One Markup to Rule Them All: Taxation by Liquor Pricing Regulation *

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January 28, 2019

Abstract

Commodity taxation often involves uniform tax rates. We use alcohol laws that tax differentiated spirits with a comprehensive uniform markup to evaluate redistribution generated by such simple tax policy. We document preference heterogeneity among consumers, variation in product demand elasticities, and market power among producers with heterogeneous product portfolios. Relative to more flexible product-level markups recognizing demand heterogeneity and strategic price responses of firms, we find that the uniform markup underprices less elastic spirits, implicitly subsidizing low-income and less educated residents. The uniform markup grants additional market power to small specialized firms whose product positioning benefits from the policy.

Keywords: Taxation by Regulation, Optimal Taxation, Uniform Commodity Taxation, Ramsey Pricing.

JEL Codes: H21, H23, L43, L66

* We thank Thomas Krantz at the Pennsylvania Liquor Control Board as well as Jerome Janicki and Mike Ehtesham at the National Alcohol Beverage Control Association for providing us with access to the data. We are grateful for many comments and suggestions, and in particular to Jeff Campbell, Kenneth Hendricks, Louis Kaplow, Julie Mortimer, Aviv Nevo, Joel Waldfogel, and participants at the 2017 Cowles Conference in Structural Microeconometrics and the 2017 NBER Summer Institute Industrial Organization workshop. This research was supported in part by the Notre Dame Center for Research Computing.

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Forthcoming in AEJ--Microeconomics. Submitted: 05/15/2018. Accepted: 12/26/2018.

"The paramount role traditionally assigned by economists to government regulation was to correct the failures of the private market (...), but in fact the premier role of modern regulation is to redistribute income."

George J. Stigler: Preface to *Chicago Studies in Political Economy*

1 Introduction

Governments at all levels employ uniform rates to tax broad product categories such as food, clothing, hospitality, or transportation, despite the obvious differences in demand and supply elasticities of different food products, clothing varieties, accommodation types, and travel options. The present study evaluates the redistribution effects induced by the uniform taxation of spirits. We rely on data from Pennsylvania where the state regulator, the Pennsylvania Liquor Control Board ($PLCB$), operates all retail stores in the state and, by law, applies the same wholesale markup formula to all products regardless of differences in consumer demand. As the markup formula amounts to a uniform tax, our results apply to a broad array of industries in which government applies a uniform tax to a variety of goods.

Our analysis builds on the idea that employing a uniform tax policy necessarily leads to the overpricing of some items and underpricing of others as it ignores heterogeneous price elasticities. This idea dates back to Ramsey (1927) who showed that the least distorting way to raise tax revenue from goods was to tax products proportionally to the inverse of their elasticity of demand. A uniform tax also entails redistribution; consumers who prefer underpriced products benefit from uniform taxation at the expense of others who purchase overpriced products. Similarly, uniform taxation disproportionately benefits firms that offer products with relatively inelastic demand for whom the uniform tax is too low. Consequently, Posner (1971) famously referred to the use of *uniform rates* as an example of what he called "taxation by regulation," tax-induced redistribution. Surprisingly, there are almost no empirical public finance studies to validate the practical relevance of Posner's idea.[1] Industrial Organization models are built to address consumer heterogeneity and are perhaps most suitable to conduct this kind of analysis. Our study aims to do so using an equilibrium model that not only recognizes the responses of consumers to changes in tax policy, but also those of strategic suppliers.[2] To the best of our knowledge, this is the first paper where

[1] Atkinson and Stiglitz (1976) show that an optimal nonlinear income tax can always achieve the redistribution of rents induced by commodity taxation if preferences are separable in consumption and leisure.

[2] Precedents include Linneman (1980, §5), who provides back-of-the-envelope estimates of profit redistribution (in favor of large manufacturers) and uneven price increases (hurting low-income families) after the 1973 Mattress Flammability Standard. Finkelstein, Poterba and Rothschild (2009) make use of numerical simulations to evaluate the allocation efficiencies and redistribution effects of not allowing for gender-based pricing (different mortality risk) among participants of the U.K. annuity market. Hausman (1998) ignores redistribution and evaluates the allocation inefficiency of taxing interstate telephone service to subsidize internet access for schools and libraries.

an equilibrium model and the modern tools of Industrial Organization are employed to uncover redistribution issues raised by taxation.

We employ an enriched variant of a demand model from earlier work (Miravete, Seim and Thurk, 2018) to estimate consumer preferences using features of the pricing regulation. These enable us to cleanly identify demand, particularly across demographic groups. Our estimates are reasonable, robust, and demonstrate large variation in consumer preferences for different spirit types and characteristics. For example, we find that, all else equal, minorities prefer brandies and rums to vodkas and whiskeys while wealthier consumers prefer expensive varieties.

A uniform tax may be optimal when products have a common demand elasticity. We find, however, significant heterogeneity of product-level demand elasticities and show that these patterns again correlate with consumer preferences, but also vary systematically with firm portfolios with e.g., low-income consumers being more likely to purchase less expensive products with less elastic demand. Meanwhile, large firms like Diageo offer products across a broad range of characteristics while smaller firms offer specialized portfolios composed of niche products with relatively inelastic demand. To investigate the role of a uniform markup policy on firm behavior, we use the estimated preferences and firms' observed wholesale prices to assess market power by firms that compete in differentiated products pricing.

We find that – despite the large number of firms and products in this industry – the average firm generates 36 cents in income for every dollar in revenue. The large degree of product differentiation thus enables distillers to place their products in areas of the product characteristic space where they maintain significant market power. Such market power provides firms with both incentive and ability to respond strategically to tax policy, and we allow distillers to re-optimize their pricing decisions in response to any counterfactual tax policy change. We therefore account for both the *mechanical effect* and *behavioral response* to a change in policy (Saez, 2001) by not only consumers, but also firms. The retail price pass-through of counterfactual taxes then is a function of the estimated demand curvature and elasticities, which drives the optimal pricing response of distillers.

We identify redistribution from the uniform markup by comparing the observed equilibrium to counterfactual equilibria generated by alternative tax policies that allow markups to vary flexibly across all 312 spirits products offered by the *PLCB*. We therefore allow the tax rates in these alternative policies to reflect the heterogenous demand elasticities in this market. Doing so requires us to take a stand on the *PLCB*'s objective. This is difficult since the Board came into existence in 1933 to manage alcohol consumption among Pennsylvania residents, but today generates significant tax revenue for the state general fund. Recent legislation suggests that legislators use it solely as a source of tax revenue. Indeed, we show that among uniform markups, the chosen one reduces alcohol consumption and overprices spirits, but also achieves 99.6% of the potential tax revenue attainable with a single markup. Thus, we cannot reject the possibility that the state uses the *PLCB* to address both consumption and tax revenue.

We therefore bound our analysis between two objectives that determine the regulator's choice of the vector of product-level markups. First, we assume that the *PLCB* chooses policy to maximize consumer welfare subject to generating sufficient tax revenue to cover the negative externalities related to alcohol consumption. Second, we consider the maximization of tax revenue as an alternative objective, implicitly assuming that the tax revenue raised serves to finance government programs that benefit consumers.

Under both objectives, the *PLCB* sets high markups on relatively inelastic goods to minimize deadweight loss. We show that despite equilibrium wholesale price responses by distillers, moving from a uniform markup to either set of product-level markups results in higher retail prices for relatively inelastic goods and decreases retail prices for relatively elastic goods. Average retail prices, however, change little so the impact to consumers and firms is largely redistributive. We also show that the uniform markup redistributes rents among agents in the regulated industry in a predictable way as consumers who prefer relatively inelastic products and firms who produce these products benefit from a uniform markup. The quantitative importance of these effects has received little attention among economists to date.

Which consumers benefit from the uniform markup specifically? Our demand estimates indicate that low-income consumers, minority consumers, and consumers without college education prefer the 375 ml and inexpensive spirits that a uniform markup underprices. In contrast, the uniform markup makes wealthy consumers and consumers with at least some college education worse off as these consumers prefer the relatively elastically demanded 1.75 L and expensive spirits. The uniform markup therefore amounts to an implicit progressive tax that redistributes income and utility across demographic groups.

Regardless of the regulator's objective, current policy also transfers profits from large firms such as Diageo or Bacardi to small firms such as Jacquin and Sazerac. Jacquin is of particular interest as it is a small Philadelphia-based distiller that plays only a minor role in markets outside of Pennsylvania. We show that Jacquin's success under the uniform markup stems from a focus on niche products that the policy underprices. Similar to Jordan's *Producer Protection* argument for regulation (Jordan, 1972), this result demonstrates that a clever government could therefore design policy to favor local firms.

Beyond redistributive considerations, we show that ignoring demand heterogeneity also affects the *PLCB*'s ability to meet either of its objectives. When the regulator values only tax revenue, a uniform markup leaves about 9.8% ($25.1 million) in foregone tax revenues on the table. In contrast, adopting product-level markups enables the Ramsey regulator to increase consumer welfare by $32 million, or 5.2% of liquor expenditure in our sample. Interestingly, we find that adopting product-level markups under both objectives increases aggregate tax revenue, consumption, and welfare – a finding reminiscent of Varian (1985) in the context of price discrimination.

Choosing and maintaining 312 different product-level markups may not be feasible for the regulator. We therefore compare our results with a simpler policy in which the *PLCB* chooses markups based on easily observable characteristics: spirit type (6 types) and bottle size (3 sizes).

This feasible policy also tests whether there exist simple sufficient statistics, e.g., average demand elasticity by spirit type and bottle size, that government can use to approximate policies as complex as product-level markups. Our findings suggest, however, that the simpler tax structure captures only a small share of the potential rents regardless of the regulator's objective. Moreover, the feasible policy itself generates significant redistribution among consumers and firms.

Our paper contributes to two areas of research: optimal taxation and uniform pricing. Ramsey (1927) and Diamond and Mirrlees (1971) showed that in the absence of nonlinear income taxes, the least distortive way to raise a given amount of tax revenue requires an array of different commodity taxes, not just a uniform tax. Ramsey's inverse elasticity rule states that the optimal tax rate on any particular commodity needs to be proportional to the sum of its inverse demand and supply elasticities. In our – partial-equilibrium – environment, where it is reasonable to assume that marginal costs are constant, this simplifies further to be only an inverse function of the demand elasticity.[3] Boiteux (1956) rediscovered Ramsey's inverse elasticity rule in the context of the socially optimal pricing of a budget-constrained multiproduct monopolist, a close depiction of the *PLCB*'s pricing problem.

Regulators usually have a limited number of policy instruments at their disposal, in our case a single markup or uniform tax rate across all products. As Tinbergen (1952) famously noted, having insufficient instruments may lead to significant trade-offs among policy goals. If demand for spirits were inelastic, a common assumption in the public economics literature, the regulator could achieve multiple goals simultaneously: increasing tax rates would make spirits more expensive and reduce alcohol sales only somewhat, thus increasing tax revenues. However, in an oligopolistic industry, firms price so the tax-inclusive price falls in the elastic region of demand. While further tax rate increases would certainly reduce alcohol consumption, they might thus fail to increase tax revenues. Our results demonstrate that adding policy instruments – product-level markups – enables the regulator to increase tax revenue and consumer welfare simultaneously while addressing the negative health externalities related to alcohol consumption.

Sandmo (1976b) and more recently Kopczuk (2003) show that the optimal Ramsey pricing problem with externalities can be separated into two independent problems jointly defining the markup charged for each product: a Pigouvian tax targeting the externality and deviations from the resulting prices based on demand elasticities to meet revenue targets. Identifying and measuring the health externalities related to alcohol consumption is difficult, however.[4] We capture the

[3] In a general equilibrium framework we also need to consider labor supply in addition to consumption decisions. Atkinson and Stiglitz (1972) and Sandmo (1976a, §3) show that uniform taxation might be optimal if labor supply is perfectly inelastic. Deaton (1981) shows that a necessary and sufficient condition for uniform taxation to be optimal in a representative consumer framework is that preferences are separable in consumption and labor in such a way that the subutility function of consumption is homothetic and invariant to changes in labor supply. These so-called "quasi-separable" utility functions are clearly restrictive.

[4] We could assume a specific functional form for the health externality and include it in consumer utility. With sufficiently detailed data, one could identify parameters of the assumed externality function. Griffith, O'Connell and Smith (2017) adopt this approach to evaluate the effectiveness of corrective alcohol taxes using consumer survey data from United Kingdom though they ignore the strategic pricing response of retailers and firms to changes in

externality associated with ethanol consumption in a simple way: we assume the state uses the tax revenue raised by alcohol taxation to offset the external costs of alcohol consumption.[5] Our approach produces an estimate of the *PLCB*'s implicit valuation of the average external cost per liter of ethanol consumed of $15.46, which is similar to the estimates in the health policy literature. Given this shadow cost of alcohol consumption, we show that it is possible to design product-level markups that not only increase consumption and consumer welfare, but also generate sufficient additional tax revenue to cover the associated larger external costs.

A number of recent papers address the retail regulation of alcoholic beverages. Seim and Waldfogel (2013), Aguirregabiria, Ershov and Suzuki (2016), and Illanes and Moshary (2015) study the effects of entry restrictions: no entry in Pennsylvania, partial entry in the wine segment in Ontario, and privatization of the alcohol distribution system in Washington state, respectively. Others focus on the potential for regulation to facilitate collusion among wholesalers: Conlon and Rao (2015) analyze "post and hold" regulation and Miller and Weinberg (2015) use mergers in the brewing industry to identify collusive behavior. In related work (Miravete et al., 2018), we show how the market power of taxed firms limits the regulator's ability to use taxation to generate tax revenue, leading to a noncompetitive market foundation of the Laffer curve. Whereas that paper focuses on the impact of firm market power on the shape of the Laffer curve, the purpose of this study is to evaluate the distributional consequences of uniform taxation.

Finally, our paper contributes to classic questions around the value foregone through uniform pricing over sophisticated pricing and price discrimination. Cho and Rust (2010), Shiller and Waldfogel (2011), and Orbach and Einav (2007) provide evidence on uniform pricing of products of different attributes – car rentals, song downloads, and movies, respectively. Empirical evidence on uniform pricing across heterogeneous geographic markets is mixed. It includes Adams and Williams (2019) for a single product in home improvement supply stores and Chintagunta, Dubé and Singh (2003) for a small set of products in supermarkets in Chicago. Interestingly, there is new substantial evidence that retailers do not engage in local pricing as much as they should: Della Vigna and Gentzkow (2017) and Hitcsh, Hortaçsu and Lin (2017) both make use of a very large number of products across thousands of retail chain stores in the United States to show that pricing is mostly retail-chain specific and does not respond to local demand conditions. Our work complements these papers by considering cross-subsidies among heterogeneous consumers and firms due to uniform taxation – a common policy tool employed by governments to tax consumption but we abstract from additional effects induced by differentiated local pricing by private retailers, an environment that does not match the institutional features of Pennsylvania.

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taxation. Our objective instead is to measure the implicit redistribution due to uniform taxation, accounting for the important response by imperfectly competitive firms to changes in government tax policy.

[5] Quantifying the magnitude of the externality as a function of the state's aggregate expenditure liability only is consistent with legal practice. When the attorneys general of 46 U.S. states sued the tobacco industry in the late 1990s, they calculated damages using a similar approach. Specifically, they sued Philip Morris, R. J. Reynolds, Brown & Williamson, and Lorillard to recover aggregate tobacco-related Medicaid expenses related to caring for persons with smoking-related illnesses.

We begin the paper with an overview of our data and setting and an illustration of consumption patterns by demographic groups in Section 2. Section 3 presents an equilibrium discrete choice model of demand for horizontally differentiated spirits that incorporates the features of the current pricing regulations while accounting for oligopoly competition in the distiller market. Section 4 reports our estimates and documents significant heterogeneity of preferences for spirits and market power by producers. In Section 5 we test whether the 30% markup maximizes tax revenue conditional on choosing a uniform markup. In Section 6 we measure redistribution from the single markup by comparing the 30% uniform markup to markups that vary by product. We also evaluate the effectiveness of simpler policies as an approximation to the product-level markups. We summarize our results and offer concluding remarks in Section 7. The Appendices contain additional information on data construction, descriptive statistics, estimation algorithm, robustness, and results.

2 The Pennsylvania Market for Spirits

We begin by summarizing the regulation of alcoholic beverages in Pennsylvania. We then describe the data on sales, prices, characteristics of products sold by the *PLCB* and the distillery market. Finally, we document the heterogeneity of consumer preferences for different types of spirits and quantity of alcohol consumed behind the differentiated incidence of the current 30% taxation rule.[6]

2.1 The Mechanics of the Pricing Regulation

Pennsylvania adheres to the common three-tier alcoholic beverage distribution system: distillers sell their products to wholesale distributors who then sell to retailers, and only retailers may sell to consumers. The *PLCB* also vertically integrates and operates both the wholesale and retail distribution of wine (36% of *PLCB* revenue) and spirits (63% of *PLCB* revenue).[7] Until 2016, as well as during the period covered by our data, 2003-2004, it did so as a monopolist; today, the state allows for the controlled retail of wine, but not spirits, by private firms, although the *PLCB* continues to serve as their supplier.[8] We focus on the spirits category as it represents the majority of *PLCB* sales. Spirits further constitute a well-defined and mature product category with a small number of easily measurable product characteristics, including the type of spirit, the alcohol content, the possible addition of fruit or other flavors, and the product's country of origin.[9]

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[6] Miravete et al. (2018) provide additional detail on the market environment, in particular pertaining to pricing interaction along the supply chain.

[7] Pennsylvania also has a private system for the sale of beer, allowing the controlled entry of private retailers. During our sample, beer license revenue accounted for less that one percent of *PLCB* revenue.

[8] Our data do not include on-premise sales (in bars and restaurants) accounting for approximately 20% of total spirit sales by volume and revenue.

[9] In contrast, wines have hard-to-measure quality determinants and a large number of products with limited life cycles leading to tiny, highly volatile market shares. For example, within the popular 750 ml bottle category, the top-100 selling wines (out of 4,675) constitute only 45% of total 750 ml wine revenue.

The *PLCB* has traditionally relied on a simple pricing rule that transforms distillers' wholesale prices into retail prices (Pennsylvania Liquor Code 47 P.S. §1-101 *et seq.* and Pennsylvania Code Title 40). From 1937 until 1980, it consisted of a uniform percent markup, an ad valorem tax, over wholesale cost of 55% for all gins and whiskeys and 60% for other products. In 1980, the legislature introduced a per-unit handling fee, the *Logistics, Transportation, and Merchandise Factor* (*LTMF*) and reduced the markup to 25% for all products. In 1993, the markup increased to 30%. Simultaneously, the handling fee began varying by bottle size, resulting in a per-unit charge of \$1.05, \$1.20, and \$1.55 for 375 ml, 750 ml, and 1.75 L bottles, respectively.[10] Consumers also pay an 18% ad valorem tax on all liquor purchases – the so-called "Johnstown Flood Tax," a temporary emergency relief measure adopted in 1936 that has never been repealed.[11] Summarizing these elements, the uniform pricing rule employed by the *PLCB* during the 2003-2004 sample period is

$$p^r = [p^w \times 1.30 + LTMF] \times 1.18\,, \tag{1}$$

where p^r is the retail price of a given product with wholesale price, p^w. Given the simple structure of the pricing regulation and the vertical integration of wholesale and retail segments in Pennsylvania, the pricing rule is simply a combination of ad valorem and unit taxes. Our focus is the 30% uniform markup; we take at face value that the unit fees simply represent the storage and transportation costs of bottles of different sizes.[12]

2.2 Data: Quantities Sold, Prices, and Characteristics of Spirits

Our data, obtained under the Pennsylvania Right-to-Know Law, contain daily information on quantities sold and gross receipts at the UPC and store level for all spirits carried by the *PLCB* during 2003 and 2004. We aggregate the daily data to the monthly sales pricing periods, resulting in 22 periods for our sample. The *PLCB* also provided the wholesale cost of each product, which is constant across stores, but varies over time reflecting the temporary or permanent price changes discussed above.

Each store carries a vast variety of products among which we focus on popular 375 ml, 750 ml, and 1.75 L spirits products, representing 64.1% of total spirit sales measured in bottles

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[10] In 2016 the Legislature relaxed the requirement that the 30% tax be applied categorically to all products by allowing the *PLCB* to depart from uniform pricing on the top 150 wine and top 150 spirits products. At the time of this writing, the agency has chosen to exercise this option only a limited number of times.

[11] The *PLCB* collects an additional 6% Pennsylvania sales tax on the posted price to generate the final price paid by the consumer.

[12] Equation (1) suggests that the *PLCB* lacks any bargaining power in setting wholesale prices and that distillers effectively determine retail pricing through this pricing formula. This is indeed how interactions between distillers and the *PLCB* were organized until recently, when the passage of Act 39 in 2016 allowed for limited negotiation with distillers on the most popular products. The Tribune summarized the lack of bargaining power by the *PLCB* on 7/26/2017 `https://triblive.com/local/westmoreland/12551088-74/pennsylvania-set-to-raise-prices-on-some-liquor-wine-brands`. Similarly, the *PLCB* purchases at constant unit wholesale prices and does not benefit from any quantity discounts. See testimony by *PLCB* Board Member Mike Negra at `https://www.youtube.com/watch?v=wB4L4qjyx_8`.

and 70.1% of total spirit sales by revenue.[13] The resulting sample contains 312 products across the two-year sample. We see little variation in the product set across stores indicating that consumers have equal access to the products we consider in the sample.[14]

We classify products into six categories: brandy, cordials, gin, rum, vodka, and whiskey. For each product, the *PLCB* provided its alcohol content measured as proof (100 proof corresponds to 50% alcohol content by volume) and whether or not the product is imported or contains flavorings. Vodkas and whiskeys have significantly larger market shares (32.1% and 24%, respectively) than rum (16.3%), cordials (13.6%), or brandy (7.3%), even though cordials is one of the top categories in terms of number of products. Flavored spirits, which represent 16.3% of products, are primarily cordials and brandies and, to a lesser extent, rums and vodkas. Most whiskeys and cordials are imported while other spirits are predominantly domestically produced. There is significant variation in proof across product categories: the average across all products is 75.33, but it ranges from 55.82 for cordials to 83.42 for gins. We also obtained a product score rating products in each spirit category as a measure of within-category product quality from `Proof66.com`, a spirits ratings aggregator.

To report results and evaluate the diverse demand across demographic groups we characterize spirits as expensive when their simple averaged price exceeds the mean price of all spirits of the same type and bottle size. Expensive products are less likely to be flavored or domestically produced and have higher proof, but consumers purchase them nearly as frequently as cheaper ones. The 750 ml bottle is the most popular size in terms of unit sales and product variety, accounting for 50.3% of unit sales and 54.5% of available spirits products, followed by the 1.75 L bottle with a share of 34.5% of unit sales and 30.1% of products. The smallest bottles we consider, those in the 375 ml format, account for the remaining 15.2% of units sold and 15.4% of products.

These patterns in market shares reflect in part the product sets offered by distillers as not all brands are available in all bottle sizes. For instance, our final sample consists of 198 brands (e.g., *Captain Morgan*). Of these, 88 are available only in the 750 ml bottle size and one and 31 only in the 375 ml and 1.75 L sizes, respectively. The *PLCB* carries at least two bottle sizes for the remaining 78 brands (e.g., Diageo sold Captain Morgan in 375 ml, 750 ml, and 1.75 L sizes).

The monthly sales activity, including variation in the magnitudes of the price reductions, are our primary source of price variation to identify consumers' price responsiveness. Due to the legislated pricing formula, the wholesale pricing decisions of the *PLCB*'s suppliers – the distillers – are largely responsible for inducing retail price changes. Temporary wholesale price changes,

[13] Many products are available to consumers but are seldom purchased. The 375 ml, 750 ml, and 1.75 L bottle sizes account for 80.9% of total spirit sales by volume and 91.6% of total spirit sales by revenue. Within these bottle sizes, we further focus on popular products that account for 80% of bottle sales in each spirit type-bottle size combination. We also drop tequilas, as there were few products and these products amounted to only 1.6% of total liquor bottle sales. In total, these restrictions allow us to drop a total of 1,313 products from our sample.

[14] The median store carries 98% of the top 100 and 82% of the top 1,000 products. Stores in high-income neighborhoods are more likely to carry more expensive niche products, but consumers can order any product in the catalog in any store at no charge. See Appendix A.

typically price reductions or sales, amount to 89.7% of price changes in the sample and last for four or five weeks from the last Monday of each month. A mature product (as those we consider) can go on sale up to four times a year, or once per quarter. Permanent price changes take effect at the beginning of one of the *PLCB*'s four-week-long accounting reporting periods, a slightly different periodicity from the sale pricing periods. Distillers temporarily change a product's price 2.6 times per year on average, and most products (73%) go on sale at least once a year, with vodkas, whiskeys, cheaper products, and products in larger bottle sizes (750 ml or 1.75 L) on sale more frequently than average. A significant share of all spirits products (44%) go on sale at some point during the holidays, which we define as pricing periods that overlap with Thanksgiving through the end of the year. While over 63% of cheap products go on sale at some point in the year, the average such product goes on sale only 1.36 times, far less than other product categories. In contrast, the average 375 ml product goes on sale less frequently, but those 375 ml products with at least one sale see three temporary price reductions per year on average. See Appendix A for further detail. Finally, distillers need to inform the *PLCB* of any temporary price changes at least five months ahead of the desired sale period. Because they need to decide far ahead of time when to run temporary sales, the distillers' ability to respond to unexpected demand swings is limited, facilitating a cleaner identification of demand responses to price changes.

2.3 The Upstream Distillers

Our objective in this paper is to assess the differential effect of the uniform markup policy on equilibrium behavior of different groups of agents to uncover the effect of Posner's taxation-by-regulation. As the pricing formula in equation (1) highlights, how any alternative markup policy affects retail prices and consumer behavior depends on how wholesale prices respond to the markup policy. In our setting, markups depend on the characteristics and positioning of distillers' product portfolios.

During our sample period, 34 firms compete in the spirits market. The market leader, Diageo, accounts for 22% of total unit sales and 25% of revenue, while a large set of small fringe producers (29) account for 42% and 46% of total quantity sold and revenue, respectively. Nineteen of these firms operate product portfolios of less than five products, and seven are single product firms. Table 1 documents that while large firms such as Diageo and Bacardi operate extensive product portfolios, there is substantial heterogeneity across firms in their product offerings. For example, Diageo has a relatively balanced portfolio where rums, vodkas, and whiskeys generate approximately 21%, 31%, and 25% of revenue, respectively. In contrast, Bacardi operates a more concentrated portfolio as 71% of its revenue comes from its rum products compared to 19% from its whiskey products. Among the larger competitors, only the Pennsylvania-based firm Jacquin sells brandies, where it faces only seven small competitors and generates 22% of its revenue. With a presence in all bottle sizes and spirit types, the company's portfolio focuses exclusively on cheap products. Table 1 furthermore documents that a significant number of competitors are present in all product categories. The variation in product portfolios translates into variation in concentration

Table 1: Upstream Product Portfolios

	Diageo	Bacardi	Beam	Jacquin	Sazerac	Firms
By Spirit Type:						
BRANDY	0.00	0.00	0.00	21.57	0.00	8
CORDIALS	11.22	1.98	16.22	9.77	13.29	18
GIN	11.67	8.26	5.14	1.77	3.62	10
RUM	21.27	70.89	4.06	22.12	0.00	10
VODKA	30.99	0.00	10.4	43.26	63.9	14
WHISKEY	24.85	18.88	64.18	1.52	19.18	20
By Price:						
CHEAP	19.60	34.20	52.61	100.00	85.30	25
EXPENSIVE	80.40	65.80	47.39	0.00	14.70	25
By Bottle Size:						
375 ml	5.82	5.90	2.93	10.24	15.07	18
750 ml	54.67	50.59	38.13	27.05	20.53	31
1.75 L	39.51	43.51	58.95	62.71	64.59	25
ALL PRODUCTS	100.00	100.00	100.00	100.00	100.00	34

Notes: Table displays firms' revenue share by spirit type, price, and bottle size. "Firms" is the total number of firms with at least one product in the given category.

across categories, with Herfindahl-Hirschman indices ranging from 1,023 for cordials to 3,087 for rums (951 for spirits in total). This, combined with the observed degree of product differentiation, motivates our characterization of the distillery market as oligopolistic.

2.4 Heterogeneity of Preferences for Quantity and Varieties of Spirits

Pennsylvania is a demographically diverse state, which allows us to trace consumer preferences across a wide range of demographic profiles. We geocode the 624 stores' street addresses to link their geographic location to data on population and demographic characteristics for nearby consumers from the 2000 Census. We combine Pennsylvania's Census block groups into markets, assigning each to the operating store that is closest to them in any period. We further consolidate stores in the same ZIP code resulting in 454 total local markets.[15] Table 2 summarizes these demographic characteristics. About 39% of households in Pennsylvania earn more than $50,000 a year, but the income distribution differs significantly across markets, with rich households comprising anywhere between 10% to 76% of the population across markets. Similarly, the share of minority households in a market ranges from virtually zero to 99%, with minorities comprising 13% of residents in the average market. We see similar diversity in educational attainment with 44% of residents in the average market reporting at least some college education but this varies from 13% to 87% across the state. Finally, the average age in the average market is 40 years, ranging from 31 to 43 years across markets.

[15] As stores open and close during the year, the characteristics of stores' ambient consumers also change over time, which helps identify the effect of demographic interactions. See Appendix A for detail.

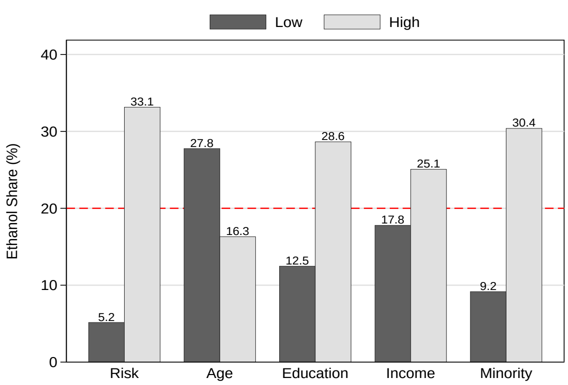
Table 2: Demographic Attributes of Pennsylvania Markets

		Percentage of Population			
	POPULATION	AGE	EDUCATION	INCOME	MINORITY
Mean	26,241	40.07	44.06	38.81	13.07
Std. Dev.	16,386	1.45	14.41	14.33	18.83
Min	1,469	31.34	12.56	9.90	0.44
Max	112,065	43.06	87.01	75.92	98.95

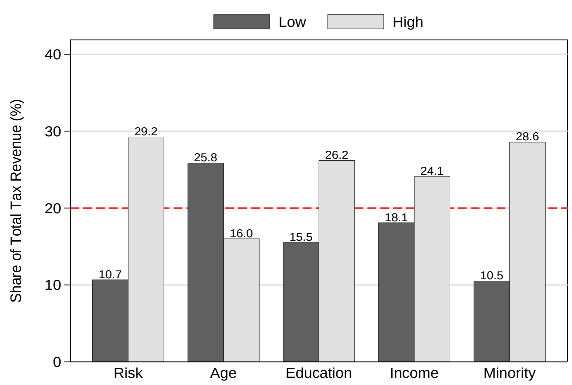
Source: 2000 Census of Population. Variables defined as average age in the market (AGE); share of population with some college education (EDUCATION); share of non-white population (MINORITY); and share of households with income greater than $50,000 (INCOME). Figure B.1 in Appendix B displays the spatial distribution of demographics.

Do these wide differences in the demographics of local markets translate into heterogeneity in terms of ethanol consumed and tax revenue generated, both measures linked to the *PLCB*'s objectives? We answer this question by dividing the store markets into quintiles based on each of the four demographic attributes – the share of households with incomes above $50,000, the share of non-white or minority households, the share of residents with some college education, and the average age. We also account for differences in per capita consumption of ethanol in each market.

Figure 1: Demographics and the PLCB's Objectives



(a) Ethanol Consumption



(b) Tax Revenue

Notes: Figures compare shares of total ethanol consumption and tax revenue attributable to markets in the bottom ("Low) and top ("High) quintiles of each demographic attribute.

In Figure 1 we present the shares of total tax revenue and total ethanol consumption for markets in the top and bottom quintiles for each attribute, relative to a 20% benchmark (the dashed line) corresponding to the case where market attributes do not correlate with consumption and expenditures. We observe high ethanol consumption and spending in markets with high concentrations of wealthy, well-educated, young, and non-white consumers.[16] Interestingly, the difference in the consumption shares of the top and bottom markets in the distribution is always greater than the difference in the share of taxes paid. High-risk markets (i.e., the top 20% of

[16] The finding that per capita ethanol consumption and income are positively correlated has been demonstrated in earlier work though the exact mechanism is unclear, e.g., see Cerda, Johnson-Lawrence and Galea, 2011. Researchers often cite social norms or even social networking as causes.

Table 3: Connecting Consumer Preferences and Demographics

	RISK		AGE		MINORITY		EDUCATION		INCOME	
	Low	High	Low	High	Low	High	Low	High	Low	High
By Spirit Type:										
BRANDY	6.6	7.3	9.8	4.6	5.2	12.3	11.4	5.4	11.9	4.2
CORDIALS	14.7	12.9	13.2	13.4	15.3	12.4	14.7	12.2	13.0	12.9
GIN	5.3	8.0	8.1	6.4	4.7	9.1	7.8	7.6	8.4	6.9
RUM	18.4	15.4	17.5	14.2	16.6	16.8	18.2	14.2	17.5	13.7
VODKA	27.7	34.5	32.5	34.1	27.4	31.8	26.9	36.9	29.6	37.3
WHISKEY	27.3	21.9	18.8	27.4	30.9	17.6	21.0	23.6	19.7	25.0
By Price:										
CHEAP	56.1	50.7	55.0	49.1	54.8	56.6	57.5	47.7	59.0	46.6
EXPENSIVE	43.9	49.3	45.0	50.9	45.2	43.4	42.5	52.3	41.0	53.4
By Bottle Size:										
375 ml	15.1	15.7	20.1	10.6	10.5	22.8	19.3	13.6	22.5	11.6
750 ml	49.9	50.6	51.1	49.1	49.3	50.8	51.0	50.6	49.9	49.7
1.75 L	35.0	33.7	28.8	40.3	40.2	26.4	29.6	35.7	27.5	38.6

Notes: Table displays market shares based on bottles sold by product characteristic for markets in the bottom ("Low) and top ("High) quintiles of each demographic attribute. RISK denotes per capita ethanol consumption. See notes to Table 2 for remaining attribute definitions.

markets by per capita consumption) consume 33% of the total ethanol in the state and generate 29% of total tax revenue. In contrast, ethanol consumption in low-risk markets accounts for only 5% of total ethanol sales and generates 11% of total tax revenue.

We complete this descriptive analysis by documenting the heterogeneity of preferences for spirit types and product characteristics across demographic attributes and alcohol consumption habits. We compare unit-sales market shares for various product categories across demographic market groupings. For instance, the top quintile of markets by income garner a 38.6% share of 1.75 L bottles. Table 3 highlights important market share differences across demographics (columns) for different product categories (rows). These purely reflect differences in preferences since retail prices at a point in time are identical across the state and stores have similar product offerings (see Appendix A).

The data indicate that minorities strongly favor brandy, gin, and 375 ml products, but not whiskey or 1.75 L products. In markets with high income and a highly educated population, vodka is far more popular than rum and brandy while consumers also buy spirits that are more expensive. Markets dominated by young, less educated, and lower income populations show a clear preference for cheap products. The popular 750 ml bottle amounts to almost exactly half of all bottle sales across demographic attributes, but between the 375 ml and 1.75 L sizes, higher-income markets clearly favor 1.75 L products. Finally, heavy drinkers, i.e., consumers in high-risk markets, prefer expensive and vodka products, but are unlikely to purchase 375 ml bottles, reflecting a positive correlation between per capita ethanol consumption and income.

To summarize, the data are useful in investigating redistribution of uniform taxation for three reasons. First, the *PLCB*'s markup is the same regardless of aggregate demand differences or by local markets. Second, the product set is heterogeneous, but varies little across retail stores, and the products characteristics correlate systematically with consumer purchases. Combined, these features provide for clean identification of preferences driven by demographic differences between local markets. Third, we observe all spirit sales in the state during the sample period. This enables us to evaluate the effects of uniform taxation not only on a diverse set of consumers, but also on the manufacturers of the taxed spirits. Unlike the majority of studies of commodity taxation, we do not assume that the taxed industry is competitive but rather allow for market power using the estimated model. To highlight the role of firm behavior, we now turn to an equilibrium model of demand and firms' oligopolistic pricing in an environment with a uniform ad-valorem tax.

3 Model

We specify a static model of oligopoly price competition with differentiated goods. We envision a two-stage Stackelberg game where the regulator first commits to a markup policy. Distillers observe the policy and then simultaneous choose wholesale prices p^w to maximize profits each period. The chosen wholesale prices translate into specific retail prices based on the regulator's policy. Finally, consumers in each market choose the product that maximizes their utility given the retail prices and characteristics of all products.

The purpose of the model is twofold. First, the model lays out how consumers respond to the chosen retail prices. To ensure that the optimality of uniform markups is not a foregone conclusion, we rely on a flexible preference specification that does not restrict elasticities of demand for individual products ex-ante. This rules out, for example, the CES preferences used in international trade or macroeconomic models that yield identical demand elasticities across products.[17] Instead, we make use of the flexible approach of Berry, Levinsohn and Pakes (1995) to estimate consumer preferences from observed consumer choices over time and across markets. The estimated preferences facilitate predicting consumer responses to counterfactual pricing policies.

Second, the model highlights that the strategic wholesale price choices in the upstream market significantly affect the retail prices the consumer pays. If the *PLCB* were to alter its pricing rule, distillers would choose different wholesale prices, leading to different retail prices and consumer purchase decisions. Accounting for such upstream responses is thus important in the counterfactual analyses that follow.

3.1 A Discrete Choice Model of Demand for Spirits

We follow the large literature on discrete-choice demand system estimation using aggregate market share data (Berry, 1994; Berry et al., 1995; Nevo, 2001) to model demand for spirits as a function

[17] Stiglitz (2015) singles out the field of macroeconomics for unnecessarily limiting the number of policy instruments to favor uniform taxation under the misguided belief of its "neutrality" in not affecting agents labor supply and consumption behavior.

of product characteristics and prices. By mapping the distribution of consumer demographics into preferences, the model enables us to estimate realistic substitution patterns between products while accounting for the heterogeneity in preferences exhibited in Table 3. We assume that consumer i in market l in period t obtains the following indirect utility from consuming a bottle of spirit $j \in J_{lt}$[18]

$$\begin{aligned} u_{ijlt} &= V_{ijlt} + \epsilon_{ijlt} = x_j \beta_i^* + \alpha_i^* p_{jt}^r + H_t \gamma + \xi_{jlt} + \epsilon_{ijlt} \,, \\ &\text{where} \;\; i = 1, \ldots, M_{lt}; \quad j = 1, \ldots, J_{lt}; \quad l = 1, \ldots, L; \quad t = 1, \ldots, T \,. \end{aligned} \tag{2}$$

The $n \times 1$ vector of observed time-invariant product characteristics x_j is identical in all markets l, though the availability of different spirits changes over time due to product introductions or removals. The $T \times 2$ matrix $H_t = [q3_t \quad m12_t]$ includes a summer dummy for periods in July, August, and September and a holiday dummy for periods t coinciding with the holiday season from Thanksgiving to the end of the year. We denote the price of product j at time t by p_{jt}^r; it is the same across all markets l. We further allow utility to vary across products, markets, and time via the time and location-specific product valuations ξ_{jlt}, which are common knowledge to consumers, firms, and the *PLCB* but unobserved by the econometrician. Lastly, ϵ_{ijlt} denotes idiosyncratic unobserved preferences by consumer i for product j in market l and period t, which we assume to be distributed Type-I extreme value across all available products J_{lt}.

We characterize consumer i in market l by a d-vector of observed demographic attributes, D_{il} including age, education, income, and race. To allow for individual heterogeneity in purchase behavior and relax the restrictive substitution patterns inherent in the multinomial Logit, we model the distribution of consumer preferences over characteristics and prices as multivariate normal:

$$\begin{pmatrix} \alpha_i^* \\ \beta_i^* \end{pmatrix} = \begin{pmatrix} \alpha \\ \beta \end{pmatrix} + \Pi D_{il} + \Sigma \nu_{il} \,, \quad \nu_{il} \sim N(0, I_{n+1}) \,, \tag{3}$$

where ν_{il} captures mean-zero, unobserved preference shifters with a diagonal variance-covariance matrix Σ (i.e., $\Sigma_{jk} = 0 \; \forall k \neq j$). Π is a $(n+1) \times d$ matrix of coefficients that measures the effect of observable individual attributes on the consumer valuation for spirit characteristics including price, allowing cross-price elasticities to vary differentially in markets with observed differences in demographics.

[18] In the absence of individual purchase information we opt to treat bottles of different sizes of the same spirit as different products with identical observable characteristics other than size. It is likely that firms use bottle size as a quantity discount and therefore they set product prices jointly, solving a second degree price discrimination problem as consumers self-select into different bottle sizes depending on their willingness to pay. Modeling such second degree price discrimination formally requires accounting for informational asymmetries between distillers and consumers. Given the reasonable substitution patterns in the estimated model (see Section 4.2), we believe our approach is a good first approximation to the complex pricing problem of second degree price discrimination among multi-product firms in oligopoly competition, especially given that, to our knowledge, there does not exist a tractable theoretical model of nonlinear multi-product oligopoly pricing.

We make the common assumption that during period t, each consumer either selects one of the J_{lt} spirits available in her market or chooses the outside option.[19] We define the potential market, M_{lt}, to be the consumption of all alcoholic beverages off the premise of the seller, i.e., not in a restaurant or bar ("off-premise consumption"), during pricing period t. We calculate M_{lt} as the number of drinking-age residents scaled by per-capita off-premise consumption, where we allocate the available annual per-capita consumption evenly across pricing periods according to the periods' lengths. The outside option thus consists of closed-container beer or wine purchases denominated in 750 ml bottle-equivalents.[20] We denote it by $j = 0$ with zero mean utility.[21]

Consumer utility-maximization connects the set of individual-specific attributes and the set of product characteristics as follows

$$A_{jt}\left(x_{\cdot}, p^r_{\cdot t}, \xi_{\cdot t}; \theta\right) = \left\{\left(D_{il}, \nu_{il}, \epsilon_{i \cdot lt}\right) | u_{ijlt} \geq u_{iklt} \quad \forall k = 0, 1, \ldots, J_{lt}\right\} , \tag{4}$$

where we summarize all model parameters by θ. We follow the literature in decomposing the deterministic portion of the consumer's indirect utility into a common part shared across consumers, δ_{jlt}, and an idiosyncratic component, μ_{ijlt}, given by

$$\delta_{jlt} = x_j \beta + \alpha p^r_{jt} + H_t \gamma + \xi_{jlt} , \tag{5a}$$

$$\mu_{ijlt} = \begin{pmatrix} x_j & p^r_{jt} \end{pmatrix} \left(\Pi D_{il} + \Sigma \nu_{il}\right) . \tag{5b}$$

In estimating the model, we integrate over the distribution of $\epsilon_{i \cdot lt}$ analytically. The probability that consumer i purchases product j in market l in period t is then

$$s_{ijlt} = \frac{\exp\left(\delta_{jlt} + \mu_{ijlt}\right)}{1 + \sum\limits_{k \in J_{lt}} \exp(\delta_{klt} + \mu_{iklt})} . \tag{6}$$

[19] Nevo (2000) discusses limitations of the present discrete choice approach when individuals purchase several products or multiple bottles of the same product at the same time. If such consumer behavior were important, Hendel (1999) and Hendel and Nevo (2006) show that assuming single-unit purchases could understate price elasticities in the case of assortment decisions, but overstate own-price elasticities in the case of stockpiling. In Miravete et al. (2018), we test for stockpiling using a similar dataset and find no evidence. Seim and Waldfogel (2013) present suggestive evidence that the *PLCB*'s demand does not respond disproportionately to price declines in areas where consumers have higher travel costs to the store and thus a higher incentive to buy larger quantities or assortments.

[20] This definition of the potential market accounts for the total volume of alcoholic beverages but not for the different average ethanol contents of beer (4.5%), wine (12.9%), and spirits (37.7%) in our sample.

[21] For example, according to Haughwout, Lavallee and Castle (2015), the average drinking-age Pennsylvanian consumed 96.2 liters of alcoholic beverages through off-premise channels in 2003, or 128.2 750 ml bottle equivalents. The 2003 potential market for location l is then the number of drinking-age residents scaled by 128.2. To put this figure in perspective, beer accounts for approximately 90% of total consumption by volume so the average drinking-age Pennsylvanian consumed slightly less than five 375 ml bottles of beer per week, but only approximately thirteen 750 ml bottles of both wine and spirits annually. We follow a similar approach in constructing the potential market for 2004.

Deriving product j's aggregate market share in each location requires integrating over the distributions of observable and unobservable consumer attributes D_{il} and ν_{il}, denoted by $P_D(D_i)$ and $P_\nu(\nu_i)$, respectively. The market share for product j in market l at time t is:

$$s_{jlt} = \int_{\nu_l} \int_{D_l} s_{ijlt} dP_D(D_i) dP_\nu(\nu_i) \, , \tag{7}$$

which we evaluate using simulating techniques. See Appendix C for detail.

Consumer Welfare. An advantage of a structural model is that it enables the researcher to assess equilibrium changes in welfare. At retail prices p^r, the (expected) consumer surplus of consumer i in location l at period t is

$$\text{CS}_{ilt}(p^r) = \frac{1}{\alpha_i^\star} \times \sum_{j \in J_{lt}} \exp\left[V_{ijlt}(p_t^r)\right] + C, \tag{8}$$

where C is an unknown constant on integration reflecting the fact that the absolute level of consumer utility cannot be measured. We identify beneficiaries of the single markup policy by evaluating changes in consumer welfare via compensating variation, i.e., the amount of income necessary to keep individuals in a given market indifferent between any counterfactual set of prices $p^{r\prime}$ and the current ones p^r. Since consumer utility is quasi-linear, changes in retail prices generate no income effects so the Marshallian demand is equivalent to Hicksian demand. As a result, therefore changes in consumer surplus (CS) are equivalent to compensating variation:

$$\text{CV}_{ilt}(p^r, p^{r\prime}) = \frac{1}{\alpha_i^\star} \ln \left[\frac{\sum_{j \in J_{lt}} \exp\left[V_{ijlt}(p_t^{r\prime})\right]}{\sum_{j \in J_{lt}} \exp\left[V_{ijlt}(p_t^r)\right]} \right] \, , \tag{9}$$

where $V_{ijlt}(\cdot)$ is given by (2). The mean compensating variation for agents living in location l is

$$\text{CV}_l(p^r, p^{r\prime}) = \sum_t M_{lt} \int_{\nu_l} \int_{D_l} CV_{ilt}(p^r, p^{r\prime}) dP_D(D_i) dP_\nu(\nu_i) \, . \tag{10}$$

Residents in location l are thus on average better off under the current policy when $CV_l(p) > 0$, indicating that they require positive compensation to be unaffected by the new policy with retail prices p'.

3.2 An Oligopoly Model for Distillers

Given optimal consumer choices, we now consider competition between distillers. A total of F firms compete in the upstream market where each firm $f \in F$ produces a subset J_t^f of the $j = 1, \ldots, J_t$ products. We assume that in each period t, distillers set wholesale prices vector of wholesale prices

$\{p^w_{jt}\}_{j \in J^f_t}$ non-cooperatively as in a Bertrand-Nash differentiated products oligopoly to maximize period t profit

$$\max_{p^w_{jt}} \sum_{j \in J^f} \left[(p^w_{jt} - c_{jt}) \times \sum_{l=1}^{L} M_{lt} s_{jlt} \Big(p^r(p^w), x, \xi; \theta \Big) \right], \tag{11}$$

where c_{jt} denotes the marginal cost of product j in period t. To simplify the notation of this static problem, we omit the period t subscripts going forward.[22] Define as $s_j(p^r, x, \xi; \theta)$ the statewide demand for product j, $\sum_{l=1}^{L} M_l s_{jl}(p^r, x, \xi; \theta)$. Profit maximization in the upstream market implies the following first-order condition for distiller f's product j, $\forall j \in J^f$:

$$s_j\Big(p^r(p^w), x, \xi; \theta\Big) + \sum_{m \in J^f} \Big(p^w_m - c_m\Big) \times \frac{\partial s_m}{\partial p^w_j} = 0\,. \tag{12}$$

The final term $\frac{\partial s_m}{\partial p^w_j}$ is the response in product m's quantity sold to a change in the wholesale price and, through the pricing rule, the retail price of product j. Assuming a pure-strategy equilibrium in wholesale prices, the vector of profit-maximizing wholesale prices is

$$p^w = c + \underbrace{[O^w * \Delta^{w\prime}]^{-1} \times s\Big(p^r(p^w), x, \xi; \theta\Big)}_{\text{vector of \$ markups}}, \tag{13}$$

where O^w denotes the ownership matrix for the upstream firms with element (j, m) equal to (minus) one if goods j and m are in J^f and firm f chooses these prices jointly. We define $\Delta^w = \Delta^d \Delta^p$ as a matrix that captures changes in demand due to changes in wholesale price,

$$\Delta^w = \begin{bmatrix} \frac{\partial s_1}{\partial p^r_1} & \cdots & \frac{\partial s_1}{\partial p^r_J} \\ \vdots & \ddots & \vdots \\ \frac{\partial s_J}{\partial p^r_1} & \cdots & \frac{\partial s_J}{\partial p^r_J} \end{bmatrix} \times \begin{bmatrix} \frac{dp^r_1}{dp^w_1} & \cdots & \frac{dp^r_1}{dp^w_J} \\ \vdots & \ddots & \vdots \\ \frac{dp^r_J}{dp^w_1} & \cdots & \frac{dp^r_J}{dp^w_J} \end{bmatrix} = \begin{bmatrix} \frac{\partial s_1}{\partial p^r_1} & \cdots & \frac{\partial s_1}{\partial p^r_J} \\ \vdots & \ddots & \vdots \\ \frac{\partial s_J}{\partial p^r_1} & \cdots & \frac{\partial s_J}{\partial p^r_J} \end{bmatrix} \times \begin{bmatrix} 1.534 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & 1.534 \end{bmatrix}, \tag{14}$$

where Δ^d is the matrix of changes in quantity sold due to changes in retail price with element (k, m) equal to $\frac{\partial s_k}{\partial p^r_m}$ and Δ^p is the matrix of changes in retail price due to changes in wholesale price with element (m, j) equal to $\frac{dp^r_m}{dp^w_j}$. In our context, the state's regulation of alcohol sales simplifies this matrix significantly by eliminating off-diagonal terms so that $\frac{dp^r_j}{dp^w_j}$ is simply $1.30 \times 1.18 = 1.534$ for all stores, reflecting the 30% uniform markup and the 18% liquor tax.

Given estimates of consumer demand, data on retail and wholesale prices, and the observed *PLCB* policy, we use this model of upstream behavior to recover product-level marginal costs via (13). Marginal cost estimates facilitate the evaluation of alternative pricing regulations as we can

[22] We ignore any dynamic considerations to distillers' pricing decisions based on regulatory restrictions on their pricing. While the *PLCB* limits the number of times distillers can temporarily change a product's price to four annually, this regulation does not constrain upstream pricing for the majority of products. In the data, 73.5% of products go on sale three times or less per year.

rely on them to predict the distillers' optimal behavior under alternative *PLCB* pricing strategies. These may include more flexible policies than the simple uniform markup reflected in Δ^p, including markups that vary by product.

4 Estimation Results

We adapt the estimation approach of Nevo (2000) to the institutional features surrounding the price regulation of spirits in Pennsylvania. We follow a three-step estimation procedure that takes advantage of the fact that the *PLCB* charges the same retail price for a given product in all local markets. This allows us to identify separately the contribution to demand of demographic taste heterogeneity across the state at a point in time and the contribution of time varying shifters of demand that are common across demographic groups, including price. In the first-stage, we use generalized method of moments techniques to estimate the determinants of deviations from a product's mean utility μ_{ijlt}, controlling for market and product by pricing period fixed effects that absorb the mean effects of price, product characteristics, and seasonality. In the second stage, we employ instrumental variables techniques to project the estimated product by pricing period fixed effects onto price, seasonality, and product fixed effects, using contemporaneous prices in distant control states and input prices as instruments. Last, we project the estimated product fixed effects from the second stage onto time-invariant product characteristics. We refer the interested reader to our Appendix C and to our companion piece, Miravete et al. (2018), which provides details of the estimation procedure for a more parsimonious version of the demand model that we estimate here.

Before discussing the estimation results, we turn to the variation in the data that allows identification of two key aspects of the demand model: heterogeneity in consumer preferences and consumer price sensitivity. We identify unobserved heterogeneity in consumer preferences – the random coefficients Σ in equation (3) – from correlation between a product's market share and its characteristics relative to other more or less similar products; see Berry and Haile (2014). We construct two instruments similar to those used in Bresnahan, Stern and Trajtenberg (1997). First, we employ the number of products in the market that share product j's characteristic. For example, to identify taste variation for brandies, we use the total number of competing brandies of the same bottle size in location l in period t as the instrument for a given brandy. Second, we use the root mean square distance in spirit product scores, as a measure of product quality, of product j and other products that share its characteristics. Thus, for the above brandy, this would be the average product score distance from other brandies available in market l at time t. This instrument provides additional identifying power since it captures the differential effect on the market share of a high-quality brandy, say, as the product quality of the brandies that it competes against changes, e.g., over time.

Variation in consumer preferences due to demographic variation across markets – the demographic interactions Π in equation (3) – reflects correlation between the market shares of products with particular characteristics in a given store market and the demographics of the population served by each store. A key feature aiding identification of Π is the uniform retail price for each product across markets, facilitating the linking of purchases to demographic variation in preferences alone. Following Waldfogel (2003), we interact the above two instruments with the prevalence of a given demographic attribute in each market. For example, we would identify the differential taste of young households for the above brandy by interacting its product score distance to and the count of other brandies with the share of young consumers in each market. To identify a differential effect of price by income, we construct similar instruments based on the set of products sharing a given product's price category (cheap vs. expensive) interacted with the share of high-income households in the market.

The mean response across locations to variation in retail prices over time identifies the price coefficient α, exploiting the fact that distillers do not change the wholesale prices p^w for all products at the same time. We rely on input costs and retail prices in other control states as instruments to address possible confounding effects of unobserved demand shocks ξ that distillers respond to in setting wholesale price. Appendix D shows that our results are robust to alternative sets of price instruments, as well as sample construction and arbitrage on the state border. We identify seasonality and mean preferences β for time-invariant product characteristics such as proof and spirit type from systematic variation in market shares of spirits by period or characteristic.

4.1 Parameter Estimates

Table 4 presents the demand estimates of our preferred specification of the mixed-logit model. The parameters estimates are precise, and the estimated demand specification captures the patterns of spirit consumption across demographic groups documented in Table 3.

We allow for rich variation across demographics by interacting consumer age and indicators for minority and high educational attainment with proof and indicators for spirit type, bottle size, and import status. The estimates of Π reveal significant differences in tastes for spirits across demographic groups. While minority consumers favor brandy, cordials and rum over gin, the reference category, older and college-educated consumers prefer gin to cordials and rum. We also find that older consumers and, to a lesser extent, college-educated consumers are more likely to purchase 1.75 L than 750 ml bottles, our reference category, while minority households are more likely to purchase 375 ml bottles. The estimated demand for wealthier consumers is steeper, which is consistent with the increased consumption of expensive spirits by high-income consumers reported in Table 3. Older and minority consumers favor spirits with higher proof.

We allow for unobserved variation in preferences for a number of the product characteristics, including proof and certain bottle sizes, product categories, and import status. The estimated random coefficients are large, in particular for brandies and for the 375 ml size, indicating that even after controlling for the significant degree of observed differences in tastes on average and by demographic groups, there still exist further similarities between products in these categories that

Table 4: Mixed-Logit Demand

	Mean Utility	Random Coeff.	Demographic Interactions (Π)			
	(β)	(Σ)	AGE	EDUCATION	INCOME	MINORITY
PRICE	-0.2763 (0.0046)				0.0787 (0.0026)	
CONSTANT	-34.8299 (0.8218)	0.1759 (0.3653)	6.2002 (0.5176)	5.7245 (0.3197)		-7.3124 (0.6198)
375 ml	4.8700 (0.2451)	2.1181 (0.5896)	0.3947 (0.1487)	-0.7853 (0.1320)		0.8109 (0.1283)
1.75 L	9.0752 (0.2330)	0.0204 (1.1874)	3.2208 (0.7540)	0.9151 (0.1621)		-0.9581 (0.0530)
BRANDY	-60.4569 (0.3636)	10.0606 (0.5963)	13.6819 (1.1016)	-2.5638 (0.1221)		3.4660 (0.1696)
CORDIALS	20.7050 (0.3343)	0.7215 (0.3827)	-6.6553 (0.5039)	-3.5539 (0.1362)		4.4148 (0.3320)
RUM	24.8060 (0.3506)		-7.3399 (0.4846)	-2.4288 (0.0972)		1.9946 (0.1501)
VODKA	24.5847 (0.2760)	0.0819 (0.4193)	-7.2702 (0.4868)	0.6748 (0.1683)		-0.2070 (0.0481)
WHISKEY	-0.9444 (0.3187)	0.3425 (0.3474)	0.8279 (0.1885)	-1.2156 (0.0770)		-1.2939 (0.0435)
FLAVORED	-0.6278 (0.2130)		-0.1211 (0.0482)	-0.1971 (0.0709)		0.6804 (0.0745)
IMPORTED	-0.6931 (0.1960)	0.4807 (0.3356)	0.1772 (0.0810)	1.6193 (0.1162)		0.1681 (0.0417)
PROOF	-14.6819 (0.7327)	0.2244 (0.4845)	1.3367 (0.1999)	-3.9805 (0.3061)		15.9646 (0.7387)
QUALITY	4.0281 (1.2690)					
HOLIDAY	0.4483 (0.0075)					
SUMMER	0.0820 (0.0065)					

Notes: Robust standard errors are reported in parentheses. Estimates for random coefficients (Σ) and demographic interactions (Π) based on *GMM* estimation using 2,237,937 observations in 8,470 store-periods and 1,000 simulated agents in each market. AGE is ln(age−20), EDUCATION is an indicator variable equal to one if the agent has some level of college education, INCOME is ln(income), and MINORITY is an indicator equal to one if the agent is non-white. Mean utility contributions of price, holiday, and summer are based on a product fixed effects regression of the product-period fixed effects from the *GMM* estimation, controlling for price endogeneity. Remaining coefficients result from a projection of the estimated product fixed effects onto time-invariant product characteristics.

influence their substitution patterns. Lastly, we find that demand increases during the summer and the holiday season and that, on average, consumers prefer products of higher quality and lower proof and favor cordials, rums, and vodkas over gins and brandy.

4.2 Elasticities

The objective of this paper is to measure redistribution due to the single markup or a uniform tax more broadly. A key determinant of such redistribution is the degree to which the estimated product elasticities vary across products; if products exhibited a common elasticity, a single markup would not induce any redistribution. A central use of the estimated demand system is therefore to

Table 5: Price Elasticities by Spirit Type, Price, and Size

	Products	Price	Price Elasticity (ε_{jj}) Avg.	SD	Cross-Price Elast. (ε_{ji}) Ratio	Best Subst.
By Spirit Type:						
BRANDY	26	14.41	−3.64	1.80	39.21	100.00
CORDIALS	62	14.08	−3.46	1.35	1.30	72.58
GIN	28	15.15	−3.90	1.82	2.09	100.00
RUM	40	13.72	−3.38	1.15	1.97	17.50
VODKA	66	16.82	−3.95	1.60	2.07	64.64
WHISKEY	90	16.77	−3.98	1.63	1.88	35.56
By Price:						
EXPENSIVE	150	20.43	−4.74	1.54	1.20	92.67
CHEAP	162	10.96	−2.81	0.84	0.98	25.93
By Bottle Size:						
375 ml	48	8.94	−2.36	0.89	1.88	100.00
750 ml	170	14.53	−3.58	1.32	0.89	89.41
1.75 L	94	20.65	−4.74	1.61	2.69	76.60
ALL PRODUCTS	312	15.16	−3.75	1.57	N/A	N/A

Notes: In columns 2-5 we present the number of products, the average retail price, plus the average and standard deviation of the estimated own-price elasticity across spirit type, price-point, and bottle size. Figure F.1 in Appendix F presents the distribution of own-price elasticity across these liquor groups. In the remaining columns we present descriptive statistics for the cross-price elasticities. "Ratio" is the average cross-price elasticity among products of a characteristic (e.g., spirit type) relative to the average cross-price elasticity among products which do not have that characteristic. Values greater than one indicate that consumers are more likely to substitute towards a product which shares the characteristic in question (e.g., same liquor type). "Best Subst." is the percent of products which share a characteristic (e.g., same liquor type) where the best substitute (i.e., the product with the largest cross-price elasticity) also shares that characteristic (e.g., is of the same liquor type). See Table F.3 for examples of best substitutes for a selection of popular products.

recover empirical elasticities from the data, as an indicator of the likely magnitude of redistribution induced by uniform markups. We summarize the empirical distribution of own-price elasticities in Table 5.

At the product level, we estimate an average own-price elasticity of −3.75, which is within the range of median elasticities of Conlon and Rao (2015, Table 8) for spirits (from −2.61 for whiskeys to −3.80 for vodkas), and somewhat more elastic than the −2.41 own-price elasticity of wine estimate of Aguirregabiria et al. (2016). Our model estimates imply an estimated price elasticity of off-premise spirit demand of −2.48 overall, more elastic than the −1.5 estimate of Leung and Phelps (1993) in their review of the literature on demand estimation for alcoholic beverages.[23] We attribute this difference to our exclusion (due to lack of data) of the on-premise consumption in bars and restaurants, which is likely less price sensitive than off-premise consumption.[24]

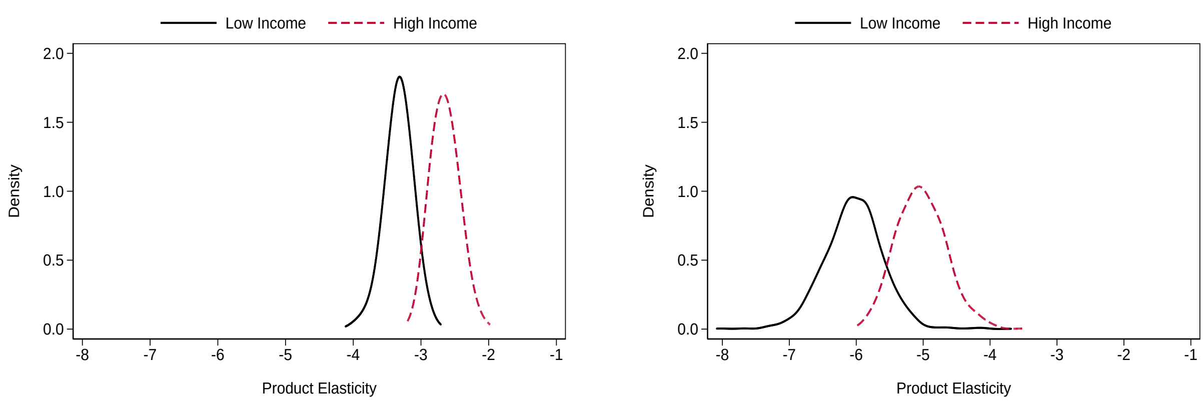
[23] The estimated price elasticity of off-premise spirit demand under a comparable multinomial logit specification is −3.39. Thus, including the flexibility of random coefficients and demographic interactions decreases consumers willingness to substitute to the outside option – a similar finding to Berry et al. (1995).

[24] Perhaps more important, most earlier studies use aggregate consumption data at the state-level whereas we have detailed local data on consumption choices. To corroborate this hypothesis, Appendix D shows that aggregation in our data set drives the price coefficient (and consequently the estimated elasticity for spirits) toward zero.

The estimated own-price elasticity exhibits substantial heterogeneity within and across spirit types and bottle sizes. Within spirit types, its distribution has the largest spread for brandies and gins and the lowest for rums. The bottom of Table 5 shows that demand responsiveness varies more widely across bottle sizes and price segments than across spirit types. The demand for 375 ml bottles is less elastic than for 1.75 L bottles, with the 750 ml bottles in-between. This ordering of elasticities mirrors unreported results from descriptive OLS regressions of log bottles sold on log price. Similarly, we find that demand for expensive products is more elastic than the nearly half as costly cheap spirits. A general increase in the *PLCB*'s markup would thus trigger a non-uniform response of demand across products, questioning the optimality of the single markup.

Posner hypothesized that a uniform policy applied to heterogeneous agents would generate cross-subsidies between groups. Table 5 shows that the estimated elasticities vary across the products in our sample. Table 3 and, in a multivariate environment, Table 4 indicate further that consumer preferences are correlated with demographics. Putting these two facts together, we find that demand in low-income areas is more price sensitive: the same product has more elastic demand the lower the income of the population served. At the same time, low-income consumers prefer less expensive products. Across products, these have relatively inelastic demand, on average.

Figure 2: Demand Elasticities and Income



(a) Smirnoff Vodka, 750 ml ($11.82)   (b) Grey Goose Vodka, 750 ml ($24.75)

Notes: Figures compare kernel densities of the own-price demand elasticity for two sample products. We denote the distributions for markets in the bottom ("Low") and top ("High") quintiles of the income distribution by solid and dashed lines, respectively.

In Figure 2 we provide an example by presenting the distribution of estimated price elasticities across our 454 local markets for two popular 750 ml bottles of vodka: *Grey Goose* and *Smirnoff*. We define *Grey Goose* as an "expensive" product as the average retail price of $24.75 lies above the median average price of 750 ml vodkas. In contrast, *Smirnoff* sells for an average retail price of $11.82, a "cheap" product under our definition. We observe that the empirical distribution of *Smirnoff*'s estimated price elasticities (panel a) is shifted to the right of *Grey Goose* (panel b). Thus, the demand for the "cheap" *Smirnoff* is typically less elastic than the "expensive" *Grey Goose* – a finding consistent with Table 5. We also observe that for both products the empirical distribution of price elasticities shifts to the left, i.e., estimated demand is more elastic, as we move from high-income (dashed line) to low-income (solid line) markets, where the average consumer is more price sensitive. Since low-income consumers prefer the inexpensive *Smirnoff* to the expensive *Grey Goose*, their consumption decisions and welfare are more sensitive to retail price changes of the relatively inelastic *Smirnoff*, however.

Turning to cross-price elasticities, we evaluate the substitution patterns in the estimated model through two statistics. In the "Ratio" column, we present cross-price elasticities for products within a group to products (e.g., brandies) outside the group (e.g., other spirit types). That is, for product j we compute

$$\text{Ratio}_j^d = \frac{\frac{1}{|\mathcal{G}_j^d|}\sum_{i \neq j, i \in \mathcal{G}_j^d} \varepsilon_{ji}}{\frac{1}{|\mathcal{G}_j^{-d}|}\sum_{i \neq j, i \in \mathcal{G}_j^{-d}} \varepsilon_{ji}}$$

where ε_{ji} is the average cross-price elasticity between products i and j in the sample and $\mathcal{G}_j$ is the products which share characteristic d with product j. For example, if product j is a RUM, $\mathcal{G}_j^{d=\text{RUM}}$ is the set of all RUM products and $|\mathcal{G}_j^{d=\text{RUM}}|$ is the total number of RUM products. Ratio_j^d then is the ratio of the average cross-price elasticity among products which share the same characteristic d with product j to the average cross-price elasticity among products which do not share characteristic d with product j (i.e., are in $\mathcal{G}_j^{-d}$). "Ratio" in Table 5 is then the average across the product set for a given characteristic d where values greater than one indicate that consumers are more likely to substitute towards another product within the group. In right-most column we present the likelihood that the "best substitute" for a product (i.e., the competing product with the greatest cross-price elasticity) shares characteristic d with product j.[25] This statistic is bounded between zero and one hundred where higher values indicate that a higher percentage of products which share characteristic d have a best substitute which also has characteristic d.

From Table 5 we observe that the random coefficients (Σ) and demographic interactions (Π) in the estimated model generate reasonable substitution patterns as consumers substitute towards products of similar characteristics (i.e., "Ratio" is greater than one and "Best Substitute" greater than 50 for most characteristics). This is particularly true for BRANDY products and to a lesser extent GIN, VODKA, EXPENSIVE, 375 ml, and 1.75 L products. We also find that an increase in the price of a CHEAP product leads consumers to substitute away from other CHEAP products (i.e., "Ratio" less than one and "Best Substitute" close to zero). Recall that a product is "CHEAP" when its average price is below the median value among products of the same spirit type and bottle size. Thus, substitution away from our definition of "CHEAP" product reflects consumers switching to "EXPENSIVE" products in a different spirit type but same bottle size, different bottle size but same spirit type, or both a different spirit type and bottle size. Given the fact that consumers appear to not switch very often across bottle size (i.e., "Best Substitute" close to 100 across all bottle size characteristics), much of this switching is across liquor type. For example, the best substitute for a 750 ml bottle of *Bacardi Light*, a CHEAP RUM, is a 750 ml bottle of *Fire Water Hot Cinnamon Schnapps*, an EXPENSIVE CORDIAL.

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[25] See Table F.3 in Appendix F for a list of specific "best substitutes" for a select number of popular products.

The analysis so far has focused on the demand side, suggesting that demand across products is sufficiently heterogeneous to question the efficiency of a uniform markup. A second dimension to the model in Section 3 is the response of distillers to the uniform markup, or any changes therein. We therefore now discuss the implications of the estimated demand model for firm competition.

4.3 Implied Upstream Marginal Cost

To consider the response in upstream behavior to alternative retail pricing policies, we require an estimate of the firms' marginal costs. We combine our demand estimates with the above assumption of Bertrand–Nash pricing to recover the marginal costs that render the observed wholesale prices optimal under the current pricing policy (see the first-order conditions in equation (13)). We rely on these marginal cost estimates in conducting our counterfactual analysis.

We find that the marginal costs of expensive products are on average 2.7 times higher than those of inexpensive products and that brandies and whiskey are the least and most costly products, respectively, to manufacture on average (see Table F.1 in Appendix F). For the subset of brandies and whiskeys with age information, we find that marginal costs are approximately 1.5 times higher for products that distillers age more than four years than for non-aged products. Imported products have 1.8 times the marginal cost of domestically produced products on average, reflecting increased transportation costs and import tariffs that the distillers pay.

Table 6 documents the significant market power implied by our cost estimates; on average, the firms earn 36.5 cents in profit per dollar in revenue. Products manufactured by larger firms, such as Diageo and Bacardi, have lower Lerner indices (roughly 34%) while smaller manufacturers such as Jacquin and Sazerac operate niche product portfolios (see Table 1) on which they keep 46.5%

Table 6: Estimates of Upstream Market Power (Select Firms)

	All	Diageo	Bacardi	Beam	Jacquin	Sazerac
By Spirit Type:						
BRANDY	45.25	-	-	-	50.73	-
CORDIALS	35.79	30.87	17.19	47.63	57.55	38.69
GIN	37.07	32.52	20.37	39.87	37.80	54.03
RUM	37.36	32.25	38.06	40.81	48.30	-
VODKA	35.82	38.58	-	37.33	38.81	43.01
WHISKEY	34.30	32.01	18.86	36.55	36.17	39.47
By Price:						
CHEAP	45.70	46.45	44.46	45.53	46.48	44.26
EXPENSIVE	27.12	28.92	24.48	27.57	-	26.52
By Bottle Size:						
375 ml	59.18	59.57	65.96	72.07	91.76	47.71
750 ml	36.99	34.16	33.78	44.45	56.80	54.25
1.75 L	29.16	23.19	21.43	29.07	35.21	37.12
ALL PRODUCTS	36.49	34.25	34.99	39.43	46.48	42.33

Notes: Table displays average Lerner index, defined as $100 \times (p^w - \hat{c})/p^w$, weighted by bottles sold.

and 42.3% of revenue in profit, respectively. Across manufacturers, CHEAP and 375 ml products are particularly profitable.

The presence of upstream market power raises two points. First, current policy may implicitly redistribute rents between firms, or between firms as a group and consumers or the *PLCB*. Second, upstream firms possess the ability to respond to changes in policy – a factor that we must account for in considering the implications of any alternative policy.

5 What is the PLCB's Objective?

Our approach to assessing the implications of uniform pricing consists of comparing current policy to markups the *PLCB* would choose were the legislature to relax the pricing rule. This requires specifying an objective the *PLCB* would strive to meet with more flexible prices. We begin our analysis by considering what the current level of the uniform markup reveals about the goals of the state's liquor regulation.

One simple objective the state might pursue is to use the *PLCB* as a vehicle to generate tax revenue. Indeed, tax revenue generated by the *PLCB* accounted for approximately 2% of the state's total general fund revenue in fiscal years 2003-2004 and therefore financed a broad set of public programs. Recent legislative efforts also suggest that tax revenue generation is a primary concern. Pennsylvania's August 2016 Act 39 grants the *PLCB* "common retail marketing abilities including pricing flexibility" in allowing it to price its best-selling items, defined as the top-selling 150 SKUs, "in a manner that maximizes the return on the sale of those items."[26] While the use of this pricing flexibility has been limited thus far, the intent of the law clearly is to raise additional revenue.

To investigate the relevance of such revenue considerations in policy design, we ask whether, within the confines of currently legislated uniform markups and given the estimated consumer preferences and firm marginal costs, the observed 30% markup maximizes revenue collection by the state. To do so, we model the interaction between the *PLCB* and the firms it regulates as a two-stage Stackelberg game. The agency chooses the uniform markup to maximize tax revenue, anticipating the distillers' optimal price responses. Distillers then set wholesale prices in response to the chosen markup following the above Bertrand-Nash pricing game. In solving for the tax-revenue maximizing markup, we thus account not only for the direct effect of changing the pricing rule, the *mechanical effect*, but also for the adjustment of firms and consumers or the *behavioral response* to policy (Saez, 2001).

Recognizing the strategic firm response stands in contrast to the optimal taxation literature, which frequently assumes perfect competition among firms. In related work (Miravete et al., 2018) we show that accounting for this response is quantitatively important. How and to what extent

[26] Full text available at `http://www.legis.state.pa.us/cfdocs/legis/li/uconsCheck.cfm?yr=2016&sessInd=0&act=39`

upstream distillers respond to changes in tax rates depends on both consumer substitution patterns and the curvature of demand. A well-known feature of the random coefficients model is that it places few restrictions on consumer substitution patterns ex ante (see Berry et al., 1995). In Section 4.2 we document that the estimated demand model does indeed generate reasonable substitution patterns. Demand curvature, a less-studied feature of discrete choice demand systems, regulates whether upstream firms decrease or increase wholesale prices in response to an increase in ad valorem tax rates (i.e., the *PLCB* markup). In log-concave demand systems, wholesale prices and ad valorem taxes are strategic substitutes whereas the strategic interaction is less clear for demand systems with higher degrees of curvature. Quint (2014, §4.3) shows that many demand systems (e.g., multinomial logit) impose log-concavity by assumption whereas the random coefficient demand model does not.

To make this point more explicit, define the curvature of product demand as $\kappa_{jlt}(p^r) = D_{jlt}(p^r) \times D''_{jlt}(p^r)/[D'_{jlt}(p^r)]^2$ where $\kappa_{jlt}(p^r) < 1$ indicates log-concave demand. For demand systems with higher curvature, i.e., $\kappa \in [1, 2)$, the direction of the firms' response is not clear and depends upon product demand elasticities, $\varepsilon(p^r)$.[27] On average, product demand curvature in our estimated equilibrium is 1.04 and 4.3% of products are log-concave. With this degree of demand curvature, the direction and magnitude of the upstream firm response to a change in the *PLCB* markup is unclear and requires comparing the estimated and counterfactual Stackelberg equilibria explicitly.

Table 7 shows that the current markup policy achieves 99.6% of the potential tax revenue afforded by a single markup policy. At 24.8%, the tax-revenue maximizing markup is modestly lower than current policy and reflects the regulatory anticipation of distillers' responses, increases in wholesale prices. The average wholesale price rises from \$8.71 to \$8.81 per bottle. Thus, wholesale prices and the *PLCB* markup are strategic substitutes. The firm response partially undoes the *PLCB*'s reduction in markup; average retail price declines by only 2.6%, from \$14.89 to \$14.50 per bottle. Interestingly, distiller profit rises by a substantial 11.1% under the lower *PLCB* markup. Industry profit, the combined *PLCB* tax revenue and distiller profit, increases by \$13.53 million, of which upstream firms capture 92.9%.[28]

Given the limited scope for tax revenue gains, one might conclude that the *PLCB*'s 30% single markup is consistent with tax revenue-maximization within the confines of uniform markup policies. We reject, however, the null hypothesis that the two policies are statistically identical with 95% confidence. Instead, it appears that the 30% markup rate overprices spirits and reduces alcohol consumption by 6.3% in terms of bottles and 7.4% in terms of liters of ethanol. Such observed efforts at limiting consumption are consistent with initial motivations for the state's

[27] See Miravete et al. (2018). Isoelastic demand, a common feature of consumer demand models in the macroeconomic literature (e.g., Dixit-Stiglitz CES preferences), is a limiting case where $\kappa(p^r) = \left(1 - \varepsilon(p^r)^{-1}\right)$, and firms (by assumption) do not alter their pricing decisions in response to changes in tax policy.

[28] This result is consistent with our earlier work (Miravete et al., 2018) where we highlight that the ability of upstream firms to strategically adjust wholesale price is key to an analysis of optimal taxation in environments such as ours. The result that tax revenue responds little to the regulator's policy choice stands in stark contrast to conclusions drawn when we assume perfectly competitive firms charging constant wholesale prices.

Table 7: What is the PLCB's Objective?

	Unit	Current	Maximizing
Uniform Markup	Percent	30.00	24.75 [19.89, 29.69]
Prices:			
Wholesale Price	Dollars	8.71	8.81 [8.71, 8.92]
Retail Price	Dollars	14.89	14.50 [14.14, 14.87]
Alcohol Consumption:			
Bottles	Bottles, millions	41.34	44.11 [41.48, 47.62]
Ethanol	Liters, millions	16.53	17.86 [16.59, 19.53]
Profits:			
Tax Revenue	Dollars, millions	255.69	256.64 [255.7, 259.86]
Distillers	Dollars, millions	113.09 [109.08, 117.83]	125.66 [111.66, 142.54]
Industry	Dollars, millions	368.79 [364.78, 373.53]	382.31 [367.4, 402.32]
PLCB Share	Percent	69.33 [68.45, 70.09]	67.13 [64.56, 69.6]

Notes: Table displays aggregate outcomes under the "Current" 30% markup policy and under the tax-revenue "Maximizing" uniform markup. Johnstown Flood Tax not included. We weight average wholesale and retail price by bottles sold. "Tax Revenue" is total *PLCB* tax revenue. "Industry" denotes the sum of *PLCB* tax revenue and distiller profits. 95% confidence intervals located in brackets. See Appendix E for details regarding the construction of these intervals.

control of alcohol markets. At the time of its inception, an objective of the *PLCB*, according to then Governor Gifford Pinchot, was to *"discourage the purchase of alcoholic beverages by making it as inconvenient and expensive as possible"*. The *PLCB* may therefore also place weight on consumer welfare in general and consumption externalities related to alcohol, in particular.

Alternative Policies. As the state appears to account for both tax revenue and social welfare in regulating spirits, we measure taxation-by-regulation by comparing the observed equilibrium under the uniform single markup to outcomes under two alternative policies. First, as in Table 7, we assume that the *PLCB*'s objective is tax revenue maximization. Now we consider a Stackelberg equilibrium of the regulator-distiller interaction that allows the *PLCB* to charge product-specific markups. The *PLCB* thus chooses the vector of 312 product-specific (e.g., *Bacardi Dry*, 750 ml), statewide markups that maximize aggregate tax revenue. As a result, the agency can generate incremental tax revenue by leveraging the different demand elasticities across products, particularly products of different size and price-points (see Table 5). We denote this equilibrium by "Profit".[29]

[29] In restricting the *PLCB* to maximize tax revenue, we implicitly assume that the state uses the revenue to finance other government programs. Thus, maximizing tax revenue in our partial equilibrium setting could still be consistent with a benevolent government that chooses its policies to maximize the aggregate utility of its residents.

Second, in line with the *PLCB* aiming to limit the consumption externalities of alcoholic beverages, we assume that the agency chooses markups to maximize consumer welfare subject to generating sufficient revenue to offset the external costs of the implied ethanol consumption:

$$\begin{aligned} \max_{\tau_j} \quad & \left\{ \sum_{t=1}^{T} \sum_{l=1}^{L} \mathrm{CS}_{lt}\left(p^r;\theta\right) \right\}, \\ s.t. \quad & p^r_{jt} = (1+\tau_j) \times p^w_{jt} + f_j\,, \\ & T(p^r) - \lambda \times E(p^r) \geq 0\,. \end{aligned} \tag{15}$$

where CS_{lt} is the mean consumer surplus of agents living in location l during period t as defined in Section 3.1. In solving this modified Ramsey problem (15) we take as given the pricing rule (1) with its product specific markup τ_j and fixed fee f_j (in practice determined by bottle size). In addition, the *PLCB* faces a modified "balanced budget" constraint where $T(p^r)$ is aggregate tax revenue, $E(p^r)$ is aggregate ethanol consumption (in liters) as a function of equilibrium retail prices, and λ is the externality cost associated with ethanol consumption. Ramsey (1927) showed that the regulator should tax each product as a function of its demand elasticity to minimize efficiency costs associated with raising a given amount of tax revenue.[30] As in the "Profit" scenario, we solve for the optimal product-level mark-ups under this alternative objective in a Stackelberg game where the *PLCB* moves first in choosing markups before distillers choose wholesale prices taking as given the regulator's policy. We denote this equilibrium by "Ramsey".

Empirically, we account for the ethanol externality by assuming that the government uses the full amount of *PLCB* tax revenue to offset the external costs of ethanol consumption. We can thus use information on aggregate tax revenue and ethanol consumption under the current policy to estimate the *average* equilibrium shadow externality per liter of ethanol contained in its aggregate sales, our proxy for λ. Given *PLCB* revenue of \$255.69 million and ethanol sold of 16.53 million liters over the sample period, we calculate $\lambda = \$15.46$. An advantage of this approach is that it allows us to incorporate the effects of the externality in a simple way and consider subsidy-free policies. Identifying and measuring the external costs of ethanol consumption is difficult and an open topic of research in the public health literature (see Greenfield et al., 2009).[31]

[30] Strictly speaking Ramsey (1927) showed this result for independent demands. In our setup demands are not independent but Ramsey pricing formulas can be generalized to "superelasticities" to account for cross-price elasticities. Ramsey's intuition still survives for well-defined demand systems with dominant own-price effects. Brown and Sibley (1986, §3.3 and §A.3) and Laffont and Tirole (1993, §A.5.1) derive these superelasticities for the two product case. See also Conlon and Rao (2015, Appendix 2) for the multiproduct case. We account for cross-price effects in our counterfactuals.

[31] Bouchery et al. (2011) and Sacks et al. (2013) provide estimates of the external costs of alcohol consumption borne during this period. Taken together, their results estimate alcohol-related costs for Pennsylvania of \$0.43 per U.S. standard drink, or equivalently \$24.29 per liter of ethanol. Bouchery et al. (2011, Table 2) decompose the total expense of alcohol consumption by source. If we exclude costs attributable to "lost productivity" due to premature mortality and absenteeism (45.4% of total expense), the estimated external cost falls to \$13.36 per liter of ethanol. Thus, our simple estimate of \$15.46 appears to be a reasonable approximation.

In both counterfactual policies, we hold the value of the outside option – off-premise beer and wine – invariant to the policies we consider.[32] We also continue to restrict the *PLCB* to charging uniform prices for a given product in all stores across the state. Furthermore, we only consider varying product markups, but hold unit fees fixed at current levels as they purportedly reflect *PLCB* transportation costs only. This allows for generalization of our results beyond Pennsylvania since nearly all US states, liquor control and otherwise, employ simple ad valorem excise taxes on alcohol.

6 Measuring Redistribution from Single Markup Pricing

In this section, we measure Posner's taxation-by-regulation and identify winners and losers of the single markup policy among the regulated firms and consumers. The idea that regulation can benefit a select few is of course not new. Stigler (1971) first articulated the hypothesis that regulation mostly served the interests of the firms in the regulated industry.[33] However, at least some consumers might also benefit from regulation. Laffont and Tirole (1993, §3.9) note that the cross-subsidization of certain population groups by others, for instance via a single markup policy, can be optimal if the regulator intentionally distorts prices to favor a targeted class of consumers.

6.1 Aggregate Effects of Simple Policy

In Table 8 we compare the observed equilibrium in years 2003-2004 to equilibria under policies where the agency chooses product-level markups to maximize tax revenue (the "Profit" column) or consumer welfare (the "Ramsey" column). The two policies yield similar outcomes.

A revenue-maximizing regulator would choose markups that, on average, amount to 53.0%. This average increase masks significant variation among the heterogeneous products. For instance, much of the increase stems from products with relatively inelastic demand: under the new policy, the *PLCB* applies average markups of 62.1% and 53.4% to 375 ml bottle and brandy products, respectively. While still higher than the current policy, the regulator marks up products with more elastic demands less, for example expensive and 1.75 L bottle products at 37.3% and 39.3% on average, respectively. Distillers respond by decreasing average wholesale price by 3.6% from $8.71

[32] As a result, we do not capture possible effects of alternative spirit pricing policies on tax revenue from wine sales or beer distributor and restaurant license fees. Recall, that wine purchases account for only 36% of *PLCB* revenue raised by state liquor stores. Meng, Brennan, Purshouse, Hill-McManus, Angus, Holmes and Meier (2014) furthermore find small cross-price elasticities between beer and spirits (0.113) and wine and spirits (0.163). Substitution to consumption of alcohol in restaurants, which may affect optimal license fees, is likely limited, due to different points of sale; Meng et al. (2014) also find very small elasticities of substitution between the on- and off-premise markets.

[33] Peltzman (1976) built on this view to consider consumers and other interest groups that may influence the design of regulatory rules and eventually the redistribution of rents among constituencies through the political process. These theories of regulation build upon the influential work by Olson (1965) on collective action and politics. Noll (1989) summarizes the political economy aspects of regulatory capture and Laffont and Tirole (1993, §11) elegantly formalize it within a principal-agent model of regulation.

Table 8: Aggregate Effects of the Single Markup

	Unit	Current	Profit	Ramsey
Markup	Percent	30.00	53.00	44.71
			[51.25, 53.96]	[44.45, 51.08]
Prices:				
Wholesale Price	Dollars	8.71	8.40	8.52
			[8.35, 8.43]	[8.43, 8.52]
Retail Price	Dollars	14.89	15.07	14.78
			[15.03, 15.39]	[14.77, 15.09]
Alcohol Consumption:				
Bottles	Bottles, millions	41.34	41.97	46.21
			[39.06, 42.28]	[43.12, 46.36]
Ethanol	Liters, millions	16.53	17.99	16.66
			[16.28, 18.17]	[16.59, 18.12]
Profits:				
Tax Revenue	Dollars, millions	255.69	280.78	257.67
			[277.82, 281.62]	[256.67, 275.87]
Distillers	Dollars, millions	113.09	110.89	133.27
			[99.76, 114.41]	[118, 134.91]
Industry	Dollars, millions	368.79	391.67	390.95
			[378.28, 393.9]	[388.54, 398.53]
PLCB Share	Percent	69.33	71.68	65.90
			[70.95, 73.79]	[65.57, 69.87]
Consumers:				
Compensating Variation	Dollars, millions	-	-8.05	-31.97
			[-9.48, 11.08]	[-32.48, -14.88]
CV as % of Expenditure	Percent	-	1.30	5.19
			[-1.79, 1.53]	[2.41, 5.27]
% Prefer Uniform	Percent	-	22.17	0.78
			[16.35, 95.3]	[0.77, 5.16]

Notes: Markups do not include Johnstown Flood Tax. We weight average wholesale and retail price by bottles sold. "Tax Revenue" is total *PLCB* tax revenue during 2003-2004. "Industry" denotes the sum of *PLCB* tax revenue and distiller profits. "Compensating Variation" is aggregate compensating variation during 2003-2004, as defined in Section 3.1, across markets. "CV as % of Expenditure" is aggregate compensating variation (in absolute value) as a percent of total liquor expenditure (i.e., $\sum_t \sum_l \sum_j p^r_{jlt} q_{jlt}$) during 2003-2004. "% Prefer Uniform" is the percent of residents with positive compensating variation. 95% confidence intervals located in brackets. See Appendix E for details regarding the construction of these intervals.

to \$8.40; significant wholesale price reductions occur in the 375 ml bottle category (-24.2%), among cheap products (-10.0%), and among brandies (-10.3%).[34] These price reductions ultimately limit the average retail price increase to consumers to only 18 cents from \$14.89 to \$15.07. Of course, the effect on retail prices is heterogeneous as some retail prices increase while other decrease, leading to an increase in the aggregate number of bottles sold of 1.5%.

The increased flexibility in the markup policy enables the *PLCB* to increase tax revenues by a significant \$25.09 million or 9.8% of current revenues. Integrated industry profits – the sum of distiller profit and *PLCB* tax revenue – rise by only 6.2%, reflecting an approximately 3% drop in distiller profit. Hence, the *PLCB* is able to capture the bulk of the incremental industry profits from a shift in its policy, which stands in stark contrast to the uniform markup analysis above. By

[34] See Table F.2 for a decomposition of wholesale and retail prices across policies and product segments.

allowing markups to vary and leveraging differences in demand across products, the *PLCB* extracts market power from firms. In aggregate, consumers prefer this policy as consumer surplus increases 8.05 million, even though 22.17% prefer the uniform markup.[35,36]

We find similar patterns for the Ramsey regulator as the *PLCB* maximizes consumer welfare by increasing the average markup to 44.7% and the upstream response leads to a net decrease in the average retail price facing consumers. Again tax revenue and ethanol consumption increase though now the former offsets the external costs of the latter by construction. Nearly all consumers are better off under this policy as aggregate consumer welfare increases $32 million, or 5.2% of total liquor expenditure. At the same time distillers are better able to leverage their price-setting power than when the regulator maximizes tax revenue and has a similar objective to their own. Their aggregate profits increase by 17.8% under a benevolent Ramsey regulator.

To summarize, we find that aggregate tax revenue and consumer welfare during 2003-2004 increase under both alternative pricing policies. Interestingly, upstream firms are largely indifferent between the uniform and the more flexible policy when the regulator adopts it to raise additional revenue. Firms with market power are thus largely able to defend their profits across different policy regimes. In contrast, the aggregate impact on consumers of more flexible pricing is theoretically ambiguous; ex ante there is no reason to believe that product-level markups designed to maximize tax revenue ("Profit") would also increase consumer welfare, an objective inherent to the "Ramsey" scenario.

6.2 Taxation by Regulation Among Distillers

Our analysis of taxation-by-regulation has thus far focused on the aggregate implications of single markup policies. Now we turn to the redistribution of profits among firms that simple policy induces. Table 9 illustrates that *PLCB* policy has heterogeneous effects on firms since distillers operate very different product portfolios (Table 1) and face consumers with different tastes (Table 3).

As the directional changes and magnitudes are similar across the "Profit" and "Ramsey" scenarios, we focus on the "Profit" case here. We find that the *PLCB*'s single markup policy increases market power in the upstream market and transfers profits from large firms like Diageo and Bacardi to small firms like Jacquin. We attribute much of the average reduction in wholesale prices of 3.5% under tax-revenue maximizing downstream markups to the smaller firms Jacquin and Sazerac that lower their prices by 13.6% and 14.3%, respectively. In contrast, large multi-product distillers like Diageo, Beam, and Bacardi respond much less to product-level *PLCB* markups, reducing their wholesale prices by 1.9%, 4.2%, and 1.4% on average, respectively. This reflects the

[35] A negative mean compensating variation in location l indicates the average amount a consumer in the market would be willing to pay the state to switch to the product-level markup policy. See Section 3.1.

[36] To make these welfare numbers more concrete, we find that mean compensating variation is negative in most store markets. After weighting each market by the local drinking-age population, we conclude that 77.83% consumers would prefer this equilibrium, or equivalently that 22.17% prefer the single markup.

Table 9: Upstream Performance under Alternative Policies

	Wholesale Price ($)			Lerner Index (%)			Profits ($M)		
Firm	Current	Profit	Ramsey	Current	Profit	Ramsey	Current	Profit	Ramsey
Diageo	9.96	9.77	10.01	34.42	32.09	34.04	26.59	27.56	34.06
		[9.69, 9.8]	[9.87, 10.01]	[33.21, 36.11]	[31, 33.62]	[31.74, 34.88]	[25.58, 27.91]	[24.77, 28.82]	[30.86, 35.15]
Beam	7.85	7.52	7.55	41.53	37.33	38.33	10.86	8.92	8.36
		[7.47, 7.54]	[7.51, 7.57]	[40.13, 43.04]	[36.08, 38.91]	[36.27, 39.85]	[10.48, 11.31]	[8.41, 9.3]	[8.05, 9.68]
Jacquin	5.22	4.51	4.40	55.61	51.40	51.58	10.09	6.13	4.86
		[4.49, 4.55]	[4.38, 4.49]	[53.95, 57.7]	[49.19, 54.24]	[49, 54.29]	[9.8, 10.49]	[5.89, 6.56]	[4.76, 5.97]
Bacardi	9.59	9.46	9.58	33.15	31.33	32.69	9.97	11.88	12.61
		[9.38, 9.48]	[9.38, 9.58]	[32.04, 34.6]	[30.25, 32.64]	[30.17, 33.52]	[9.61, 10.43]	[10.1, 12.12]	[10.1, 12.74]
Sazerac	4.88	4.18	4.07	49.74	49.85	50.40	8.28	5.56	4.75
		[4.16, 4.22]	[4.04, 4.17]	[48.21, 51.64]	[47.16, 53.51]	[47.05, 53.65]	[8.01, 8.64]	[5.26, 5.93]	[4.6, 5.46]
All Firms	8.71	8.40	8.52	37.52	34.90	36.13	113.09	110.89	133.27
		[8.35, 8.43]	[8.43, 8.52]	[36.26, 38.93]	[33.6, 36.43]	[33.84, 37.42]	[109.08, 117.83]	[99.76, 114.41]	[118, 134.91]

Notes: Table arranges distillers in descending order by total profit under the current policy. "Wholesale Price" is the average wholesale price (p^w) weighted by bottles sold. "Lerner Index" denotes the average Lerner index, defined as $100 \times (p^w - \hat{c})/p^w$, weighted by bottles sold. All numbers correspond to the entire sample, 2003-2004. 95% confidence intervals located in brackets. See Appendix E for details regarding the construction of these intervals.

compositional advantages of a large product portfolio with limited exposure to reduced profits from a subset of products.

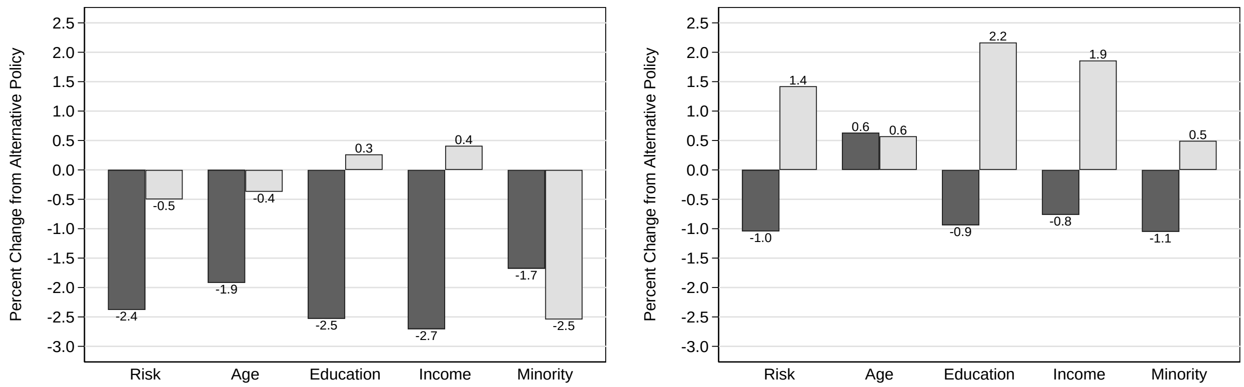
Average product-level price cost margins thus decline for all firms, but increases in quantity sold offset lower margins for some competitors. For instance, profits for Diageo and Bacardi increase under tax-revenue maximizing product-level markups by 3.6% ($0.97 million) and 19.2% ($1.91 million), respectively. This growth comes at the expense of the smaller, more specialized firms. For example, profits earned by Jacquin decrease significantly under product-level markups so the firm is a clear beneficiary of the single markup.

Jacquin's success under the single markup policy stems from its focus on CHEAP, relatively inelastically demanded products (Table 1 and Table 5). Recall that in Table F.2 we show that the *PLCB*'s single markup policy underprices inexpensive products, leading to greater upstream market power in this segment (Table 6). While Jacquin's success under the single markup would fit the narrative of Jordan's *Producer Protection* argument for regulation (Jordan, 1972), an alternative hypothesis is that the firm's management chose to sell products favored by the regulatory policy in its home market. In contrast, large global firms like Diageo and Bacardi face many diverse sets of local market conditions, including diverse sets of regulations, so they are less likely to design their product portfolios to benefit from the nuances of a particular market or regulation. The fact that Jacquin is at best the 18$^{\text{th}}$ largest distiller based on unit sales in the remaining liquor control states lends further evidence to this hypothesis.

6.3 Taxation by Regulation Among Consumers

In this section, we evaluate whether the single markup benefits certain consumer groups over others. As above, we identify the implicit redistribution due to the single markup by comparing the estimated equilibrium to equilibria generated by product-level markups that the regulator chooses to maximize either tax revenue ("Profit") or consumer welfare ("Ramsey").

Figure 3: Changes in Retail Price



(a) Objective: Maximize Tax Revenue

(b) Objective: Maximize Consumer Welfare

Notes: Figures display percent change in retail price, weighted by bottles sold, of the 30% markup policy relative to the "Profit" (panel a) and "Ramsey" (panel b) equilibria for markets in the bottom ("Low) and top ("High) quintiles of each demographic attribute. See Tables 2 and 3 for definitions of the attributes.

In Figure 3, panels (a) and (b) compare retail prices paid under the single markup to the equilibrium retail prices under each alternative in select market groupings. To reflect differences in preferences across consumer types, we calculate the average percent change in retail price paid in each market in moving from the alternative policies to the current uniform markup using quantity sold under the uniform markup as weights. Thus, a positive percent change indicates that consumers pay a higher price under the current 30% markup for the products they select than under product-level markups. As in Figure 1, we compare markets in the top and bottom quintile of each demographic attribute.

Figure 3 indicates that by ignoring preference heterogeneity, the current 30% single markup policy induces substantial price distortions that vary systematically with demographic attributes. Panel (a) indicates that relative to the "Profit" equilibrium, the prices of products bought by consumers in the least affluent markets are 2.7% lower under the 30% markup. In turn, prices of the products bought in wealthy neighborhoods are 0.4% higher – a 3.1 percentage point difference across markets between the bottom and top income quintiles. As educational attainment is highly correlated with income, similar results arise when contrasting markets with a varying prevalence of consumers with some college education (and to a lesser extent markets with varying age of consumers).

The intuition behind these results is as follows. Lower income consumers prefer 375 ml and CHEAP products (Table 3) with relatively inelastic demand (Table 5). Firms' wholesale pricing reflects such differences in demand, but competition limits the degree to which firms can extract consumer surplus. The *PLCB*, on the other hand, faces no downstream competition. A more flexible markup policy therefore allows it to internalize demand differences across the full product set. As a result, the regulator chooses markups that increase the average equilibrium retail prices

Table 10: Does the Single Markup Favor Certain Consumers?

	MAXIMIZE TAX REVENUE		MAXIMIZE CONSUMER WELFARE	
AGE	-2.317	-2.289	7.132	7.312
	[-2.066, -1.07]	[-2.039, -1.054]	[0.948, 7.198]	[1.043, 7.376]
EDUCATION	-5.706	-5.525	-4.990	-3.854
	[-5.411, -4.068]	[-5.264, -3.946]	[-5.162, -3.227]	[-4.421, -2.849]
INCOME	-3.090	-3.063	-3.650	-3.483
	[-3.317, -2.359]	[-3.296, -2.341]	[-3.765, -2.131]	[-3.598, -2.079]
MINORITY	1.422	1.541	-2.871	-2.120
	[1.068, 1.86]	[1.149, 1.958]	[-2.994, 1.528]	[-2.238, 1.761]
URBAN		-0.125		-0.787
		[-0.136, -0.084]		[-0.795, -0.239]
N	454	454	454	454
R^2	0.651	0.652	0.424	0.452
	[0.644, 0.657]	[0.645, 0.658]	[0.41, 0.556]	[0.418, 0.573]

Notes: Dependent variable for each regression is market l compensating variation divided by market l liquor expenditure. URBAN is an indicator for a market in the Philadelphia and Pittsburgh Metropolitan Statistical Areas. Remaining demographic attributes are defined in Table 2. 95% confidence intervals located in brackets. See Appendix E for details regarding the construction of these intervals.

of 375 ml and CHEAP products (Table F.2), which adversely affects consumers who prefer these products. Put differently, the blunt policy instrument of the uniform markup restricts the *PLCB*'s ability to target specific products, and the consumers who prefer these products, either to increase tax revenue or increase consumer welfare.

Turning to product-level markups that maximize consumer welfare (panel (b) in Figure 3), relative to such "Ramsey" prices, the single markup entails the same gradient seen in panel (a) for sales-weighted retail price changes across markets in the tails of the income and educational attainment distributions. The prices of products disproportionately purchased in high-risk markets are, however, significantly higher than those that maximize consumer welfare. One possible objective of the uniform markup policy may therefore be to reduce consumption in these markets by driving up the relevant subset of retail prices. Our results indicate that such an objective generates significant distortions, however, harming consumers in high-income, well-educated, and low-consumption markets.

An advantage of our empirical approach is that we are able to not only investigate price changes under alternative regulatory objectives, but also use the estimated model to evaluate changes in consumer welfare directly. In Table 10, we project mean compensating variation in each market onto observable demographics where we normalize market l compensating variation (CV_l) by market l liquor expenditure to control for differences in market size. We find that in line with the above changes in prices paid in markets in the tails of the demographic distributions, average compensating variation is generally higher in markets with a lower share of college-educated and lower-income consumers. The effect of education is the most pronounced; on average, increasing the share of households with some college education in a market by one percentage point is associated with a reduction in compensating variation of twice the amount associated with the same increase in the share of high-income households. The single markup thus implicitly favors low income and poorly educated consumers, regardless of the regulator's objective. This conclusion is also consistent with the results of an unreported probit model identifying attributes of markets where consumers prefer the 30% single markup on average ($\text{CV}_l > 0$).[37]

Our assumption regarding the regulator's objective influences, however, our interpretation of the 30% markup's effect on minority consumers. If we assume the *PLCB*'s objective is to maximize tax revenue (columns two and three), minorities clearly benefit from the regulator's inability or disinterest in employing a more sophisticated markup policy. If, on the other hand, the *PLCB* is benevolent but has to meet a budget constraint accounting for external costs of ethanol consumption (i.e., columns four and five), minority consumers are indifferent. Put differently, for minority consumers the estimated equilibrium under the 30% single markup is indistinguishable from the "Ramsey" equilibrium in which the state maximizes aggregate consumer surplus.

6.4 Feasible Policy

Thus far, we have shown that the 30% markup is a policy that leaves both tax revenue and consumer welfare on the table while introducing distortions among both firms and different consumer groups. We have remained agnostic, however, about whether setting 312 product-level markups is a feasible government policy. Instead, we have relied on alternative notions of equilibria to point out the implicit redistribution that results from ignoring heterogeneity in product demand. But setting 312 different markups or commodity tax rates might not appear transparent for consumers. A single markup or one defined on the basis of alcohol content might be better understood by consumers even though it will lead to inefficiencies as they cannot completely capture the heterogeneous substitution pattern across all products. In this section, we address the issue of feasibility directly and ask whether a policy that targets differences in product demand in a simpler way can be an effective substitute for the more complex product-level "Profit" and "Ramsey" policies.

The feasible policy we consider to approximate the "Profit" equilibrium is one where the *PLCB* chooses separate markups for the six spirit types and for the three bottle sizes, or nine altogether. We stray from including markups based on product attributes that distillers could manipulate easily in response to a change in policy, such as price points. This approximation to product-level complex pricing captures the most prominent sources of differences in demand elasticities (Table 5). Under this feasible policy, the markup applied to a 750 ml bottle of *Bacardi Dry* is the sum of the markup applied to RUM and the markup applied to 750 ml: $\tau_j = \tau_{\text{Spirit Type}} + \tau_{\text{Bottle Size}}$. We design the feasible policy that approximates the "Ramsey" equilibrium analogously with the objective of maximizing aggregate consumer surplus subject to the ethanol-adjusted budget constraint. We present results in Table 11.

Are the simpler policies we consider a good approximation for more complex product-level pricing? Put differently, is it sufficient to design policy around broad patterns in demand? The

[37] Figure F.2 in Appendix F shows the low share of markets where consumers are currently better off against alternative optimal policies aiming at maximizing either tax revenues or consumer surplus. Figure F.3 depicts the distribution of consumers benefiting from the current policy by demographic traits.

Table 11: Effectiveness and Impact of Simple Policies

		MAXIMIZE TAX REVENUE		MAXIMIZE CONSUMER WELFARE	
	CURRENT	FEASIBLE	COMPLEX	FEASIBLE	COMPLEX
Number of Markups	1	9	312	9	312
Constrained?	-	N	N	Y	Y
Markup:					
Average	30.00	37.87 [35.47, 43.13]	53.00 [51.25, 53.96]	25.84 [25.66, 28.06]	44.71 [44.45, 51.08]
PLCB Objectives:					
Tax Revenue	255.69	264.90 [262.6, 266.19]	280.78 [277.82, 281.62]	236.49 [234.11, 241.58]	257.67 [256.67, 275.87]
Compensating Variation	-	-15.10 [-22.69, 4.6]	-8.05 [-9.48, 11.08]	-12.80 [-13.61, -10.65]	-31.97 [-32.48, -14.88]
CV as Percent of Expenditure	-	2.45 [-0.74, 3.68]	1.30 [-1.79, 1.53]	2.07 [1.73, 2.21]	5.19 [2.41, 5.27]
Impact on Firms:					
Avg. Wholesale Price	8.71	8.64 [8.54, 8.69]	8.40 [8.35, 8.43]	8.77 [8.74, 8.78]	8.52 [8.43, 8.52]
Upstream Profits	113.09	121.47 [109.51, 123.69]	110.89 [99.76, 114.41]	126.95 [123.5, 129.85]	133.27 [118, 134.91]
- Diageo	26.59	28.33 [25.36, 29.01]	27.56 [24.77, 28.82]	30.41 [29.4, 31.1]	34.06 [30.86, 35.15]
- Beam	10.86	13.24 [12.05, 13.42]	8.92 [8.41, 9.3]	11.82 [11.35, 12.26]	8.36 [8.05, 9.68]
- Jacquin	10.09	10.13 [9.72, 10.27]	6.13 [5.89, 6.56]	9.19 [8.87, 9.63]	4.86 [4.76, 5.97]
- Bacardi	9.97	10.45 [9.27, 10.73]	11.88 [10.1, 12.12]	10.09 [9.69, 10.38]	12.61 [10.1, 12.74]
- Sazerac	8.28	8.57 [8.21, 8.74]	5.56 [5.26, 5.93]	7.57 [7.3, 7.91]	4.75 [4.6, 5.46]
Impact on Consumers:					
Avg. Retail Price	14.89	14.73 [14.57, 15.12]	15.07 [15.03, 15.39]	14.89 [14.87, 14.94]	14.78 [14.77, 15.09]
Ethanol Consumed	16.53	19.24 [17.26, 19.96]	17.99 [16.28, 18.17]	15.29 [15.13, 15.62]	16.66 [16.59, 18.12]
% Prefer Alt. Policy	-	92.75 [23.11, 97.66]	77.82 [4.69, 83.64]	96.64 [92.06, 97.18]	99.21 [94.83, 99.22]

Notes: "Number of Markups" refers to the number of markups chosen by the *PLCB*. "Constrained" denotes the optimal markup subject to an aggregate budget constraint under "Ramsey" policies. "Feasible" denotes the optimal markup policy based on bottle size (3) and spirit type (6). Markups do not include the 18% Johnstown Flood Tax. All statistics correspond to the entire sample, 2003-2004. "CV as % of Expenditure" is aggregate compensating variation (in absolute value) as a percent of total liquor expenditure (i.e., $\sum_t \sum_l \sum_j p^r_{jlt} q_{jlt}$) during 2003-2004. "Ethanol Consumed" is in millions of liters of ethanol. "% Prefer Alt. Policy" is the percent of residents with negative compensating variation. 95% confidence intervals located in brackets. See Appendix E for details regarding the construction of these intervals.

answer to both questions is "No" as the feasible policies we consider capture only 36.7% of potential tax revenue in the "Profit" scenario and leave \$19.2 million in consumer welfare, equivalent to 3.1% of liquor expenditure, on the table in the "Ramsey" scenario. Interestingly, by restricting attention to feasible policies, firms are better off by 7.4% when the *PLCB* is tasked with maximizing tax revenue, but they would prefer the more complex system of taxation when the *PLCB* maximizes consumer welfare.

While suboptimal, the majority of consumers prefer the feasible policies to the single markup policy. Constraining the revenue-maximizing regulator to feasible policies increases consumer welfare for 92.75% of residents – an increase from the 77.83% when the regulator seeks to maximize tax revenue with product-level markups. Pricing policy feasibility in this environment limits the ability of the regulator from exploiting differences in product-level demand and therefore transfers surplus to consumers in the form of lower retail prices ($14.73 versus $15.07 on average). Finally, we find that the simple policy we consider for the Ramsey regulator does manage to benefit the vast majority of consumers. This suggests that, at least in our setting, even a small increase in the set of taxation instruments allows a benevolent government to benefit most consumers.

7 Concluding Remarks

In this paper, we study the redistributive effects of simple taxation policy when agents have heterogeneous preferences over outcomes. We focus on the regulation of spirits where we observe the pricing decisions of all firms and consumption choices of all consumers affected by the policy. In our setting, the regulator by law charges a uniform 30% markup on all horizontally differentiated products it sells in state-run stores. We find significant heterogeneity in the consumption patterns of different population groups and in the product portfolios offered by the upstream suppliers. Hence, the uniform policy generates winners and losers among both consumers and firms, but also affects tax revenue collection. This paper therefore not only contributes to our understanding of optimal taxation, it also amounts, to the best of our knowledge, to the first empirical evidence of Posner's taxation-by-regulation argument.

It is often the case that policy design fails to address moral hazard and adverse selection issues envisioned by economists (e.g., Laffont and Tirole, 1993). Instead, simple policy rules prevail. This may well be the result of technological and administrative limitations but it might also respond to achieving specific distributional outcomes beyond the stated policy goals, e.g., Kahn (1970, §7). We cannot speak to intent on the part of the Pennsylvania state legislature in explicitly targeting some firms or consumers groups with the single markup. Our view is that the induced redistribution is but an unintended, yet significant, consequence of the uniform markup regulation. Proponents of uniform tax rates often argue that they are inherently fair as they treat everyone equally. Our results indicate just the opposite.

One could rationalize the use of simple policy like the single markup with sufficiently high managerial decision-making costs or the political infeasibility of implementing and maintaining product-level markups. Such explanations are not fully satisfactory in our context. First, we show that a small modification to pricing policy with an eye towards targeting classes of products with similar demand elasticities achieves gains in both tax revenue and consumer welfare, albeit less than under more complex pricing policies. Second, the increased pricing flexibility granted to the *PLCB* in recent policy reforms suggests that the state believes the agency to be capable of managing a complex markup policy. Continually falling costs of installing and maintaining information technology systems and increasing use of "Big Data" algorithms might contribute to this belief. Our results thus indicate an opportunity for government to use complex taxation systems to increase tax revenue and consumer welfare simultaneously.

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Appendix

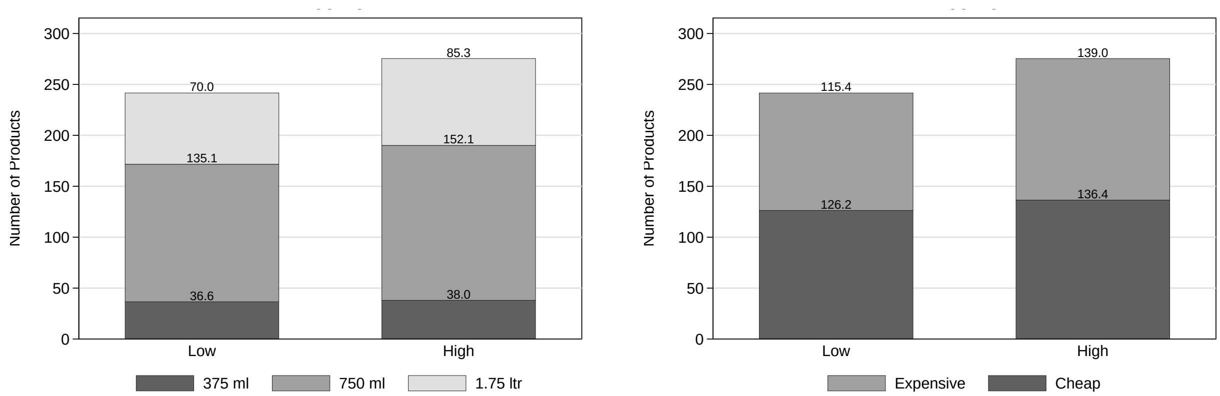
A Data

In this section we discuss the data in more detail. We begin with a discussion of how we aggregate the initial daily, store-level *PLCB* data and how we define market areas served by each store. We also address the possibility of stock-outs and how we link the available demographic information to our geographic market definition.

To reduce the size of the estimation sample, we consider the periodicity with which we observe price changes in the data. *PLCB* regulation in place during our sample period allows price to change only for two reasons: permanent and temporary wholesale price changes. Both follow set timing requirements. Permanent price changes can take effect on the first day of one of the *PLCB*'s four-week long accounting reporting periods. Temporary sales, on the other hand, begin on the last Monday of each month and last for either four or five weeks until the day before the last Monday of the following month. Reporting periods and temporary sales periods thus align largely, but not perfectly. To recognize that temporary price reductions are more prevalent than permanent ones (89.7% of price changes in the sample are temporary in nature) and avoid having multiple very short periods, we use sales periods as our time interval. In case of permanent price changes that take effect at the beginning of a reporting period that bisects two sales periods, we assume that the price change takes effect in the sales period that most overlaps with the given reporting period. This results in 22 "pricing periods" during which prices remain constant. In aggregating our daily sales data to the level of sales during a pricing period, we treat a product as being available in a store if we observe a sale at least once during a given pricing period. The length of the pricing period alleviates concern about distinguishing product availability from lack of sales in the period.

Product Set Variation Across Stores. Stores exhibit significant variation in the product composition of purchases but little variation in their product offering. These differences reflect heterogeneity in consumer preferences more than differences in the availability of products across stores: Of the 100 best selling products statewide in 2003, the median store carried 98.0%, while a store at the fifth percentile carried 72.0% of these products. Similarly, of the 1000 best selling products statewide in 2003, the median store carried 82.0%, while a store at the fifth percentile carried 44.2% of the products. The product availability at designated "premium" stores is somewhat better than the average, with the median premium store carrying all of the top 100 products and 95.1% of the top 1000 products. In addition, a consumer can request to have any regular product in the *PLCB*'s product catalog shipped to his local store for free, should that store not carry the product. In Figure A.1 we demonstrate the product set available to consumers in wealthier markets is greater for 1.75 L and EXPENSIVE products though the difference is small and consumers in poor neighborhoods clearly have access to a large set of these products. Further, the products purchased more often in high-income markets are all in the far right-tail of the sales distribution so it is reasonable to assume any bias they may introduce into our demand estimates are very small.

Figure A.1: Product Availability and Income



(a) Bottle Size (b) Price

Notes: A product is considered in the product set of a geographic market if it is ever sold during 2003-2004. Numbers reflect the average number of products in each category (e.g., 1.75 L products) carried by stores in the relevant income group.

The fact that most stores carry most popular products and can provide access to all products in the catalog easily, together with the absence of price differences across stores, supports an important assumption underlying our demand model: Differences in product availability do not drive consumers' store choices to a significant degree and as a result, consumers visit the store closest to them. In making this assumption, which allows us to focus on the consumer's choice between different liquor products available at the chosen store, we follow previous studies using scanner data such as Chintagunta et al. (2003).[38]

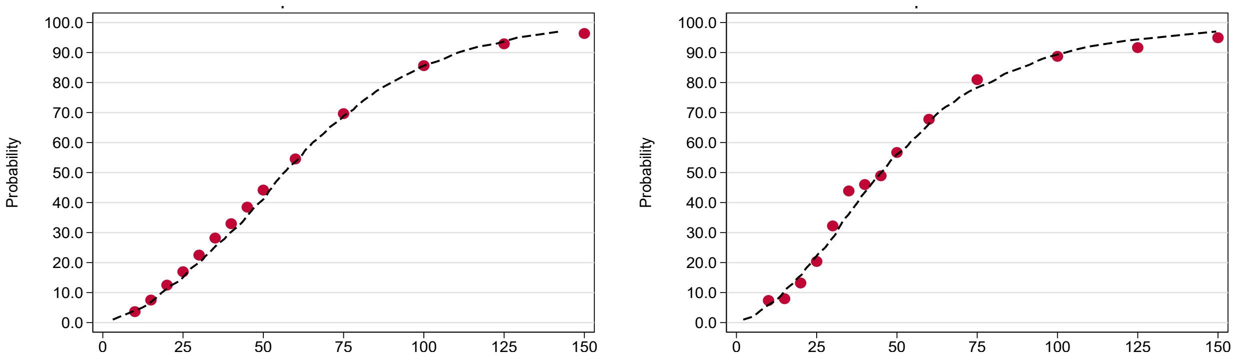
Simulating Consumers. To define the population served by each store, we calculate the straight-line distance to each store from each of Pennsylvania's 10,351 regular block groups and assign consumers to the closest open store for each pricing period. In instances where the *PLCB* operates more than one store within a ZIP code, we aggregate sales across stores to the ZIP code level; there are 114 such ZIP codes out of a total of 1,775. Note that these instances include both store relocations, where a store moved from one location in a ZIP code to another during 2003, but the data contain separate records for the store in the two locations, and instances where the *PLCB* operates two stores simultaneously within a ZIP code.[39] We consider the resulting block group zones as separate markets.

We derive consumer demographics for the stores' market areas by calculating the total population and population-weighted average demographics. We obtained detailed information on each block group's discrete income distribution by racial identity of the head of household, with household income divided into one of 16 categories. We aggregate across racial groups and across

[38] Near the state's borders, the *PLCB* runs seven outlet stores that sell products, such as multi-packs, not available in regular stores to reduce the so-called 'border bleed' of consumers' shopping in lower-priced neighboring states. The addition of these stores to the sample has little qualitative or quantitative effects on the results. See Appendix D

[39] We drop wholesale stores, administrative locations, and stores without valid address information, for a total of 13 stores.

Figure A.2: Income Distributions Conditional on Race



(a) White Consumers (92.2%) (b) Minority Consumers (7.8%)

Notes: In each panel we compare estimated income distribution (dashed line) and the block group discrete income distribution (dots). Income distributions are organized by racial identity of the head of household where panel (a) corresponds to white consumers and panel (b) corresponds to non-white (minority) consumers. In parentheses we present the share of consumers each racial category represents in the market. Results correspond to a store located in Reading, Pennsylvania.

block groups in a store's market area to derive the discrete income distribution separately for white and non-white households. We construct two income measures. First, we calculate the share of high-income households by minority status, defined as households with incomes above \$50,000. We use this measure in constructing the figures and descriptive statistics in the text. Second, we fit continuous market-specific distributions to the discrete distributions of income conditional on minority status. We use this measure in estimating the model and conducting counterfactual experiments. We employ generalized beta distributions of the second kind to fit the empirical income distribution for each market l. McDonald (1984) highlights that the beta distribution provides a good fit to empirical income data relative to other parametric distributions. In Figure A.2 we compare the estimated cumulative distribution functions for income conditional on minority status for a store located in Reading, PA. We observe that in this location the income distribution for white consumers first-order stochastically dominates the income distribution for minority consumer.

We also used a generalized beta distribution to estimate the continuous market-specific age distribution though due to data census limitations we could not condition this on race or income. We also obtained information on educational attainment by minority status and aggregated across several categories of educational attainment to derive the share of the population above the age of 25 with at least some college education, by minority status and market. Any correlation between educational attainment and income is therefore captured through the correlation between education and minority status and then minority status and income.

We construct the sample of simulated consumers for each market by relying on the empirical distributions of the demographic attributes considered above – whether a consumer is young, non-white, college-educated, and their income level – incorporating correlations between demographic attributes where possible. Conditional on a realization of a consumer's minority status, we take random draws from the corresponding income and educational attainment distributions and assign the consumer to an age bin based on the unconditional distribution of age above 21 years in the relevant location. Since the ambient population of stores changes with store openings and closings over the course of the year, the simulated set of agents changes in each pricing period. Lastly, we account for the unobserved preferences (ν_{il}) via scrambled Halton draws. As demonstrated by Train (2009), using Halton draws enables us to more efficiently cover the space of unobserved preferences (ν_{il}).

To summarize:

1. We use census data to construct a joint distribution of demographics for each market l.
   - We use census data for each market l to estimate the joint income distribution conditional on racial status (minority, non-minority). This yields L-by-2 estimated generalized beta distributions.
   - We complement this with census data on educational attainment conditional on racial status (minority, non-minority) by market l.
   - We include consumer age using the unconditional age distribution for each market l.
2. We simulate market l agents by drawing from the corresponding market l joint distribution, adding unobserved preferences (ν_{il}) via scrambled Halton draws.
3. In order to ensure we adequately cover the space of consumer characteristics, we chose a large number of simulated agents (1,000).

Price Instruments. Our price instruments come from two sources. First, the data on retail prices in other liquor control states consists of monthly product-level shelf prices by liquor control state. We assign a month to our Pennsylvania pricing periods to facilitate a match between the two data sets. Second, we attained historical commodity prices for corn and sugar from Quandl, a data aggregator. The prices are the monthly price of a "continuous contract" for each commodity where a "continuous contract" is defined as a hypothetical chained composite of a variety of futures contracts and is intended to represent a the spot market price of the given commodity. We also attained prices for rice, sorghum, wheat, barley, oats, and glass (as a cost input for bottle size) but found these input costs provided little additional explanatory power.

B Additional Descriptive Statistics

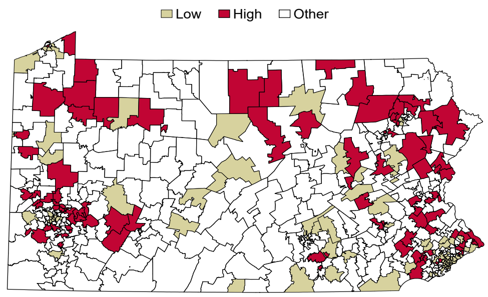
Table B.1 presents the distribution of bottle prices contained in our sample of 312 products. Average price is increasing across bottle sizes both within a category and for the whole sample. Vodkas are the most expensive products on average, while rums are least expensive. Figure B.1 documents the demographic diversity of Pennsylvania. Although correlated, the spatial distribution of demographics are not perfectly aligned.

Table B.1: Average Price and Market Shares by Type and Size

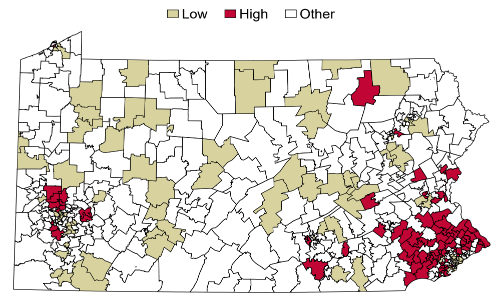
			Share of Market	
	Products	Avg. Price	By Quantity	By Revenue
BRANDY	26	14.41	7.26	6.75
375 ml	7	8.54	1.75	1.09
750 ml	13	15.56	4.28	4.13
1.75 L	6	18.76	1.22	1.52
CORDIALS	62	14.08	13.59	13.71
375 ml	13	10.76	2.11	1.49
750 ml	46	14.16	10.80	11.05
1.75 L	3	27.34	0.67	1.17
GIN	28	15.15	6.72	7.04
375 ml	4	7.80	0.62	0.33
750 ml	46	12.40	3.19	2.92
1.75 L	3	21.06	2.91	3.79
RUM	40	13.72	16.31	15.70
375 ml	5	6.59	1.65	0.73
750 ml	23	12.66	9.56	8.11
1.75 L	12	18.71	5.11	6.86
VODKA	66	16.82	32.10	29.80
375 ml	8	8.14	6.76	2.34
750 ml	33	15.54	10.85	11.08
1.75 L	25	21.29	14.50	16.37
WHISKEY	90	16.77	24.03	27.01
375 ml	11	9.12	2.33	1.37
750 ml	42	15.50	11.61	11.70
1.75 L	37	20.49	10.10	13.94
ALL PRODUCTS	312	16.35	100.00	100.00

Notes: "Quantity" market share is based on bottles while "Revenue" is based on dollar values.

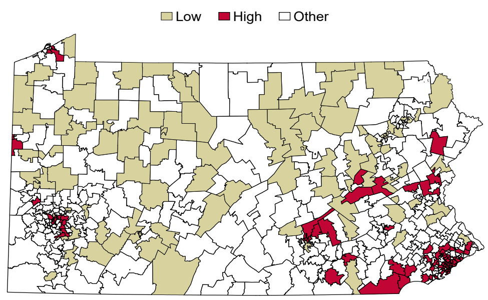
Figure B.1: Spatial Distribution of Consumer Characteristics



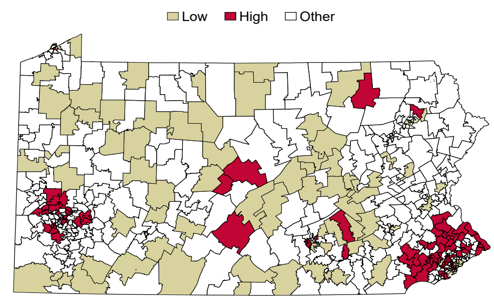
(a) Age



(b) Income



(c) Minority



(d) Education

Notes: Maps correspond to the spatial distribution of characteristics in Pennsylvania during the sample. Outlined polygons correspond to geographic markets (i.e., "stores" in the text). Dark shaded regions correspond to markets in the top quintile of the demographic attribute ("High" in the text). Lightly shaded regions correspond to markets in the bottom 20% for the corresponding demographic attribute ("Other" in the text). Remaining markets ("Other" in the figures) are not shaded.

C Estimation Procedure

In this Appendix, we lay out the three-stage estimation procedure we adopt to estimate contributions to the consumer's mean utility from a given product, δ_{jlt}, and individual-specific contributions to utility, μ_{ijlt}. We discuss each stage in turn, highlighting the variation in the data that allows us to identify the relevant parameters in each stage.

Stage 1: Random Coefficients and Demographic Interactions. In the first of the three stages, we estimate the contributions of unobserved (Σ) and observed (Π) demographic interactions to deviations from mean utility, μ_{ijlt}, controlling for location and product by time fixed effects. We decompose the unobserved product valuations, ξ_{jlt}, as follows

$$\xi_{jlt} = \zeta_l^1 + \xi_{jt} + \Delta\xi_{jlt}\,. \tag{C.1}$$

In equation (C.1), ζ_l^1 is a market fixed effect that captures systematic variation across locations in the preference for spirits consumption, relative to beer and wine.[40] We control for systematic variation in preferences for a given product over time via ξ_{jt}, to reflect the fact that across the state, a product's mean demand varies over the course of the year. The remaining structural error $\Delta\xi_{jlt}$ represents deviations in unobserved product valuations within a store from these mean product-time valuations, controlling for the average taste for spirits in market l.

This decomposition of ξ_{jlt} simplifies the mean utility of product j, δ_{jlt} in equation (5a), to

$$\delta_{jlt} = \zeta_l^1 + \zeta_{jt}^2 + \Delta\xi_{jlt}\,, \tag{C.2}$$

where the product and time specific fixed effect ζ_{jt}^2 comprises the effect of product characteristics ($x_j\beta$), seasonal buying ($H_t\gamma$), price (αp_{jt}^r), and ξ_{jt} on a product's mean utility.

Equation (C.2) highlights an advantage to our setting: since price does not vary across locations l, we are able to control for its mean contribution to utility via product by time fixed effects, which we then use in a second stage estimation to isolate α.

Given a guess at $\theta_A = \{\Sigma, \Pi\}$, we solve for the structural error $\Delta\xi_{jlt}(\theta_A)$ using the following algorithm. We first find the mean-utility levels $\delta_{jlt}(S_{jlt};\theta_A)$ that set the predicted market share of each product, s_{jlt} in equation (7), equal to the market share observed in the data, S_{jlt}.[41] To evaluate the integral in equation (7) we simulate for each market l the purchase probabilities of 1000 randomly drawn heterogeneous consumers who vary in their demographics.

Given mean utility levels that equate predicted and actual market shares, we then follow Somaini and Wolak (2015) and use a within transformation of δ to remove the store and product-

[40] This accounts for the fact that the potential market is defined based on the average Pennsylvanian's consumption as disaggregated per-capita consumption of alcoholic beverages is not available.

[41] We make use of the contraction mapping procedure outlined in Appendix I of *BLP*, imposing a tolerance level for the contraction mapping of 1e-14 as advised by Dubé, Fox and Su (2012, §4.2) to ensure convergence to consistent stable estimates.

period fixed effects ζ_l^1 and ζ_{jt}^2, leaving only $\Delta\xi_{jlt}$. We follow the earlier literature in using a generalized method of moments (*GMM*) estimator that interacts $\Delta\xi$ with within-transformations of suitable instruments Z. We include in Z the following information: the number of products of the same type and price category, the root mean square distance in spirit product scores, plus interactions between these variables and demographics (see Section 4 for further detail). Define Z^+ as the within transformation of the instruments matrix; e.g., for instrument k, $Z_{jlt}^{+,k} = Z_{jlt}^k - \overline{Z_{jt}^k} - \overline{Z_l^k}$.

The *GMM* estimator exploits the fact that at the true value of parameters $\theta^\star = (\Sigma^\star, \Pi^\star)$, the instruments Z^+ are orthogonal to the structural errors $\Delta\xi(\theta^\star)$, i.e., $E\left[Z^{+'}\Delta\xi(\theta^\star)\right] = 0$, so that the *GMM* estimates solve

$$\hat{\theta}_A = \underset{\theta_A}{\operatorname{argmin}} \left\{\Delta\xi(\theta_A)' Z^+ W^+ Z^{+'} \Delta\xi(\theta_A)\right\}, \tag{C.3}$$

where W^+ is the weighting matrix, representing a consistent estimate of $E[Z^{+'}\Delta\xi\Delta\xi' Z^+]$.[42] To increase the likelihood of achieving a global minimum, we employed the Knitro Interior/ Direct algorithm suggested by Dubé et al. (2012) starting from several different initial conditions.

Stage 2: Mean Utility – Price and Seasonality Coefficients. In the second of the three stages of the estimation procedure, we decompose the mean utility implied by the estimated first-stage coefficients $\hat{\theta}_A$, $\delta_{jlt}(\hat{\theta}_A)$, into the associated location and product by type fixed effects, $\zeta_l^1(\hat{\theta}_A)$ and $\zeta_{jt}^2(\hat{\theta}_A)$. We then project ζ_{jt}^2 onto price and the seasonal indicators, controlling for product fixed effects ζ_j,

$$\zeta_{jt}^2 = H_t\gamma + \alpha p_{jt} + \zeta_j + \xi_{jt}\,. \tag{C.4}$$

Equation (C.4) highlights the potential for price endogeneity, to the extent that price responds to time varying preference variation for a given product that is common across locations, in the form of, for example, category-specific seasonal variation in consumption. The *PLCB* pricing cannot respond to unobserved demand shocks. However, the predictable link between wholesale and retail prices opens the possibility to spirit prices being endogenous because of the pricing behavior of distillers whose wholesale prices reflect, through their products' market shares, the unobserved common tastes for product characteristics of spirits, ξ_{jt}. Recall the pricing optimality conditions in equation (13).

In principle, such endogeneity concerns are mitigated by the fact that distillers need to request both temporary and permanent changes to their wholesale price a number of months before the new price takes effect. Prices thus only respond to predictable variation in a product's demand over time. At the same time, none of the available product characteristics vary across time, limiting our ability to flexibly represent such time varying preference heterogeneity at the level of the product. We therefore use instrumental variables techniques to estimate the parameters in

[42] In constructing our optimal weighting matrix, we first assume homoscedastic errors and use $W^+ = [Z^{+'}Z^+]^{-1}$ to derive initial parameter estimates. Given these estimates, we solve for the structural error $\Delta\xi$ and construct $E[Z^{+'}\Delta\xi\Delta\xi' Z^+]^{-1}$ as a consistent estimate for W^+.

equation (C.4) using the contemporaneous average price of a given product from liquor control states outside of the Northeast and Mid-Atlantic regions (Alabama, Iowa, Idaho, Michigan, Mississippi, North Carolina, Oregon, Utah, and Wyoming) as an instrument for price denoted as Z_B. Our identifying assumption is that cost shocks are national (since products are often produced in a single facility) but demand shocks are at most regional, perhaps due to differences in demographics or climate.[43] We add to this instrument changes in input prices, sugar and corn, interacted with spirit-type dummies to account for exogenous cost shifts across spirit types. For instance, a major input for rums is sugar while corn is an input to gins, vodkas, and whiskeys. We found that contemporaneous futures prices worked best while including price-type interactions for barley, glass, oats, rice, rye, sorghum, and wheat does not improve our estimates. Collapsing the second stage parameters into vector θ_B, this implies the following parameter estimates

$$\hat{\theta}_B = (\hat{X}_B' \hat{X}_B)^{-1} \hat{X}_B' \zeta^2 \,, \tag{C.5}$$

where $\hat{X}_B = Z_B(Z_B' Z_B)^{-1} Z_B' X_B$, with $X_B = [H_t \quad p_{jt} \quad \zeta_j]$. The price coefficient is identified by variation in prices over time, benefiting from the fact that distillers do not change the wholesale prices p^w for all products simultaneously.

Stage 3: Mean Utility – Product Characteristics Coefficients. In the third and final estimation stage, we recover product fixed effects ζ_j from equation (C.5) and project them onto observable product characteristics x_j, resulting in

$$\hat{\theta}_C = (x'x)^{-1} x' \zeta \,. \tag{C.6}$$

where mean preferences for these product characteristics are identified by variation in market shares of spirits of differing characteristics, e.g., proof or spirit type.

[43] For example, whiskey consumption, more so than the consumption of other spirits, peaks during the colder fall and winter months. Whiskey consumption also varies significantly across demographic groups; for example, African American households consume larger amounts of whiskey than other racial groups relative to their baseline levels of spirit consumption.

D Robustness

In this Appendix, we present the results of several alternative demand specifications.

In Table D.1 we demonstrate the robustness of our demand results to alternative samples using a simple OLS multinomial logit demand system. For each model, we regress the logged ratio of product to outside share on product-period and store fixed effects, including interactions between mean demographics and product characteristics (e.g., % minority-X-rum dummy). In Column (i) we presents results using the sample in the main text. This model generates product elasticities that are similar to our preferred mixed-logit model while the elasticity for spirits as a category is more elastic reflecting the IIA problem of logit demand systems (see *BLP*). In Columns (ii)-(iv) we vary the number of markets to show that including markets with premium (i.e., large stores) and border stores (i.e., stores located within five miles of the PA border) as well as the holiday period has little effect on our estimated price coefficient and elasticities. This indicates that restricting the sample has little effect on our results.

Table D.1: OLS Demand Estimates Based on Different Samples (Multinomial Logit Demand)

	(i)	(ii)	(iii)	(iv)
PRICE	−0.2396	−0.2469	−0.2238	−0.2341
	(0.0032)	(0.0033)	(0.0032)	(0.0028)
Product FEs	Y	Y	Y	Y
Premium Stores	Y	N	Y	Y
Border Stores	Y	Y	N	Y
Holiday Period	Y	Y	Y	N
Statistics:				
R^2	0.9584	0.9589	0.9564	0.9736
N	6,852	6,852	6,852	5,606
Elasticities:				
Average	−3.7454	−3.8610	−3.4916	−3.6618
% Inelastic	0.7353	0.3626	0.7477	0.7389
Spirits	−3.3936	−3.5374	−3.1225	−3.3134

Notes: The dependent variable for all models is the estimated product-period fixed effect from a first-stage regression of $\ln(S_{jmt})-\ln(S_{0mt})$ onto product-period fixed effects and demographic-product interactions. Robust standard errors in parentheses. "% Inelastic" is the percentage of products with inelastic demand. "Spirits" is the price elasticity of total *PLCB* off-premise (i.e., sold in a state-run store) spirit sales. "Premium Stores" are a *PLCB* designation. These stores typically carry greater number of products. "Border Stores" are stores located within five miles of the Pennsylvania border.

In Table D.2, we show that our estimation approach based on disaggregated data provides superior identification. In Model (i) we deviate from our multi-step approach and estimate the model in a single step, regressing the logged ratio of product share to outside share on price, brand fixed effects, bottle size fixed effects, pricing period fixed effects, market fixed effects, and mean demographic interactions, where brand refers to all bottle sizes of a particular "brand name", e.g., "Absolut Vodka". Demand becomes steeper relative to the Model (i) in Table D.1 when following this alternative approach leading to less elastic demand. We see even steeper effects when aggregating product demand across the state (Models iii and iv).

Interestingly, we see that not conducting the estimation via the steps outlined in the text leads to price elasticity estimates found by Leung and Phelps (1993) as well as other studies. Less elastic product demands increase estimated dollar markups for upstream firms, ultimately driving down estimated distiller marginal costs. Miravete et al., 2018 show using similar data that spirit category elasticities presented in the health literature (e.g., Leung and Phelps, 1993) imply negative marginal costs for these firms. Table D.2 therefore suggests that such studies may suffer from an aggregation bias that leads to less elastic estimated demand.

Table D.2: OLS Demand Estimates Using Different Approaches (Multinomial Logit Demand)

	(i)	(ii)	(iii)	(iv)
PRICE	−0.1224	−0.0513	−0.0822	−0.0103
	(0.0004)	(0.0003)	(0.0022)	(0.0016)
Brand FEs	Y	N	Y	N
Statistics:				
R^2	0.5129	0.2420	0.8218	0.1441
N	2,237,937	2,237,937	6,852	6,852
Elasticities:				
Average	−1.9133	−0.8028	−1.2853	−0.1610
% Inelastic	12.9738	77.7657	39.1113	100.0000
Spirits	−1.7512	−0.7393	−1.1805	−0.1488

Notes: The dependent variable for models (i)-(ii) is $\ln(S_{jmt}) - \ln(S_{0mt})$ while it is $\ln(S_{jt}) - \ln(S_{0t})$ for models (iii)-(iv). Robust standard errors in parentheses. "% Inelastic" is the percentage of products with inelastic demand. "Spirits" is the price elasticity of total *PLCB* off-premise (i.e., sold in a state-run store) spirit sales.

In Model (ii) we replace the product fixed effects with observable characteristics (e.g., dummies for spirit type, imported). Demand becomes even steeper and demand becomes more inelastic due the coarseness of our observable characteristics. For example, two brands of imported rum could have different unobservable quality to consumers thereby leading different product shares and firms choosing to charge different prices but in this specification, the estimation wrongly correlates differences in price with the differences in shares (quantity sold). In Models (iii)-(iv) we aggregate consumption to the state-level requiring us to drop the demographic interactions but otherwise using the same controls as Models (ii)-(iii). Again, we see the inclusion of brand fixed effects is important to absorbing differences in unobservable (to the econometrician) characteristics across brands. We further see that aggregation drives the elasticity of off-premise spirits to become more inelastic, well within the set of estimates included in Leung and Phelps (1993).

As discussed in Section C, we use the contemporaneous average price in distant control states as an instrument for price in the second step. In Table D.3, we consider the sensitivity of our results to the particular instrumentation strategy. We compare the estimated price coefficient from alternative two-stage least squares regression models of the estimated first stage product-period fixed effects underlying the estimates in Table 4 projected onto price, seasonal dummies, and product fixed effects.

Relative to $IV1$, our preferred specification, the estimated price coefficients are stable across alternative instruments, and, as expected, entail larger price responses than an uninstrumented OLS specification. Each estimated price coefficient is significant at the 95% level and the sets of IVs generate significant F-statistics for all specifications. Removing the average price in other states decreases the price coefficient but also decreases the F-Statistic.

Table D.3: Price Endogeneity

	OLS	*IV1*	*IV2*	*IV3*	*IV4*
PRICE	-0.2412	-0.2763	-0.2781	-0.2775	-0.3145
	(0.0038)	(0.0046)	(0.0046)	(0.0046)	(0.0051)
Instruments:					
Input Prices		Y	Y	Y	Y
Alabama		Y		Y	
Iowa		Y	Y		
Idaho		Y	Y	Y	
Michigan		Y			
Mississippi		Y	Y		
North Carolina		Y	Y		
Oregon		Y	Y	Y	
Utah		Y	Y		
Wyoming		Y	Y	Y	
F-Statistic		1,280.2	1,235.1	1,235.8	920.79
N	6,852	6,852	6,852	6,852	6,852

Notes: Specifications include the same covariates as in Table 4. “Input Prices” is the interaction of spirit type and commodity prices. This amounts to nine interactions: corn-x-gin, corn-x-vodka, corn-x-whiskey, sugar-x-brandy, sugar-x-cordials, sugar-x-gin, sugar-x-rum, sugar-x-whiskey, and sugar-x-vodka where “corn” and “sugar” corresponds to the futures price of corn and sugar during the period. In models 1-4 we also include contemporaneous average price in distant control states as an instrument for price but vary the states used to compute the average.

E Confidence Intervals for Counterfactual Experiments

For each counterfactual exercise, we constructed 95% confidence intervals via bootstrap simulation based on the multivariate empirical distribution implied by the estimated demand parameters (Table 4). The confidence intervals are based on $n = 1, \ldots, 100$ random samples of the demand parameters where we restricted the draws to be over the nonlinear parameters $\{\Sigma, \Pi\}$ and the linear price coefficient (α). This both increases tractability of the bootstrap procedure and focuses the analysis on the parameters, especially the mean price coefficient α and the income-price interaction (in Π), which drive the own and cross-price elasticities and, ultimately, redistribution due to the uniform markup.

A counterfactual simulation proceeds as follows. Define $\theta_n = \{\alpha_n, \Sigma_n, \Pi_n\}$ as the bootstrap parameters for sample n. We use $\{\Sigma_n, \Pi_n\}$ and the observed vector of product market shares s_j to recover the mean utility $\delta(\theta_n; s_j)$ following the solution method outlined in Section C of this Appendix. Estimates of firm-level marginal costs then follow using the observed product-ownership matrix and equation (13) as discussed in section 4.3. By using this procedure, we guarantee that each bootstrap simulation n generates predicted market shares which match the data and marginal costs estimates which are consistent with upstream Bertrand–Nash pricing. Thus, each counterfactual equilibrium generated from a bootstrap simulation generates the data under the 30% markup rule, or, equivalently, starts from the same place.

Define $\overline{\xi}_n = \delta(\theta; s_j) - \alpha_n p^r$ where p^r is the vector of observed retail prices in the data. We then use $\{\alpha_n, \Sigma_n, \Pi_n, c_n, \overline{\xi}_n\}$ to solve for each of the counterfactual equilibria in the main text (e.g., "Profit") where changes in the markup rule lead to a new set of equilibrium upstream firm prices (p_n^w) and retail prices (p_n^r). The retail prices impact consumer mean utility since $\delta_n = \alpha_n p_n^r + \overline{\xi}_n$, and ultimately lead to changes in consumer demand via equation 6.

For each bootstrap simulation and counterfactual equilibrium, we compute the descriptive statistics presented in the text (e.g., aggregate tax revenue in Table 7). To compute compensating variation in each simulation, we compare consumer surplus (up to an additive constant) given observed prices and θ_n (i.e., consumer surplus in the observed equilibrium conditional on θ_n) to the consumer surplus generated in the counterfactual Stackelberg equilibrium.

Most of our analysis compares summary statistics from the current equilibrium to summary statistics from counterfactual Stackelberg equilibria using the point-estimates from our demand estimation ($\hat{\theta}$). Where possible, we also include the 95% confidence intervals from the bootstrap simulations in order to demonstrate the robustness of our conclusions. The 95% confidence intervals presented in the text correspond to the range of bootstrap simulation-counterfactual equilibria for the given statistic which fall between the 2.5% and 97.5% quartiles, i.e., the middle 95%.

F Additional Results and Figures

Table F.1: Estimated Marginal Costs (Select Firms)

	All	Diageo	Bacardi	Beam	Jacquin	Sazerac
By Spirit Type:						
brandy	5.34	-	-	-	3.66	-
cordials	6.16	7.18	15.00	3.21	1.98	5.08
gin	6.43	7.72	12.51	4.90	4.29	2.67
rum	5.66	7.05	5.48	4.47	3.45	-
vodka	6.37	6.07	-	4.64	4.24	3.83
whiskey	7.11	8.17	14.82	6.05	4.67	4.88
By Price:						
cheap	3.67	3.66	3.67	3.62	3.59	3.70
expensive	9.04	8.53	10.46	8.08	-	7.78
By Bottle Size:						
375 ml	2.39	2.13	1.45	1.02	0.23	2.89
750 ml	5.81	6.13	5.83	3.51	2.02	2.97
1.75 L	8.24	11.28	11.84	7.54	5.00	4.68
all products	6.33	6.33	6.89	5.14	3.59	4.14

Notes: Estimated upstream marginal costs weighted by sales.

Table F.2: Retail and Wholesale Prices by Product Category

		Wholesale Price (p^w)			Retail Price (p^r)		
	Elast.	Current	Single	Profit	Current	Single	Profit
By Spirit Type:							
BRANDY	-3.64	8.09	8.19 [8.09, 8.3]	7.25 [7.24, 7.3]	13.85	13.50 [13.18, 13.83]	15.70 [15.64, 15.85]
CORDIALS	-3.46	8.88	8.98 [8.88, 9.08]	8.72 [8.66, 8.73]	15.03	14.63 [14.25, 15]	15.00 [14.96, 15.29]
GIN	-3.9	9.14	9.24 [9.15, 9.35]	8.83 [8.78, 8.85]	15.61	15.19 [14.8, 15.58]	16.15 [16.12, 16.44]
RUM	-3.38	8.35	8.45 [8.36, 8.55]	8.13 [8.07, 8.16]	14.34	13.97 [13.63, 14.32]	14.57 [14.47, 14.83]
VODKA	-3.95	7.99	8.09 [7.99, 8.19]	7.62 [7.55, 7.64]	13.82	13.48 [13.15, 13.8]	13.79 [13.77, 14.14]
WHISKEY	-3.98	9.89	9.99 [9.89, 10.1]	9.69 [9.63, 9.71]	16.74	16.28 [15.85, 16.71]	16.68 [16.63, 17.06]
By Price:							
CHEAP	-2.81	5.85	5.95 [5.85, 6.05]	5.26 [5.24, 5.29]	10.50	10.28 [10.08, 10.48]	11.46 [11.41, 11.56]
EXPENSIVE	-4.74	11.94	12.04 [11.94, 12.15]	11.95 [11.86, 11.96]	19.85	19.27 [18.72, 19.82]	19.15 [19.1, 19.72]
By Bottle Size:							
375 ml	-2.36	3.89	3.99 [3.89, 4.09]	2.94 [2.94, 3.02]	7.20	7.11 [7.02, 7.2]	7.87 [7.75, 7.92]
750 ml	-3.58	8.53	8.64 [8.54, 8.74]	8.24 [8.18, 8.26]	14.51	14.13 [13.78, 14.49]	15.08 [15.03, 15.34]
1.75 L	-4.74	11.09	11.19 [11.09, 11.3]	11.05 [10.96, 11.06]	18.84	18.31 [17.81, 18.81]	18.24 [18.21, 18.79]
ALL PRODUCTS	-3.75	8.71	8.81 [8.71, 8.92]	8.40 [8.35, 8.43]	14.89	14.50 [14.14, 14.87]	15.07 [15.03, 15.39]

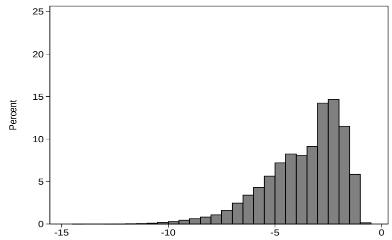
Notes: "Elast." corresponds to the average estimated demand elasticities from Table 5. Other reported statistics are average wholesale and retail price ($). "Cheap" ("Expensive") products are those products whose mean price is below (above) the mean price of other spirits in the same spirit type and bottle size. "Single" indicates the counterfactual where the *PLCB* chooses the revenue-maximizing markup ("Maximizing" in the main text). The *PLCB* employs 312 product-specific markups to maximize tax revenue ("Profit" in the main text).

Table F.3: Best Substitutes

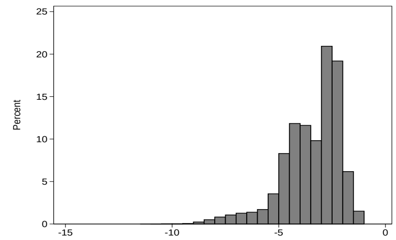
		Closest Substitute		
Product	Type	Product	Type	ϵ_{ji}
HENNESSY V. S. COGNAC - 375 ML	BRANDY	COURVOISIER V. S. COGNAC - 375 ML	BRANDY	0.2522
E & J CAL. BRANDY - 375 ML	BRANDY	E & J CAL. V.S.O.P. BRANDY - 375 ML	BRANDY	0.1005
THE CHRISTIAN BROS. CAL. BRANDY - 375 ML	BRANDY	E & J CAL. V.S.O.P. BRANDY - 375 ML	BRANDY	0.0547
E & J CAL. BRANDY - 750 ML	BRANDY	PAUL MASSON GRANDE AMBER BRANDY - 750 ML	BRANDY	0.1503
HENNESSY V. S. COGNAC - 750 ML	BRANDY	MARTELL V. S. COGNAC - 750 ML	BRANDY	0.3900
THE CHRISTIAN BROS. CAL. BRANDY - 750 ML	BRANDY	THE CHRISTIAN BROS. CAL. BRANDY - PET BOTTLE - 750 ML	BRANDY	0.1114
E & J CAL. BRANDY - 1.75 LTR	BRANDY	E & J CAL. V.S.O.P. BRANDY - 1.75 LTR	BRANDY	0.1216
THE CHRISTIAN BROS. CAL. BRANDY - 1.75 LTR	BRANDY	E & J CAL. BRANDY - 1.75 LTR	BRANDY	0.1118
JACQUIN'S BLACKBERRY FLAV. BRANDY - 1.75 LTR	BRANDY	JACQUIN'S APRICOT FLAV. BRANDY - 1.75 LTR	BRANDY	0.1261
BAILEYS ORIGINAL IRISH CREAM LIQUEUR - 375 ML	CORDIALS	GREY GOOSE IMP. VODKA - 375 ML	VODKA	0.0073
JAGERMEISTER IMP. HERB LIQUEUR - 375 ML	CORDIALS	YUKON JACK CANADIAN LIQUEUR - 375 ML	CORDIALS	0.0292
KAHLUA IMP. COFFEE LIQUEUR - 375 ML	CORDIALS	DI SARONNO AMARETTO IMP. LIQUEUR - 375 ML	CORDIALS	0.0095
KAHLUA IMP. COFFEE LIQUEUR - 750 ML	CORDIALS	ABSOLUT IMP. VODKA - 100 PROOF - 750 ML	VODKA	0.0147
SOUTHERN COMFORT - 76 PROOF - 750 ML	CORDIALS	FIRE WATER HOT CINNAMON SCHNAPPS - 750 ML	CORDIALS	0.0297
HPNOTIQ IMP. LIQUEUR - 750 ML	CORDIALS	BELVEDERE IMP. VODKA - 750 ML	VODKA	0.0112
SOUTHERN COMFORT - 76 PROOF - 1.75 LTR	CORDIALS	WILD TURKEY STR. BOURBON WKY. - 101 PROOF - 750 ML	WHISKEY	0.0272
DEKUYPER PEACHTREE SCHNAPPS - 1.75 LTR	CORDIALS	KAHLUA IMP. COFFEE LIQUEUR - 1.75 LTR	CORDIALS	0.0018
KAHLUA IMP. COFFEE LIQUEUR - 1.75 LTR	CORDIALS	GREY GOOSE IMP. FRENCH VODKA - 1.75 LTR	VODKA	0.0078
SEAGRAM'S EXTRA DRY GIN - 375 ML	GIN	BANKER'S CLUB DRY GIN - 375 ML	GIN	0.0164
TANQUERAY IMP. DRY GIN - 375 ML	GIN	BANKER'S CLUB DRY GIN - 375 ML	GIN	0.0141
GORDON'S DRY GIN - PET - 375 ML	GIN	BANKER'S CLUB DRY GIN - 375 ML	GIN	0.0083
TANQUERAY IMP. DRY GIN - 750 ML	GIN	BOMBAY IMP. SAPPHIRE GIN - 750 ML	GIN	0.0610
SEAGRAM'S EXTRA DRY GIN - 750 ML	GIN	FIVE O'CLOCK EXTRA DRY GIN - 750 ML	GIN	0.0136
GORDON'S DRY GIN - 750 ML	GIN	BEEFEATER IMP. DRY GIN - 750 ML	GIN	0.0078
GORDON'S DRY GIN - 1.75 LTR	GIN	BOMBAY IMP. SAPPHIRE GIN - 1.75 LTR	GIN	0.0319
BANKER'S CLUB DRY GIN - 1.75 LTR	GIN	BEEFEATER IMP. DRY GIN - 1.75 LTR	GIN	0.0136
SEAGRAM'S EXTRA DRY GIN - 1.75 LTR	GIN	TANQUERAY IMP. DRY GIN - 1.75 LTR	GIN	0.0174
BACARDI LIGHT-DRY P. R. RUM - 375 ML	RUM	SOUTHERN COMFORT - 100 PROOF - 375 ML	CORDIALS	0.0171
CAPTAIN MORGAN P. R. SPICED RUM - 375 ML	RUM	YUKON JACK CANADIAN LIQUEUR - 375 ML	CORDIALS	0.0130
BACARDI LIMON P. R. RUM - 375 ML	RUM	SOUTHERN COMFORT - 100 PROOF - 375 ML	CORDIALS	0.0051
CAPTAIN MORGAN P. R. SPICED RUM - 750 ML	RUM	CAPTAIN MORGAN PRIVATE STOCK P. R. SPICED RUM - 750 ML	RUM	0.0358
BACARDI LIGHT-DRY P. R. RUM - 750 ML	RUM	FIRE WATER HOT CINNAMON SCHNAPPS - 750 ML	CORDIALS	0.0207
CAPTAIN MORGAN P. R. SPICED RUM PET - 750 ML	RUM	CAPTAIN MORGAN PRIVATE STOCK P. R. SPICED RUM - 750 ML	RUM	0.0211
BACARDI LIGHT-DRY P. R. RUM - 1.75 LTR	RUM	WILD TURKEY STR. BOURBON WKY. - 101 PROOF - 750 ML	WHISKEY	0.0547
CAPTAIN MORGAN P. R. SPICED RUM - 1.75 LTR	RUM	SMIRNOFF VODKA - 100 PROOF - 1.75 LTR	VODKA	0.0512
JACQUIN'S WHITE RUM - 1.75 LTR	RUM	WILD TURKEY STR. BOURBON WKY. - 101 PROOF - 750 ML	WHISKEY	0.0204
NIKOLAI VODKA - 80 PROOF - 375 ML	VODKA	STOLICHNAYA IMP. VODKA - 80 PROOF - 375 ML	VODKA	0.0402
JACQUIN'S VODKA ROYALE - 80 PROOF - 375 ML	VODKA	NIKOLAI VODKA - 80 PROOF - 375 ML	VODKA	0.0287
SMIRNOFF VODKA - 80 PROOF - 375 ML	VODKA	STOLICHNAYA IMP. VODKA - 80 PROOF - 375 ML	VODKA	0.0199
ABSOLUT IMP. VODKA - 80 PROOF - 750 ML	VODKA	ABSOLUT IMP. VODKA - 100 PROOF - 750 ML	VODKA	0.0496
SMIRNOFF VODKA - 80 PF. PORTABLE - 750 ML	VODKA	ABSOLUT IMP. VODKA - 100 PROOF - 750 ML	VODKA	0.0220
SMIRNOFF VODKA - 80 PROOF - 750 ML	VODKA	ABSOLUT IMP. VODKA - 100 PROOF - 750 ML	VODKA	0.0154
JACQUIN'S VODKA ROYALE - 80 PROOF - 1.75 LTR	VODKA	BEEFEATER IMP. DRY GIN - 750 ML	GIN	0.0448
NIKOLAI VODKA - 80 PROOF - 1.75 LTR	VODKA	NIKOLAI VODKA - 100 PROOF - 1.75 LTR	VODKA	0.0375
VLADIMIR VODKA - 1.75 LTR	VODKA	BEEFEATER IMP. DRY GIN - 750 ML	GIN	0.0272
JACK DANIEL'S OLD NO. 7 BLACK LABEL WKY. - 375 ML	WHISKEY	WILD TURKEY STR. BOURBON WKY. - 101 PROOF - 375 ML	WHISKEY	0.0450
CROWN ROYAL CANADIAN WKY. - 375 ML	WHISKEY	TANQUERAY IMP. DRY GIN - 375 ML	GIN	0.0225
WINDSOR CANADIAN SUPREME WKY. - 375 ML	WHISKEY	TANQUERAY IMP. DRY GIN - 375 ML	GIN	0.0110
JACK DANIEL'S OLD NO. 7 BLACK LABEL WKY. - 750 ML	WHISKEY	WILD TURKEY STR. BOURBON WKY. - 101 PROOF - 750 ML	WHISKEY	0.0506
JIM BEAM STR. BOURBON WKY. - 750 ML	WHISKEY	WILD TURKEY STR. BOURBON WKY. - 101 PROOF - 750 ML	WHISKEY	0.0195
CROWN ROYAL CANADIAN WKY. - 750 ML	WHISKEY	TANQUERAY IMP. DRY GIN - 1.75 LTR	GIN	0.0348
WINDSOR CANADIAN SUPREME WKY. - 1.75 LTR	WHISKEY	BEEFEATER IMP. DRY GIN - 1.75 LTR	GIN	0.0462
JIM BEAM STR. BOURBON WKY. - 1.75 LTR	WHISKEY	CROWN ROYAL CANADIAN WKY. - 1.75 LTR	WHISKEY	0.0351
SEAGRAM'S 7 CROWN AMERICAN BLEND WKY. - 1.75 LTR	WHISKEY	BEEFEATER IMP. DRY GIN - 1.75 LTR	GIN	0.0233

Notes: Table presents the three best-selling products by number of bottles for each spirit type, bottle size pair, and the corresponding best substitute based on cross-price elasticity.

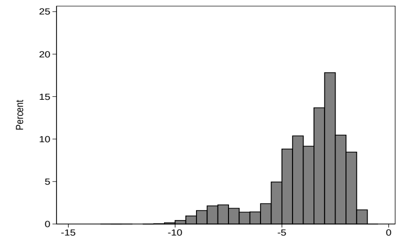
Figure F.1: Distribution of Demand Elasticities



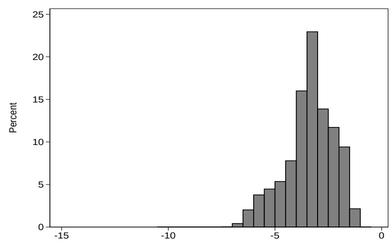
(a) Brandy



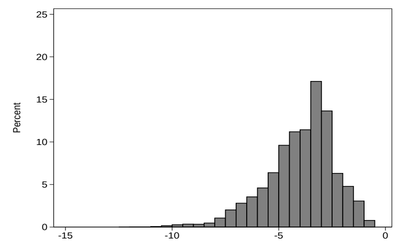
(b) Cordials



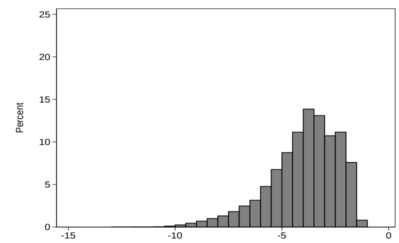
(c) Gin



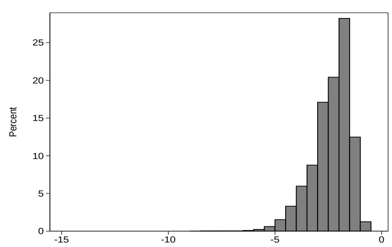
(d) Rum



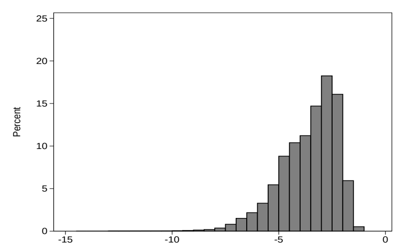
(e) Vodka



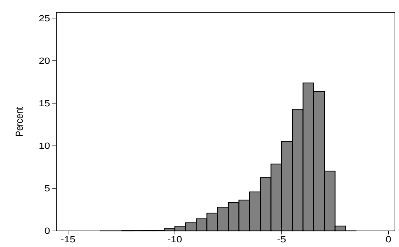
(f) Whiskey



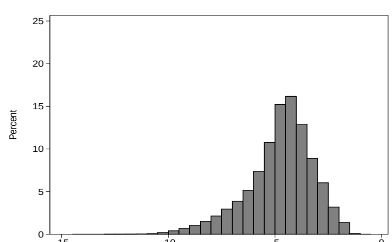
(g) 375 ml



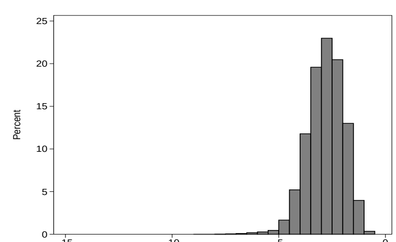
(h) 750 ml



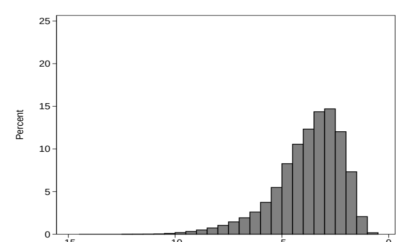
(i) 1.75 Ltr



(j) Expensive

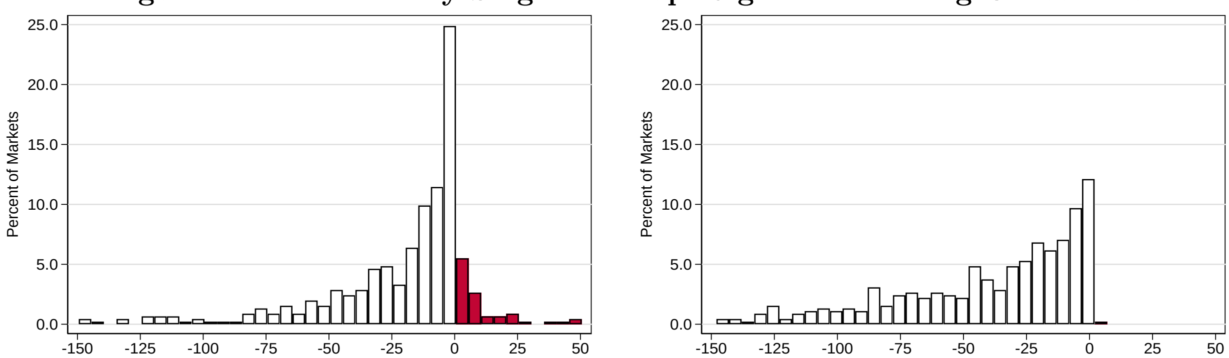


(k) Cheap



(l) All Products

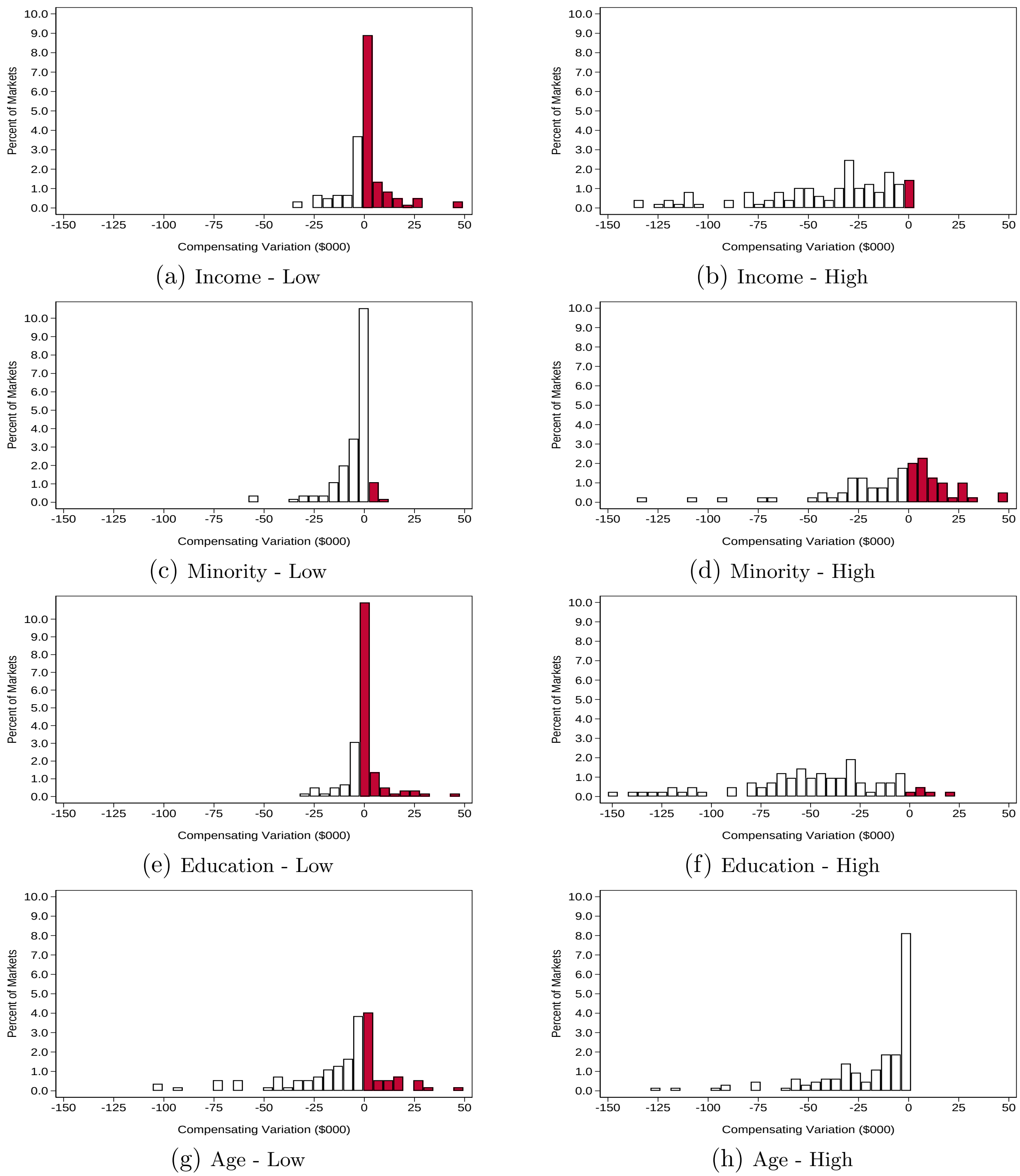
Figure F.2: Taxation by Single Markup Regulation Among Consumers



(a) Objective: Maximize Tax Revenue (b) Objective: Maximize Consumer Welfare

Notes: We present the distribution of compensating variation $\{CV_l\}_{l=1}^{454}$, denominated in thousands of dollars, calculated as the mean compensating variation in each market l using the Stackelberg equilibria under the alternative markup policy to the one observed under the current 30% markup policy.

Figure F.3: Compensating Variation by Consumer Demographics



(a) Income - Low

(b) Income - High

(c) Minority - Low

(d) Minority - High

(e) Education - Low

(f) Education - High

(g) Age - Low

(h) Age - High

Notes: We present the distribution of compensating variation $\{CV_l\}_{l=1}^{454}$, denominated in thousands of dollars, calculated as the mean compensating variation in each market l using the Stackelberg equilibria under the alternative markup policy to the one observed under the current 30% markup policy. Average of markets with top and bottom 20% of AGE, MINORITY, EDUCATION, and INCOME as defined in Table 2.