# Firm Scope and the Value of One-Stop Shopping in Washington State's Deregulated Liquor Market

Boyoung Seo*

January 14, 2016

**Abstract**

Firm scope benefits consumers by allowing them to purchase multiple goods at one location like supercenters, malls, or department stores. This paper quantifies the consumer benefit of introducing one-stop shopping as a new shopping choice, and in turn, estimates the benefit to firms. I exploit an exogenous change in the allowable firm scope in Washington State, which recently deregulated the retail liquor industry to allow liquor sales in grocery stores. After deregulation, the number of liquor-selling stores is increased fourfold, and 75% of the liquor shopping has been done by one-stop shopping with groceries. Moreover, the liquor quantity sold has increased despite the increased after-tax price of liquor, implying that the choice set of shopping trips has improved. To disentangle the value of one-stop shopping from the value of reduced shopping distance due to more liquor-selling stores, I build a structural demand model of choices for shopping trips. I use household panel and retailer sales data from both before and after deregulation and extend the standard method to allow for endogenous prices to the setting where a store can have two separate qualities of grocery and liquor sections. The estimated consumer benefit of one-stop shopping is \$2.52 per trip per household, which is 8% of the household's expenditure on liquor. Selling liquor inside of a grocery store increases its grocery sales by 4.5%, and liquor sales are increased by 30% compared to being sold outside of the grocery store.

*University of Minnesota, seoxx114@umn.edu. For the latest version check my website: `https://sites.google.com/a/umn.edu/boyoung-seo`. I am greatly indebted to Amil Petrin, Thomas J. Holmes, Joel Waldfogel, and Naoki Aizawa for advice. I thank Melissa Norton at the Washington State Liquor and Cannabis Board for providing data. This research was supported by the University of Minnesota Doctoral Dissertation Fellowship.

# 1 Introduction

Firms have increasingly expanded their scope of products over time to offer consumers economies of scope in purchasing; the convenience of saving time by one-stop shopping. For example, food retailers have evolved to include pharmacies, banks, and clothing, such as Wal-Mart, providing one-stop shopping for general merchandise and groceries. However, little empirical work has been done to quantify the value of one-stop shopping.

This paper estimates the value of one-stop shopping to consumers and to stores with four different data sources. The deregulation of Washington's liquor market creates a rare environment where one-stop shopping for groceries and liquor is introduced to the consumer choice set. As part of this paper, though not the main purpose, I also analyze the welfare effects of the deregulation of policies which limit the scope of products carried by retailers. Washington privatized liquor stores in 2012 and allowed grocery stores to sell liquor. Before deregulation, consumers could purchase liquor only from state stores which did not sell groceries, but now consumers have the option of one-stop shopping for groceries and liquor. The number of liquor-selling stores has increased fourfold and 97% of this entry is from grocery stores.

The market outcomes in Washington provide qualitative evidence that the consumer choice set of liquor shopping has improved. Post deregulation, Nielsen household panel data shows that 75% of liquor shopping has been done by one-stop shopping with groceries. Moreover, state tax revenue data reveals that the quantity sold has increased despite the increase in average after-tax liquor price, due to an extra tax imposed on the liquor retailers as part of deregulation policies. These empirical facts suggest that the choice set of shopping trips has improved. However, this improvement could stem from the introduction of one-stop shopping with groceries as a new type of shopping, or from reduced distances of general liquor shopping trips due to the introduction of a large number of new liquor selling stores.

To disentangle the impact of one-stop shopping from other market outcomes of deregulation, I construct a structural demand model of choices of shopping trips where a trip consists of store choices for groceries, liquor, or both. I include extensive control variables in the model: seasonality and store-chain fixed effects by linking the store-level data from Nielsen and from the state. The value of one-stop shopping is identified by tracking consumers' switching patterns of shopping trips for groceries and liquor in response to the change in scope of offerings at grocery stores. From the household panel data, I observe where consumers purchase liquor, whether they shop for groceries at the same time, how much they paid, and demographic information. Consumers' switching to one-stop shopping after deregulation enables me to identify the value of one-stop shopping, conditional on demographics, price, and travel distance.

Even though the demand model uses a rich set of control variables, I do not observe some characteristics related to shopping, such as the quality of the store's grocery and liquor selection, promotion, and advertisement. Therefore, a common endogeneity problem in demand estimation can exist; the price coefficient is biased upward if prices are positively correlated with the unobserved characteristics. I extend the standard approach suggested by Berry (1994) and Berry et al. (1995) (henceforth BLP) to allow for endogenous prices to the setting where there are two separate unobserved shopping characteristics per choice – unobserved store qualities of grocery sections and liquor sections. Extending the BLP's method, I control for the store-grocery specific terms and store-liquor specific terms. I locate those terms by matching model-predicted market shares of grocery sales and liquor sales of each store to data. I obtain a precise measure of the market shares by linking store-level revenue data from Nielsen and from the state. It is new in the demand estimation literature to allow for two demand errors and their correlation with prices.

I find that the value of one-stop shopping is \$2.52 per trip per household, which is 8% of the expenditure on liquor, or \$4.46 per household annually. Allowing one-stop shopping contributes approximately half of the overall consumer gain from deregulation as the overall gain is \$9.35 per household in a year, which is a 55% increase in consumer surplus. The rest half of the gain stems from reduced distances of liquor shopping trips. Even though the average consumer welfare improves after deregulation, it was not Pareto improving: consumers in rural areas lose 63 cents of their consumer surplus while those in cities gain \$10.93. The reason is that rural areas have almost no increase in the number of liquor-selling stores but they face the highest increase in prices. Moreover, the gain is not distributed uniformly across consumers: consumer gains increase as population density and income level increase.

Offering one-stop shopping opportunities is also beneficial to firms. Selling liquor inside of a grocery store increases its grocery sales by 4.5% on average, and a stand-alone grocery store loses 0.5% of its grocery sales. The aggregate grocery sales remain unchanged when allowing liquor sales in grocery stores. On the other hand, liquor sales are increased by 30% if liquor sections are located inside of grocery stores, rather than being located outside. In contrast, liquor sales at a stand-alone liquor store decrease by 0.81% on average. The aggregate liquor sales increase by 20% when liquor can be sold in grocery stores. The revenue increase when adding liquor sections into a grocery store and the revenue loss in stand-alone grocery or liquor stores suggest that retailers have incentives to expand their scope of product offerings.

The convenience benefit of one-stop shopping has important implications to firms' assortment decisions or decisions on the scope of product offerings. Previous literature on firm scope has primarily focused on the supply side benefits as a motivation to expand firm scope, such as efficiency gains or cost reduction (Holmes (2001); Ellickson (2011); and Basker et al. (2012)). As a flip side of putting a new category of products into a store, this paper addresses the demand-side economies of scope, which arise from one-stop shopping convenience. Therefore, my paper opens up the discussion about the one-stop shopping benefit as a determinant of which categories of products generate the most attraction if sold under one roof.

There are several differences between this paper and previous research on one-stop shopping. Berger et al. (1996), Yuan and Phillips (2008), and Cummins et al. (2010) examine the benefits of one-stop shopping to financial firms. Their studies rely on the assumptions of firms' optimal decisions and focus on measuring the revenue raised from the variety of financial products to firms without modeling demand. Likewise, Sen et al. (2013) estimate revenue economies of scope to retailers raised by one-stop shopping for groceries and gas, but without accounting for price. In contrast, my paper directly models the demand for one-stop shopping and identifies the benefits to consumers based on consumer switching behavior in shopping. Second, most papers approximate the extent of one-stop shopping by the store size or the variety of products in a store. However, these proxies measure the *love of variety* rather than the convenience benefit of one-stop shopping. Finally, Arentze et al. (2005) study consumers' choices of one-stop shopping, which arise from complementarities between groceries and other goods, but without including prices in demand.

Consumer benefits from one-stop shopping can be interpreted as complementarities between product categories as Betancourt and Gautschi (1990) pointed out. In turn, the demand setup resembles the setup in the existing empirical studies on complementarity, such as Gentzkow (2007) and Wakamori (2015). Gentzkow's paper differs from my paper in that the choice set in his paper is small enough to have observations on demand of each choice, and some prices are zero. Wakamori's notion of complementarities is closer to the idea of a love of variety, raised within a product category (automobiles), whereas complementarities from one-stop shopping in this paper are raised in between categories (grocery and liquor).

This paper is also different from previous studies on the welfare effects of deregulation on consumers in the retail industry. Seim and Waldfogel (2013) examined the effects of privatization in Pennsylvania as a counterfactual experiment. They consider reduced travel distance due to the entry of private stores as the source of potential gains to consumers, holding price fixed. In contrast, I account for economies of scope from the expanded offerings by retailers and changes in prices in addition to store entry in the welfare analysis with the realized data.

The rest of the paper is organized as follows. Section (2) documents changes in market outcomes as a result of privatizing the retail liquor industry and describes household panel data used for the documentation. The demand model is described in Section (3). Section (4) describes store-level datasets used in demand estimation in addition to the household data. Section (5) details the identification and estimation approach used in the paper. Then, the results for estimated demand and changes in welfare from privatization are presented in Section (6).

# 2 Liquor Deregulation in Washington

## 2.1 Background

Initiative 1183 was approved in November 2011 and enacted in June 2012 to privatize liquor stores and introduce license system in Washington[1]. Prior to privatization, liquor for off-premises consumption was only sold through state stores. The number of stores had been capped by 330; 167 state-run and 163 contract stores. Washington auctioned off the state-run stores and granted the rights to the operators of the former contract stores.

There were also three primary policies implemented as part of privatization: (1) introducing 17% additional tax, leading to 37.5% effective tax on revenue, (2) requiring a minimum store size of 10,000 square feet, which is the typical size of a full-service neighborhood grocery store[2], and (3) allowing grocery stores to sell liquor.

### Change in the Number of Liquor-Selling Stores

As 83% of the existing grocery stores satisfying the minimum store size requirement started selling liquor, the number of liquor retailers increased from 330 to 1,373 by six months after privatization. Figure (1) compares store locations before and after privatization. The red dots indicate the former state stores, which have exited after privatization. The green dots indicate those which still operate. Lastly the blue dots are the entrants as of February

[1] Beer and wine sales were never regulated. The Washington State Liquor and Cannabis Board (WSLCB) uses the term spirits instead of liquor.

[2] The only exemptions are granted to the former state stores, and none of them satisfy the requirement.

2015. The number of liquor-selling stores increased in most areas, but the distribution of the increase is not uniform across urban and rural areas. I account for the distributional effects of deregulation and examine the gains and losses across areas in the results section.

Combined with the minimum store size restriction, allowing grocery stores in the liquor retail business led 97% of the new liquor-selling stores are existing grocery stores. Table (1) summarizes the change in the number of liquor stores by grocery and stand-alone liquor stores. Post privatization 80% of the stores are grocery stores, and they account for 75% of the total market share of liquor. On the other hand, there are only 20 to 40 stand-alone liquor stores besides the former state stores. The number of former state stores has been decreasing down to two third. Notice that *liquor store* in this paper refers not only stand-alone liquor stores but also grocery stores selling liquor.

#### Increase in Price and Quantity Sold

Table (2) summarizes the change in liquor price and quantity sold between a year before and a year after deregulation. The post-tax prices (consumer prices) increased from $20.71 to $23.03 on average, which is an 11% increase. Price is defined as the average post-tax price per liter weighted by liter sold, deflated in January 2006 dollars, by using the aggregate sales and quantity data from the Washington State Department of Revenue. On the other hand, the average pre-tax price (shelf price) fell from $15.02 to $14.61, which may have been the consequence of the increase in competition or efficiency gains. Despite the increase in price, liquor quantity sold also increased by 5.97%, which is equivalent to 1.75 liters per household who has purchased liquor from a store at least once a year. These empirical facts provide first pass evidence that the choice set for liquor shopping trips has improved. See online appendix for robustness of the increases in price and quantity conditional on the week, month, national trend, and brand.

### 2.2 Consumer Shopping Behavior

Following suggestive evidence from the household panel data shows that the improvement of the choice set of shopping trips can arise from two channels – *convenience* of one-stop shopping, which saves time and effort of having to find a parking spot, waiting at the checkout line, and carrying children between stores, and reduced total distance of shopping trips.

### Household Panel Data

From the Nielsen Consumer Panel dataset, I describe consumer's shopping behavior for groceries and liquor. Each year about 1,500 registered panelists in Washington logs every store visit and purchase from the store, including store, visit date, products purchased, quantity purchased, and the price paid. The panelists are given a device to scan each product purchased and manually enter the quantity and price into the device. About one-third of these panelists purchase liquor at least once each year. The dataset also provides the panelist's demographics, including home zip code, income, race, education, and the number of children under 7. Zip code is used to measure the travel distance to the store. Even though each store is given a unique ID by Nielsen, the actual store location is masked in the dataset. Therefore, I approximate the distance by assuming that the panelist visited the closest store conditional on matching the store type. Online appendix describes how the distance is derived, how grocery and liquor shopping trips are defined as well as summary statistics of the panelists.

### Switching to One-Stop Shopping

After privatization, 75% of the liquor shopping is done by one-stop shopping with groceries. Conditional on purchasing liquor, Table (3) summarizes share of shopping trips by type: liquor-shopping-only (L only), grocery and liquor shopping at two stores (GL2), and grocery and liquor shopping at one store (GL1), which is one-stop shopping. The one-stop shopping received zero shares before privatization because it was not an available option. By tracking consumers' choices of shopping trips in the data, I observe 65% of the households who used to choose GL2 the most before privatization switched to GL1 after. Similarly, 60% of the households who chose L only the most before switched to GL1 after. Moreover, given that a stand-alone liquor store is less than 0.1 miles away from a grocery store which also sells liquor, 86% of the times consumers chose one-stop shopping at the grocery store. All these pieces of empirical evidence show that *convenience* of making fewer stops is the important margin which led to switches to one-stop shopping.

### Reduced Shopping Trip Distance

Due to the increase in liquor-selling stores, the average distance to the closest liquor store from zip code is reduced by 0.33 miles (0.19 in median), which is a 19% decrease (17%), shown in Table (4). Distance between a zip code and a store is derived by averaging distance between each census block within the zip code and the store, weighted by the population of the block. It suggests that reduced distance to a liquor store is another potential channel of the consumer gains from deregulation. The table also shows that the reduction in distance is not evenly distributed across the state because the increase number of stores is not evenly distributed; the higher the population density, the larger the percentage decrease in distance to the closest liquor store.

By using the household panel data, I compare the total trip distance conditional on shopping for groceries and liquor in Table (5). Before privatization purchasing groceries and liquor in a given day required traveling 8.5 miles on average, which is the triangular distance between home, a store for groceries, and another store for liquor. After privatization, it takes 6.9 miles to purchase groceries and liquor, mainly because one-stop shopping is only 6.3 miles long on average. In other words, consumers save 35% of the trip distance (27% in median) by switching from shopping at two stores before privatization to one-stop shopping after. The reduced distance of one-stop shopping stems from avoiding traveling between a store for groceries and another store for liquor, which were 3.8 miles apart on average (2.11 in median).

In summary, the above evidence shows that there are two possible avenues through which consumers gain from deregulation: one-stop shopping and reduced distance. To disentangle these two effects, I build a structural demand model and apply the household panel data.

# 3 Model

A market is defined as a week. Each week consumer $i$ considers a shopping trip for groceries, liquor, or both. Let the set of all stores be $S \subset \mathbb{N} \cup \{0\}$. A trip choice is defined as a 2 by 1 vector of store pair $j = (g, \ell)$, which is an element of $T \subset S \times S$, where $g$ indexes a store choice for grocery purchase and $\ell$ indexes a store choice for liquor purchase. $T$ only includes the subset of possible trips that consumers could make and includes $(\cdot, 0)$ for the choices of *not shopping for liquor* and $(0, \cdot)$ for the choices of *not shopping for groceries*. For example, if store 1 only sells liquor, then $(0, 1) \in T$ and $(1, 0) \notin T$. Before privatization, available choices were no shopping where $j = (0, 0)$; shopping at a grocery store $g$ for groceries only ($G$) where $j = (g, 0),\ g > 0$; shopping at a liquor-selling store $\ell$ for liquor only ($L$) where $j = (0, \ell),\ \ell > 0$; or shopping at two separate stores for groceries and liquor ($GL2$) where $j = (g, \ell),\ g \neq \ell,\ g, \ell > 0$. After privatization, a new choice, shopping at one store for both groceries and liquor ($GL1$) where $j = (g, \ell) - g = \ell,\ g, \ell > 0$ – is added to the choice set.

Consumer $i$ receives the utility $u_{ij}$ from choosing a trip $j = (g, \ell)$. $u_{ij}$ is defined by

$$\begin{aligned} u_{ij} &= \delta_j + \Gamma_j + \mu_{ij} + \varepsilon_{ij} \\ \delta_j &= \lambda \delta_g^G + (1-\lambda)\,\delta_\ell^L \\ \delta_0^G &= \delta_0^L = 0. \end{aligned} \tag{1}$$

The first two terms $\delta_j$ and $\Gamma_j$ are choice specific and do not vary by consumer. $\delta_j$ is defined by the convex combination of the quality of groceries $\delta_g^G$ at the store chosen for groceries $g$ and the quality of liquor $\delta_\ell^L$ at store $\ell$. The weight parameter is $\lambda$. The subscripts $g$ and $\ell$ indicate stores, and the superscripts $G$ and $L$ indicate the product categories – groceries and liquor, respectively. If groceries are purchased at store $g$, the consumer receives $\delta_g^G$ with weight $\lambda$. Likewise, if liquor is purchased at store $\ell$, then the consumer receives $\delta_\ell^L$ with weight $1-\lambda$. Grocery-shopping-only trip yields $\delta_j = \lambda\delta_g^G$ and liquor-shopping-only trip yields $\delta_j = (1-\lambda)\,\delta_\ell^L$. $\Gamma_j$ contains the fixed effects for the type of choices. The consumer-trip specific term $\mu_{ij}$ includes demographics and interaction of price and income. $\varepsilon_{ij}$ is assumed to be i.i.d. across consumers and choices and follows Type 1 Extreme Value distribution.

The store-grocery and store-liquor specific utilities, $\delta^G$ and $\delta^L$, are defined by

$$\begin{aligned} \lambda\delta_g^G &= -\alpha_0 p_g^G + X_g'\beta + \xi_g^G \\ (1-\lambda)\,\delta_\ell^L &= -\alpha_0 p_\ell^L + X_\ell'\beta + \xi_\ell^L \end{aligned} \tag{2}$$

$\lambda\delta_g^G$ consists of price $p_g^G$, other observed characteristics $X_g^G$, and unobserved (to econometricians) characteristics $\xi_g^L$ and the same applies to $(1-\lambda)\,\delta_\ell^L$. $p_g^G$ is the price index for groceries at store $g$ and $p_\ell^L$ is the price index for liquor at store $\ell$. When choosing $j = (g, \ell)$, the consumer faces prices $p_j = p_g^G + p_\ell^L$ if both groceries and liquor are purchased, $p_j = p_g^G$ if only groceries are purchased, and $p_j = p_\ell^L$ if only liquor is purchased. The price coefficient $\alpha_0$ measures the base marginal utility of income. $\beta$ is a vector of coefficients of the observed store characteristics $X_g^G$ and $X_\ell^L$. These characteristics include 13 season-varying quarter fixed effects and the fixed effects for 40 store-chain brands, controlling for heterogeneity in liquor or grocery quality across store-chain brands. Two unobserved qualities to econometricians in my setting – one for groceries $\xi_g^G$ and the other for liquor $\xi_\ell^L$ – may include advertisements, assortment size, and product selection specific to grocery or liquor sections of the store. If these unobserved qualities are positively correlated with prices, then the estimate of $\alpha_0$ is biased upward. I ultimately instrument for prices by modifying the standard trick suggested by Berry (1994) and Berry et al. (1995) (BLP) in Section (5).

The choice specific constant term $\Gamma_j$ contains the fixed effects for types of trip choices. Letting $G$ be the left-out choice, $\Gamma_j$ is defined as

$$\Gamma_j \;=\; \gamma_{GL1}\;\{GL1\}_j + \gamma_{GL2}\;\{GL2\}_j + \gamma_L\;\{L\}_j$$

where $\{\cdot\}_j$ is an indicator variable of type of choice $j$. *Convenience* of one-stop shopping is given by the difference between $\gamma_{GL1}$ and $\gamma_{GL2}$. Households with young children may have different preference towards one-stop shopping; one-stop shopping reduces hassle for parents to get the children in and out of the car multiple times. As an extended model, I allow the fixed effects to interact with an indicator variable of young children under 7, $k_i$:

$$\Gamma_j \;=\; \left(\gamma_{GL1} + \gamma_{GL1}^k k_i\right)\{GL1\}_j + \left(\gamma_{GL2} + \gamma_{GL2}^k k_i\right)\{GL2\}_j + \left(\gamma_L + \gamma_L^k k_i\right)\{L\}_j.$$

If a household has at least one young child, the value of one-stop shopping is $\gamma_{GL2} + \gamma_{GL2}^k - \left(\gamma_{GL1} + \gamma_{GL1}^k\right)$.

$\mu_{ij}$ varies across consumers, and it is specified by

$$\mu_{ij} \;=\; \sum_{b=2}^{4} \alpha_b p_j\;\{b\}_i - \beta_d d_{ij} + Z_i' \beta_z.$$

Consumers are assumed to have different price sensitivities, varying by their income levels. $\{b\}_i$ is an indicator variable for whether $i$'s income level belongs to the income bin $b$ where $b = 1$ is the base income bin. A consumer in the base income bin has the marginal utility of income $\alpha_0$ whereas a consumer in a higher income bin has the marginal utility of income $\alpha_0 - \alpha_b$. $d_{ij}$ indicates the total trip distance in miles. If a trip was made to two stores, then $d_{ij}$ measures the distance of the triangular path between home, the grocery store, and the liquor store. Otherwise, it is a round trip distance to the store. $\beta_d$ measures disutilities from traveling. $\beta_z$ is the vector of coefficients for demographics $Z_i$ which control for race and education.

This model nests a standard demand model of single store choice; by removing the option of shopping for multiple purposes either at one or more stores, i.e. all $\gamma$'s equal 0, the model is reduced to a single store choice demand. Specifically, $\lambda = 1$ reduces the model to a single store choice for grocery shopping, whereas $\lambda = 0$ reduces the model to a single store choice for liquor shopping.

Let $J^G$ and $J^L$ be the number of grocery and liquor-selling stores, respectively. Given some $\lambda$, define $\boldsymbol{\delta}^*$ is defined as $\left(\lambda\delta_1^G,\ ...,\ \lambda\delta_{J^G}^G,\ (1-\lambda)\,\delta_1^L,\ ...,\ (1-\lambda)\,\delta_{J^L}^L\right)$, which is a vector of length $J^G + J^L$. $\theta$ is defined as $\left((\alpha_b)_{b=2,\ \ldots,\ 4}, \beta_d, \beta_z, \lambda\right)$, which is comprised of the parameters outside of $\delta_g^G$ and $\delta_\ell^L$. The market share of choice $j = (g, \ell)$ is derived by aggregating the individual probability of choosing $j$:

$$s_j(\boldsymbol{\delta}^*; \theta) \;=\; \int \frac{exp\left(\delta_j + \Gamma_j + \mu_{ij}\right)}{1 + \sum_{j' \in T \setminus \{(0,0)\}} exp\left(\delta_{j'} + \Gamma_{j'} + \mu_{ij'}\right)} di. \tag{3}$$

# 4 Data

In addition to the household level data described in subsection (2.2), two store-level datasets are used for demand estimation. From the WSLCB, I obtained quarterly store-level liquor sales revenue from both before and after the deregulation to construct the market shares of liquor, which help controlling the correlation between price and unobserved store quality. For pre-privatization, the dataset also includes retail prices, which are used to create the liquor price index[3]. The liquor price index is defined by the quarterly average quantity-weighted-prices for 1.75 liters of liquor, which is the median quantity purchased per trip per every quarter, observed from the household data. The last column in Table (6) shows the average and standard deviation of the liquor price index. Moreover, the state stores' wholesale prices and operational costs, including: wages, benefits, rents, etc., are given by the data, and I use those costs to calculate the retail surplus without estimating the costs as in Miravete et al. (2014). Finally, locations of all grocery and liquor stores before and after, are used to derive shopping trip distance alongside with zip code information from the household panel data.

The Nielsen Retail Scanner dataset provides the price and quantity of every product sold in four major grocery chain stores, two major discount chain stores, and two drug chain stores in Washington. All establishments whose parent company belongs to the Nielsen chain stores are included in the dataset, and I designate these stores as *Nielsen-affiliated stores*. They account for 50% of the liquor sales and at least 48% of the grocery sales in Washington (Lazich and Burton (2014)). Out of 679 Nielsen-affiliated stores, 676 all started selling liquor in June 2012. From this dataset I construct market shares of groceries and grocery price index before and after, as well as liquor price index after. The grocery price index is the sum of the average sales-weighted-prices of the 11 most commonly purchased products per quarter[4]. Table (6) summarizes grocery price index before and after.

[3] Since liquor prices before privatization were set uniformly every month by the WSLCB, technically there was no price variation across stores. However, the difference in product selection across stores generates variation in liquor price index among the state stores.

[4] See online appendix for details.

For the non-Nielsen-affiliated stores, I use the household data to construct the price index and market shares of groceries before and after and price index of liquor after. All panelists are included in the analysis even if some did not purchase liquor during the sample period because they still affect the demand for groceries.

The sample period runs from 2011 to 2013. Since the sales and price data is defined by quarter, I assume that the weekly market shares and price indices remain the same within a quarter. There are about 600 grocery stores observed as visited by the panelists both before and after deregulation whereas the observed liquor stores in the household data is increased from 104 before and 229 after. The average number of trip choices observed in the data per quarter is 797 before and 849 after deregulation. I treat the pair of stores which were never chosen by the panelists as part of outside option to ensure the manageable size of the choice set. The first column of the Table (6) shows that grocery-shopping-only type of choices are chosen most frequently. The two-store choice previously had the second largest trip shares but it has shifted to the one-stop shopping.

# 5 Identification and Estimation

## 5.1 Allowing for Endogenous Price

If prices are positively correlated with either of the unobserved store qualities $\xi_g^G$ or $\xi_\ell^L$, ignoring this correlation will lead to upwardly biased estimates of the price parameter, making consumers look less price sensitive than they are. For example, qualities of grocery and liquor selections which econometricians do not observe can be positively correlated with prices. In addition, stores' promotions and advertisements can also have positive correlation with prices if stores increase prices due to advertisement cost. On the other hand, it is possible that the promotional activities are negatively correlated with prices if promotions include price discounts, biasing the price coefficient downward.

To address endogenous prices in nonlinear demand, I extend the standard approach from Berry (1994) and Berry et al. (1995) (BLP) to the setting, which allows up to two unobserved qualities – store characteristics of grocery sections and liquor sections – for each store. Extending the BLP's idea to this setting, I control for the store-grocery and store-liquor specific terms – $\delta_g^G$ and $\delta_\ell^L$ – so that the correlation between prices and unobserved qualities is buried inside of those terms. I modify the BLP's method to locate those two terms by matching the model's predicted shares of grocery sales and liquor sales to the shares observed in the data through a contraction mapping operator which is tweaked based on the operator used in the BLP papers. The precise measure of stores' market shares for grocery sales and for liquor sales is obtained from the WSLCB and Nielsen dataset.

Let $\boldsymbol{\delta} = \left(\delta_1^G,\ ...,\ \delta_{J^G}^G,\ \delta_1^L,\ ...,\ \delta_{J^L}^L\right)$ be a vector of length $J^G + J^L$, which is the stacked up store qualities of groceries and liquor without weight $\lambda$ unlike $\boldsymbol{\delta}^*$. Given any $\lambda \in [0,1]$ and $\theta$, I prove that the following operator $f$, the modified operator of BLP, has a unique fixed point $\boldsymbol{\delta}(\theta)$ which matches the model-predicted market shares of grocery sales and liquor sales for each store, $\boldsymbol{s}(\boldsymbol{\delta}^*;\theta)$, to the market shares in the data:

$$\begin{aligned} f &: R^{J^G+J^L} \rightarrow R^{J^G+J^L} \\ f(\boldsymbol{\delta}) &= \boldsymbol{\delta}^* + log\left(\boldsymbol{s}^{\text{data}}\right) - log\left(\boldsymbol{s}(\boldsymbol{\delta}^*;\theta)\right) \end{aligned} \tag{4}$$

where $s_g^{\text{data}}$ is the observed market shares of groceries across $J^G$ grocery stores and shares of liquor across $J^L$ liquor-selling stores. Appendix (A) provides a proof that $f$ is a contraction mapping with modulus less than 1. The operator $f$ in (4) is different from the BLP's operator in two ways. First, while the BLP's operator identifies choice-specific constant, the operator $f$ identifies the store-specific constant for groceries and for liquor. Second, the formulation of $f$ in (4) includes the weighting parameter $\lambda \in [0,1]$ to guarantee the existence of the unique fixed point. One part of the BLP's proof requires that the inside share should be less than 1 so that there exists a unique $\boldsymbol{\delta}$ at which the predicted shares match with data. However, in my setup, there are two inside shares, one for groceries and the other for liquor, and the sum of those inside shares is not necessarily less than 1. By formulating $\delta_j = \lambda\delta_g^G + (1-\lambda)\,\delta_\ell^L$, the weighting parameter $\lambda$ guarantees that $f$ is a contraction and has a unique fixed point that matches predicted market shares with data.

Once parameters $\theta$ are estimated while holding fixed store-specific constant for groceries and liquor, the resulting $\boldsymbol{\delta}^*(\theta)$, which is linear in price and unobserved store qualities, is then regressed on its arguments with instrumented price to control for the potential endogeneity.

## 5.2 Estimation

Let the market be indexed by $t$. The first step parameters $\theta$ are estimated by maximizing the log likelihood function,

$$\max_\theta\ log\ L(\theta) = \sum_t \sum_j \sum_i\ w_{it}\ Y_{ijt}\ log\ s_{ijt}\left(\boldsymbol{\delta}_t^*(\theta), \theta\right) \tag{5}$$

where $w_{it}$ is the weight on each household $i$ within a market $t$ and $Y_{ijt} = 1$ if $i$ chose $j$ in week $t$ and 0 otherwise. At each iteration of nonlinear parameter search, $\boldsymbol{\delta}_t^* (\theta)$ is identified by using the contraction mapping in (4).

Given the estimated $\hat{\theta}$ and $\boldsymbol{\delta}^* \left(\hat{\theta}\right)$ from the first step, marginal utility of income, $\alpha_0$, is estimated in the second step by using the system of equations in equation (2):

$$\begin{aligned} \boldsymbol{\delta}^{*G} &= -\boldsymbol{p}^G \alpha_0 + \boldsymbol{X}^G \beta + \boldsymbol{\xi}^G \\ \boldsymbol{\delta}^{*L} &= -\boldsymbol{p}^L \alpha_0 + \boldsymbol{X}^L \beta + \boldsymbol{\xi}^L \end{aligned} \tag{6}$$

where the dependent variable $\boldsymbol{\delta}^{*G}$ is the first $J^G$ elements of $\boldsymbol{\delta}^*$, which is a stacked vector of $\lambda \delta_g^G$. $\boldsymbol{\delta}^{*L}$ is the rest of the elements of $\boldsymbol{\delta}^*$, which is a stacked vector of $(1-\lambda)\,\delta_\ell^L$. $\boldsymbol{p}^G$, $\boldsymbol{X}^G$, and $\boldsymbol{\xi}^G$, respectively, are stacked vectors of $p_g^G$, $X_g^G$, and $\xi_g^G$. The same is applied to $\boldsymbol{p}^L$, $\boldsymbol{X}^L$, and $\boldsymbol{\xi}^L$. The effects of store-chain brands and seasons with respect to grocery products are allowed to be different from those with respect to liquor products. I use the average price of other stores outside of a 5-mile radius of a store as an instrument, similar to Hausman (1996)'s. The price coefficient is identified by assuming that the statewide supply side cost, such as wholesale price, distribution cost, or wage, is correlated with price but it is uncorrelated with the local store quality or promotions, conditional on store-chain brand and seasons in $\boldsymbol{X}^G$ and $\boldsymbol{X}^L$.

Standard errors are derived by adjusting the overall number of observations. Weights between the first step moment condition (the score of MLE) and the second step moment from (6) are determined according to Arellano and Meghir (1992) since the observations for the likelihood function are from the distribution of households while those for the linear equation are from the distribution of grocery and liquor stores.

# 6 Results

## 6.1 Demand Results

Table (7) shows the nonlinear demand estimates of the first step. The estimates represent the marginal effects on utility, not on purchasing probability. The first column is the model specification where the fixed effects for type of choices are not interacted with the indicator variable for whether there is at least one young child whereas second column allows the interaction. The fixed effects for type of choices in each specification reveal that the most preferred shopping is grocery-shopping-only ($G$), followed by one-stop shopping ($GL1$) and grocery and liquor shopping at two stores (*GL*2). This order of preference lines up with the order of trip shares in Table (6). It is reasonable that *G* type is most preferred since two third of the consumers do not buy liquor at all during the sample period. Conditional on purchasing liquor, one-stop shopping is most preferred. That is, consumers value the *convenience* of one-stop shopping. The average difference in utility from two-stop and one-stop shopping for households with children (0.8) is twice larger than that for other households with no young children (0.4). It implies that switching from two-stop to one-stop shopping increases utility more when shopping with young children than without children.

Consumers also value their time and dislike traveling longer distances. If a trip's total distance increases 1%, the probability of choosing that trip decreases 1.7%. The estimated weight between quality of groceries and liquor, $\lambda$, still lies between 0 and 1 without imposing the restriction. Consumers with income of $35,000 or more are slightly less elastic to price than those with less than $35,000 of income. This result is consistent with findings of previous works. For example, Goolsbee and Petrin (2004) showed that price elasticities decreases as household income increases. Race and education are also important factors in determining shopping probability.

Table (8) contains the results of the second stop estimation on $\alpha_0$. The first two columns are OLS results and the last two columns are 2SLS results. The price coefficients are almost identical whether trip type fixed effects are interacted with young children indicator. The estimated price coefficient without instrumenting price is overestimated (biased upward) by six times compared to the instrumented price coefficient. This implies that, after controlling for the store chain and seasonality, there is still correlation between price and unobserved store qualities of groceries and liquor. Based on the instrumented price coefficient with the base specification, -0.23, the mean elasticity with respect to the liquor basket price at own store is about -8.34. This is consistent with the literature on store choice model. For example, Smith (2004) found that store level own price elasticities for supermarkets lie between -7 and -9. Furthermore, by translating the nonlinear parameters into dollar values from the marginal utility of income $\alpha_0$, the estimated travel cost per mile is about $1.76. This is the consumer's willingness to pay to reduce a given trip's distance by one mile[5]. The estimated travel cost is also consistent with the literature to what others have found. For example, Seim and Waldfogel (2013) estimated travel costs of $1.01 per mile.

Switching from *GL*2 type of shopping before privatization to one-stop shopping after can benefit consumers through two channels. First, *convenience* of *GL*1 compared to *GL*2

[5]See Chapter 3 in Train (2009).

translates to \$1.65: a consumer must be compensated by \$1.65 to be indifferent between $GL1$ and $GL2$ types of trips with exactly the same price, distance, store quality. This is equivalent to 5% of the average expenditure on liquor per shopping trip. Second, the gains from reduced distance (1.57 miles) realized by switching from $GL2$ to $GL1$ is \$2.77, holding all other trip characteristics constant. Combining the gains from these two channels, consumers gain \$4.42 when switching from a $GL2$ trip before privatization to $GL1$ after, holding all other characteristics constant, and *convenience* accounts for 37% of such gains. This exercise assumes the choice is fixed.

## 6.2 The Benefit of One-Stop Shopping to Consumers

To measure the value added by one-stop shopping to consumers who shop for liquor, I select households which purchased liquor at least once in the given year and normalize utility components from grocery shopping to be 0. The value of one-stop shopping, *convenience*, is derived by simulating consumer surplus with and without the one-stop shopping option in the shopping choice set, holding all other variables constant: distance, price, a total number of liquor stores, store brand, and store quality. In other words, I disentangle the gains of one-stop shopping from other potential gains from increased number of liquor-selling stores and from potential loss from increased price. This exercise is different from subsection (6.1) because consumers can switch to other choices. I use the estimates of the base model without children interaction but the results are almost identical if the extend model estimates are used.

First of all, the per-trip value of *convenience* by one-stop shopping is \$2.52, which is about 8% of the expenditure on liquor per trip. Column "One-Stop Shopping" in Table (9) summarizes the compensating variation for banning one-stop shopping; the monetary compensation given to consumers such that they are indifferent between the realized economic environment after privatization and the counterfactual environment where grocery stores are not allowed to sell liquor. The counterfactual experiment assumes that the liquor sections inside of grocery stores are relocated right next to those stores, holding fixed prices and qualities. On average, a household is willing to pay \$2.52 per liquor shopping trip to have an option of one-stop shopping or \$4.46 annually. On average, households with young children value the one-stop shopping convenience by \$5.23 while those without young children value the convenience by \$4.58. By allowing one-stop shopping, consumers gain aggregate 4.5 million dollars in a year. This gain is a 31% increase of consumer surplus.

Second, deregulation expands the choice set of shopping trips through two margins: the introduction of one-stop shopping as a new type of trip and reduced travel distance due to the increased number of liquor selling outlets. The following exercise derives the benefits from increased number of stores. I first simulate the consumer surplus where the total number of stores is capped at the same as before privatization to estimate the value generated by the influx of stores, possibly through a reduction in trip distance. The counterfactual assumes that there are only 330 stores, which are the top 330 stores by their market shares of liquor sales in 2013, and their store characteristics remain fixed. Column "Reduced Distance" in Table (9) shows that a household's valuation of the increased number of stores is \$3.36 per liquor shopping trip or \$5.85 per year on average, which is equivalent to 45% increase of consumer surplus. Thus, the value of *convenience* of one-stop shopping is about two-thirds of the value of the reduced distance, which is consistent with the simple exercise in subsection (6.1).

Third, I evaluate the gross gains of expanded choice set for shopping trips holding price constant. Holding price constant, the gross gains from deregulation is derived by the compensating variation between the economic environment after privatization and the counterfactual environment where one-stop shopping is not allowed and the total number of stores is limited to 330, holding all other variables fixed. This compensating variation is reported in column "Combined Gains" and reveals how much consumers gain from the expansion of the choice set. Holding price constant, deregulation benefit a household \$5.32 per liquor shopping trip or \$9.35 annually on average. The value of *convenience* accounts for approximately 37 to 47% of this benefit from deregulation.

Fourth, I estimate the costs from increased price. The compensating variation between the benchmark economy setup before privatization and the world where prices are increased as 11% without any benefit of improved choice set is \$1.56 per household per liquor shopping trip or \$2.86 per year. The increase in price reduces the consumer surplus by 21%.

Finally, the overall gain from deregulation is \$3.86 per household per liquor shopping trip or \$6.70 per year. This gain is equivalent to a 56% increase of the consumer surplus compared to 2011. This is a net gain from the the combined effects – the increased price and expansion of the choice set, which is led by one-stop shopping and the increased number of stores. The value added by one-stop shopping is equivalent to two-thirds of the net gain from deregulation.

## 6.3 The Benefit to Stores by Expanding the Scope

The consumer benefit of one-stop shopping has implications to stores' sales revenue. If a store sells both groceries and liquor, it attracts more consumers and more frequent visits to the store, and in turn, raises the store revenue. In this subsection, I compare grocery sales in 2013 to those in the counterfactual world where grocery stores are not allowed to sell liquor, holding all other factors constant. It is the same experiment as shutting down all liquor sections inside of grocery stores and placing those liquor sections adjacent to the grocery stores without sharing the same roof. Selling liquor inside of grocery stores increases grocery sales by 4.5% on average. On the other hand, stand-alone grocery stores lose 0.5% of its grocery sales on average. Standard deviations are reported in Table (10). Overall grocery sales remain almost unchanged, implying that the sales increase in grocery stores selling both product categories is mainly due to business stealing from those not selling liquor. This result is sensible because most grocery stores arise from "groceries only" type of shopping, which has no connection with liquor shopping, and therefore, allowing liquor sales in grocery stores or not has little impact on aggregate grocery sales.

Table (11) describes the change in liquor sales when stores are allowed to accommodate both groceries and liquor. Liquor sales are increased by 30% on average if liquor sections are located inside of a grocery store, rather than being located outside. Approximately one-third of the increase is due to the business stealing effect from other stand-alone liquor stores, which lose 0.81% of their liquor sales. The aggregate liquor sales are increased by 20%. This increase in liquor quantity sold in stores does not imply that total liquor consumption is increased; consumers could have substituted liquor purchases at bars or restaurants for the on-premises consumption, which are considered as an outside option in this paper's setup, with purchases at stores for the off-premises consumption. See the online appendix for more details.

This result suggests that there is a strong incentive for a store to expand their scope of product offerings because it raise sales revenue and it also prevents from losing sales revenue. If the incentive exists for other combination of product categories, such as general merchandise and groceries, some retailers with resources could potentially grow larger and the others, especially specialty shops, may exit the market, leading to a concentrated market structure similar to the current retail industry.

## 6.4 Distribution of Consumer Gains from Deregulation

Even though a household benefits \$3.86 per trip or \$6.70 per year from deregulation on average, it is not Pareto improving; there are some consumers who lose after deregulation. Moreover, among the consumers who are better off, the gains are not distributed uniformly across demographics and density of the area. Table (12) summaries distribution of the annual consumer gains. The zip code areas where per square mile density is less than 83 people lose the most: the consumer surplus decreases by 63 cents, which is a 34% decrease on average. This is because reduced travel distance in rural areas is not big enough to compensate for the increase in price in those areas. In addition, consumers in areas where the median income is less than \$35,000 lose 1.14% of the consumer surplus. The rest of the demographical groups benefit from deregulation but at a different rate. Gains increase with population density, income, and non-Caucasian population. The distribution of gains is also consistent with data observations on the distribution of the number of liquor stores, price increase, and decrease in distance in the online appendix. Moreover, the percentage gain for consumers with young children is twice as large as that for consumers without children. This result is consistent with the fact that $\gamma_{GL2} - \gamma_{GL1}$ for consumers with children is twice higher than that for consumers without children. On the other hand, the level of gain for consumers with children is lower than the others because households with children generally dislike liquor shopping more than those without children.

One-stop shopping and the increased number of liquor stores also have different impacts across consumers. Table (13) shows the percentage change in consumer surplus by demographics under different counterfactual experiments. Column "One-Stop Shopping" shows that the gains from one-stop shopping are relatively uniformly distribution across area density, income, and race. In contrast, the effect of more stores in column "Reduced Distance" is disproportionate to different demographic groups.

## 6.5 Total Welfare Change From Deregulation

After privatization the total welfare in liquor industry increases by 34 million dollars or \$34 per household (including non-liquor purchasers) per year, a 15% increase. The welfare change between 2011 and 2013 is presented in Table (14). Among all economic players, the government makes the most surplus both before and after privatization, and its gains are the largest. The state makes 58% more revenues due to increases in the tax rate and quantity sold. The annual consumer surplus increases by \$6.70, which is a 55% increase. The retailer surplus in 2013 is derived by change in profits, assuming that the marginal cost remains unchanged since 2011[6]. Negative retailer surplus in 2013 suggests that the marginal cost or markup must have decreased, since retailers have the option to exit the market rather than make negative profits. Therefore, the estimated total welfare can be interpreted as the lower bound. If the retailer surplus were zero, then gains from deregulation almost double to a 28% increase in total welfare.

# 7 Conclusion

While the impact of expanding the firm scope has been studied mainly on the cost side, little is known on the consumer side. Deregulation in the liquor market in Washington provides an environment where grocery stores are allowed to expand the scope of product categories to liquor. This paper exploits the change in retailer scope to evaluate the value of one-stop shopping as a consumer side mechanism of economies of scope. By using the sets of household and store level data before and after deregulation, I trace consumer's switching behavior on shopping trips before and after to separately identify the value of one-stop shopping from the other effects of deregulation, such as reduced distance, a number of stores, and price change. The value of one-stop shopping per trip per household is estimated to be \$2.52, which is 8% of the liquor expenditure. I find that the complementarities between grocery and liquor products are significant: the benefits from one-stop shopping account for 47% of the gross gains from deregulation. Moreover, if liquor is sold inside of a grocery store instead of outside, it raises grocery sales by 5% and the liquor sales are increased by 30%.

The results suggest that retailers have incentives to add more categories of products into their stores if there are enough complementarities between categories. This finding opens up the possibility that the recent trend in big box stores or supercenters may have been motivated to raise revenue by offering one-stop shopping convenience. Moreover, the implication that some retailers accommodate a wide range of assortment while the specialty shops exit the market is consistent with the concentrated market structure of both on-line and off-line retail industries.

The framework in this paper can be applied to study the consumer side motivation for expanding firm scope. It identifies complementarities between combinations of products and sheds light on firm scope decision affected by consumer side economies of scope. Moreover,

[6] The retail surplus does not include the fixed cost of entering into the retail liquor industry. Since most new liquor-selling stores are existing grocery stores, the fixed cost of adding a few aisles is expected to be small.

the framework provides an identification strategy to allow for correlation between price and multiple unobserved store qualities. This framework is useful even when the store level data is limited to the marginal market share of each product category rather than the joint share of each combination of product categories. The applicable examples of this framework include measuring the consumer benefits from shopping at Wal-Mart, department stores, or a mall. Moreover, this framework can be used to find the optimal combination of product categories which generates the largest economies of scope when sold by the same firm.

The application is not limited to the retail industry: it can be applied to examine the economies of scope for occupational licensing or supply chain. Some regulations limit what an occupation can do. For example, in some states physicians are not allowed to dispense drugs. The supply chain of alcoholic beverage in the U.S. are regulated such that a firm can only operate in one of the three tiers; supplier, distributor, or retailer. Studying the economies of scope which arise from complementarities between occupations or firms can shed light on complementarities between different tasks and the costs of the regulations which limit the firm scope.

# References

**Arellano, Manuel and Costas Meghir**, "Female Labour Supply and On-the-Job Search: An Empirical Model Estimated Using Complementary Data Sets," *The Review of Economic Studies*, 1992, *59* (3), 537–559.

**Arentze, Theo, Harmen Oppewal, and Harry J.P. Timmermans**, "A Multipurpose Shopping Trip Model to Assess Retail Agglomeration Effects," *Journal of Marketing Research*, 2005, *42* (1), 109–115.

**Basker, Emek, Shawn Klimek, and Pham Hoang Van**, "Supersize It: The Growth of Retail Chains and the Rise of the "Big-Box" Store," *Journal of Economics and Management Strategy*, 2012, *21* (3), 541–582.

**Berger, Allen N., David B. Humphrey, and Lawrence B. Pulley**, "Do consumers pay for one-stop banking? Evidence from an alternative revenue function," *Journal of Banking and Finance*, 1996, *20* (9), 1601–1621.

**Berry, Steven**, "Estimating Discrete Choice Models of Product Differentiation," *The RAND Journal of Economics*, 1994, *25* (2), 242–262.

**_ , James Levinsohn, and Ariel Pakes**, "Automobile Prices in Market Equilibrium," *Econometrica*, 1995, *63* (4), 841–890.

**Betancourt, Roger and David Gautschi**, "Demand Complementarities, Household Production, and Retail Assortments," *Marketing Science*, 1990, *9* (2), 146–161.

**Cummins, J. David, Mary a. Weiss, Xiaoying Xie, and Hongmin Zi**, "Economies of scope in financial services: A DEA efficiency analysis of the US insurance industry," *Journal of Banking & Finance*, 2010, *34* (7), 1525–1539.

**Ellickson, Paul B.**, "The Evolution of the Supermarket Industry: From A&P to Wal-Mart," *SSRN Electronic Journal*, 2011, (April), 1–20.

**Gentzkow, Matthew**, "Valuing new goods in a model with complementarity: Online newspapers," *American Economic Review*, 2007, *97* (3), 713–744.

**Goolsbee, Austan and Amil Petrin**, "The Consumer Gains From Direct Broadcast Satellites and The Competition with Cable TV," *Econometrica*, 2004, *72* (2), 351–381.

**Hausman, Jerry**, "Valuation of new goods under perfect and imperfect competition," in "The economics of new goods," University of Chicago Press, 1996, pp. 207–248.

**Holmes, Thomas J**, "Bar codes lead to frequent deliveries and superstores.," *RAND Journal of Economics (RAND Journal of Economics)*, 2001, *32* (4), 708–725.

**Lazich, Ed. Robert S. and Virgil L. III. Burton**, *Market Share Reporter*, 2 ed. 2014.

**Miravete, Eugenio J, Katja Seim, and Jeff Thurk**, "Complexity , E ciency , and Fairness of Multi-Product Monopoly Pricing," 2014.

**Seim, Katja and Joel Waldfogel**, "Public monopoly and economic efficiency: Evidence from the pennsylvania liquor control board's entry decisions," *American Economic Review*, 2013, *103* (2), 831–862.

**Sen, Boudhayan, Jiwoong Shin, and K Sudhir**, "Demand Externalities from Co-Location: Evidence from a Natural Experiment," 2013.

**Smith, Howard**, "Supermarket choice and supermarket competition in market equilibrium," *Review of Economic Studies*, 2004, *71* (1), 235–263.

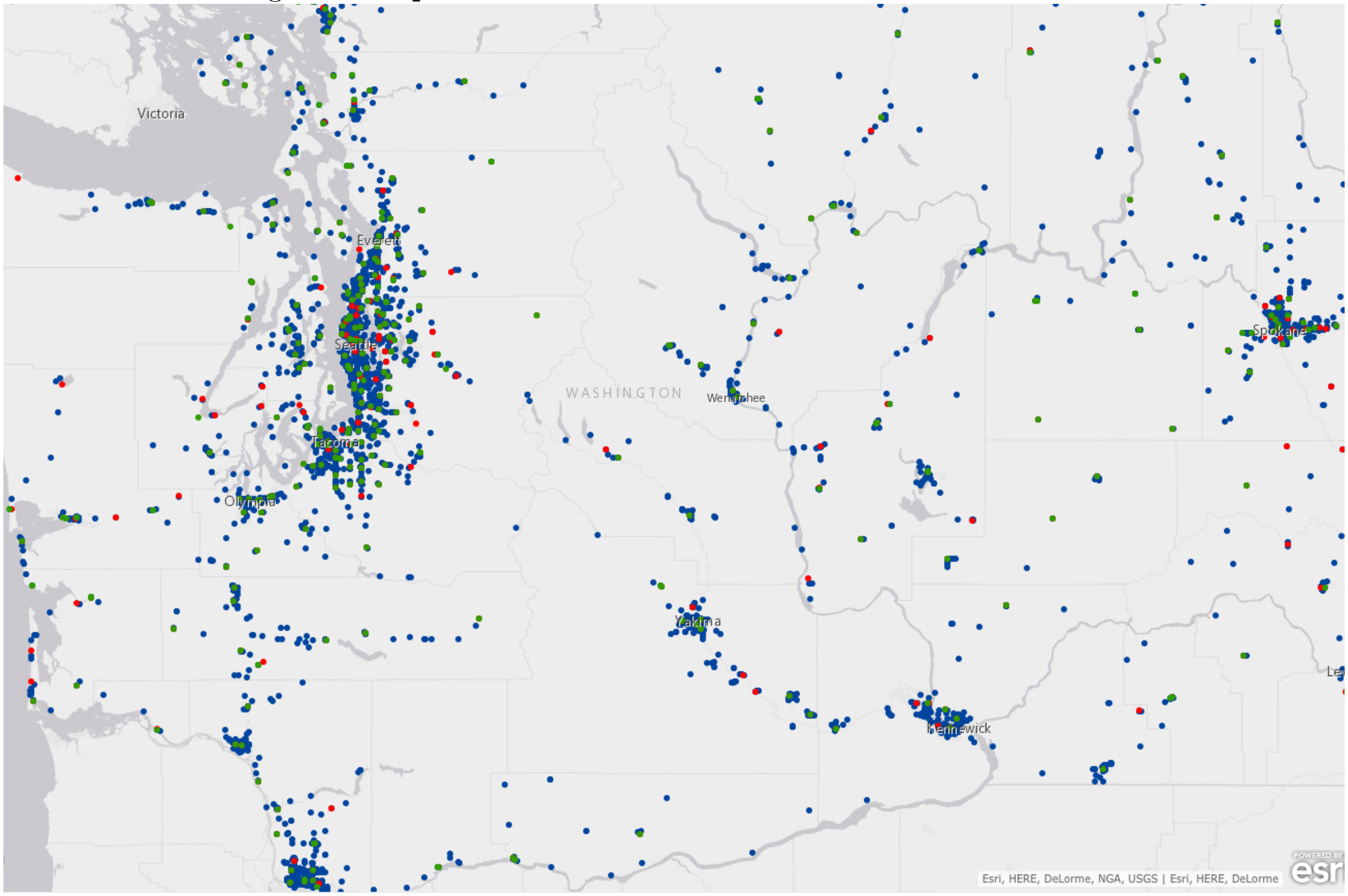
**Train, Kenneth E.**, *Discrete Choice Methods with Simulation*, Vol. 2 2009.

**Wakamori, Naoki**, "Portfolio Considerations in Automobile Purchases : An Application to the Japanese Market," *Dissertation*, 2015, *49* (499).

**Yuan, Y and Rd Phillips**, "Financial integration and scope efficiency in US financial services post Gramm-Leach-Bliley," *Journal of Banking and Finance*, 2008.

# 8 Tables and Figures

Figure 1: **Liquor Store Location Before and After**




*Notes:* The longitude and latitude was derived by using ArcGIS API from the business address given by the WSLCB dataset.

- Red: former state stores, which no longer exist, as of January 2012.
- Green: former state stores, which still exist, as of February 2015.
- Blue: new stores after privatization.

Table 1: **Number of Liquor Stores**

| Year | Total | Grocery[a] | Stand-alone[b] | |
|---|---|---|---|---|
| | | | Former State | New |
| Jan.-May 2012 | 330 | 0 | - | - |
| June-Dec. 2012 | 1373 | 1075 | 276 | 22 |
| 2014 | 1398 | 1125 | 235 | 38 |

[a] Grocery stores selling liquor

[b] Stand-alone liquor stores

*Data source:* the Washington State Liquor and Cannabis Board

Table 2: **Change in Price and Quantity Sold**

| | Before[a] | After | % Change |
|---|---|---|---|
| Post-tax price ($) | 20.71 | 23.03 | 11.20 |
| Pre-tax price ($) | 15.02 | 14.61 | -2.73 |
| Quantity sold (million liter) | 29.65 | 31.42 | 5.97 |

*Note:* Price is defined as the average price per liter weighted by liter sold, deflated in January 2006 dollars.

[a] "Before" refers to a year prior to privatization and "After" refers to a year after.

*Data source:* Spirits Tax Collections and Sales data from the Washington State Department of Revenue

Table 3: **Share of Trips by Type Conditional on Purchasing Liquor**

| Type | Trip Shares | | |
|---|---|---|---|
| | Before | After | % Change |
| GL1[a] | N/A | 0.7457 | |
| GL2[b] | 0.5005 | 0.1009 | -79.85 |
| L only[c] | 0.4995 | 0.1534 | -69.29 |
| N[d] | 2751 | 5294 | 92.44 |
| Panelists[e] | 423 | 625 | -0.60 |

*Note:* Deregulation occurred in June 2012. "Before" refers to from January 2011 to May 2012 and "After" is from June 2012 to December 2013.

[a] GL1: shopping for groceries and liquor at one store

[b] GL2: Shopping for groceries and liquor at two different store

[c] L only: Shopping for liquor only

[d] The number of observed shopping trips with liquor purchase

[e] The number of panelists who have purchased liquor at least once during the period.

*Data source:* the Nielsen Consumer Panel

Table 4: **Distance the Closest Liquor Store**

| | Upper Bound | Before | After | % Change |
|---|---|---|---|---|
| Mean | | 1.13 | 0.94 | -16.99 |
| Median | | 1.71 | 1.38 | -19.69 |
| Zip density[a] | 13 | 3.23 | 2.98 | -7.59 |
| | 116 | 2.18 | 1.84 | -15.49 |
| | 1185 | 1.71 | 1.32 | -22.76 |
| | Above | 1.14 | 0.84 | -26.45 |

*Notes:* Distance between a zip code and a store is derived by averaging distance between each census block within the zip code and the store, weighted by the population of the block.
[a] The zip code density is population divided by square miles. The results do not change much if population is only 21+.

Table 5: **Trip Distance Conditional on Shopping for Grocery and Liquor**

| | Before | After | % Change |
|---|---|---|---|
| Mean | 8.51 | 6.94 | -18.45 |
| Median | 5.06 | 3.49 | -31.03 |
| Mean GL1[a] | | 6.34 | |
| Median GL1 | | 3.49 | |

*Notes:* Distance of total shopping trip in miles. Deregulation occurred in June 2012. "Before" refers to from January 2011 to May 2012 and "After" is from June 2012 to December 2013.

[a] Round trip distance of one-stop shopping for groceries and liquor

Table 6: **Trip Shares and Price per Trip Type**

| Type | Trip Shares | | Grocery Price[a] | | Liquor Price[b] | |
|---|---|---|---|---|---|---|
| | Before | After | Before | After | Before | After |
| GL1 | | 0.0545 | | 62.30 | | 25.10 |
| | | (0.0036) | | (30.03) | | (13.79) |
| GL2 | 0.0236 | 0.0090 | 70.53 | 65.78 | 32.21 | 34.41 |
| | (0.0041) | (0.0016) | (30.18) | (26.61) | (18.76) | (23.75) |
| L only | 0.0179 | 0.0081 | | | 31.86 | 32.80 |
| | (0.0038) | (0.0012) | | | (15.52) | (22.06) |
| G only | 0.9584 | 0.9283 | 61.91 | 60.43 | | |
| | (0.0073) | (0.0061) | (29.29) | (28.87) | | |

*Notes:* Mean values and standard deviation in the parenthesis. Deregulation occurred in June 2012. "Before" refers to from January 2011 to May 2012 and "After" is from June 2012 to December 2013.

[a] Price index for groceries, i.e. sum of sales weighted prices of the 11 most commonly purchased products. See online appendix.

[b] Price index for liquor, i.e. liter-sold weighted price per 1.75 liters.

Table 7: **Nonlinear Demand Estimates**

| | No Int. | Kids |
|---|---|---|
| GL1 | -4.3239 | -4.3634 |
| | (0.6827) | (0.6606) |
| GL2 | -4.7067 | -4.7655 |
| | (0.3264) | (0.5917) |
| L | -6.3008 | -6.2727 |
| | (2.5297) | (2.2314) |
| Kids*GL1[a] | | -0.8706 |
| | | (0.0622) |
| Kids*GL2 | | -1.2685 |
| | | (0.0902) |
| Kids*L | | -1.2204 |
| | | (0.0871) |
| Distance | -0.4094 | -0.4097 |
| | (0.0315) | (0.0265) |
| $\lambda$[b] | 0.3596 | 0.3601 |
| | (0.0244) | (0.0247) |
| $p$*Income1[c] | 0.0005 | 0.0005 |
| | (0.0000) | (0.0000) |
| $p$*Income2 | 0.0003 | 0.0003 |
| | (0.0000) | (0.0000) |
| $p$*Income3 | 0.0003 | 0.0004 |
| | (0.0000) | (0.0000) |
| Education[d] | -0.4035 | -0.3935 |
| | (0.0268) | (0.0261) |
| Race[e] | -0.4774 | -0.4877 |
| | (0.0346) | (0.0343) |
| Dist. Elas. | -1.874 | -1.2037 |

[a] Kids: indicator variable if there is at least one child under 7

[b] Weight on unobserved characteristics for grocery ($\lambda$) is derived without restriction of $0 \leq \lambda \leq 1$.

[c] Baseline income: less than $35,000. Income1: between $35,000 and $59,999. Income2: between $60,000 and $99,999. Income3: above $100,000.

[d] 1 if holding at least college degree, 0 otherwise

[e] The proportion of Caucasians compare to other races

Table 8: **Linear Demand Estimates**

| | OLS | | 2SLS[a] | |
|---|---|---|---|---|
| | No Int.[b] | Kids | No Int. | Kids |
| Intercept | 0.8212 | 0.8653 | 9.567 | 9.7796 |
| | (0.0718) | (0.0725) | (0.2696) | (0.274) |
| Price | -0.0452 | -0.0463 | -0.2321 | -0.2371 |
| | (0.0014) | (0.0014) | (0.0059) | (0.006) |
| Chain FX | Y | Y | Y | Y |
| Season FX | Y | Y | Y | Y |
| Mean Elas.[c] | -1.9216 | -1.9803 | -8.3366 | -8.5699 |
| Entire Elas.[d] | -0.4796 | 0.1734 | -6.5529 | -6.1869 |
| Travel Cost[e] | 7.62 | 7.44 | 1.76 | 1.73 |
| Convenience of OSS[f] | 7.13 | 7.31 | 1.65 | 1.70 |
| Reduced distance[g] | 11.96 | 11.69 | 2.77 | 2.71 |
| Total $GL2 \rightarrow GL1$[h] | 19.09 | 19.00 | 4.42 | 4.41 |

*Dependent variable:* $\boldsymbol{\delta}^*$

[a] Instrument: average price at other stores outside of the 5-mile radius of the store

[b] Fixed effects for type of choices are not interacted with kids.

[c] Elasticities with respect to the entire liquor price of own store

[d] Elasticities with respect to the liquor price in the entire state

[e] Dollar value of traveling one mile

[f] Dollar value of switching from $GL2$ before to $GL1$ after, conditional on distance, price, and other characteristics

[g] Dollar value of reduced distance (1.57 miles) by switching from $GL2$ before to $GL1$ after

[h] Total effects of switching from $GL2$ before to $GL1$ after, conditional on price and other characteristics

Table 9: **Gains from One-Stop Shopping and Reduced Distance**

| 2013 | One-Stop Shopping[a] | | Reduced Distance[b] | | Combined Gains[c] | |
|---|---|---|---|---|---|---|
| | CV | % Change | CV | % Change | CV | % Change |
| Total | 4,503 | 30.89 | 5,904 | 44.80 | 9,438 | 97.85 |
| Per hhld[d] | 4.46 | 30.89 | 5.85 | 44.80 | 9.35 | 97.85 |
| Per trip | 2.52 | 30.43 | 3.36 | 45.56 | 5.32 | 98.03 |

*Notes:* All values are in $1,000 except "Per" and "% Change" which are in $. The choice set for shopping trips is improved by (1) having the one-stop shopping option and (2) reduced distance. The benchmark economy is 2013 when one-stop shopping is allowed and entry is not limited.

[a] Grocery stores are not allowed to sell liquor under the same roof, holding prices, locations of stores, and the total number of liquor-selling stores fixed. The compensating variation is the consumer's valuation of *convenience* from one-stop shopping.

[b] The total number of liquor-selling stores is limited to 330 – the same as before privatization – so that the trip distance of liquor shopping is approximately the same as before, holding all other variables constant. One-stop shopping is allowed. The compensating variation is the value of reduced shopping distance.

[c] One-stop shopping is banned and the number of liquor-selling stores is limited to 330. The compensating variation is the total gains from the improved choice set by deregulation, holding price constant.

[d] Average annual value per household who has purchased liquor at least once in 2013. There are 1,009 thousand households who purchased liquor at least once in 2013.

Table 10: **Average Percentage Change in Grocery Sales**

| | Stand-Alone Grocery Store | Store Selling Both |
|---|---|---|
| Per store | -0.50 | 4.51 |
| | (0.01) | (0.28) |
| Aggregate Change | 0.74 | |

*Notes:* Sales weighted average percentage change in grocery sales across grocery stores. Numbers in parentheses are standard deviations.
Grocery sales in 2013 are compared to those in the counterfactual world where grocery stores are not allow to sell liquor, holding all other factors constant. It is the same experiment as shutting down all liquor sections inside of grocery stores and placing those liquor sections adjacent to the grocery stores without sharing the same roof.

Table 11: **Average Percentage Change in Liquor Sales**

| | Stand-Alone Liquor Store | Store Selling Both |
|---|---|---|
| Per Store | -0.81 | 29.27 |
| | (0.03) | (0.23) |
| Aggregate Change | 20.10 | |

*Notes:* Sales weighted average percentage change in liquor sales across liquor-selling stores. Numbers in parentheses are standard deviations.

Liquor sales in 2013 are compared to those in the counterfactual world where grocery stores are not allow to sell liquor, holding all other factors constant. It is the same experiment as shutting down all liquor sections inside of grocery stores and placing those liquor sections adjacent to the grocery stores without sharing the same roof.

Table 12: **Distribution of Consumer Gains from Deregulation**

| | Upper Bound | CV | % Change |
|---|---|---|---|
| Zip density[a] | 83 | -0.63 | -34.44 |
| | 508 | 1.21 | 16.29 |
| | 3,222 | 6.39 | 67.36 |
| | Above | 10.93 | 60.41 |
| Income[b] | 34,999 | -0.16 | -1.14 |
| | 59,999 | 5.37 | 44.33 |
| | 99,999 | 7.07 | 71.35 |
| | Above | 6.20 | 58.16 |
| Race[c] | 0.74 | 9.67 | 68.22 |
| | 0.86 | 6.38 | 55.92 |
| | 0.91 | 3.47 | 34.03 |
| | Above | 0.23 | 4.65 |
| Kids[d] | Yes | 6.02 | 108.36 |
| | No | 6.37 | 51.32 |

*Notes:* Annual consumer gains from deregulation per household (with 11% price increase). The overall consumer gain is \$6.70 on average.

[a] The zip code density is population divided by square miles. The results do not change much if population is only 21+.

[b] Median income in zip code tabulated area.

[c] Race is the proportion of Caucasians compared to other races.

[d] Whether the household has any children under age 7. The extended model which allow interaction between the type fixed effects and children dummy variable. Using these estimates, the overall annual consumer gain from deregulation is \$5.98.

Table 13: **Counterfactual Consumer Gains Across Demographics**

| | Upper Bound | One-Stop Shopping[a] | | Reduced Distance[b] | | Combined Gains[c] | |
|---|---|---|---|---|---|---|---|
| | | CV | % Change | CV | % Change | CV | % Change |
| Zip density | 83 | 0.33 | 37.49 | 0.51 | 73.36 | 0.71 | 146.19 |
| | 508 | 2.12 | 32.51 | 2.82 | 48.19 | 4.32 | 99.59 |
| | 3,222 | 4.02 | 33.91 | 3.83 | 31.79 | 7.17 | 82.50 |
| | Above | 6.66 | 29.79 | 9.55 | 49.02 | 14.90 | 105.37 |
| Income | 34,999 | 2.99 | 27.92 | 5.02 | 57.95 | 7.06 | 106.70 |
| | 59,999 | 4.16 | 31.20 | 5.13 | 41.44 | 8.45 | 93.40 |
| | 99,999 | 4.13 | 32.14 | 5.07 | 42.59 | 8.41 | 98.39 |
| | Above | 3.37 | 25.01 | 9.11 | 117.68 | 11.25 | 200.71 |
| Race | 0.74 | 5.36 | 29.04 | 8.01 | 50.58 | 12.38 | 108.03 |
| | 0.86 | 4.61 | 35.00 | 4.73 | 36.21 | 8.38 | 89.20 |
| | 0.91 | 3.32 | 32.04 | 3.97 | 40.99 | 6.54 | 91.93 |
| | Above | 1.21 | 29.92 | 1.39 | 36.08 | 2.30 | 78.05 |
| Kids | Yes | 5.23 | 82.33 | 3.42 | 41.96 | 4.28 | 58.66 |
| | No | 4.58 | 32.28 | 5.81 | 44.86 | 2.54 | 15.63 |

*Notes:* Annual net gains per household.

[a] Grocery stores are not allowed to sell liquor under the same roof, holding prices, locations of stores, and the total number of liquor-selling stores fixed. The compensating variation is the consumer's valuation of *convenience* from one-stop shopping.

[b] The total number of liquor-selling stores is limited to 330 – the same as before privatization – so that the trip distance of liquor shopping is approximately the same as before, holding all other variables constant. One-stop shopping is allowed. The compensating variation is the value of reduced shopping distance.

[c] One-stop shopping is banned and the number of liquor-selling stores is limited to 330. The compensating variation is the total gains from the improved choice set by deregulation, holding price constant.

Table 14: **Total Welfare Change From Privatization**

| | 2011 | 2013 | Change | % Change |
|---|---|---|---|---|
| Consumer Surplus[a] | 12,323 | 19,083 | 6,760 | 54.86 |
| Retailers Surplus[b] | 43,253 | -30,255 | -73,508 | -169.95 |
| Government Revenue | 175,025 | 276,201 | 101,175 | 57.81 |
| Total | 230,601 | 265,029 | 34,427 | 14.93 |
| CS per hhld[c] | 12.21 | 18.91 | 6.70 | 54.86 |
| RS per store | 131 | -22 | -152 | -116.56 |
| GR per hhld[d] | 58.04 | 91.59 | 33.55 | 57.81 |
| Per hhld | 76.48 | 87.90 | 11.42 | 14.93 |

*Notes:* All values are per year in $1,000 except "Per hhld" and "% Change" which are in $.
[a] Estimated by 1,009 thousand households who had purchased liquor at least once in 2013. The rest of the "Per hhld" measures are based on 3,016 thousand population households.
[b] Assuming that the marginal cost of operating a liquor store remains unchanged over time.
[c] Per household who has purchased liquor at least once a year: 1,009 thousand households.
[d] Per any household: 3,015 thousand households.

Table 15: **Welfare Change Under Counterfactual Experiments**

| | One-Stop Shopping[a] | | Reduced Distance[b] | | Combined Gains[c] | |
|---|---|---|---|---|---|---|
| | Change | % Change | Change | % Change | Change | % Change |
| Consumer Surplus | 4,503 | 30.89 | 5,904 | 44.80 | 9,438 | 97.85 |
| Retailer Surplus | -8,267 | -26.23 | -3,689 | -11.70 | -9,749 | -30.93 |
| Government Revenue | 57,988 | 19.85 | 116,985 | 40.05 | 162,671 | 55.68 |
| Total | 54,225 | 76.97 | 119,201 | 96.55 | 162,360 | 184.46 |
| CS per hhld | 4.46 | 30.89 | 5.85 | 44.80 | 9.35 | 97.85 |
| PS per store | -6 | -26.23 | -3 | -11.70 | -7 | -30.93 |
| GR per hhld | 19.23 | 19.85 | 38.79 | 40.05 | 53.94 | 55.68 |
| Per hhld | 17.98 | 19.39 | 39.53 | 42.62 | 53.84 | 58.05 |

*Notes:* All values are in $1,000 except "Per hhld" and "% Change" which are in $.

[a] Grocery stores are not allowed to sell liquor under the same roof, holding prices, locations of stores, and the total number of liquor-selling stores fixed. The compensating variation is the consumer's valuation of *convenience* from one-stop shopping.

[b] The total number of liquor-selling stores is limited to 330 – the same as before privatization – so that the trip distance of liquor shopping is approximately the same as before, holding all other variables constant. One-stop shopping is allowed. The compensating variation is the value of reduced shopping distance.

[c] One-stop shopping is banned and the number of liquor-selling stores is limited to 330. The compensating variation is the total gains from the improved choice set by deregulation, holding price constant.

# A Proof of Contraction Mapping

**Claim**: $f$ defined in (4) is a contraction mapping with modulus less than 1.

**Proof**: This proof uses Theorem in Appendix I from Berry et al. (1995) and follows their proof. They proved that if the following assumptions on $f$ are satisfied, then $f$ is a contraction mapping with modulus less than 1. For simplicity, market $t$ is suppressed.
(0) $f : R^{J^G+J^L} \to R^{J^G+J^L}$, $d(\boldsymbol{\delta}, \boldsymbol{\delta}') = \|\boldsymbol{\delta} - \boldsymbol{\delta}'\|$ where $\|\cdot\|$ is the sup-norm in Euclidean space.
(1) $\forall \boldsymbol{\delta} \in R^{J^G+J^L}$, $f(\boldsymbol{\delta})$ is continuously differentiable, and $\forall n, m$,

$$\begin{aligned} \frac{\partial f(\boldsymbol{\delta})_n}{\partial \delta_m} &\geq 0 \\ \sum_{m=1}^{J^G+J^L} \frac{\partial f(\boldsymbol{\delta})_n}{\partial \delta_m} &< 1. \end{aligned}$$

(2) $\min_n \inf_{\boldsymbol{\delta}} f(\boldsymbol{\delta}) > -\infty$
(3) There is a value, $\bar{\boldsymbol{\delta}}$ such that if for any $\boldsymbol{\delta}$ where $\delta_n > \bar{\delta}_n$, then there exists some $m$ such that $f(\boldsymbol{\delta})_m < \delta_m$.

The rest of the proof is to show that $f$ defined in (4) satisfies the assumptions above with respect to $\boldsymbol{\delta}$. If $1 \leq n \leq J^G$, then $n$ represents the grocery sections at store and $\delta_n = \delta^G_{g(n)}$ where $g(n)$ indexes the $n$th grocery store. $g(0)$ refers to no grocery shopping. If $J^G < n \leq J^G + J^L$, $\delta_n = \delta^L_{\ell(n)}$ where $\ell(n)$ indexes the $n - J^G$th liquor store. $\ell(0)$ indexes no liquor shopping. First of all, $s(\boldsymbol{\delta}^*; \theta)$, which is defined in (3), is continuously differentiable with respect to $\boldsymbol{\delta}$. Therefore $f$ is, too.

Second, the marginal share of groceries at the $n$th grocery store is derived by summing the share of trips with grocery purchases at store $g(n)$ across all liquor store:

$$s^G_n = \sum_{m=0}^{J^L} s_{(g(n),\ell(m))}$$

If $1 \leq n \leq J^G$, the own derivative of $f$:

$$\begin{aligned} \frac{\partial f(\boldsymbol{\delta})_n}{\partial \delta_n} &= \lambda - \frac{1}{s^G_{g(n)}} \frac{\partial s^G_{g(n)}}{\partial \delta_n} \\ \frac{\partial s^G_{g(n)}}{\partial \delta_n} &= \sum_{m=0}^{J^L} \frac{\partial s_{(g(n),\ell(m))}}{\partial \delta_n} \end{aligned}$$

$$
\begin{aligned}
&= \sum_{m=0}^{J^L} \left( \lambda s_{(g(n),\ell(m))} - \lambda s_{(g(n),\ell(m))} \sum_{w=0}^{J^L} s_{(g(n),\ell(w))} \right) \\
&= \lambda s^G_{g(n)} \left(1 - s^G_{g(n)}\right) \\
\therefore \frac{\partial f(\boldsymbol{\delta})_n}{\partial \delta_n} &= \lambda s^G_{g(n)} \\
&\geq 0.
\end{aligned}
$$

If $n > J^G$, own derivative changes to

$$
\begin{aligned}
\frac{\partial f(\boldsymbol{\delta})_n}{\partial \delta_n} &= (1-\lambda)\, s^L_{\ell(n)} \\
&\geq 0.
\end{aligned}
$$

Cross derivative of $f$ given $1 \leq n \leq J^G$ and $1 \leq m \leq J^G$ is

$$
\begin{aligned}
\frac{\partial f(\boldsymbol{\delta})_n}{\partial \delta_m} &= -\frac{1}{s^G_{g(n)}} \frac{\partial s^G_{g(n)}}{\delta_{g(m)}} \\
\frac{\partial s^G_{g(n)}}{\delta_{\ell(m)}} &= \lambda s^G_{g(n)} s^G_{g(m)} \\
\therefore \frac{\partial f(\boldsymbol{\delta})_n}{\partial \delta_m} &= \lambda s^G_{g(m)} \\
&\geq 0.
\end{aligned}
$$

Likewise, for $m > J^G$,

$$
\begin{aligned}
\frac{\partial f(\boldsymbol{\delta})_n}{\partial \delta_m} &= (1-\lambda)\, s^L_{\ell(m)} \\
&\geq 0.
\end{aligned}
$$

Sum of the derivatives with respect to any $n = 1, ..., J^G + J^L$ is

$$
\begin{aligned}
\sum_{m=1}^{J^G+J^L} \frac{\partial f(\boldsymbol{\delta})_n}{\partial \delta_m} &= \sum_{m=1}^{J^G} \frac{\partial f(\boldsymbol{\delta})_n}{\partial \delta_m} + \sum_{m=J^G+1}^{J^L} \frac{\partial f(\boldsymbol{\delta})_n}{\partial \delta_m} \\
&= \sum_{m=1}^{J^G} \lambda s^G_{g(m)} + \sum_{m=J^G+1}^{J^L} (1-\lambda)\, s^L_{\ell(m)} \\
&= \lambda \left(1 - s^G_{g(0)}\right) + (1-\lambda)\left(1 - s^L_{\ell(0)}\right) \\
&< 1.
\end{aligned}
$$

This guarantees that the contraction mapping has modulus less than 1. Formulating $\delta_j$ in (1) as a sum of $\lambda\delta_g^G$ and $(1-\lambda)\,\delta_\ell^L$ ensures the sum of inside share of each good is less than 1.

Next step is to show that $f$ is bounded from below. $f_n$ for $1 \leq n \leq J^G$ can be rewritten by

$$\begin{aligned} f(\boldsymbol{\delta})_n &= log\left(\text{share}_n^{\text{data},G}\right) - log\left(D_n(\boldsymbol{\delta})\right) \\ D_n(\boldsymbol{\delta}) &= \sum_{m=0}^{J^L}\int_i \frac{exp\left(\mu_{i(g(n),\ell(m))} + \Gamma_{(n),\ell(m))} + (1-\lambda)\,\delta_{\ell(m)}^L\right)}{1+\sum_{(g,l)\in J^G\times J^L\setminus\{(0,0)\}} exp\left(\mu_{i(g,l)} + \Gamma_{(g,l)} + \lambda\delta_g^G + (1-\lambda)\,\delta_l^L\right)}di \\ &\underset{\delta\downarrow-\infty}{\rightarrow} 0 \end{aligned}$$

Therefore, the lower bound of $f$ is $\underline{\delta}_n = log\left(\text{share}_n^{\text{data},G}\right)$. If $n > J^G$, then the $D_n$ is defined the same as above except $(1-\lambda)$ in the numerator is substituted by $\lambda$.

The last step is to find the upper bound of $f$. Following Berry (1994), set $\delta_m = -\infty, \forall m \neq n, 0$ for $1 \leq n \leq J^G$ and let $\bar{\delta}_n$ be such that

$$\begin{aligned} \text{share}_0^{\text{data},G} &= s_0^G(\boldsymbol{\delta}^*;\theta) \;\text{ where } \delta_{g(n)}^* = \lambda\bar{\delta}_n \\ &= 1 - \int_i \frac{exp\left(\mu_{i(g(n),0)} + \Gamma_{i(g(n),0)} + \lambda\bar{\delta}_n\right)}{1+exp\left(\mu_{i(g(n),0)} + \Gamma_{i(g(n),0)} + \lambda\bar{\delta}_n\right)}di \end{aligned}$$

$\bar{\delta}_n$ is the implied linear utility when the choice set has one element, $(n,0)$. Likewise, if $n > J^G$, $\bar{\delta}_n$ is defined the same way as above except replacing $\lambda$ with $1-\lambda$ in front of $\bar{\delta}_n$. Let the maximum as the upper bound of $f$ be $\bar{\boldsymbol{\delta}} = \max_n \bar{\delta}_n$. Then, w.l.o.g. $1 \leq n \leq J^G$, if a $\boldsymbol{\delta}$ with $\delta_n > \bar{\delta}_n$, then $\text{share}_0^{\text{data},G} > s_0^G(\boldsymbol{\delta}^*;\theta)$. Then, the inside share implied by $\boldsymbol{\delta}$ should be larger than the inside share observed in data, which implies that there exists at least one $m$, such that $\text{share}_{g(m)}^{\text{data},G} < s_{g(m)}^G(\boldsymbol{\delta}^*;\theta)$ and, therefore, $f(\boldsymbol{\delta})_m < \delta_m$. □