–)	-0.202	(–)	-0.185	(–)
Density	β^{d2}	-0.062	(–)	-0.044	(–)	0.042	(–)	0.132	(–)
Fringe	ω	1.704	(–)	1.508	(–)	1.408	(–)	0.932	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		3.101	(–)	3.277	(–)	3.270	(–)	2.341	(–)
Sam's Club		2.134	(–)	2.460	(–)	2.636	(–)	1.759	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		–	–	–	–	–	–	–	–
JC Penney		0.311	(–)	-0.034	(–)	2.152	(–)	0.305	(–)
Kohl's		1.495	(–)	0.491	(–)	2.616	(–)	1.203	(–)
Macy's		0.503	(–)	-0.517	(–)	2.270	(–)	0.869	(–)
Neiman Marcus		-1.654	(–)	-2.048	(–)	-0.093	(–)	-1.620	(–)
Nordstrom		1.473	(–)	0.154	(–)	2.687	(–)	0.957	(–)
Saks Fifth Avenue		-2.043	(–)	-3.119	(–)	-0.328	(–)	-0.111	(–)
Sears		-1.211	(–)	-2.858	(–)	0.326	(–)	-0.870	(–)
Burlington		3.265	(–)	0.824	(–)	1.317	(–)	0.264	(–)
Citi Trends		3.120	(–)	-0.499	(–)	0.023	(–)	-0.884	(–)
Five Below		1.875	(–)	-1.441	(–)	-0.404	(–)	-1.533	(–)
Marshalls		2.849	(–)	-0.091	(–)	1.446	(–)	1.079	(–)
Ross Dress for Less		3.425	(–)	1.117	(–)	1.682	(–)	0.633	(–)
T.J. Maxx		2.606	(–)	0.290	(–)	0.987	(–)	0.569	(–)
Big Lots		2.064	(–)	1.579	(–)	1.242	(–)	-0.594	(–)
Target		4.515	(–)	4.084	(–)	3.832	(–)	2.367	(–)
Walmart		5.544	(–)	4.920	(–)	4.406	(–)	2.501	(–)
99c Only		4.166	(–)	3.264	(–)	2.459	(–)	1.036	(–)
Dollar General		2.869	(–)	1.689	(–)	0.760	(–)	-1.358	(–)
Dollar Tree		4.146	(–)	3.304	(–)	2.733	(–)	1.496	(–)
Family Dollar		2.783	(–)	1.648	(–)	0.721	(–)	-0.920	(–)
Random Coefficients	σ_k								
Warehouse Stores		2.273	(–)	2.655	(–)	0.000	(–)	0.000	(–)
Traditional Stores		0.066	(–)	0.079	(–)	0.064	(–)	0.000	(–)
Discount Stores		0.000	(–)	0.712	(–)	1.076	(–)	0.000	(–)
Supercenters		0.129	(–)	2.192	(–)	1.408	(–)	0.000	(–)
Dollar Stores		1.781	(–)	1.406	(–)	1.150	(–)	0.000	(–)
Summary									
Log Likelihood		-203830.8		-1396536.0		-2604610.4		-3945667.0	
Number of Visits		97,509		640,540		1,162,102		1,742,213	
Number of Devices		9,631		52,460		84,668		107,543	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.29: St. Louis, MO-IL Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.216	(–)	-0.230	(–)	-0.248	(–)	-0.244	(–)
Density	β^{d2}	-0.421	(–)	-0.407	(–)	-0.445	(–)	-0.383	(–)
Fringe	ω	1.907	(–)	1.741	(–)	1.535	(–)	1.597	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		0.281	(–)	-0.474	(–)	1.584	(–)	0.963	(–)
Sam's Club		1.286	(–)	1.077	(–)	2.143	(–)	1.293	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		-1.755	(–)	-1.734	(–)	-5.245	(–)	1.335	(–)
JC Penney		-0.554	(–)	-0.451	(–)	-5.256	(–)	1.582	(–)
Kohl's		-0.657	(–)	0.030	(–)	-3.075	(–)	2.257	(–)
Macy's		-0.318	(–)	-0.431	(–)	-5.505	(–)	2.226	(–)
Neiman Marcus		-3.403	(–)	-4.408	(–)	-9.069	(–)	0.784	(–)
Nordstrom		-1.041	(–)	-0.861	(–)	-5.381	(–)	2.756	(–)
Saks Fifth Avenue		-3.944	(–)	-4.593	(–)	-8.954	(–)	1.086	(–)
Sears		-6.224	(–)	-3.679	(–)	-8.419	(–)	-1.024	(–)
Burlington		1.998	(–)	1.763	(–)	0.995	(–)	0.262	(–)
Citi Trends		1.199	(–)	0.796	(–)	-0.702	(–)	-2.199	(–)
Five Below		0.448	(–)	0.464	(–)	0.292	(–)	-0.520	(–)
Marshalls		1.058	(–)	0.791	(–)	0.430	(–)	0.019	(–)
Ross Dress for Less		2.622	(–)	2.713	(–)	2.394	(–)	1.797	(–)
T.J. Maxx		2.461	(–)	2.642	(–)	2.561	(–)	2.213	(–)
Big Lots		1.705	(–)	1.266	(–)	0.489	(–)	-0.316	(–)
Target		3.608	(–)	3.725	(–)	3.652	(–)	3.430	(–)
Walmart		5.079	(–)	4.884	(–)	4.390	(–)	3.728	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		2.923	(–)	2.714	(–)	1.304	(–)	-0.398	(–)
Dollar Tree		3.439	(–)	3.412	(–)	2.703	(–)	2.806	(–)
Family Dollar		3.239	(–)	2.860	(–)	0.888	(–)	-0.426	(–)
Random Coefficients	σ_k								
Warehouse Stores		2.843	(–)	2.834	(–)	5.166	(–)	0.000	(–)
Traditional Stores		0.050	(–)	0.022	(–)	0.000	(–)	0.000	(–)
Discount Stores		0.577	(–)	0.199	(–)	1.396	(–)	1.669	(–)
Supercenters		0.720	(–)	0.000	(–)	0.000	(–)	0.217	(–)
Dollar Stores		2.408	(–)	2.929	(–)	1.832	(–)	2.492	(–)
Summary									
Log Likelihood		-388746.2		-1673566.8		-2063706.5		-1284173.2	
Number of Visits		210,351		912,786		1,053,107		601,577	
Number of Devices		19,553		70,630		70,753		36,985	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.30: San Diego-Chula Vista-Carlsbad, CA Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.156	(–)	-0.192	(–)	-0.189	(–)	-0.242	(–)
Density	β^{d2}	0.494	(–)	0.019	(–)	0.173	(–)	0.215	(–)
Fringe	ω	0.092	(–)	0.361	(–)	0.348	(–)	0.703	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		–	–	–	–	–	–	–	–
Costco		-0.959	(–)	0.081	(–)	0.742	(–)	1.136	(–)
Sam's Club		-3.483	(–)	-2.203	(–)	-1.719	(–)	-2.582	(–)
Bloomingdale's		-0.104	(–)	1.039	(–)	0.906	(–)	1.117	(–)
Dillard's		–	–	–	–	–	–	–	–
JC Penney		-1.360	(–)	-0.155	(–)	-0.260	(–)	-0.850	(–)
Kohl's		-1.462	(–)	-0.285	(–)	-0.322	(–)	-0.395	(–)
Macy's		-1.418	(–)	0.093	(–)	-0.047	(–)	-0.652	(–)
Neiman Marcus		-3.558	(–)	-1.606	(–)	-1.966	(–)	-2.552	(–)
Nordstrom		-1.976	(–)	-0.589	(–)	-0.747	(–)	-0.450	(–)
Saks Fifth Avenue		-4.636	(–)	-3.776	(–)	-2.685	(–)	-2.271	(–)
Sears		-4.695	(–)	-2.008	(–)	-2.886	(–)	-3.425	(–)
Burlington		-1.513	(–)	-1.790	(–)	-0.717	(–)	-0.137	(–)
Citi Trends		–	–	–	–	–	–	–	–
Five Below		-5.597	(–)	-4.882	(–)	-4.352	(–)	-3.695	(–)
Marshalls		-1.731	(–)	-1.264	(–)	-0.527	(–)	0.863	(–)
Ross Dress for Less		-0.465	(–)	-0.310	(–)	0.662	(–)	1.270	(–)
T.J. Maxx		-2.249	(–)	-1.380	(–)	-0.840	(–)	0.461	(–)
Big Lots		-2.165	(–)	-2.393	(–)	-2.547	(–)	-0.384	(–)
Target		0.175	(–)	0.844	(–)	0.557	(–)	2.428	(–)
Walmart		1.166	(–)	1.638	(–)	1.309	(–)	2.585	(–)
99c Only		-0.092	(–)	0.653	(–)	0.380	(–)	0.733	(–)
Dollar General		–	–	–	–	–	–	–	–
Dollar Tree		0.201	(–)	1.016	(–)	0.900	(–)	1.520	(–)
Family Dollar		-3.090	(–)	-2.766	(–)	-2.964	(–)	-2.943	(–)
Random Coefficients	σ_k								
Warehouse Stores		0.026	(–)	0.000	(–)	0.020	(–)	1.816	(–)
Traditional Stores		0.000	(–)	1.643	(–)	2.108	(–)	0.000	(–)
Discount Stores		0.005	(–)	0.015	(–)	0.045	(–)	0.000	(–)
Supercenters		0.102	(–)	1.549	(–)	0.000	(–)	0.000	(–)
Dollar Stores		1.695	(–)	1.811	(–)	1.469	(–)	2.710	(–)
Summary									
Log Likelihood		-104410.0		-432782.9		-886064.1		-3103065.5	
Number of Visits		45,926		188,858		384,237		1,387,395	
Number of Devices		3,812		13,352		25,579		95,325	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.31: Tampa-St. Petersburg-Clearwater, FL Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.271	(–)	-0.241	(–)	-0.240	(–)	-0.238	(–)
Density	β^{d2}	0.790	(–)	0.739	(–)	0.814	(–)	0.737	(–)
Fringe	ω	1.148	(–)	1.299	(–)	1.410	(–)	1.611	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		1.409	(–)	1.554	(–)	1.820	(–)	2.191	(–)
Costco		1.688	(–)	1.963	(–)	2.396	(–)	3.209	(–)
Sam's Club		2.302	(–)	2.524	(–)	2.666	(–)	2.805	(–)
Bloomingdale's		–	–	–	–	–	–	–	–
Dillard's		-6.709	(–)	-5.047	(–)	-5.899	(–)	-5.617	(–)
JC Penney		-8.895	(–)	-5.118	(–)	-6.524	(–)	-9.783	(–)
Kohl's		-8.181	(–)	-2.579	(–)	-3.110	(–)	-4.197	(–)
Macy's		-8.092	(–)	-3.410	(–)	-4.238	(–)	-4.998	(–)
Neiman Marcus		-13.492	(–)	-6.845	(–)	-8.080	(–)	-7.966	(–)
Nordstrom		-12.467	(–)	-6.322	(–)	-7.237	(–)	-5.916	(–)
Saks Fifth Avenue		–	–	–	–	–	–	–	–
Sears		-10.777	(–)	-6.980	(–)	-8.561	(–)	-10.131	(–)
Burlington		1.279	(–)	1.452	(–)	1.478	(–)	1.531	(–)
Citi Trends		0.924	(–)	0.646	(–)	0.012	(–)	-0.306	(–)
Five Below		-2.138	(–)	-2.043	(–)	-1.810	(–)	-2.048	(–)
Marshalls		0.996	(–)	1.147	(–)	1.344	(–)	1.611	(–)
Ross Dress for Less		1.278	(–)	1.493	(–)	1.671	(–)	2.037	(–)
T.J. Maxx		0.728	(–)	0.787	(–)	1.026	(–)	1.886	(–)
Big Lots		-1.658	(–)	-0.617	(–)	-0.058	(–)	1.466	(–)
Target		0.314	(–)	1.296	(–)	2.137	(–)	3.306	(–)
Walmart		3.521	(–)	3.663	(–)	3.630	(–)	3.716	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		-0.004	(–)	0.095	(–)	-0.265	(–)	-1.177	(–)
Dollar Tree		0.598	(–)	1.471	(–)	1.450	(–)	1.430	(–)
Family Dollar		-0.352	(–)	0.098	(–)	-0.280	(–)	-0.722	(–)
Random Coefficients	σ_k								
Warehouse Stores		5.590	(–)	3.623	(–)	4.140	(–)	4.964	(–)
Traditional Stores		2.255	(–)	1.650	(–)	1.300	(–)	0.000	(–)
Discount Stores		3.011	(–)	2.333	(–)	2.325	(–)	2.402	(–)
Supercenters		0.035	(–)	0.000	(–)	0.000	(–)	0.000	(–)
Dollar Stores		0.205	(–)	0.000	(–)	0.000	(–)	0.000	(–)
Summary									
Log Likelihood		-313679.2		-2090354.3		-2886156.7		-1834122.0	
Number of Visits		156,850		1,007,931		1,368,475		861,670	
Number of Devices		13,136		67,325		81,097		48,563	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.

Table C.32: Washington-Arlington-Alexandria, DC-VA-MD-WV Metro Area — Exogenous Distance

Income Quartile		Inc. 1	Inc. 1 SE	Inc. 2	Inc. 2 SE	Inc. 3	Inc. 3 SE	Inc 4.	Inc. 4 SE
Parameter									
Distance	β^{d1}	-0.311	(–)	-0.249	(–)	-0.235	(–)	-0.325	(–)
Density	β^{d2}	0.477	(–)	0.394	(–)	0.370	(–)	0.616	(–)
Fringe	ω	0.701	(–)	0.567	(–)	0.573	(–)	1.164	(–)
Control Function	ρ	–	–	–	–	–	–	–	–
Chain Preferences									
BJ's Wholesale Club		-1.976	(–)	-0.368	(–)	-1.491	(–)	-1.502	(–)
Costco		-1.092	(–)	0.424	(–)	-0.133	(–)	0.623	(–)
Sam's Club		-2.311	(–)	-0.167	(–)	-1.283	(–)	-1.977	(–)
Bloomingdale's		0.156	(–)	0.728	(–)	0.770	(–)	0.850	(–)
Dillard's		–	–	–	–	–	–	–	–
JC Penney		-0.953	(–)	-0.966	(–)	-1.087	(–)	-1.166	(–)
Kohl's		0.242	(–)	-0.193	(–)	-0.347	(–)	-0.502	(–)
Macy's		0.492	(–)	0.072	(–)	-0.117	(–)	-0.159	(–)
Neiman Marcus		-0.474	(–)	-0.240	(–)	-0.095	(–)	0.228	(–)
Nordstrom		-0.225	(–)	-0.624	(–)	-1.054	(–)	-0.175	(–)
Saks Fifth Avenue		-1.904	(–)	-1.354	(–)	-1.300	(–)	-0.770	(–)
Sears		-3.863	(–)	-2.931	(–)	-2.750	(–)	-2.309	(–)
Burlington		0.769	(–)	0.089	(–)	-0.113	(–)	1.256	(–)
Citi Trends		1.807	(–)	0.595	(–)	0.178	(–)	1.630	(–)
Five Below		-1.356	(–)	-1.856	(–)	-1.637	(–)	0.042	(–)
Marshalls		1.127	(–)	-0.139	(–)	-0.770	(–)	0.898	(–)
Ross Dress for Less		0.976	(–)	-0.139	(–)	-0.554	(–)	0.784	(–)
T.J. Maxx		0.955	(–)	0.077	(–)	-0.136	(–)	1.418	(–)
Big Lots		-1.080	(–)	-1.033	(–)	-1.343	(–)	-0.061	(–)
Target		1.206	(–)	0.963	(–)	0.837	(–)	1.911	(–)
Walmart		2.313	(–)	1.852	(–)	1.595	(–)	1.893	(–)
99c Only		–	–	–	–	–	–	–	–
Dollar General		-0.598	(–)	-0.036	(–)	-0.319	(–)	0.373	(–)
Dollar Tree		1.195	(–)	1.128	(–)	0.932	(–)	1.922	(–)
Family Dollar		1.269	(–)	0.894	(–)	0.344	(–)	0.300	(–)
Random Coefficients	σ_k								
Warehouse Stores		0.971	(–)	0.000	(–)	0.035	(–)	1.836	(–)
Traditional Stores		1.448	(–)	0.014	(–)	0.000	(–)	1.561	(–)
Discount Stores		1.522	(–)	0.000	(–)	0.042	(–)	0.959	(–)
Supercenters		0.000	(–)	0.050	(–)	0.000	(–)	0.032	(–)
Dollar Stores		2.763	(–)	0.952	(–)	1.688	(–)	2.959	(–)
Summary									
Log Likelihood		-129736.8		-819000.4		-1891841.2		-4717278.5	
Number of Visits		58,945		369,707		866,640		2,272,060	
Number of Devices		5,398		29,092		62,717		159,427	

Note: Demand estimates using simulated maximum likelihood with 100 Halton draws per random coefficient.