Alcohol regulation and consumer choice for product variety

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Abstract

Regulation on alcohol sales in the United States since the Repeal of Prohibition Act in 1933 varies across states and has led to wide differences in the availability of stores and products to consumers. While the original goal of regulation on alcohol beverages was to reduce social harms related with excessive drinking, the regulation on retail alcohol availability may impact consumer choices. This study uses the Nielsen HomeScan Data between 2004 and 2014 to investigate the effect of regulation on the probability and the level of diversity in household alcohol purchases. We develop a new measure of product variety that considers the level of product similarity between distinct products to measure the annual purchase diversity at the household level. We create a pooled time-series dataset and use the correlated random-effects Tobit model, while controlling for a set of covariates and household socio-demographic variables. Our results show that the probability and the level of purchase diversity is higher in states that allow alcohol sales in grocery stores, for beer, wine and spirits. Using standard Entropy index which treats distinct products as completely different may overestimate the effect of deregulation of alcohol sales in grocery stores on the variety in household purchases. In general, our key finding is robust to alternative specifications where we account for the type of store ownership, the rurality of the residence county, and the migration decision of households.

Keywords: regulation, alcoholic beverages, product variety, Entropy index, consumer choice

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Introduction

Policies influencing the exit or entry of firms govern the choice set of products facing consumers. For example, sales tax on all the food and non-food groceries might reduce some firms' profitability, which leads to the exit of firms and reduces the product varieties (Kroft et al., 2017). Regulation is at the different end of the spectrum of the policy that influence the market structure and consumer behavior (Stewart and Scammon, 2016). Regulations on alcohol distribution, as an example, restricts the type of the retail channels that are allowed to sell alcoholic beverages and iwere originally designed to reduce the associated social harms of excessive drinking (Hahn et al., 2012). Consumer shopping choices are adjusted under such type of policy. Illanes and Moshary (2017) found that after the privatization of the liquor retail in Washington State, retailers diversify their product offerings and households diversify their spending on a wider variety of products. The purpose of this study is to examine consumer responses in terms of long-run product choices to the type of policy that alters the retail availability and the consequently level of product variety, focusing on household alcohol purchases under different levels of regulated alcohol distribution system in the United States.

The retail and wholesale system of alcohol is highly regulated in the United States. Consumers in certain states face constrained set of store choices for alcohol. The availability of alcohol-selling stores is determined by whether the state law allows grocery stores to sell beer, wine and spirits. Purchase decisions might differ among the type of stand-alone liquor stores that are state-run or private-own and grocery stores that sell both food and alcohol. Alcohol regulation on distribution and retailing varies across states after the repeal of Prohibition Act in 1933. Alcohol purchases for households in states that limit alcohol sales in grocery stores could generate the disutility of multi-stop shopping that requires separate trips and increases driving distance, compared with the utility of one-stop shopping for both groceries and liquor. Convenience or less travel distance is the dominant factors affecting consumers' store choices, more influential than retail assortments and prices, in their choosing over different retail outlets (Briesch et al., 2009). One-stop shopping benefits consumers with reduced travel costs and larger assort-

ments (Messinger and Narasimhan, 1997). Under less regulated system, in spite of the expanded choice sets and reduced shopping costs, consumers face the trade-off between the value of convenience from one-stop shopping and the shallower product assortment depth in grocery stores for alcoholic beverages. Given a set of available choices, consumers make purchase decisions that are habitual or varietal. Repeated purchase of the same alternative is viewed as a strategy to reduce cognitive burden and facilitate the decision process, especially on food purchases (Adamowicz and Swait, 2013). Searching for different alternatives could be motivated by consumer's intrinsic need for novelty, change or unexpectedness (McAlister and Pessemier, 1982). Households may adopt different decision strategies to realize their preference for varietal or repeated purchases in the long run, given the store choice they made and the time they economize on shopping trips .

The level of firm entry determines the supply of product and store variety. Concentrated market creates barriers for new entry of both firms and products to protect their producer rents from higher prices, however from which the impact hinges on the regulatory environment and post-entry firm positioning strategy. Bhattacharya and Innes (2016) found that a more concentrated food industry would increase product variety if new entrants who produce substitute alternatives subsequently merge with the incumbent large firms. Berry and Waldfogel (2001) found that the increased consolidation in the radio market due to the deregulation Act expands consumers' choice set with more available stations. Kroft et al (2016) found that product variety varies with the variation in sales tax rate across counties and states; lower tax rates contribute to greater product variety through its likely impact on the firms' profitability and consequent exit decisions. On the other hand, free entry does not always lead to desirable social efficiency. The number of firms could be insufficient to satisfy consumer taste for variety and heterogeneous market demand when the welfare-enhancing effect from the increased product variety brought by the new entrant was dampened by the reduced sales for incumbent firms resulting from the marginal entrant (Mankiw and Whinston, 1986). Social inefficiency from free entry could also lead to the underserved demand in less-populated areas by commercial interests.

The economic gains from alcohol privatization that increase alcohol-selling outlet densities favors urban consumers with more convenient shopping experiences while it leads to surplus losses for alcohol shoppers in the rural areas who face overall higher prices and more distant store options (Seim and Waldfogel, 2013; Seo, 2016). These competing findings lead to an uninformed question that is the central inquiry of this study: How does the regulatory environment influence consumers' purchase decision on different or same product alternatives over time through its impact on the scope of the retail operations and therefore on the supply of product variety and the store availability for household shopping?

This study aims at understanding the effect of policy that limits and regulates the retail availability on household choice of product variety. We use a diversification index that considers the product similarities and dissimilarities following and extending the seminal work by Gollop and Monahan (1991). The Entropy index has been used to quantify the level of dispersion among attribute levels within certain attribute in assessing assortment variety in the marketing literature (Fasolo et al., 2009; Van Herpen and Pieters, 2002). However, such intra-attribute Entropy index fails to capture the disassociation level among attributes. The UPC-based generalized Entropy index developed in this study addresses both the intra-attribute and inter-attribute variety by using the most disaggregate product information, UPC, from the Nielsen HomeScan dataset and by incorporating the similarity level among core attributes that distinguish each distinct UPC product. We create a panel dataset by pooling across times the household purchase data between 2004-2014. We examine the dimension of alcohol regulation in direct relation with retail availability and the distribution environment that are associated with the choice set of alcohol-selling stores. One is the prohibition on sales of wine, beer and spirits in grocery stores. Another consideration is whether the state government allows private business to enter into the alcohol market under the regulatory framework for grocery store sales. We also consider the heterogeneous effects of the retail availability on household purchase patterns driven by level of rurality/urbanity of the residence county, by household migration decision, and by the spillover effect of private states on bordering

counties. Household socio-demographic characteristics and county-level alcohol retailing environment indicator such as the number of alcohol-selling stores are controlled to identify the influence of regulatory retailing environment on product selections for each type of alcoholic beverages in household purchase patterns.

Alcohol regulation

After the repeal of Prohibition Act in 1933, the regulation of sales of alcoholic beverages went from the federal level to the state level in the United States. Individual states were authorized to establish their own rules and control over the type of outlets that allow alcohol sales and the distribution system for alcoholic beverages. For the past 80 years, state-level authority in alcohol regulation have led to wide but fairly fixed differences in the distribution and sales of alcohol across states. Some states require that the alcoholic beverages are sold in stand-alone liquor stores only. Some states allow alcohol sales in stores that also sell food and groceries like grocery stores, convenience stores, big box stores, drug stores, and gas stations. There are 12 states allowing no or limited alcohol sales in grocery stores, 6 states allowing only beer sales, and 15 states allowing only wine and beer sales (Rickard et al., 2013). In Kansas, Minnesota, Oklahoma, and Utah, grocery stores are not permitted to sell beer with alcohol content exceeding 3.2% alcohol by volume.

Privatization of alcohol sales has continued to be debated in states with highly regulated alcohol market. Multi-product retail chains and some consumer groups have proposed to lift restrictive law on liquor sales in grocery store to enhance the convenience of buying alcohol and to expand the product line that attracts more customers. Such call for alcohol sales in grocery stores has confronted opposition from local wine & spirits stores and craft breweries, wineries, or distilleries who argued that access to off-premise alcohol in food or big box stores could undermine profitability and reduce product variety. Legislative proposals to reform such alcohol laws have surfaced across regions at different periods of time in recent years. The deregulation of the Washington market for alcohol

in 2012 allows grocery store to sell spirits, with requirement on the store size to be at least 10,000 square feet. The license system now either replaces the state-run store with licensed ones or transferred the ownership to the operators of former contract/agency stores[1]. In June 2016, Colorado government passed a bill that allows grocers and major retail chains to gradually expand sales of wine, full-strength beer and spirits over the next two decades as phase-in expansion of alcohol sales. In Pennsylvania, the reformed liquor law takes effect in August 2016 that allows the sales of wine in addition to beer in grocery stores, while before wine and beer were only allowed to be sold in state-operated stores within grocery store. In Tennessee, localities have the option to allow the wine or spirit sales in grocery stores. In April 2017, Kansas legislature passes the bill that will go into effect in 2019, which allows the sales of full-strength beers, up to 6 percent ABV, in grocery, convenience and big box stores. Oklahoma legislature passed a bill in October 2016 that grocery and convenience stores are allowed to sell wine and beer above 3.2% ABV starting in October 2018. Later in August 2017, a new liquor law was enacted in Pennsylvania. Grocery stores selling beer are allowed to sell wine. Spirits sales are limited in the state-run store operated within grocery store.

For the type of operation at the wholesale and retail level, state governments can run the stores, contract with an agent, or licenses private retailing business to sell alcohol. Some states exercise full monopoly on either or both distribution systems, known as the control or monopoly states while other states allow limited licensee to operate either system, known as the private or license states. There are total 17 control states, and the rest are license states. The line between control and license system in alcohol distribution is not always clearly divided. Across states, it could vary by the type of alcohol, the content of alcohol by volume (ABV), and the distribution level. None of the states has control system for beer wholesale and retail. Pennsylvania and Utah are the only two states that have a state monopoly on the wine retail market. State-run retail system for spirits is present in Pennsylvania, Utah, Montana, North Carolina, Oregon and Vermont.

[1] An off-premises retail alcohol outlet operated on behalf of the State under a State-run system by a private contractor who may be paid a fee or commission (National Institute on Alcohol Abuse and Alcoholism., 2017)

Other control states have both the control and license system, or called the mixed system, for beer, wine and/or spirits at the wholesale and/or retail level. Regulation may specify different retail distribution systems for different alcoholic beverage types based on the range of alcohol content, also referred to as the beverage subtype (National Institute on Alcohol Abuse and Alcoholism., 2017). There is a mixed system between the control and license system. Some states allow some alcohol subtypes to be sold either in state-run or private-run stores but not in both, mixed/not overlapping system. Others allow some subtypes to be sold through both systems, mixed/overlapping system. In this paper, we combine these two groups into one aggregate mixed system. For the control states that allow beer and wine sales in grocery stores, Alabama, Idaho, Maine, Montana, New Hampshire, North Carolina, Oregon, Vermont and Virginia, some have a state-run system for at least one subtype of wine and beer, usually with higher ABV compared to those having overlapping system with ABV less than 16–24%. For the states that allow all beer, wine and spirit sales in grocery stores, there are four control states that remain to be involved with certain degree of public monopoly in the alcohol distribution[2].

State-run liquor stores might provide only the leading brands and carry more standardized stocks or have the display that increase consumer search cost for preferred item, which reduces overall variety in purchase (Ornstein and Hanssens, 1985). While the number of UPCs is not necessarily less in the state-run store compared to private-run stores (Seim and Waldfogel, 2013). The control system aims to reduce consumption by reducing the number of shopping trips for alcohol, possibly increasing the amount of bottles purchased per trip to hold inventory for future consumption (Nelson, 1990). However, recent evidence has shown that the private system increases the volume of alcohol consumption, total expenditure and more varietal product selection (Illanes and Moshary, 2017). Regulating the availability of one type of alcohol could have substitution effect on the demand for another. Control system on liquor has been found to increase the consumption of beer and wine (Nelson, 2003). Figure 1 shows the state average

[2]Iowa has control system for liquor wholesale, both control and license system for wine and beer wholesale. Michigan has mixed system for wine wholesale. Ohio has mixed system for retail and wholesale of spirits. West Virginia has control system for liquor wholesale, and mixed system for retail and wholesale of wine and beer.

number of distinct UPC products purchased, as the measure for product variety, for wine, beer, spirits in 2014 by different level of alcohol regulation. The thin line indicates the states operating the private system and thick line indicates the control system. Purchase diversity for beer and/or wine is on average higher for states allowing sales in grocery stores while there is heterogeneity among states. Purchase diversity for spirits does not show significant difference between regulation groups. Comparing between the private and control systems, differences in household purchase diversity between private and control states is not obvious. This figure provides a descriptive background on how the regulation on store sales and the type of business operation may have or have not affected household's choice of product variety.

Privatization of the alcohol market through allowing sales of different alcohol beverages in grocery stores, allowing full or partial private entry to replace the state-run retail system, or both, benefits alcohol shoppers. Allowing alcohol sales in grocery store or other common retail outlets increases economic gains to consumers by reducing consumers' travel distance between grocery stores or home and liquor stores (Seo, 2016). Expanded choice set in grocery stores also provides the convenience of one-stop shopping for both groceries and alcohol purchases. Seo (2016) quantifies the benefits of one-stop shopping to consumers in Washington State by comparing economic gains before and after the deregulation took effect in 2012. Overall, consumers gain despite of the increase in price after the deregulation. The benefits from reduced distance in shopping contribute to the 45% increase in consumer surplus, and the value of convenience contributes to about two-thirds of value of reduced distance. The license system on wholesale or retail distribution generates similar economic gains to alcohol shoppers. State monopoly on retail sales generally leads to insufficient number of liquor stores compared to license states (Seim and Waldfogel, 2013). Using the counterfactual experiment to the current monopoly system in Pennsylvania, Seim and Waldfogel (2013) found that, with price held fixed, consumer surplus would increase due to the rising density of available alcohol-selling stores in nearby areas where purchase probability ncreases with reduced driving distance for households.

Data on household alcohol purchases

The Nielsen HomeScan Panel are longitudinal data comprised of a cross-sectional panel of households who constantly provide the transaction information on their grocery purchases using in-home scanner to the Nielsen Company. Households record, for each shopping trip, the date of purchase, barcodes or Uniform Product Code (UPC), units bought for each UPC, total spending, deals and coupon, and store or retail chain information. Household demographic and geographical information are collected through the survey that include questions like the state and county of the residence, household size, annual income, presence and the number of child under 18, race, and age, education, employment and occupation of the female and male household head. The UPC products are matched with detailed product characteristics. There are four core attributes distinguishing among UPCs: product module, brand, size, multi-pack. Alcoholic beverages is one of the 10 broad product departments in the dataset, composed of three product groups, wine, beer and spirits. Product modules are assigned for each beverage group. Table 1 presents the hierarchical structure of the data with the number of brands and UPCs purchased for each alcohol product module in 2014.

We use UPC as a distinct product to create the quantity-based diversification index that measures the patterns in beer, wine and spirit purchases by each household on an annual basis. We construct a panel dataset by pooling annual cross-sectional Nielsen HomeScan data from 2004 to 2014, which could help mitigate the likely bias in inference from using cross-sectional data which fails to account for time-invariant unobserved heterogeneity that might be correlated with preference for varietal or habitual choices. To obtain valid observations for analysis, we drop the households who made only one shopping trip for alcohol in a single year and purchase only one UPC. The main reason is that the diversity index for the single-unit purchase is equal to zero, which is the same as the value of diversity measure for multiple purchases of one UPC by households who are frequent alcohol shoppers, therefore inappropriately augmenting the observations preferring zero variety which does not necessarily reflect the true habitual purchase behavior.

The Nielsen Consumer Panel data is available since 2004. In 2004-2006, the total participating households wew between 35,000 and 40,000, and increased to about 60,000 households from 2007 to 2014. The percentage of alcohol-purchasing households increased starting in 2007; the share is more than 50% for spirits and more than 60% for wine and beer. The percentage of observation for analysis (after dropping the single-trip-one-quantity observations) is consistent across the 11 years, more than 70% for all types of alcohol. The percentage of households who exhibit zero diverse purchase patterns, of which the data feature presents the limited dependent variable issue concerning the empirical strategy in this study, also remains constant across the length of data years. The degree of censoring, out of total valid observations, is higher for beer purchases at 15–16%, compared to 12–14% for wine and to 10–12% for spirits.

Measuring product variety

We consider the household choice of product variety in this study as the level of diversity in purchases within each alcoholic beverage category, wine, beer, and liquor. Gollop and Monahan (1991) presented a generalized framework to formulate the index for diversification and highlighted key properties. They applied it to U.S. Census of Bureau data on manufacturing sector and found that industries are toward more homogeneous production within the establishment (single plant) while producing more diversified outputs across establishments. Number, distributions, heterogeneity are three criteria for a well-designed diversification index. This paper modifies the generalized Berry index proposed in Gollop and Monahan (1991) paper and extends their framework to create a generalized Entropy index. We applied the HomeScan data on alcohol purchases to these diversification indices to measure household purchase patterns in the long run, at the annual level.

The Berry index and the Entropy index reveals both the number and distribution dimension of an ideal diversification index compared to the count of total variants. Consider the purchase of two goods, in one case, there is 50% of total purchased amount on

one product and 50% on another. In a second case, 90% of the purchased amount is on one good while 10% on another. The count measure gives the same value to these two cases where only the number of different products bought matters. While the measure incorporating the distribution information will reflect how total purchases are allocated among different products and assigns a larger value to greater diversity with more equal distribution of purchases. Berry index is defined as:

$$\text{BI} = 1 - \sum_{i=1}^{n} s_i^2 \tag{1}$$

where s_i is the expenditure or quantity share of the product i in total expenditure or total quantity on all the products purchased. It equals to one minus Herfindahl index, known as the measure for market concentration, varying from 1 when total expenditure is spent only on one product (zero-variety) to $\frac{1}{n}$ when budget shares over n different products are equal. Entropy index is defined as

$$\text{EI} = \sum_{i=1}^{n} s_i \ln(\frac{1}{n}) \tag{2}$$

which places greater weight on goods with smaller share and the value ranges between 1 and $\ln(n)$. The Entropy index gives more weight to the purchase of varieties that are devoted with smaller amount of quantity, compared with the equal weight given to each variety in Berry index. A third important characteristic, heterogeneity, is however missed in both Entropy and Berry index (Gollop and Monahan, 1991). We modify the Berry and Entropy index by introducing a heterogeneity term to reduce the bias resulting from the case when two products share similarities over certain attributes but are treated as two completely different variants that share none of the attributes in common.

Extending the work by Gollop and Monahan (1991) on the Berry Index, we develop a similar generalized measure of diversification for Entropy index. Consider the case when a household purchases three different UPC products, y_i, with share in terms of quantity bought, s_i, the level of purchase diversity is:

$$\mathrm{EI}|_{i=3} = s_1 \ln(\frac{1}{s_1}) + s_2 \ln(\frac{1}{s_2}) + s_3 \ln(\frac{1}{s_3}) \tag{3}$$

If two products fall under certain attribute group and could be treated as identical, the Entropy index should take up the following form:

$$\begin{aligned}
\mathrm{EI}|_{i=2} &= s_1 \ln(\frac{1}{s_1}) + (s_2 + s_3) \ln(\frac{1}{s_2 + s_3}) \\
&= s_1 \ln(\frac{1}{s_1}) + s_2 \ln(\frac{1}{s_2}) + s_3 \ln(\frac{1}{s_3}) - \Big[s_2 \ln(\frac{1}{s_2}) - s_2 \ln(\frac{1}{s_2 + s_3})\Big] - \Big[s_3 \ln(\frac{1}{s_3}) - s_3 \ln(\frac{1}{s_2 + s_3})\Big] \\
&= \sum_{i=1}^{3} s_i \ln(\frac{1}{s_i}) - s_2 \cdot \Big[\ln(\frac{1}{s_2}) - \ln(\frac{1}{s_2 + s_3})\Big] - s_3 \cdot \Big[\ln(\frac{1}{s_3}) - \ln(\frac{1}{s_2 + s_3})\Big] \\
&= \sum_{i=1}^{3} s_i \ln(\frac{1}{s_i}) - s_2 \cdot \ln(\frac{s_2 + s_3}{s_2}) - s_3 \cdot \ln(\frac{s_2 + s_3}{s_3})
\end{aligned} \tag{4}$$

The last two terms in equation (4) distinguish the corrected index from uncorrected one, based on the grouping procedure. Generalize the example into n products:

$$\widetilde{\mathrm{EI}} = \sum_{i=1}^{n} s_i \ln(\frac{1}{s_i}) - \sum_{A} \omega^A \cdot \sum_{i=1}^{n} s_i \cdot \ln(1 + \frac{\sum_{j \neq i}^{m} s_j \cdot z_{ij}^A}{s_i}) \tag{5}$$

Combined with the generalized Berry index, which is modified based on the work by Gollop and Monahan (1991):

$$\widetilde{\mathrm{BI}} = 1 - \sum_{i=1}^{n} s_i^2 - \sum_{A} \omega^A \cdot \sum_{i=1}^{n} \sum_{j \neq i}^{m} s_i s_j z_{ij}^A \tag{6}$$

where for both indices,

$$z_{ij}^A = \begin{cases} 1 & \text{if } i^{th} \text{ and } j^{th} \text{ products belong to same } A^{th} \text{ product attribute} \\ 0 & \text{if } i^{th} \text{ and } j^{th} \text{ products belong to different } A^{th} \text{ product attributes} \end{cases},$$

$A = \{\text{module, brand, module \& brand}\}$ and $\omega^A = [0, 1]$.

The term in equation (5), $1 + \frac{\sum_{j \neq i}^{m} s_j \cdot z_{ij}^A}{s_i}$, mitigates the upward bias resulting from not differentiating the two products of different UPC that share the same product attribute from that remaining UPC products that are different in all attributes; z_{ij}^A rep-

resents the similarity indicator for whether two products are in the identical attribute space.

We identify three main sources of homogeneity, which is exclusive to each other, masked within the heterogeneity at the UPC level when two products belong to: the same product module but have different brands, same brand but fall under different modules, the same module and brand but differ by other different extra attributes like flavor or style[3]. Table 2 provides a snapshot of the relationship between product module, brands and UPC for each type of alcoholic beverages. It presents the corresponding product modules for wine, beer and spirits respectively, and the number of brands and UPC purchased by households in a single year, 2014, under each module. We can see that some modules have more brands and more UPC than others, such as dry table wine, Ale, beer, Cordials, Vodka. Each UPC represents one distinct product. Although two products could belong to the same module, same brand, or both, any two UPC would never be the same product having exactly all the same attributes. We multiple the heterogeneity component, $\sum_{i=1}^{n} s_i \cdot \ln(1 + \frac{\sum_{j \neq i}^{m} s_j \cdot z_{ij}^A}{s_i})$ for Entropy index and $\sum_{i=1}^{n} \sum_{j \neq i}^{m} s_i s_j z_{ij}^A$ for Berry index, by weight, ω^A, which is assigned to each source of the similarity among products to reverse the downward bias from inappropriately grouping the different UPC products into the bundle of exactly the same attributes.

Due to the hierarchical structure of the product assortments, we assume $\omega^A = 0.5$ for the case either when two similar products belong to the same product module (but different brands) or when two similar products belong to the same brand (but different modules) and $\omega^A = 0.75$ for both the same brand and product module. The weight values are chosen to reflect the corrective term that the extent of dissimilarity between products is greater when compared over single attribute space than over multiple attribute spaces. This notion is different from the rationale behind the generalized Berry index developed in Gollop and Monahan (1991) paper where they define the heterogeneity term

[3]There are data on extra product attributes such as flavor, container, type, style, variety, organic etc. Not all the UPC products have such corresponding information. These data are not as complete and exhaustive as the product modules and brands for each UPC products. We leave the work incorporating more detailed product attributes for alcoholic beverages into the generalized diversity index for future research that could combine HomeScan dataset with complementary external dataset sharing the same UPC codes.

as $\sum_{i=1}^{n}\sum_{j\neq i}^{m} s_i s_j(z_{ij}-\sigma_{ij})$. They introduce σ_{ij} as a continuous variable in capturing the level of dissimilarity between any two products that were produced using different share of input costs only when these two products are not identical, $z_{ij}=0$. When two products are identical, $z_{ij}=1$, in their framework σ_{ij} is equal to zero and there is no adjustment term to scale down the similarity level when products could only be deemed as identical over certain (usually broader) attribute category.

Empirical strategy

Figure 2(a)–(c) shows the kernel distribution for the generalized Entropy index of wine, beer, and spirits purchases respectively. It implies that there is significant portion of observations having zero purchase diversity for each alcohol type. We use the corner solution approach to address the issues of zero-value observations for diversity measure in the pooled cross-section data. The positive probability for dependent variable having zero value make Tobit regression a more ideal specification than linear regression that neglects the effect of distribution of observations at extreme values like zero on the consistency of coefficient estimates (Tobin, 1958). The Tobit model is used to distinguish between those observations that are incompletely observed at the censored threshold and those that are fully observed. Different from the censored demand studies that use the Tobit specification to model zero expenditure resulting from missing data due to no consumption or no purchase, the diversity measure in this study is fully observed at the threshold value, zero, since households exhibiting strong habit-persistent purchase behavior still make purchases, but purchase only one alternative over time. Wooldridge (2010) highlights the use of a corner solution model, rather than censored model, to distinguish the difference between a dependent variable that is latent (incompletely observed) at given low or high threshold and that has skewed distribution of the outcome variable (observed with high frequency at zero).

In panel-data analysis, fixed-effect approach has been widely used to identify the effect of time-varying explanatory variables by controlling for unobserved time-invariant

individual effects across panels in the study of policy incidence on economic outcomes, where the source of policy variation is both temporal and spatial across areas (Besley and Case, 2000). A Fixed effect model allows for a flexible relationship between unobserved individual heterogeneity and covariates to estimate time-varying explanatory variables only. When time-invariant variables are of interest, a random-effects model that imposes stronger assumptions between individual-level effects and the covariates is a more appropriate approach. The key variable in this study is the state-level regulation on alcohol sales among retailing channels, which, by construct, does not vary over time since the regulation on alcohol distribution and retail remains mostly unchanged across states after the repeal of Prohibition Act in 1933. Given the observation of zero value for outcome variables in the dataset in this study, a random-effects model under the non-linear estimation setting below assumes that the unobserved individual-specific heterogeneity, c_i, is uncorrelated with both the time-varying and time-invariant covariates as well as uncovers the effect of time-constant variables:

$$\begin{aligned} D_{it} &= \max(0, \beta_x \mathbf{X}_{it} + \beta_R R_{i(s)} + c_i + u_{it}) \\ u_{it}|\mathbf{X}_{it}, R_i, c_i \quad & u_{it} \sim N(0, \sigma_u^2) \\ c_i|\mathbf{X}_{it}, R_i \quad & c_i \sim N(0, \sigma_c^2) \end{aligned} \tag{7}$$

Correlated random-effects model relaxes such strong assumption by introducing the individual-specific mean of the time-variant variables that allows c_i and $\mathbf{X}_{it}$ to be correlated (Mundlak, 1978). The time-averaged term absorbs the likely correlation between the remaining unobserved individual heterogeneity and the covariates, which mitigates the likely bias resulting from the strict independence assumption in a standard random-effects model:

$$c_i = \psi + \beta_{\bar{X}} \overline{\mathbf{X}}_i + a_i \tag{8}$$

The correlated random effects Tobit model then follows:

$$
\begin{aligned}
&D_{it} = \max(0, \psi + \beta_x \mathbf{X}_{it} + \beta_R R_{i(s)} + \beta_{\overline{X}} \overline{\mathbf{X}}_i + a_i + u_{it}) \\
&u_{it}|\mathbf{X}_{it}, R_i, c_i \quad u_{it} \sim N(0, \sigma_u^2) \\
&a_i|\mathbf{X}_{it}, R_i \quad a_i \sim N(0, \sigma_a^2)
\end{aligned} \tag{9}
$$

We specify a correlated random-effects Tobit model for each type of alcohol. In equation (9), D_{it} represents the Berry and Entropy index for respective wine, beer and spirits purchases by household i in year t; $R_{i(s)}$ represents the dummy variable for the presence of regulation restricting grocery store sales for alcohol type a, where $a \in \{\text{beer}, \text{wine}, \text{spirits}\}$, in state s where household i resides in; $\mathbf{X}_{it}$ is a vector of explanatory variables affecting the diversity in alcohol purchases, including the intercept, the time-variant, household-specific purchase patterns and shopping behaviors for the type of alcohol considered, household socio-demographic characteristics, county-level number of alcohol-selling stores and the year dummies to reflect aggregate effects that do not vary by households; u_{it} is the idiosyncratic error term. We specify the number of retail outlets allowed to sell alcohol at the county level as the availability measure, $\texttt{availability}_{i(c)t}$, to control for the time-variant, county-specific heterogeneity, especially the variation of retail availability for counties under same regulation, which might confound the effect of regulation on purchase patterns. The data on number of the types of retailing businesses that could be common channels selling alcohols when off-premise alcohol sales are allowed in , such as grocery store, convenience stores, big box stores, wine and spirits stores, winery, brewery and distillery, and warehouses etc, are collected from County Business Patterns for 2004-2014 at the county level (U.S. Census Bureau., 2017). We then use the alcohol regulation status at the state level to adjust for the actual number of alcohol-selling stores at the county level for each type of alcohol. For example, for the counties in the states that allow only wine and beer sales in grocery stores, the number of stores selling wine and beer is the number of all alcohol retailers while the number of stores selling spirit is the number of business selling spirits only.

For the covariates represented by $\mathbf{X}_{it}$, we include the intensity of in-store promo-

tions, $\texttt{coupon}_{it}$ and $\texttt{deal}_{it}$, and the average length of time between trips, $\texttt{intertrip}_{it}$. In-store marketing activities and inter-purchase time would influence consumer's purchase behavior. External marketing environment such as advertising might lead a habitual buyer to consider a variety-seeking strategy for a new choice (Adamowicz and Swait, 2013). We create an intensity measure for coupon and deal on each UPC purchased across the whole year for each household. We use the common Herfindahl index to quantify the level of promotional intensity on UPC products, $\sum_i^N (s_{it}^{\texttt{promo}})^2$, where promo $= \{\texttt{coupon}, \texttt{deal}\}$; $s_{it}^{\texttt{promo}}$ is the share of coupon value for specific UPC, i, of total coupon value summed over the year t and $s_{it}^{\texttt{deal}}$ is the share of the times that specific UPC is offered the deal of total deal offers. The longer the length of time between purchase, the more likely that household may switch to searching for variety due to the change in product offering, information received, household composition, or inventory (Adamowicz and Swait, 2013). We generate a measure, $\texttt{intertrip}_{it}$, by averaging the amount of time (in days) between every sequential purchase occasion within a single year. We also control for the type of alcohol consumption among three beverages, $\texttt{type}_{it}$, to isolate the regulation effect from individual preference for the type and the combination of alcoholic beverages that might affect the purchase diversity for specific alcohol products: Wine alone, beer alone, spirits alone, wine and beer, wine and spirits, beer and spirits, wine, beer and spirits. In addition, household characteristics such as age, education, and employment status of both male and female head, number of children under 18, family size, income, race, and marital status that could be either time-varying or time-variant are included to control for socio-demographic factors that may affect long-run product choices.

Results

Descriptive statistics for repeated observations are summarized in Table 2. Total observations between 2004-2014 for the wine-purchase model are 188,961 and the share of zero observation for the diversity measure is 13%. For beer purchases, total observa-

tions are 155,206 and zero dependent variables accounts for 15%. For spirit purchases, total observations are 128,811 and the censored observations take 11%. The generalized diversification indices are smaller than standard Berry and Entropy index, due to the corrective term incorporating the level of similarity between two different products. Wine purchases are found to have the most diverse purchase pattern, followed by spirits and beer. The annual average number of different UPC purchased by households is highest for wine, 7, compared to around 5 for beer and spirits. Promotions, including coupons and deal, on UPCs are less concentrated in beer and spirits in household purchases compared to wine products. On average, household purchase wine less frequently compared to beer and spirits purchase; inter-purchase time is longer for wine than beer and spirits. There are more retail outlets for beer than for wine and spirits, available in counties where households reside in.

Restricted alcohol sales in grocery stores are determined by the alcohol content of the beverage. In grocery stores where wines sales are prohibited, beer sales must also be limited. In stores where spirits sales are allowed, wine and beer sales are also permitted. We define the policy variable in two ways. First to understand the regulation effect by the level of alcohol content of each beverage type, we use the categorical variable, 1 to 4, to indicate gradual phase-in allowance of alcohol sales in grocery stores, as presented in Figure 1. Second, we redefine the regulation status as a dummy variable in wine, beer and spirits model respectively. For beer sales in grocery stores, regulation dummy variable of zero indicates no or limited sales in grocery stores, and one indicates other categories. For wine sales in grocery store, no or limited sales and only beer sales allowed in grocery stores are represented by regulation dummy of value zero, else of value one. For spirits sales in grocery store, regulation dummy of one indicates all alcohol sales allowed in grocery store, and zero indicates other categories. The subsequent analysis use regulation dummies for corresponding alcohol type.

We first compare the regulatory effect using three different measures of the variety: 1) number of UPC purchased, 2) Entropy index, 3) generalized Entropy index for wine, beer and spirits purchases. Table 3 shows that different diversity measures lead

to different effects of alcohol sales allowed in grocery stores on both the probability of purchasing at least two different UPCs and the level of diversity in alcohol purchases. In terms of the probability of entering into a diverse purchase, two types of Entropy index that incorporates the distribution of purchased quantities gives relative smaller effect of alcohol sales regulation in grocery stores than the simple product count, except for beer purchases where the Entropy measure leads to greater regulation effect. The generalized Entropy index that incorporates the product similarity between two distinct UPC products only slightly increases the effect of grocery store sales regulation. For the degree of variety in alcohol purchases, the product count measure gives significantly greater effect of retail regulation due to the construct of the count measure ranging from 1 to as high as 195 with mean of about 5.5 among all the alcohol types. The generalized Entropy index gives consistently smaller and significant effect of the regulation on all types of alcohol sales in grocery stores than the Entropy index. It implies that without considering the level of product similarity between two UPC products, the regulatory effects might be overemphasized.

The consistently positive and significant effect of regulation in grocery store sales across all alcoholic beverages and different diversity measures show that the households are more likely to purchase at least two different UPC products and are inclined to make more varietal purchases for any beverage type in the states that allow alcohol sales in grocery stores than in states that restrict alcohol to be sold in liquor stores only, after controlling for household socio-demographic variables and county-level number of actual alcohol-selling stores adjusted for the existing regulatory rules. We use the generalized Entropy Index in the subsequent analysis. The next result in Table 4 first presents the overall effect of grocery stores sales regulation on household purchase diversity for wine, beer, and spirits, respectively, which includes selected covariates. We further decompose the regulation effect in subsequent tables of analysis, by the level of alcohol content (Table 5), by the type of store operation, under control or license system (Table 6), by the level of rurality of the county households reside in (Table 7), and by the migration decision of households (Table 8). Marginal effects of the variable of interest for all the specification

are reported. The marginal effects are divided into two parts: first is the level of impacts on the probability of exhibiting diversity in purchases (hurdle component), and second the magnitude of the diversity (level component).

Table 4 shows the average marginal effects of retail regulation and a set of covariates on purchase diversity for each type of alcohol. Allowing alcohol sales in the grocery stores increases the probability of households purchasing at least two UPC products (diverse patterns in contrast to single UPC purchase in given year) by .03 for wine, .04 for beer and .024 for spirits compared to restricting the sales of corresponding alcohol types in grocery stores. Allowing wine sales in grocery stores leads to greater diversity in wine purchases, an .071 increase in the Entropy index value for states where sales are not restricted. Allowing beer sales increases the level of diversity by .062, and allowing spirit sales increases the level by .06, compared to the household purchase level facing restricted sales in grocery stores.

The more concentrated the coupon discounts are available for distinct UPC products, the greater purchase diversity households exhibit for all wine, beer and spirits. While the more disperse the deals are available for distinct UPC products, the greater variety it appears in alcohol purchases. The longer the time is between each shopping trip, the less diverse patterns are for wine and beer purchases (insignificant effect for spirits purchase). This result is aligned with the finding showing that consumers tend to adopt more habitual decision strategy for more durable goods compared to frequently purchased products (Adamowicz and Swait, 2013).

We also control the effect of various combination of alcohol purchases either single or mixed type, for each household in the model. It shows that the more different type of alcohol households have purchased in given year, the more diverse pattern is observed in all beer, wine and spirits purchases. The county-level store availability gives the opposite effect on purchase diversity among different alcoholic beverages. The more stores selling alcohol in the county the households reside in leads to greater purchase diversity for wine, while decreases the diversity in beer and spirits purchases, in both the probability and the level of purchase diversity. For every additional increase in the number of alcohol-selling

stores per 1,000 population in the county, it increases the level of purchase diversity for wine by .024 while reduce that for beer and spirits by .012 and .039 respectively. It implies that the households tend to purchase more variety among wine products when there are more alcohol outlets allowing wine sales. At the same time it implies a contradictory effect to the effect of regulation on grocery store sales for beer and spirits: Households tend to purchase more variety in beer or spirits products where there are less available outlets selling beer and spirits in the neighborhood.

Table 5 shows the effect of sales regulation in grocery stores by the level of alcohol content by volume, controlling for the same set of covariates as included in Table 4. We choose a different reference category in the regulatory framework in different alcohol models, since the sales of beer, wine and spirits allowed in the grocery store differ by the level of alcohol by volume. Compared to the purchase diversity in the states where only beer sales are allowed in grocery stores, the level of wine purchase diversity in states where both beer and wine sales are allowed is higher by .11, of which the deregulation effect is also greater than in states where all alcohol sales are allowed, .086. Compared to the purchase diversity in states where there are limited or no alcohol sales in grocery stores, the deregulation effect on the level of beer purchase diversity is the highest in states where only beer sales are allowed, higher by .073, than .071 in states where beer and wine sales are allowed and than .058 in states where all alcohol sales are allowed. The spirits purchase diversity is higher in states where all alcohol sales is allowed than where only beer and wine sales are allowed, by .072. In wine and spirits model, surprisingly, there is greater variety in purchase in more regulated states where wine and spirits sales are both restricted in the grocery stores. We also find the similar effect of retail outlet availability as in the model presenting the overall effect of deregulated alcohol sales in the respective model for each alcohol type in Table 4: The probability and the level of purchase diversity is positively affected by the retail environment where there are more alcohol-selling stores for wine, while the effect of retail availability on purchase diversity is negative for beer and spirits.

Table 6 compares the marginal effects of the types of store ownership on purchase

diversity under existing regulation on grocery store sales. For all wine, beer and spirits, no states that allow the corresponding alcohol sales in grocery stores exercise the full public monopoly on the distribution system. Compared to the purchase pattern in states that do not allow alcohol sales and have the control system, the purchase diversity are significantly greater by about .038 for wine in states that allow wine sales in grocery stores and restrict the operation of wine-selling stores to be both government-run and private-owned. The deregulation effect in a license system is insignificant. The purchase diversity is .041 higher for spirits in the license states that allow spirits sales in grocery stores. For beer purchases, there is no significant diverse pattern in states that allow beer sales in grocery store, regardless of the mixed or license system. Under the regulatory framework where no alcohol sales are allowed in grocery stores for each alcoholic beverage, the purchase diversity is however lower in the license states than in control states for all beer, wine and spirits, by .059, .094 and .023 respectively. We find no absolute evidence showing that purchase patterns in license states are always more diverse for all beer, wine and spirits, under the existing regulatory framework for alcohol retail sales.

In Table 7, we use the percentage of the population living in rural areas using the 2010 Census for the urban/rural classification at the county level (U.S. Census Bureau., 2010). The four categories are: (1) completely urban, with 100% of the population living in the urban areas; (2) mostly urban, less than 50% living in rural areas; (3) mostly rural, 50 99% in rural areas; (4) completely rural, 100% in rural areas. The reference category across three models is the completely urban area in states where either beer, wine or spirits sales are not allowed in grocery stores. We can infer the marginal effect of the rurality/urbanity in states where alcohol sales are allowed by subtracting the estimate of completely urban area category from the estimate for the remaining three categories. The level of purchase diversity for wine, beer and spirits is consistently lower in mostly rural area compared to in urban area in the states that do not allow the corresponding alcohol sales in grocery stores. In the states that allow alcohol sales in grocery stores, there is no significant effect of urban areas that leads to greater purchase diversity compared to relatively rural areas. Household purchase patterns in completely urban areas is only

significantly more diverse than in mostly urban area and only for wine, by index value of .03 (= .091 − .061). This line of result suggests an alternative interpretation of the regulation impacts to the studies which find alcohol deregulation on the grocery store sales and state monopoly system bring about welfare losses to rural consumers (Seim and Waldfogel, 2013; Seo, 2016).

In Table 8, we identify whether the household migration under the existing regulatory framework for alcohol sales affect their purchase diversity. Households are classified into three groups: (1) non-movers, those who have not moved across states between 2004-2014; (2) movers to the states that have the same regulation on alcohol sales in grocery stores as where they originally resided in; (3) movers to the states that have different regulation. The reference category across three models is the non-movers where alcohol sales are not allowed in grocery stores. We can also infer the marginal effect of the migration status of households in states where alcohol sales are allowed by subtracting the estimate of no-move from the estimate for the move, to states under either the same or different alcohol regulation compared to that in their original residing states. Our hypothesis is that the regulation effects would vary by the type of household residence, including within movers whose destination states have either the same or different types of alcohol regulation compared to their original residence.

Our results show that, across all types of alcohol, the purchase diversity is consistently higher among the households who have moved across the borders and to the destination state that has different regulatory framework compared to the no-migrating households, regardless of in the states where alcohol sales are not allowed or allowed in the grocery stores. For wine purchases, purchase diversity of non-movers in states where wine sales are allowed in grocery stores is higher by .066 than their counterparts in states where sales are not allowed. The deregulation effect on purchase diversity for wine by households who have moved to states under different wine regulation is insignificant. For beer purchase, the deregulation in grocery store sales of beer increases the purchase diversity by .062 for no-migrating households and by .062 (= .11 − .048) for households who have moved to states under different regulation on beer sales. The deregulation in grocery

store sales of spirits increases the purchase diversity by .039 for no-migrating households and by .041 (= .08 − .039) for households who have moved to states under different regulation on spirits sales from that in their original residence states. The moving decision to states with different regulation from original residence states also make households living in states where wine sales are allowed in grocery stores make more varietal choices in all beer, wine and spirits purchases, with Entropy index increased by .01 (= .12 − .11), by .024 (= .11 − .086), and by .006 (= .08 − .074) respectively.

The deregulation on the spirits market in one state could have spillover effects on the alcohol market in bordering counties in its neighboring states. Taxes and fees imposed on the retail spirits prices to compensate the revenue from state-run liquor stores and to prevent excess alcohol consumption after privatization leads to higher retail prices, compared to neighboring states not experiencing changes in law. Privatization of liquor law in Washington is found to increase alcohol sales in bordering counties in Oregon and Idaho (Winfree and Watson, 2015; Ye and Kerr, 2016). Retail price for spirits in Washington state increases by 11% after the privatization (Seo, 2016). To understand whether such spillover effect influences the degree of impact of state alcohol regulation on household choice of product variety, we create a border-effect variable by reassigning the regulation status for originally control counties which is adjacent to the counties in the states that have otherwise allowed alcohol sales in the grocery stores to the retail regulation status of its bordering county in each wine, beer, and spirits model. Table 9 shows that effect of deregulation in grocery store sales for beer, wine and spirits on both the probability and the level of diverse alcohol purchases is dampened (compared to the estimates in Table 4) once the spillover effect of deregulated grocery store sales across counties under different regulation is considered. It implies that the spillover effect of the deregulation in alcohol retailing to certain extent reduces the diversity in household alcohol purchases.

Conclusion

Policy intervention in the markets determines retail availability and product variety facing consumers. This study considers the empirical evidence on the potential effect of alcohol regulation that determines the alcohol-selling outlet availability and the store ownership on household purchase diversity for alcohol. Regulation on alcohol sales in U.S. since the Repeal of Prohibition Act in 1933 varies across states and leads to wide differences in the availability of stores and products to consumers. State-level regulation on grocery store sales and the store ownership has limited the availability of alcoholic beverage to consumers in states that have a highly regulated retail environment for alcohol. Regulation on grocery store sales varies by the content of alcohol by volume across states; beer sales are allowed in 39 states, wine sales are allowed in 33 states, and spirit sales are allowed in 19 states. Control states exercise state monopoly, either full or mixed with license system, on alcohol distribution and retailing. Private states license stores selling alcohol only as well as stores also selling food and other groceries. While the goal of regulation on alcohol beverages is to reduce social harms related with excessive drinking, the impact of regulation on alcohol distribution and retail on consumer choices of product variety has been unclear and may lead to unintended consequences.

This study uses the Nielsen HomeScan Data in 2004-2014 and the exogenous state-level time-invariant policy shock to investigate the effect of regulation on the probability and the level of diversity in household alcohol purchases. We develop a generalized Entropy Index that incorporate the level of product similarity between distinct products over certain attribute space, compared to standard Entropy index, to measure the annual purchase diversity at the household level. We create a pooled time-series dataset and use the correlated random-effects Tobit model that address the limited dependent variable issue arising from the zero-value observations in the outcome variable, while controlling for a set of covariates and household socio-demographic variables. The result shows that the standard Entropy index that does not incorporate the product similarity among distinct UPC products into the variety measure may overestimate the deregulation effect in alcohol sales in grocery store on purchase diversity.

We find that the probability and the level of purchase diversity is higher in states that allow alcohol sales in grocery store, for all beer, wine and spirits. Consumer choice for product variety is influenced by the institutional factor that regulates the level of availability of stores which are allowed to sell alcohol. Allowing alcohol sales in grocery stores offers the benefits of one-stop shopping and leads to both the higher probability of households purchasing at least two different UPC products over a year and the greater magnitude of such purchase diversity. Restricting alcohol sales in grocery stores creates the inconvenience and cost of multi-shopping for households, which may lead to less variety in alcohol purchases. The effect of deregulation in grocery store sales varies by the type of store ownership, by the rurality of the residence county, and by the migration decision of households while the general results are robust to these various specifications. The state-run stores do not necessarily discourage consumers from purchasing a greater variety of wine, beer or spirits products. The increased driving distance to liquor-selling stores due to less outlet density in relatively rural areas does not always lead to less diverse purchase patterns, particularly in states where alcohol sales are allowed in grocery stores. Choosing to move across borders, especially to the state with different regulation on alcohol, makes households more inclined to diversify their purchases over a variety of products in the long run. Such effect holds for all beer, wine, and spirits. Among the frameworks for both the overall and decomposing effect of the deregulation of alcohol sales in grocery stores, the covariate of the county-level number of actual alcohol-selling stores shows mixed effects among beverages: The increasing level of the availability of retail outlets selling alcohol only leads to greater diverse pattern in wine purchases, while reducing the purchase diversity for beer and spirits. The inconsistent effect of privatizing alcohol sales in stores that also sell foods and groceries across living neighborhoods, alcohol-selling store types and migration decisions implies there is behavioral heterogeneity among consumers choosing over a wide variety of products, which is not captured by the institutional determinants that regulate the retail environment and availability of alcoholic beverages.

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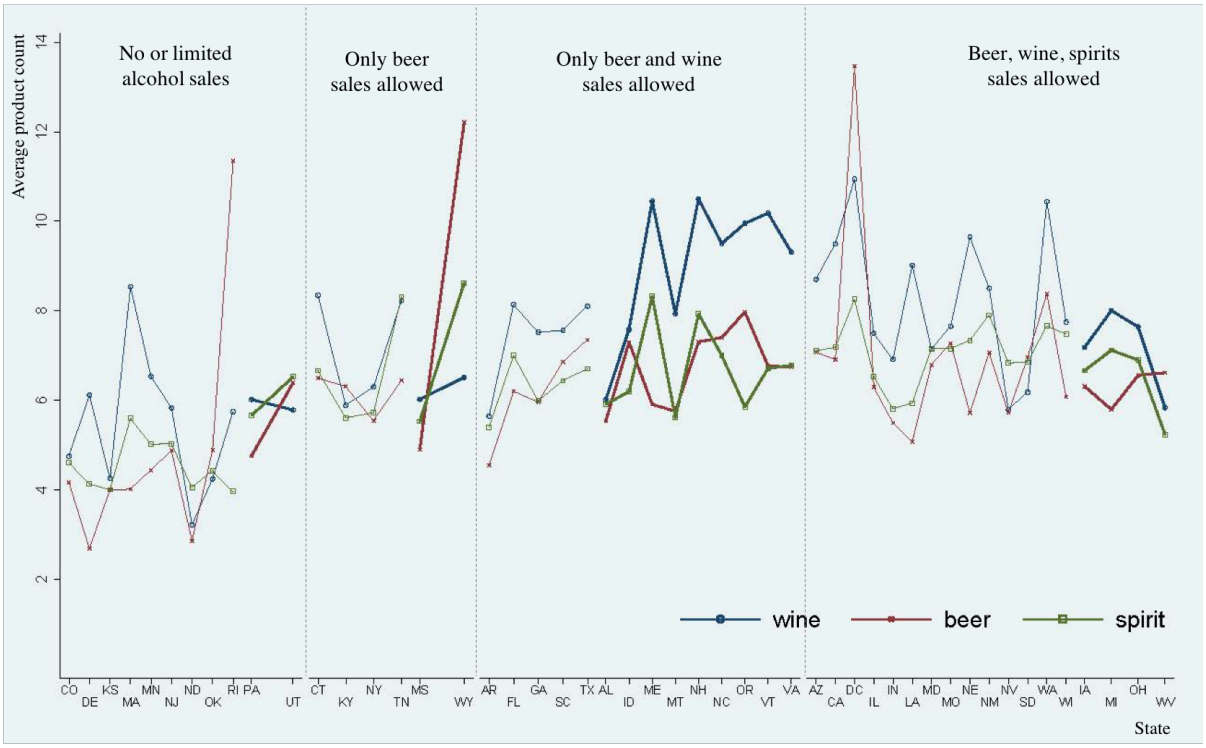
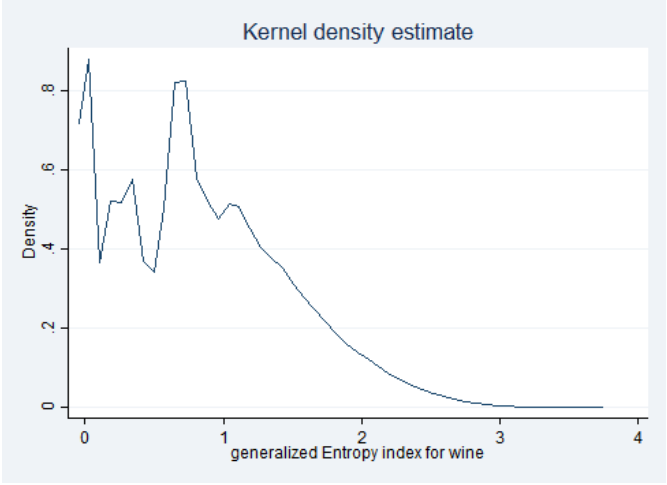
Figure

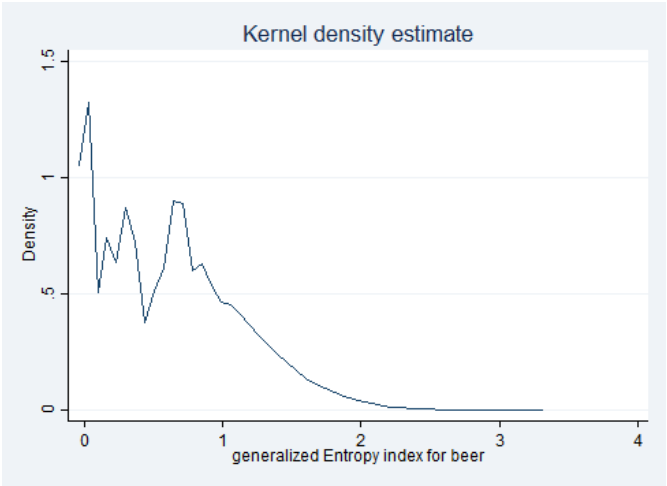


Source: APIS (2017), Nielsen HomeScan Dataset (2014), Rickard et al (2013).

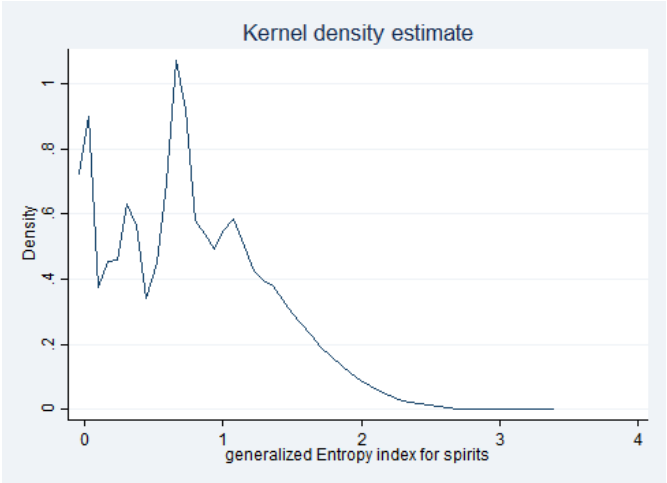
Figure 1: State average of product count for wine, beer, spirits purchases in 2014, by the level of alcohol regulation



(a) Kernel density estimate for wine purchase diversity



(b) Kernel density estimate for beer purchase diversity



(c) Kernel density estimate for spirits purchase diversity

Figure 2. Distribution of generalized Entropy index for wine, beer, and spirits purchases

Table 1. Hierarchy of alcoholic beverage products - Household purchases of wine, beer, and spirits, in total number of brand and UPC by product modules, 2014

Wine	number of brands	number of UPC	Beer	number of brands	number of UPC	Spirits	number of brands	number of UPC
Aperitifs	6	8	Ale	2,233	3,049	Bourbon-blended	31	125
Dry table - domestic	1,832	5,973	Beer	961	2,137	Bourbon-straight/bonded	156	519
Dry table -imported	2,285	4,725	Light beer (low calorie/alcohol)	88	522	Brandy/cognac	72	254
Flavored/refreshment	286	905	Malt liquor	36	129	Canadian whiskey	61	314
Kosher table	33	119	Near beer/malt beverage	66	136	Cordial & proprietary liquors	375	1,680
Sake	36	90	Stout and porter	429	521	Gin	82	282
Sangria	40	134				Irish whiskey	21	63
Sparkling	248	646				Remaining whiskey	34	101
Sweet dessert - domestic	31	127				Rum	190	926
Sweet dessert - imported	58	144				Scotch	132	331
Vermouth	15	75				Tequila	127	495
Non-alcoholic	30	172				Vodka	365	1,978
						Alcohol cocktails	112	645
						Coolers -remaining	122	548
						Fruit and vegetable in alcohol	5	12

Source: Nielsen Consumer Panel Dataset, 2014.

Table 2. Descriptive statistics for diversity measures and main variables in the analysis

	Wine			Beer			Spirits		
	mean	s.d.	median	mean	s.d.	median	mean	s.d.	median
Count of UPC product	6.9	8.7	4	4.59	4.74	3	4.86	4.49	3
Entropy Index	1.23	0.82	1.1	0.96	0.66	0.91	1.05	0.65	1.03
Generalized Entropy Index	0.88	0.63	0.8	0.65	0.51	0.64	0.82	0.55	0.75
Berry Index	0.57	0.28	0.64	0.49	0.27	0.51	0.53	0.26	0.58
Generalized Berry Index	0.45	0.27	0.5	0.36	0.25	0.37	0.44	0.25	0.49
Promotion intensity - coupon	0.11	0.28	0	0.09	0.26	0	0.09	0.27	0
Promotion intensity - deal	0.3	0.37	0.11	0.27	0.38	0	0.27	0.37	0
Average inter-purchase time	44.5	56.9	25.29	38.8	51.2	21.6	36.4	50.4	19.5
Type of alcohol buyer	4.79	2.33	5	5.4	1.9	6	6.07	1.3	7
County-level number of alcohol-selling stores per 1000 population	0.66	0.36	0.73	0.76	0.36	0.78	0.41	0.40	0.21
Observations		188,961			155,206			128,811	
Censored observations		20,823			20,969			13,472	

Table 3. Baseline model for the effects of alcohol-selling store availability for wine, beer and spirits - Three diversity measures, probability and level of diverse purchase patterns

	Wine			Beer			Spirits		
	product count	Entropy index	generalized Entropy index	product count	Entropy index	generalized Entropy index	product count	Entropy index	generalized Entropy index
Hurdle effect: Alcohol sales allowed in grocery stores	0.051***	0.03***	0.036***	0.038***	0.053***	0.049***	0.043***	0.022***	0.029***
(Base: sales not allowed)	(0.0054)	(0.003)	(0.0034)	(0.0076)	(0.004)	(0.0045)	(0.0062)	(0.003)	(0.0035)
Level effect: Alcohol sales allowed in grocery stores	0.59***	0.095***	0.075***	0.53***	0.11***	0.068***	0.34***	0.073***	0.067***
(Base: sales not allowed)	(0.06)	(0.0087)	(0.0064)	(0.039)	(0.0076)	(0.0055)	(0.0495)	(0.01)	(0.0082)
Observations	188,961	188,961	188,961	155,206	155,206	155,206	128,811	128,811	128,811
Censored observations	20,823	20,773	20,773	20,969	20,809	20,809	13,472	12,226	12,226
Log likelihood	-569502	-159630	-202231	-391303	-146736	-109597	-333018	-122521	-101004
Chi-squared value	2887	3403	3237	1932	2513	2476	1364	1339	1450
Panel-level unobserved heterogeneity	6.92	0.49	0.65	3.79	0.51	0.39	3.31	0.46	0.4
Idiosyncratic heterogeneity	5.07	0.45	0.57	3.13	0.5	0.39	3.21	0.52	0.43
Contribution of panel-level variation to overall variation	0.65	0.55	0.56	0.59	0.51	0.5	0.52	0.45	0.47

Notes: Delta-method standard errors in parentheses. * $p < .05$, ** $p < .01$, *** $p < .001$. Coefficient estimates represent average marginal effects in correlated random effect Tobit model. The model controls for household socio-demographic characteristics, such as age, education, employment, occupation of male and female head, income, race, marital status, number of children under 18, year fixed effect and the number of alcohol-selling stores in the county household resides in.

Table 4. Baseline model for the effects of alcohol-selling store availability - Generalized Entropy index

	Wine		Beer		Spirits	
	probability of diverse purchases	level of purchase diversity	probability of diverse purchases	level of purchase diversity	probability of diverse purchases	level of purchase diversity
Alcohol sales allowed in grocery stores	0.031***	0.071***	0.041***	0.062***	0.024***	0.059***
(Base: sales not allowed)	(0.003)	(0.0062)	(0.0037)	(0.0055)	(0.0033)	(0.008)
promotion intensity - coupon	0.043***	0.11***	0.013***	0.02***	0.011***	0.027***
	(0.0014)	(0.0035)	(0.0021)	(0.0034)	(0.0018)	(0.0044)
promotion intensity - deal	-0.043***	-0.1***	-0.0047**	-0.0074**	-0.00046	-0.0011
	(0.0011)	(0.0027)	(0.0014)	(0.0024)	(0.0013)	(0.0032)
average inter-purchase time, (10^{-3})	-0.17***	-0.42***	-0.048***	-0.076***	-0.0016	-0.004
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Type of alcohol buyer						
only wine	(base)					
only beer			(base)			
only spirits					(base)	
wine, beer	0.056***	0.1***	0.048***	0.061***		
	(0.0015)	(0.0028)	(0.0021)	(0.0026)		
wine, spirits	0.063***	0.12***			0.063***	0.11***
	(0.0015)	(0.0029)			(0.0025)	(0.0038)
beer, spirits			0.049***	0.062***	0.052***	0.083***
			(0.0022)	(0.0028)	(0.0026)	(0.004)
wine, beer, spirits	0.094***	0.21***	0.089***	0.13***	0.1***	0.2***
	(0.0014)	(0.0028)	(0.002)	(0.0026)	(0.0024)	(0.0037)
Number of stores per 1000 population in county	0.0097***	0.024***	-0.0077*	-0.012*	-0.016***	-0.039***
	(0.0029)	(0.0071)	(0.0031)	(0.0049)	(0.004)	(0.0098)
Observations	188,961		155,206		128,811	
Censored observations	20,773		20,809		12,226	
Log likelihood	-153443		-107845		-99014	
Chi-squared value	17159		6194		5599	
Panel-level unobserved heterogeneity	0.43		0.37		0.37	
Idiosyncratic heterogeneity	0.44		0.39		0.43	
Contribution of panel-level variation to overall variation	0.49		0.48		0.43	

Notes: Delta-method standard errors in parentheses. * p < .05, ** p < .01, *** p < .001. Coefficient estimates represent average marginal effects in correlated random effect Tobit model. The model also controls for household socio-demographic characteristics, such as age, education, employment, occupation of male and female head, income, race, marital status, number of children under 18, year fixed effect, and the average of time-varying household-specific variables such as promotion intensity and average inter-purchase time.

Table 5. Effects of different level of availability by alcohol type in grocery stores on purchase diversity

	Wine		Beer		Spirits	
	probability of diverse purchases	level of purchase diversity	probability of diverse purchases	level of purchase diversity	probability of diverse purchases	level of purchase diversity
Availability in grocery stores						
limited or no alcohol sales	0.021***	0.041***	(base)		0.018***	0.041***
	(0.0035)	(0.0067)			(0.0024)	(0.0056)
only beer sales allowed	(base)		0.047***	0.073***	-0.0014	-0.0028
			(0.005)	(0.0076)	(0.003)	(0.0061)
beer and wine sales	0.051***	0.11***	0.046***	0.071***	(base)	
	(0.0039)	(0.0077)	(0.0039)	(0.0058)		
all alcohol sales	0.041***	0.086***	0.038***	0.058***	0.03***	0.072***
	(0.0039)	(0.0075)	(0.0038)	(0.0056)	(0.0035)	(0.0084)
Number of stores per 1000 population in residing county	0.0089***	0.022***	-0.01**	-0.016**	-0.018***	-0.044***
	(0.0029)	(0.0071)	(0.0033)	(0.0052)	(0.004)	(0.0098)
Observations	188,961		155,206		128,811	
Censored observations	20,773		20,809		12,226	
Log likelihood	-153400		-107835		-98983	
Chi-squared value	17262		6214		5666	
Panel-level unobserved heterogeneity	0.43		0.37		0.37	
Idiosyncratic heterogeneity	0.44		0.39		0.43	
Contribution of panel-level variation to overall variation	0.49		0.48		0.43	

Notes: Delta-method Standard errors in parentheses. * p < .05, ** p < .01, *** p < .001. Coefficient estimates represent average marginal effects in correlated random effect Tobit model. The model controls for household socio-demographic characteristics, promotion intensity, inter-purchase length, type of alcohol buyers, time average of household-level variables and year fixed effect as the estimation in Table 4.

Table 6. Effects of control vs. license system on purchase diversity, under existing regulation on grocery store sales

		Wine		Beer		Spirits	
		probability of diverse purchases	level of purchase diversity	probability of diverse purchases	level of purchase diversity	probability of diverse purchases	level of purchase diversity
Grocery store availability	Store type						
Alcohol sale not allowed	Control	(Base)		(No observation)		(Base)	
	Mixed	(No observation)		(Base)		-0.0023	-0.0054
						(0.0042)	(0.0099)
	License	-0.028***	-0.059***	-0.06***	-0.094***	-0.01***	-0.023***
		(0.0041)	(0.0094)	(0.016)	(0.026)	(0.0029)	(0.0067)
Alcohol sale allowed	Control	(No observation)		(No observation)		(No observation)	
	Mixed	0.015**	0.038**	0.00079	0.0013	-0.0044	-0.01
		(0.0047)	(0.012)	(0.0168)	(0.0278)	(0.0055)	(0.0126)
	License	0.008	0.02	-0.018	-0.029	0.016***	0.041***
		(0.0043)	(0.0103)	(0.016)	(0.0264)	(0.004)	(0.01)
Number of stores per 1000 population in county		0.009**	0.022**	-0.0082**	-0.013**	-0.013**	-0.032**
		(0.0029)	(0.0072)	(0.0031)	(0.0049)	(0.0041)	(0.0098)
Observations		188,961		155,206		128,811	
Censored observations		20,773		20,809		12,226	
Log likelihood		-153417		-107832		-98987	
Chi-squared value		17226		6223		5658	
Panel-level unobserved heterogeneity		0.43		0.37		0.37	
Idiosyncratic heterogeneity		0.44		0.39		0.43	
Contribution of panel-level variation to overall variation		0.49		0.48		0.43	

Notes: Delta-method standard errors in parentheses. * p < .05, ** p < .01, *** p < .001. Coefficient estimates represent average marginal effects in correlated random effect Tobit model. The model controls for household socio-demographic characteristics, promotion intensity, inter-purchase length, type of alcohol buyers, time average of household-level variables and year fixed effect as the estimation in Table 4.

Table 7. Decomposing effects of liquor-selling store availability on purchase diversity, by the level of rurality/urbanity of the residence county

		Wine		Beer		Spirits	
		probability of diverse purchases	level of purchase diversity	probability of diverse purchases	level of purchase diversity	probability of diverse purchases	level of purchase diversity
Grocery store availability	Rurality/Urbanity of county						
Alcohol sale not allowed	Urban	(Base)		(Base)		(Base)	
	Mostly urban	-0.0034	-0.007	-0.0085	-0.013	-0.021***	-0.05***
		(0.0055)	(0.0116)	(0.0115)	(0.0173)	(0.0048)	(0.0123)
	Mostly rural	-0.043***	-0.079***	-0.04**	-0.057**	-0.032***	-0.073***
		(0.0086)	(0.0156)	(0.0149)	(0.0217)	(0.0058)	(0.0139)
	Rural	-0.015	-0.031	0.009	0.014	-0.0088	-0.022
		(0.0158)	(0.03)	(0.0232)	(0.0354)	(0.0091)	(0.0223)
Alcohol sale allowed	Urban	0.037***	0.091***	0.032*	0.05*	0.015	0.042
		(0.0082)	(0.021)	(0.0137)	(0.021)	(0.009)	(0.0268)
	Mostly urban	0.026***	0.061***	0.032**	0.05**	0.0063	0.017
		(0.0056)	(0.012)	(0.0115)	(0.0173)	(0.0053)	(0.0141)
	Mostly rural	0.00096	0.002	0.011	0.017	-0.0019	-0.005
		(0.0064)	(0.0135)	(0.0119)	(0.0179)	(0.0064)	(0.0166)
	Rural	-0.0017	-0.0036	0.011	0.017	0.017	0.048
		(0.0102)	(0.0213)	(0.014)	(0.0212)	(0.0094)	(0.0286)
Number of stores per 1000 population in county		0.011***	0.028***	-0.0059	-0.0093	-0.02***	-0.049***
		(0.0031)	(0.0075)	(0.0035)	(0.0056)	(0.0043)	(0.0104)
Observations		188,961		155,206		128,811	
Censored observations		20,773		20,809		12,226	
Log likelihood		-153373		-107814		-98994	
Chi-squared value		17341		6266		5644	
Panel-level unobserved heterogeneity		0.43		0.37		0.37	
Idiosyncratic heterogeneity		0.44		0.39		0.43	
Contribution of panel-level variation to overall variation		0.49		0.48		0.43	

Notes: Delta-method standard errors in parentheses. * p < .05, ** p < .01, *** p < .001. Coefficient estimates represent average marginal effects in correlated random effect Tobit model. The model controls for household socio-demographic characteristics, promotion intensity, inter-purchase length, type of alcohol buyers, time average of household-level variables and year fixed effect as the estimation in Table 4.

Table 8. Decomposing effects of liquor-selling store availability on purchase diversity, by household moving decision

		Wine		Beer		Spirits	
		probability of diverse purchases	level of purchase diversity	probability of diverse purchases	level of purchase diversity	probability of diverse purchases	level of purchase diversity
Grocery store availability	Moving decision						
Alcohol sale not allowed	No move	(Base)		(Base)		(Base)	
	Move - to states under same regulation	0.026	0.057	-0.0043	-0.0062	0.011	0.025
		(0.0137)	(0.0335)	(0.0322)	(0.0468)	(0.0057)	(0.0135)
	Move - to state under different regulation	0.0036	0.0073	0.031**	0.048**	0.017**	0.039**
		(0.0068)	(0.0141)	(0.0102)	(0.016)	(0.0056)	(0.0141)
Alcohol sale allowed	No move	0.029***	0.066***	0.041***	0.063***	0.025***	0.061***
		(0.003)	(0.0064)	(0.0038)	(0.0057)	(0.0033)	(0.0081)
	Move - to states under same regulation	0.045***	0.11***	0.055***	0.086***	0.03***	0.074***
		(0.0046)	(0.0122)	(0.0062)	(0.0098)	(0.0079)	(0.0224)
	Move - to state under different regulation	0.05***	0.12***	0.071***	0.11***	0.032***	0.08***
		(0.0054)	(0.0156)	(0.0101)	(0.0167)	(0.0057)	(0.0163)
Number of stores per 1000 population in county		0.0097***	0.024***	-0.0076*	-0.012*	-0.016***	-0.039***
		(0.0029)	(0.0071)	(0.0031)	(0.0049)	(0.004)	(0.0098)
Observations		188,961		155,206		128,811	
Censored observations		20,773		20,809		12,226	
Log likelihood		-153423		-107835		-99008	
Chi-squared value		17203		6217		5613	
Panel-level unobserved heterogeneity		0.43		0.37		0.37	
Idiosyncratic heterogeneity		0.44		0.39		0.43	
Contribution of panel-level variation to overall variation		0.49		0.48		0.43	

Notes: Delta-method standard errors in parentheses. * p < .05, ** p < .01, *** p < .001. Coefficient estimates represent average marginal effects in correlated random effect Tobit model. The model controls for household socio-demographic characteristics, promotion intensity, inter-purchase length, type of alcohol buyers, time average of household-level variables and year fixed effect as the estimation in Table 4.

Table 9. Bordering effect of alcohol availability in grocery stores

	Wine		Beer		Spirits	
	probability of diverse purchases	level of purchase diversity	probability of diverse purchases	level of purchase diversity	probability of diverse purchases	level of purchase diversity
Alcohol sales allowed in grocery stores	0.022***	0.051***	0.035***	0.05***	0.016***	0.038***
(Base: sales not allowed)	(0.0026)	(0.0057)	(0.0044)	(0.0058)	(0.0025)	(0.006)
Number of stores per 1000 population in county	0.021***	0.05***	0.0025	0.0039	-0.0053	-0.013
	(0.0025)	(0.006)	(0.0028)	(0.0044)	(0.0031)	(0.0074)
Observations	188,961		155,206		128,811	
Censored observations	20,773		20,809		12,226	
Log likelihood	-153467		-107871		-99021	
Chi-squared value	17,101		6136		5582	
Panel-level unobserved heterogeneity	0.43		0.37		0.37	
Idiosyncratic heterogeneity	0.44		0.39		0.43	
Contribution of panel-level variation to overall variation	0.49		0.48		0.43	

Notes: Delta-method standard errors in parentheses. * p < .05, ** p < .01, *** p < .001. Coefficient estimates represent average marginal effects in correlated random effect Tobit model. The model controls for household socio-demographic characteristics, promotion intensity, inter-purchase length, type of alcohol buyers, time average of household-level variables and year fixed effect as the estimation in Table 4.