Market Power as Second-Worst Regulation: Welfare Consequences of Post and Hold Pricing in Distilled Spirits

Christopher Conlon,

Department of Economics, NYU Stern School of Business and NBER
cconlon@stern.nyu.edu

Nirupama Rao

Business Economics and Public Policy, University of Michigan Ross School of Business.
nirurao@umich.edu

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Abstract
In many product markets with negative externalities, regulations structure markets to limit competition. Intuition from the single-product case suggests that whether output is restricted via corrective taxes or by limiting competition represents only a transfer among parties and does not affect aggregate welfare. However, when products are differentiated, firms with market power may not only reduce aggregate purchases, but distort the purchase decisions of inframarginal consumers. We look at a regulation known as post-and-hold (PH) used by a dozen states for the sale of alcoholic beverages. Theoretically PH eliminates competitive incentives among wholesalers selling identical products. Empirically, we use a unique dataset on distilled spirits from Connecticut, including matched manufacturer and wholesaler pricing, to evaluate the welfare consequences. For similar levels of ethanol consumption, PH leads to significantly lower consumer welfare (and government revenue) when compared to various tax measures (excise taxes, sales taxes, and Ramsey taxes) by distorting the set of products away from high-quality/premium brands and towards low-quality/no-name brands. Replacing PH with volumetric or ethanol-based taxes that maintain the same aggregate ethanol consumption would increase consumer surplus by roughly 7% while boosting government revenues by more than 250%.

Keywords: Excise Tax, Pigouvian Tax, Tax Efficiency, Regulation, Vertical Restraints.

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1. Introduction

The manufacture, distribution, and selling of alcoholic beverages are big business in the United States, with sales exceeding $250 billion in 2018. Alcohol markets are also subject to an unusual degree of government intervention. Federal, state, and even local governments levy excise taxes on alcohol, raising more than $17.7 billion annually. In addition to being subject to industry-specific taxation, the sale and distribution of alcohol are tightly regulated. In this paper we study the implications of a particular but popular regulatory framework on the pricing of alcoholic spirits and measure the potential welfare gains of alternative tax policies to restrict alcohol consumption. Understanding these policies is particularly relevant now, given the evolving legal standing of these regulations and the growing interest among state governments in modifying alcohol regulations and increasing alcohol taxes.[1]

We examine a state regulation called *post and hold* (PH), which governs wholesale pricing in 12 states – more than a third of states where alcohol is not sold by a state-run monopoly. PH requires wholesalers to submit a uniform price schedule to the state regulator, and commit to that schedule for 30 days. Prior to sales taking place, wholesalers are offered a "lookback" period where they are allowed to match but not undercut competitor prices. One way to understand this regulation is as a strong interpretation of the Robinson-Patman Act of 1936, which prevents wholesalers from price discriminating across competing retailers. Indeed, proponents of the system cite the protection of small retail businesses as a key benefit of PH. We show that PH softens competition, and facilitates supra-competitive pricing in the wholesale market. Theoretically, we show that the unique iterated weak dominant Nash equilibria of the PH pricing game leads to prices as high as a single product monopolist would charge.[2] For consumers, PH leads to unambiguously higher prices, particularly for more inelastically demanded (higher quality) products.

At first glance it may seem attractive to regulators to limit consumption by outsourcing the decision to raise prices to private firms. In fact, one of the motivations for for PH regulations was to limit alcohol consumption by raising prices (Saffer and Gehrsitz, 2016). Intuition from the homogenous products case suggests that it is irrelevant from a total welfare perspective whether we limit harmful consumption via a Pigouvian tax or by restricting supply through increased market power (perhaps from lax merger approval, weaker antitrust enforcement, or market designs like PH).[3] Indeed, this argument is made by proponents of the "Green Antitrust" movement for

[1]The recent split between the Second Circuit court's ruling in *Connecticut Fine Wine & Spirits, LLC v. Seagull* and the prior Ninth Circuit ruling in *Costco Wholesale Corp. v. Maleng* created an opening for the Supreme Court to decide the legal standing of post and hold and related regulations, but the Court denied the request to review the Second Circuit ruling in 2019, leaving the legal parameters of alcohol regulations that restrict competition uncertain. Even more recently, the Federal Trade Commission (FTC), Department of Justice Antitrust Division, and US Treasury Department recently issued a joint report on competition in alcoholic beverage distribution which included a section on post-and-hold (Treasury, 2022).

[2]Thus even the effects on small retailers are ambiguous, as they trade off a potentially more competitive retail market against a less competitive wholesale market characterized by a cartel.

[3]Levy et al. (2021) discuss public health externalities regarding the FTC investigation into the merger of cigarette

allowing consolidation (and sometimes coordination) among fossil fuel companies, and restricting "excessive competition" has been a key feature of market design in the legalization of marijuana.[4]

The intuition from the single product case fails when products are differentiated. Put simply, we can think about alcoholic beverages as a bundle of two characteristics: ethanol and branding/quality. A social planner concerned only with limiting the negative externalities would levy a Pigouvian tax on ethanol alone. A firm with market power recognizes that if consumers value both characteristics, it is optimal to "tax" both relative to their elasticities. This means that firms trade off the desired distortion in ethanol consumption against distortions in the choice of brand conditional on purchase (even for *inframarginal consumers*). For example, the cheapest plastic bottle vodka and the most expensive scotch might contain equal amounts of ethanol, but differ vastly when it comes to consumer perceptions of quality or willingness to pay. These products will bear the same Pigouvian tax but firms with market power might set very different markups.

Under PH markups on high quality products lead to inframarginal distortions so that consumers who substitute from premium products to inexpensive ones may in fact consume similar amounts of ethanol but be worse off. We show that replacing PH with an ethanol tax set to leave aggregate ethanol consumption unchanged leads consumers to shift away from low-priced value brands and towards premium products, leaving most substantially better off. Our estimates show that replacing PH with ethanol-based taxes that leave aggregate ethanol consumption unchanged would increase consumer welfare by 6.7%, while a volumetric tax like those levied in most states would boost consumer welfare by 7.6% relative to PH. Put differently, the cost of PH price distortions to consumers are high enough that consumers would be equally well off under volumetric or ethanol taxes that cut aggregate ethanol consumption by 12%. Both taxes would increase tax revenues by more than 250%. If revenues scaled similarly across PH states, this would amount to an additional $1B in tax revenue.

To assess the welfare implications of PH and tax alternatives we assemble new, unique data from the Connecticut Department of Consumer Protection and private data sources. These data track the monthly prices of spirits products at the manufacturer, wholesaler and retailer level and measure the quantities sold in Connecticut from August 2007 to June 2013. Using these data, we show that retail spirits prices are higher in Connecticut than elsewhere, particularly for premium products, and that spirits consumption in Connecticut is skewed towards lower quality products despite being one of the wealthiest states in the country. We also assess competition among wholesalers under the PH arrangement and find no evidence that increasing the number of wholesale "competitors" increases any measure of competitive outcomes.

Combining the price and quantity data we then estimate a demand model that characterizes

maker Altria and leading e-cigarette (vape) manufacturer Juul.

[4]See Hollenbeck and Giroldo (2021); Thomas (2019) on entry restrictions in marijuana markets; Hollenbeck and Uetake (2021) on market the interaction between taxes and market power in marijuana; and Hansen et al. (2020) for analysis of a (Pigouvian) "potency tax". For Green Antitrust see Kingston (2011); Linklaters (2020) in favor and Schinkel and Treuren (2020) against.

substitution patterns within product categories such as gin or vodka. Using our estimated demand model, we compare the social welfare effects of tax alternatives to PH in a world with product differentiation, and with and without imperfect competition. Our analysis shows that the state could achieve the same public health goal while reducing product choice distortions (and raise new revenue) by repealing laws that dampen wholesale competition and increasing specific or even volumetric taxes such that aggregate ethanol consumption was unchanged. While households across the income distribution gain from swapping PH for volumetric or ethanol taxes, the gains are concentrated among high income households who are more likely to consume the high-end products that face the highest markups under PH and thus benefit most from its abolition. Replacing PH with volumetric taxes raises consumer surplus by more than 8% for households with more than $70K while households with less than $25K and between $25K and $45K in household income gain only 2.9% and 3.5% more surplus, respectively. Ethanol taxes offer greater gains across the board, but again, upper income households benefit most with gains at the top outpacing gains at the bottom by roughly 2-to-1.

We add to the growing literature examining policies towards alcohol markets, such as the use of minimum prices (Griffith et al., 2021) and heterogeneous taxes across alcoholic beverage categories (Griffith et al., 2019) to reduce consumption and its associated externalities, and the welfare effects of constraints on when alcohol can be sold relative to taxes Hinnosaar (2016). Ours is the first to incorporate the upstream prices of manufacturers when detailing the impact of counterfactual policies on pricing and purchases of alcoholic beverages.

Our analysis further provides a full assessment of the consequences of PH pricing for consumers at a time when its legal standing is precarious given recent Circuit court decision splits. States like Washington have reacted to this uncertainty by preemptively abandoning the PH system and others, including Connecticut, have considered repealing PH. Our findings suggest that PH is a highly costly way for the state to achieve its objective of constraining alcohol consumption and other policies could identically curb consumption with benefits for both consumers and state coffers. More broadly, our findings suggest that attempts to allow market power to restrict consumption of products thought to bear negative externalities may be similarly inefficient where the offending product features differentiating characteristics outside of the damaging factor that consumers value. We show that in these cases non-competitive pricing can be a highly distortionary and costly way to curb consumption.

2. Alcohol Regulations and Taxes in the US

2.1. State regulations regarding alcohol beverages

While the federal government imposes substantial taxes on alcohol beverages, the regulation of alcohol beverage markets is almost wholly the purview of state governments.[5] Nearly all states have instituted a *three-tier* system of distribution, in which the manufacture, distribution, and sale of alcoholic beverages are vertically separated. A common feature of nearly all systems is that retail firms (bars, restaurants, supermarkets, and liquor stores) must purchase alcoholic beverages from an in-state wholesaler.

In 18 states, known as *control states*, the state directly operates the wholesale distribution or retail tier, and in some cases does both. The state monopoly applies to all alcoholic beverages in some states and and just distilled spirits but not wine or beer in others.[6] Recent empirical work has focused on these control states and understanding the behavior and welfare consequences of state run monopolies. Miravete et al. (2020) study Pennsylvania's policy of setting a uniform markup (of over 50%) on all products, and Miravete et al. (2018) shows this uniform markup is set above the revenue maximizing level. Seim and Waldfogel (2013) show that Pennsylvania locates more stores in rural areas and fewer stores in urban areas than a profit maximizing firm would choose. Other studies have examined how both quantity and prices rose when Washington state privatized its state monopoly. Different authors have offered competing explanations: Illanes and Moshary (2020) explain this phenomenon with increases in product variety, while Seo (2019) focused on increased convenience and one-stop shopping.

The majority of states are like Connecticut where private businesses own and operate the wholesale and retail tiers. These *license states* often have ownership restrictions that restrict not only cross-tier ownership, and cross-state shipping but a variety of other practices.[7] The welfare effects of both exclusive territories and exclusive dealing in the beer industry have been studied in Sass and Saurman (1993); Sass (2005); Asker (2016).

The distribution of distilled spirits in Connecticut involves a substantial amount of *common agency*. The same product is often sold by as many as four statewide wholesalers, wholesalers distribute products from multiple competing distiller/manufacturers, and do not divide markets geographically. In other words, the *market structure* bears many of the hallmarks of competition, but the *market outcomes* in Connecticut appear anything but competitive. We attribute this to

[5] The 21st Amendment ended Prohibition by turning the power to regulate the import, distribution and transportation of alcoholic beverages within their borders over to the states, largely exempting their regulations from scrutiny under the Commerce and the Import-Export Clauses of the U.S. Constitution. Since then numerous Supreme Court cases have eroded state control over alcohol policy, as the Court has held that state control of alcohol is subject to federal power under the Commerce Clause, the First Amendment and the Supremacy Clause, among others. Recently, the Courts have deemed Connecticut's alcohol laws to be constitutional.

[6] A few control states, for example Maine and Vermont, maintain a state monopoly on the distribution and sale of spirits but contract with private firms for retail operations (including pricing).

[7] License states may also impose other restrictions, such as which days alcohol beverages can be sold, whether supermarkets can sell spirits, wine or beer, and the number of retail licenses a single chain retailer can hold.

the regulatory environment known as *post and hold* which governs how wholesalers set prices, and which we discuss in the subsequent section.

2.1.1. Legal Environment of Post and Hold

Under PH manufacturers and wholesalers must offer the same uniform (case) prices to all purchasers, and quantity discounts are prohibited.[8] This is implemented by requiring manufacturers and wholesalers to provide the regulator with a price list for the following period (usually a month). In Connecticut, prices must be posted by the 12th day of the preceding month, and cannot be changed until the next posting period. However, some PH states, including Connecticut, also allow a *lookback* period, during which prices can be amended, but only downwards, and not below the lowest competitor price for the same item from the initial round.[9] During this period wholesale firms are able to observe the prices of all competitors. In Connecticut, the lookback period lasts for four days after prices are posted. Many states, including Connecticut, also employ a formula which maps posted wholesale prices into minimum retail prices. This limits retailers from pricing below cost (with limited exceptions to clear excess inventory).[10]

While both manufacturers and wholesalers must post and hold their prices in Connecticut, our analysis focuses on the implications of PH for wholesale prices. Unlike manufacturers who sell only their own products, wholesalers sell overlapping sets of products. That is, while Diageo is the only manufacturer selling *Smirnoff* vodka, multiple wholesalers distribute *Smirnoff* in any given month. As such we expect that Diageo has market power in the sale of *Smirnoff*; what is less obvious is why wholesalers located only dozens of miles apart selling identical bottles of *Smirnoff* statewide appear to also enjoy market power.

The legal status of PH laws has recently been challenged in several court cases with different circuit courts drawing different conclusions as to whether Section 1 of the Sherman Act preempts PH alcohol pricing statutes.In a Supreme Court case, *California Retail Liquor Dealers Ass'n v. Midcal Aluminum, Inc* (1980), the court ruled that the wholesale pricing system in California at the time was in violation of the Sherman Act. The California system at the time resembled PH, but with the additional restriction that retail prices were effectively set via a resale price maintenance agreement by wholesale distributors.[11] The court's ruling established a two-part test for determining when state actions were immune to antitrust scrutiny: 1. a law must *clearly articulate* a valid state

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[8] It is worth noting that the *Robinson-Patman Act of 1936* prevents distributors from charging different prices to competing retailers. In practice, Robinson-Patman cases are rare and offering the same menu of quantity discounts to retailers appears to be sufficient. PH can be viewed as a much stronger version of Robinson-Patman.

[9] In practice manufacturers are not able to amend their prices as each manufacturer is the only purveyor of its brands. As such there is no lower price from a competitor they could amend to match.

[10] There is a long history of policymakers being concerned about retailers using alcoholic beverages as "loss leaders". Some states (not including Connecticut) allow a limited number of "post offs" where retailers can price below the most recent wholesale price in order to clear inventory. See `https://www.cga.ct.gov/2000/rpt/2000-R-0175.htm` for a list of various state regulations.

[11] It is worth pointing out that prior to the *Leegin* decision in 2007, resale price maintenance was a *per se* violation in the United States.

interest (such as temperance) 2. the policy must be *actively supervised* by the state. The PH system was directly challenged in *Battipaglia v. New York State Liquor Authority (1984)*. In this case, Judge Henry Friendly wrote for the Second Circuit:

> New York wholesalers can fulfill all of their obligations under the statute without either conspiring to fix prices or engaging in "conscious parallel" pricing. So, even more clearly, the New York law does not place "irresistible pressure on a private party to violate the antitrust laws in order to comply" with it. It requires only that, having announced a price independently chosen by him, the wholesaler should stay with it for a month.

A more recent challenge in the state of Washington found essentially the opposite. In *Costco v Maleng (2008)*, the Ninth Circuit's appellate decision affirmed that "the post-and-hold scheme is a hybrid restraint of trade that is not saved by the state immunity doctrine of the Twenty-first Amendment."

In 2019, the Second Circuit (which comprises Connecticut, New York and Vermont) upheld Connecticut's PH statute, splitting with the conclusions of the Fourth and Ninth Circuits which had previously struck down similar PH provisions in Maryland and Washington state, as *per se* violations of the Sherman Act. This circuit split could prompt the Supreme Court, which has so far declined to weigh in, to resolve the issue. The Second Circuit majority opinion (perhaps incorrectly) focused on the lack of communication between wholesalers:

> Nothing about this arrangement requires, anticipates, or incents communication or collaboration among the competing wholesalers. Quite to the contrary: A post-and-hold law like Connecticut's leaves a wholesaler little reason to make contact with a competitor. The separate, unilateral acts by each wholesaler of posting and matching instead are what gives rise to any synchronicity of pricing.

and the Second Circuit's sharp dissenting opinion criticized the majority's reasoning:[12]

> allow[ing] de facto state-sanctioned cartels of alcohol wholesalers to impose artificially high prices on consumers and retailers across all three states in our Circuit...The problem with Connecticut's law is not that it affirmatively compels wholesalers to collude in order to fix prices, but that it provides no incentive – or ability – for wholesalers to compete on price.

As we illustrate with our theoretical model in Section 3, both parties are partially correct. Connecticut's PH system leads to supra-competitive wholesale prices (in some cases as high as monopoly) in a one-shot game via unilateral incentives, without requiring any communication or repeated-game cooperation among the parties.

[12]We should disclose that we were not engaged or compensated by any parties in the Connecticut case (or any other case). However, previous versions of this paper were cited by the briefs of several parties, including the theoretical result that PH could lead to prices as high as the collusive prices in a static unilateral effects framework.

2.2. Taxes on Distilled Spirits

Federal, state and even some municipal governments levy their own excise taxes on distilled spirits. The overwhelming majority of these taxes take the form of specific taxes, which are a fixed dollar amount per unit (either volume or alcohol content), though in most states the general sales tax also applies to alcohol purchases.[13]

Federal taxes are remitted by the distiller/manufacturer, or upon import.[14] At the federal level distilled spirits are generally taxed at \$13.50 per proof-gallon where a proof-gallon is one liquid gallon that is 50 percent alcohol. Most spirits are bottled at 80 proof or 40% alcohol by volume (ABV). This means that there are \$2.85 in taxes per liter of distilled spirits (at 80 proof), and that flavored spirits (generally 60 proof) incur lower taxes, and overproof spirits (often over 100 proof) pay higher taxes per liter.

Most state excise taxes, on the other hand, are volumetric and do not vary by alcohol content, and are remitted by the wholesaler. Connecticut's specific tax on spirits was raised from \$4.50 per gallon (\$1.18 per liter) to \$5.40 per gallon (\$1.42 per liter) on July 1, 2011. Like most states Connecticut also includes alcohol products in its general retail sales tax base. Connecticut also increased its general sales tax rate from 6% to 6.35% at the same time it raised its excise taxes on alcohol.

As a share of the overall retail price, these excise taxes can be large, particularly for the least expensive products. For example, a 1.75L bottle of 80 proof Vodka in Connecticut (after 2011) includes \$7.48 in combined state and federal taxes. Meanwhile a 1.75L plastic bottle of Dubra Vodka (one of the best-selling and least expensive products) typically sells for \$11.99 at retail so that taxes account for more than 60% of the price. On the other end of the spectrum, a 750mL bottle of premium Vodka (Grey Goose or Belvedere) or Scotch Whisky (Johnnie Walker Black) might retail for over \$40.00 of which only \$3.21 would go to taxes.

3. A Theoretical Model of Post and Hold

Our theoretical model shows that the post-and-hold (PH) system used by Connecticut functions like a "price matching game". This eliminates the incentive to cut prices and increase market share. Even when multiple firms sell identical products, the iterated weak-dominant strategy is to set the monopoly price and then match any competitor price in the second stage. This will lead to higher prices when compared to competitive wholesale markets. We consider both a simple single-product example in Section 3.1 and also more realistic example with multi-product firms in Section 3.2.

[13] This applies largely to *license* states. In control states it is hard to differentiate retailer markups from *ad valorem* taxes.

[14] Imported spirits may also be subjected to additional *ad valorem* tariffs. In October 2019, President Trump imposed a 25% tariff on Scotch Whisky imports, which was later suspended for five years in June 2021 by the Biden administration.

3.1. PH with a Single Homogenous Good

Consider the following two stage game among wholesale firms (designed to resemble the actual PH process in Connecticut described in Section 2). In the first stage, each wholesaler submits a uniform price to the regulator. Then, the regulator distributes a list of all prices to the same wholesale firms. During the second stage, firms are allowed to revise their prices with two caveats: a) prices can only be revised downwards from the first stage price, and b) prices cannot be revised below the lowest competitors' price for that item. Only after this second stage is demand realized. For the purposes of illustration, we focus on the case of a single product:

1. **Price Posting:** Each wholesale firm $f \in \mathcal{F}$ submits an initial price p_0^f to the regulator.
2. **Lookback:** Firms observe all initial prices and may choose any price $p^f \in [\underline{p_0}, p_0^f]$ where $\underline{p_0} = \min_g \{p_0^g\}$ (the lowest initial price among all competitors).
3. **Sales take place:** Only after all prices are amended do sales take place.

Suppose that consumer demand is described by $Q(P)$, where P is the market price, and firms charging p^f face demand:

$$q^f(p^f, p^{-f}) = \begin{cases} 0 & \text{if } p^f > \min_g p^g; \\ \frac{Q(p^f)}{\sum_g \mathbb{I}[p^f = \min_g p^g]} & \text{if } p^f = \min_g p^g. \end{cases}$$

If each firm has constant marginal cost mc^f, then in the second stage firms solve:

$$p^{f*} = \arg\max_{p^f \in [\underline{p_0}, p_0^f]} \pi^f = (p^f - mc^f) \cdot q^f(p^f, p^{-f})$$

which admits the dominant strategy:

$$p^{f*} = \max\{mc^f, \underline{p_0}\}$$

In the second stage, firms match the lowest price from the first stage $\underline{p_0}$ as long as it is above marginal cost. Now consider the first stage game under the additional assumption of symmetric marginal costs $mc^f = mc$.[15] Given the dominant strategy in the second stage, a (symmetric) subgame perfect Nash equilibrium choice for p_0^f is:

$$p_0^f \in [mc^f, p_m^f]. \tag{1}$$

[15] In the Appendix, we consider the case of heterogeneous marginal costs. In this case, we order the firms by marginal costs and must also check each "limit price" the highest possible price (below the monopoly price) for each possible number of firms. In the case where costs are "sufficiently similar" and demand is "well-behaved" we can rule out most cases of limit pricing.

One possible (symmetric) equilibrium is the monopoly pricing equilibrium. That is, all firms set $p_0^f = p_m$. Here there is no incentive to deviate. In the second stage, all firms split the monopoly profits (symmetric costs rule out limit pricing). Cutting prices in the first stage merely reduces the size of the profits *without any change to the division.* Any upward deviation in the first stage has no effect because it doesn't change $\underline{p_0}$.

Another possible equilibrium is marginal cost pricing. Here there is no incentive to cut one's price and earn negative profits. Also, no single firm can raise its price and increase $\underline{p_0}$ as long as at least one firm continues to set $p_0^f = mc$. There are a continuum of (symmetric) equilibria in between.

While it might appear to be ambiguous as to which price is played in the initial period, there are several reasons to think that the monopoly price is the most likely. First, this is obviously the most profitable equilibrium for all of the firms involved; that is, the monopoly pricing equilibrium Pareto dominates all others. However, Pareto dominance is often unsatisfying as a refinement because it need not imply stability. Second, we show that the monopoly price is the only equilibrium to survive iterated weak dominance, Selten (1975)'s trembling-hand-perfect refinement, or Myerson (1978)'s proper equilibrium refinement.

Proposition 1. *In the absence of limit pricing (or under symmetric marginal costs $mc^f = mc$ $\forall f$), the unique equilibrium of the single-period game under (a) iterated weak dominance and (b) trembling-hand-perfection is the monopoly price: $\sigma(p_0^f, p^f) = (p_m^f, \underline{p_0})$ where $\underline{p_0} = \min_f p_0^f$. (Proof in Appendix).*

Thus an iterated weak dominant strategy is for firms to set their first-stage prices at their perceived monopoly price p_m^f given their costs mc^f; and in the second-stage match the lowest of the prices from the first stage (as long as price exceeds marginal cost) $p^f = \max\{mc^f, \underline{p_m}\}$. It is important to notice that the monopoly price is the unique equilibrium to survive iterated weak dominance in the one-shot game, and that we did not need to employ repeated games/Folk Theorem arguments. Moreover, while we could extend the analysis to repeated games, we can already sustain the monopoly price in the one-shot game, so allowing for cooperation seems unlikely to further increase profits.

3.2. PH with Heterogeneous Costs and Multiproduct Firms

Consider the a multi-product wholesale firm $f \in \mathcal{F}$ which chooses prices for all products they sell $j \in \mathcal{J}_f$. Following the single-product example in Section 3.1, an iterated weak-dominant strategy is for f to set the initial price p_j^f as if it can do so unilaterally, and then simply to match the lowest competitor price in the second stage (assuming it exceeds marginal cost).

We relax the assumption that firms setting equal prices $p_j^f = p_j^g$ split the market equally and instead allow firms to split the market for each product in a fixed (known) proportion γ_j^f. Now, firm f's sales of product j are given by $q_j^f(\mathbf{p}) = \gamma_j^f \cdot Q_j(\mathbf{p})$, where $Q_j(\mathbf{p})$ represents the total sales of product j, and $\mathbf{p}$ represents the vector of prices for all products available in that period.[16]

We write the profits of firm f (if all sellers charge the "market price" P_j) as:

$$\pi_f(\mathbf{p}) = \gamma_j^f \cdot Q_j(\mathbf{p}) \cdot (P_j - mc_j^f) + \sum_{k \in \mathcal{J}_f \setminus j} \gamma_k^f \cdot Q_k(\mathbf{p}) \cdot (P_k - mc_k^f) \tag{2}$$

If we assume that each firm f which sells j can unilaterally set the price, we can take first order condition of (2) with respect to P_j, and divide by $\gamma_j^f > 0$ to obtain:

$$\left[Q_j + \frac{\partial Q_j}{\partial P_j}(P_j - mc_j^f)\right] + \sum_{k \in \mathcal{J}_f} \frac{\gamma_k^f}{\gamma_j^f} \cdot \left[\frac{\partial Q_k}{\partial P_j}(P_k - mc_k^f)\right] = 0 \tag{3}$$

This is meant to reflect the FOC which governs the initial choice of price for j by f in the first stage. In the second stage, firms should still match the lowest-priced seller (as long as the price exceeds marginal cost). This means that (3) holds with equality for at least one firm (the initial lowest-priced seller), and with inequality (> 0) for the others. What we would like to do is characterize the equilibrium of these second-stage prices, and identify which firm $f \in \mathcal{F}$ is the price-setter in the first stage. In the data, we observe second-stage prices (which are nearly always identical across wholesalers) but do not observe initial prices.[17] We can rewrite (3) in one of two ways. First, we solve for the price f would choose if it were able to unilaterally set the price p_j in terms of the own-price elasticity ϵ_{jj} and the opportunity cost:

$$p_j^f = \frac{1}{1 + 1/\epsilon_{jj}} \cdot \left[mc_j^f + \sum_{k \in \mathcal{J}_f} \frac{\gamma_k^f}{\gamma_j^f} \cdot D_{jk} \cdot (p_k - mc_k^f)\right] \tag{4}$$

The bracketed term in (4) represents the full *opportunity cost* of selling j. In addition to the marginal cost mc_j, when customers leave j as the price rises, some fraction (the diversion ratio) $D_{jk} = \frac{\partial Q_k}{\partial P_j} / \left|\frac{\partial Q_j}{\partial P_j}\right|$ switch to k, earning markup $p_k - mc_k^f$ and firm f will capture a fraction γ_k^f (as compared to γ_j^f of the customers of j).

This is important because the firm with the lowest opportunity cost will choose the lowest price p_j^f, and the other firms will simply match this price. In our empirical example, we observe (or can estimate) all of the objects in the bracketed expression from (4) and thus can determine which firm f is the "price setter" for product j. Taking this to data requires the additional assumption that

[16] We still assume that firms which set $p_f > p_g$ sell zero units. The substantive restriction is that γ_j^f is constant and does not depend on prices. In practice, this allows us to estimate γ_j^f from our shipment data.

[17] Also notice that if a firm reduced its price in the first stage to p'_f so that $\underline{p} \leq p'_f < p_f$, this would have no effect on the market price in the second stage. This is the non-uniqueness of subgame perfect equilibria in (1), whereas the second-stage equilibrium is unique as long as the price-setting firm for each product j doesn't play a weakly-dominated strategy.

mc_j does not vary by firm. In practice, the wholesalers' marginal costs are determined primarily by: uniform (by law) manufacturer prices and state excise taxes, both of which we observe.[18]

$$\kappa_{jk} \equiv \frac{\gamma_k^f}{\gamma_j^f}, \text{ such that } f = \arg\min_{f':\gamma_j^{f'}>0} \left[mc_j^{f'} + \sum_{k \in \mathcal{J}_{f'}} \frac{\gamma_k^{f'}}{\gamma_j^{f'}} \cdot D_{jk} \cdot (p_k - mc_k) \right] \tag{5}$$

$$p_j = \frac{1}{1 + 1/\epsilon_{jj}} \cdot \left[mc_j + \sum_{k \in \mathcal{J}} \kappa_{jk} \cdot D_{jk} \cdot (p_k - mc_k) \right] \tag{6}$$

Once we know which firm "sets the price" for each product j, we can re-write (3) in matrix form as (where $\odot$ denotes the Hadamard product):

$$\mathbf{q}(\mathbf{p}) = \big(\mathcal{H}(\kappa) \odot \Delta(\mathbf{p})\big) \cdot (\mathbf{p} - \mathbf{mc}) \tag{7}$$

where the elements of the matrix $\Delta_{(j,k)} = \frac{\partial Q_j}{\partial P_k}$, and the elements of the vector $\mathbf{mc}$ correspond to mc_j^f for the lowest *opportunity cost* firm from (4). Here, the *ownership matrix* has entries $\mathcal{H}_{(j,k)} = \kappa_{jk} = \frac{\gamma_k^f}{\gamma_j^f}$ which can be interpreted as *profit weights* or how the firm setting the price of j treats \$1 of (market-level) profit from k relative to \$1 of (market-level) profit from j. The profit weights depend on the relative share of the market controlled by f for products j and k. Following a long literature in industrial organization, we can solve the linear system in (7) for the (additive) markups:[19]

$$\boldsymbol{\eta} \equiv (\mathbf{p} - \mathbf{mc}) = \big(\mathcal{H}(\kappa) \odot \Delta(\mathbf{p})\big)^{-1} \mathbf{q}(\mathbf{p}). \tag{8}$$

The idea is that even though multiple firms sell identical products in a two-stage game with price matching, we can still recover a mapping from consumer demand for products $(\mathbf{q}(\mathbf{p}), \Delta(\mathbf{p}))$ and price cost margins $(\mathbf{p} - \mathbf{mc})$ using only second-stage prices by constructing the "ownership matrix" of lowest opportunity cost firms on a product-by-product basis. The only additional requirement is the assumption that the pivotal firm f for each product j does not play a weakly-dominated strategy.

[18]Later, we ignore the possibility that wholesalers possess additional heterogeneous costs involved in transporting products to retailers. This seems reasonable because Connecticut is a small and most of the wholesalers are located within a very small geographic region near the center of the state. Allowing for some homogenous (across firms and products) transportation cost is also straightforward.

[19]See other examples from the IO literature going back to Bresnahan (1987) and Nevo (2001, 2000) for mergers, Villas-Boas (2007) for double marginalization, Miller and Weinberg (2017); Miller et al. (2021) for coordinated effects, and Backus et al. (2021a,b) for partial (common) ownership.

4. Some Descriptive Evidence

In this section, we present several stylized facts and patterns in the data consistent with the theory in Section 3. We show that: (1) Prices are higher in PH states than in other license states. When comparing Connecticut (our PH state) and Massachusetts (a non-PH license state): (2) prices are higher in Connecticut; (3) relative prices are higher for "premium" products; (4) relative shares are lower for "premium" products; (5) when multiple wholesalers offer a product, prices largely move in lockstep, and appear not to decline longterm when additional wholesalers begin selling a product.[20]

4.1. Cross State Evidence from Retail Prices

Our first set of stylized facts come from the NielsenIQ Retail Scanner Dataset (through the Kilts Center at Chicago Booth). These data report weekly unit sales and total revenue for each product (a unique UPC) for a set of retail stores that voluntarily share their data with NielsenIQ. We use the data from 2013 (the final year in our administrative dataset), and compute a volume-weighted average price for each product for the entire year.[21]

To compare prices we construct an index that measures how the average retail price for a fixed set of products varies across states. Using the 250 best-selling products nationwide, we construct the index value for each state:

$$PI^x = \frac{\sum_{i=1}^{250} p_i^x q_i^{US}}{\sum_{j=1}^{250} q_j^{US}} \tag{9}$$

where q_i^{US} is the retail quantity measured in liters of product i sold nationwide and p_i^x is the per-liter retail price of product i in state x. Figure 1 plots index values for control states in blue, license states with PH in red and license states without PH regulations in gray. Dark bars on the left indicate the state excise tax for the national bundle in each license state. Retail prices are always inclusive of the excise tax (but not the general sales tax). We do not separate out excise taxes for control states.

Figure 1 illustrates two key facts. First, PH states feature some of the highest prices. In fact, PH states outrank nearly all other license states with one notable exception being Texas, which has a different and unusual market structure. Second, price differences are not fully explained by differences in tax rates. PH states have fairly typical tax burdens, ranking roughly in the middle

[20]The Appendix also extends panel data analysis by Cooper and Wright (2012) to show that aggregate sales of alcoholic beverages are lower under PH.

[21]While coverage across states in the NielsenIQ data for supermarkets is excellent, coverage for liquor stores is imperfect. This is because some control state monopolies don't share data with NielsenIQ at all. In some license states, supermarkets are allowed to sell distilled spirits (such as California) leading to good coverage, while in others only standalone liquor stores can sell spirits (including Massachusetts, New York, New Jersey, and Connecticut). Other license states such as Rhode Island and Delaware where Nielsen records fewer than 1,000 sales are excluded from the analysis.

of the distribution of taxes, but are uniformly in the upper third of the price distribution.

A simple way to think about what would happen if we eliminated PH in Connecticut might be to consider another license state as a counterfactual. For example, Illinois has prices that are approximately \$3 per liter lower, while having tax rates that are roughly double those we see in Connecticut.

A more obvious comparison for Connecticut is the neighboring state of Massachusetts.[22] The two states are demographically similar, and are likely to have similar local wages and transportation costs. Moreover much of Connecticut is either in the Boston media market, or the shared Hartford-CT/Springfield-MA media market, so we might expect that preferences for distilled spirits might be similar in the two states.[23] However, as Figure 1 suggests, prices are around \$1.90 per liter lower in Massachusetts, while excise taxes are only \$0.35 per liter lower.

In Figure 2 we plot the average retail price per liter in Connecticut against the average retail price per liter in Massachussets for each brand of vodka in the NielsenIQ data. We focus on vodka because it represents around 45% of the sales volume in each state. Different bottle sizes are indicated by color, and within brand, there is a substantial discount in the per-liter price for larger (1.75L) bottles. If the prices were identical in both states, all points would lie along the 45 degree line shown in solid black. Instead, prices in Connecticut generally exceed prices in Massachusetts. Moreover, the price premium is larger for more expensive products. We can see that budget brand Popov is priced similarly in the two states while Smirnoff, a mid-tier brand, is subject to a sizable Connecticut premium and Belvedere, a high-end brand, is subject to an even larger premium. The best-fit line, $P_{CT} = 0.723 + 1.068 \cdot P_{MA}$, indicates that on average Connecticut consumers pay approximately \$1.44 per liter more for discount vodka, \$2.08 per liter more for mid-tier vodka and \$3.44 per liter more for premium vodka.[24] (Recall, the tax difference is only a flat \$0.35 per liter).

What we expect to be an important distortion from the PH policy is that firms with market power charge relatively higher markups on more expensive products, and thus influence the set of products consumers purchase. Again we use Massachusetts as our comparison. In Figure 3, we categorize vodkas based on the *national average* price per liter, and plot the share of sales (by volume) in each price band for each state. The idea is that the national average price captures some

[22]There has been some controversy in the literature as to whether Massachusetts is a PH state. Cooper and Wright (2012) report that Massachusetts ended PH in 1998 while Saffer and Gehrsitz (2016) claim that this is a coding error and draw their data regarding PH laws from the NIAAA's catalogue of wholesale pricing restrictions (`https://alcoholpolicy.niaaa.nih.gov/apis-policy-topics/wholesale-pricing-practices-and-restrictions/3`). To clarify the status of the PH statute in Massachusetts we contacted the Massachusetts Alcoholic Beverages Control Commission. The General Counsel of the Massachusetts Alcoholic Beverages Control Commission explained that "The US District Court ruled the post and hold provision to be unconstitutional, so while it remains 'on the books,' it is not enforced so licensees do not need to post and hold (although they are still required to post prices). The case on point is Canterbury Liquors & Pantry v. Sullivan, 16 F.Supp.2d 41 (D.Mass.1998), as well as a Massachusetts Appeals Court case recognizing the District Court's ruling [in] Whitehall Company Limited v. Merrimack Valley Distributing Co., 56 Mass. App. Ct. 853 (2002)." As such, we follow Cooper and Wright (2012) and treat Massachusetts as a non-PH state after 1998.

[23]The remainder of southern Connecticut is in the New York media market.

[24]Here we've defined discount, mid-tier, and premium vodkas to be \$10, \$20, \$40 per liter respectively.

objective measure of "quality".[25] The upper panel describes purchase shares by volume for 750mL products while the lower panel describes 1.75L products. The purchase patterns in Figure 3 show that relative to their Massachusetts neighbors, consumers in Connecticut are more likely to purchase products from the two lowest "quality" tiers, and much less likely to purchase products from the two highest "quality" tiers.[26] Again, this is purely descriptive, and it may be that preferences for vodka in plastic bottles are higher and preferences for *Grey Goose* are lower in Connecticut for other idiosyncratic reasons.[27]

4.2. Administrative Data from Connecticut

Our main dataset is meant to capture the universe of distilled spirits sales at the *wholesale level* in the state of Connecticut from July 2007 through July 2013. This dataset has been collected and compiled by us (the authors), and has not been previously analyzed, but parts of which we can make publicly available.

The first source is the monthly price postings from Connecticut's Department of Consumer Protection (DCP). The PH system necessitates that all *wholesalers* submit a full price lists for all products they sell.[28] A similar regulation applies to the manufacturer/distillers (firms like Bacardi, Diageo, Jim Beam, etc.). This means that we see monthly product-level pricing for both the *manufacturer* tier and the *wholesale* tier.

There are several challenges related to data construction. The first is that the format of price filings is irregular. While some firms provide spreadsheets, others provide printed PDF reports, and many provide scans of faxed-in price lists. The second challenge is that a single product such as *Johnnie Walker Red* is sold by a single manufacturer (Diageo) but by as many as four wholesalers, and there is no product identifier which links the product between manufacturer and wholesaler or across wholesalers. This means that all of the matching of products, and assignment to a unique product identifier must be done primarily by hand. A third challenge is that reporting of product flavors can be inconsistent, we might see shipments of one flavor (Cherry) but price postings only for another flavor (Orange). Within a brand-size-proof combination, we consolidate multiple flavors so that *750mL Smirnoff Vodka (Flavored)* is a unique product, but "Orange" or "Raspberry" is not.

The most serious limitation of the price-posting data is that we usually don't observe both: (a) the initial price postings; and (b) the amended or revised price postings. In some cases we see only the initial price posting, and some handwritten (or faxed) amendments. In others, we see only

[25] Alternatively, we could think about this as a measure of "expected prices" that is purged of local demand or preference shocks.

[26] A similar pattern holds for 1L bottles, but we exclude these from the analysis because 1L bottles are primarily purchased by bars and restaurants and account for only 4% of retail liquor store sales in Massachussets and Connecticut.

[27] Another possibility is that consumers in Connecticut drive to Massachusetts to save \$9 on Grey Goose, but not to save \$0.50 on Popov.

[28] Recall that the legislation prohibits quantity discounts, so firms are restricted to *uniform* prices.

initial price postings and don't know whether prices were amended or not. And finally, in other cases, we observe only a list of amendments to prices and no price postings at all.[29] When in doubt, we treat price postings as if they are "as amended". This requires some careful data cleaning, and filling prices backwards and forwards when there are gaps.[30] One limitation is that we don't have two separate sets of prices we would need to analyze the two stages of the price-posting process. We can offer anecdotal evidence that when firms amend prices they are required to list the competitor whose price they "match".

The second data source tracks shipments of distilled spirits from manufacturer/distiller/importers to wholesalers. These data were obtain from the Distilled Spirits Council of the United States (DISCUS). The DISCUS data track monthly shipments from member manufacturers, generally the largest distillers, to wholesalers for each product.[31] These distillers constitute 78% of total shipments of distilled spirits (by volume) in the state of Connecticut.[32]

A key aspect of the DISCUS data, is that it contains all shipments (of covered brands) to the state of Connecticut. This includes products that ultimately end up in bars in restaurants, and those sold in retail liquor stores. Another advantage of the DISCUS data is that we see total shipments not only by product, but to each wholesaler. This lets us estimate the γ_j^f parameters from our theoretical model in (5) directly from the shipment data. The primary disadvantage is that for less popular products, shipments can be lumpy with only a handful of shipments per year. For this reason, we focus our analysis primarily at the *quarterly* level of observation, and for the least popular products (one shipment per year or less, around 6% of total sales) we have to apply some further smoothing. For the 21.9% of products not included in our DISCUS sample, rather than exclude them from the analysis, we forecast shipments using the NielsenIQ Retail Scanner data totals from 34 stores in Connecticut. We describe the construction of the quantity data in detail in our Data Appendix.

Table 1 reports summary statistics for the 1,361 products in our data set by category and bottle size. Products are brand-size combinations, such as *Smirnoff Vodka 750mL* or *Tanqueray Gin 1L*. Vodka is the largest product category, accounting for 324 products, and 44% of all spirits liters sold. While 750mL products are sold more frequently than 1L and 1.75L products combined, it is 1.75L products that account for the bulk of sales volume. Most products are 80 proof and as such proof averages near 80 for most categories and bottle sizes with some notable exceptions.[33]

[29] As best we can tell these are mistakes made when inputting prices into the DCP's posting system.

[30] We discuss this in detail in our Data Appendix. Some manufacturers tend to post only the list of prices for products whose price changed from the previous month, which requires some care in constructing the full sequence of prices.

[31] DISCUS members include: Bacardi U.S.A., Inc., Beam Inc., Brown-Forman Corporation, Campari America, Constellation Brands, Inc., Diageo, Florida Caribbean Distillers, Luxco, Inc., Moet Hennessy USA, Patron Spirits Company, Pernod Ricard USA, Remy Cointreau USA, Inc., Sidney Frank Importing Co., Inc. and Suntory USA Inc.

[32] Some of the largest non-DISCUS members include: Heaven Hill Distillery and Ketel One Vodka.

[33] Some popular gins and imported Scotch Whiskies are over-proof. Most flavored vodkas are 60 proof, and flavored rums can be as low as 42 proof (*Malibu Coconut Rum*).

Our "products" largely consist of different brands offered by a smaller set of manufacturer/distillers. In Table 2, we provide the same information but broken out by manufacturer. Diageo, for example, accounts for 225 products and 31.6% of sales by volume. To produce meaningful summary measures across differently sized products, product prices and margins are measured in per liter terms and all means are weighted by liters sold. The final columns report the average (per liter) prices for manufacturers, wholesalers, and retailers.[34] We also report the estimated Lerner markup, which for wholesalers is $\frac{p_j^w - p_j^m - \tau_j}{p_j}$, where p_j^m represents the manufacturer price and τ_j represents the state excise tax. For manufacturers we don't observe production costs and simply fill in the price of the lowest cost product in the category. This provides an (extreme) upper bound on manufacturer markups. The average retailer earns a $2.89 profit on a price of $19.99 for at Lerner markup of 0.14. Meanwhile, the average wholesaler margin is $3.87 on a (per liter) price of $17.02 for a Lerner markup of 0.22.

4.3. Wholesaler Pricing Behavior

Our main focus is the pricing behavior and market power of the wholesale tier. As many as four wholesalers sell identical products, yet each charges a substantial markup above the manufacturer price, and identical prices as one another. There are several innocuous possibilities including the fact that wholesaling activities are costly to produce, provide valuable ancillary services, or that wholesale firms are substantially differentiated in ways we cannot observe.

Absent the PH system, a simple way to think about a counterfactual would be if wholesale markups were competed away so $p_j^w = p_j^m + \tau_j$ (manufacturer price plus excise taxes). We plot the wholesale prices and manufacturer prices in Figure 4. Rather than plot the 45 degree line, we plot the zero markup line: $p_j^w = p_j^m + \tau_j$. We see that (after accounting for taxes) wholesaler price-cost margins are larger on more expensive products with products like *Grey Goose* and *Johnnie Walker Black* having very high price-cost margins. High wholesale price-cost margins are not exclusive to the most expensive products as the most popular product *Smirnoff Vodka* also has a high markup, though other inexpensive products such as *Dubra Vodka* have small markups.

Figure 5 tracks the wholesale (case) prices of up to four different wholesale firms in addition to the manufacturer price for four popular spirits products: Stolichnaya Vodka (1000mL), Tullamore Dew Irish Whiskey (1750mL), Dewars White Label (750mL), and Johnnie Walker Black (1750mL). For each product, the prices set by the different wholesalers move in near lockstep with one another. Occasional price deviations are short-lived and typically involve only one of three to four wholesalers selling a product. These relatively rare and temporary price disagreements appear to be a firm "trying" a new price that no other wholesaler follows; these are likely to be revised in the second round of PH price setting, which we do not always observe. As such in our subsequent analysis we will use the lowest wholesale price observed in each month.

[34] Retail prices come from the NielsenIQ Scanner Dataset for Connecticut.

While one innocuous explanation might be that this synchronous movement simply reflects changes in input prices, the manufacturer price plotted alongside the wholesale prices do not support this reasoning. Manufacturer prices change only rarely while wholesale prices move more frequently and together. Instead it appears that wholesalers are pricing in parallel, which is what we would expect given the incentives created by PH.

5. Econometric Model of Demand and Supply

In much of the industrial organization literature, the goal of econometric estimates of supply and demand is to estimate own and cross elasticities in a setting with endogenous prices, and then use first order conditions to recover markups and marginal costs.[35] We observe both wholesaler and manufacturer prices directly. Instead, we use these prices and wholesale shipments from Section 4.2 and the unique iterated weak-dominant equilibrium of the price posting game from Section 3 to inform the elasticities in our demand system.

We rely on the estimated system of demand to explain how consumers will adjust purchase patterns under counterfactual pricing where the wholesale tier has incentives to compete (rather than incentives not to compete). In a sense, we are asking the demand system to do less than the usual case, but we still need it to evaluate counterfactual welfare.

5.1. Demand Specification

Our model for consumer demand assumes that in each period t (quarter), a consumer i makes a discrete choice to purchase a single product j, or chooses not to make a purchase. We define a "product" to be a brand-flavor-proof-size combination (ie: *750mL of Smirnoff Flavored Vodka at 60 proof*).[36] We standardize the purchase volume at one liter and maintain the fiction that a consumer can purchase one liter of any product (irrespective of size) at the per-liter price.[37]

We estimate *derived wholesale demand* using the prices and quantities at the *wholesale* level, and abstract away from retailers. This allows us to capture statewide demand for spirits at bars and restaurants as well as liquor stores. As we document in our prior work (Conlon and Rao, 2020), the retail pricing decision at liquor stores can be complicated by nominal rigidities around prices ending in 0.99. The main limitation of this approach is that our calculation of Marshallian "consumer surplus" combines both retailers (bars, restaurants, and liquor stores) and final consumers.[38] As we document in Figure 5, we rarely see price dispersion among wholesalers, but when we do we take the *minimum wholesale price*, and assume that all consumers face the same "market price".

[35] See for example Nevo (2001) or Backus et al. (2021a) for RTE cereal, Villas-Boas (2007) for yogurt, or Miller and Weinberg (2017) for beer.

[36] We don't specify the particular flavor and thus consolidate Orange, Raspberry, and Cherry Vodka into a single "Flavored Smirnoff" option as long as they are all 60 proof.

[37] Similar assumptions are common in the literature. For example, Nevo (2001); Backus et al. (2021a) assume that consumers purchase a single serving of RTE cereal at the per-serving price.

[38] Margins of retail liquor stores are small compared to those of wholesalers in Table 1

We assume that consumer demand follows the random coefficients nested logit model (Brenkers and Verboven, 2006; Grigolon and Verboven, 2013). This model combines the random coefficients logit demand model of Berry et al. (1995) with a nested logit structure on the error term ε_{ijt}. The nesting structure is important because we want to allow for more substitution within a product category (Gin, Rum, Tequila, North American Whiskey, Irish/Scotch Whisky, and Vodka) than across categories.[39] The degree to which consumers substitute within the nest is governed by the parameter ρ, with $\rho = 0$ representing the plain (IIA) logit model, and $\rho = 1$ representing the case where all consumers substitute within the same category.

The utility of consumer i for product j in market t is given by:

$$u_{ijt} = \beta_i \, x_{jt} + \alpha_i \, p_{jt} + \xi_{b(j)} + \xi_t + \Delta\xi_{jt} + \varepsilon_{ijt}(\rho) \tag{10}$$

Here p_{jt} represents the minimum wholesale per-liter price, and x_{jt} represents additional product characteristics (bottle size, proof), and $(\xi_{b(j)}, \xi_t)$ represent brand and time fixed-effects respectively. We define the individual purchase probability $s_{ijt} = Pr(u_{ijt} > u_{ij't} \mid \alpha_i, \beta_i)$ for all $j \neq j'$ and the aggregate market share is given by:

$$s_{jt}(\boldsymbol{\xi_t}; \theta_1, \theta_2) = \int s_{ijt}(\alpha_{it}, \beta_{it}, \boldsymbol{\xi_t}; \theta_1, \theta_2) f(\alpha_i, \beta_i \mid y_i, \theta_2) \, g(y_i) \, \partial\alpha_i \partial\beta_i \partial y_i \tag{11}$$

We allow consumers to have heterogeneous preferences for product characteristics that are determined by observed demographics y_i (income) and unobserved characteristics ν_i (a vector of standard normal draws). We also require that the price coefficient α_i is lognormally distributed, so that all consumers have downward sloping demand curves and in our main specification we discretize income into five quintiles, and allow each quintile to have a separate set of parameters so that:[40]

$$\begin{pmatrix} \ln \alpha_i \\ \beta_i \end{pmatrix} = \begin{pmatrix} \overline{\alpha} \\ \theta_1 \end{pmatrix} + \Sigma \cdot \nu_i + \sum_k \Pi_k \cdot \mathbb{I}\{y_i \in \text{bin}_k\} \tag{12}$$

Following Conlon and Gortmaker (2020), we partition the parameters into those that enter the problem linearly $\theta_1 = \overline{\beta}$ and those that enter the problem non-linearly or pertain to the endogenous objects $\theta_2 = [\rho, \overline{\alpha}, \Sigma, \Pi]$. Each of the parameters in θ_2 requires at least one instrument for identification. For the vector $\boldsymbol{\xi_t}(\theta_1, \theta_2)$ which sets (11) equal to the observed shares we can construct conditional moment restrictions of the form $\mathbb{E}[\xi_{jt} \mid z_{jt}^D] = 0$.

[39] We made this assumption in our original draft, and it has since been adopted in other studies of distilled spirits Miravete et al. (2018) and beer Miller and Weinberg (2017).

[40] As a robustness test, we estimate a model that treats income y_i as continuous and estimates a single interaction for each element of α_i and β_i.

5.2. Specification of Supply Moments

While it is possible to estimate parameters and recover markups from the demand-side alone, the original BLP papers (Berry et al., 1995, 1999) found it valuable to impose additional moments from the first order conditions of firms. As shown in Conlon and Gortmaker (2020), a correctly specified supply side can aid in the estimation of the θ_2 parameters.

We have already derived an expression for the additive wholesale markups $\eta_{jt} = p^w_{jt} - mc_{jt}$ (in matrix form) in (8) for the PH game. We specify the marginal costs in four parts: the manufacturer prices p^m_{jt}, state excise taxes τ_{jt} (all measured per-liter), labor and other marginal wholesaling costs outside of purchases from manufacturers wc_{jt}, and the unobserved cost shock ω_{jt}:

$$p^w_{jt} - \eta_{jt}\left(\mathcal{H}_t(\kappa), \theta_2\right) = mc_{jt} \equiv p^m_{jt} + \tau_{jt} + wc_{jt} + \omega_{jt}. \tag{13}$$

Normally we would specify $mc_{jt} = h(\mathrm{x}_{jt}; \theta_3) + \omega_{jt}$ and estimate the parameters of the marginal cost function θ_3 with some instruments $\mathbb{E}[\omega_{jt} | z^s_{jt}] = 0$. However, because we observe the manufacturer prices for each product p^m_{jt}, and excise taxes τ_{jt}, we know not only the determinants of the marginal cost, but the coefficients as well. This allows us to construct moments of the form:

$$\mathbb{E}[\omega_{jt}] = 0, \text{ with } \omega_{jt} = \left(p^w_{jt} - p^m_{jt} - \tau_{jt} - wc_{jt}\right) - \eta_{jt}\left(\mathcal{H}_t(\kappa), \theta_2\right). \tag{14}$$

This provides additional over-identifying restrictions on the parameters in θ_2 (most importantly the price sensitivity α) by setting the observed price cost margins in the data $p^w_{jt} - p^m_{jt} - \tau_{jt}$ as close as possible to those implied by the demand model $\eta_{jt}\left(\mathcal{H}_t(\kappa), \theta_2\right)$. This is particularly helpful because we have a small number of markets (we observe statewide quarterly wholesale shipments), and the spirits are becoming more popular over time, even as they become more expensive (particularly after the tax hike in July 2011). Absent these additional restrictions, we would estimate demand curves that are substantially less elastic, and would imply much larger wholesale markups than those we see in the data.

An important non-issue here is the "endogeneity of p^m_{jt}" or that manufacturers may choose prices p^m_{jt} with $\Delta\xi_{jt}$ (the demand shock) in mind. This may certainly be the case, but it is not problematic in (14) because we fix the coefficients on (p^m_{jt}, τ_{jt}) at unity, rather than estimate them.[41]

This approach is not without its drawbacks. The observed manufacturer price and excise taxes are a lower bound on the wholesaler marginal cost. A better approach might instead impose the inequality $\mathbb{E}[\omega_{jt}] \geq 0$.[42] We test sensitivity to adding a strictly positive (and fixed) wholesaling cost $\mathrm{wc}_{jt} \in \{\$0, \$0.5, \$1, \$2\}$ per liter, with larger wholesaling costs leading to slightly more elastic demand (and worse fit), while not imposing the supply moments at all tends to lead to less elastic

[41] This is an old solution to the endogeneity problem, and the basis for the Anderson and Rubin (1949) test. Concerns about a relationship between ξ_{jt} and p^m_{jt} would suggest not including p^m_{jt} in z^D_{jt} the demand-side instruments.

[42] In practice we find that this leads to $\omega_{jt} = 0$ for all (j, t). That is, the unconstrained model would set $wc_{jt} = 0$ (or a negative value if allowed).

demand. Our preferred specification implicitly assumes that the wholesaler incurs no additional cost to take delivery from manufacturer/distillers store the products, and deliver them to bars, restaurants, and liquor stores.

The second drawback is that we are imposing system of first order conditions from the PH game in (3), and thus cannot test them. There is a long (and growing) literature on testing conduct in differentiated products settings (Bresnahan, 1987; Villas-Boas, 2007; Berry and Haile, 2014; Backus et al., 2021a; Duarte et al., 2021). Testing conduct amounts to detecting violations of the supply moment(s) in (14) for different choices of markups $\eta_{jt}\left(\mathcal{H}_t(\kappa), \theta_2\right)$. The bigger challenge here would be specifying the markups in the absence of PH, when multiple wholesalers offer identical products.

5.3. Estimation Details

We use the quarterly data on shipments from manufacturers to wholesalers (as described in Section 4.2) to construct market shares. And we use the legal drinking age population estimates from the NIAAA to construct an estimate for the potential market size. As in Berry et al. (1995), the unobservable demand shock $\Delta\xi_{jt}$ is chosen to equate the observed market share, with the market share predicted by the demand model (11). The model is governed by the parameters $\theta = [\theta_1, \theta_2]$ and defined by the conditional moment restrictions $\mathbb{E}[\Delta\xi_{jt}|z_{jt}^d]$ and the scalar supply moment $\mathbb{E}[\omega_{jt}] = 0$.[43] We augment the supply and demand moments with some additional moments.

In July of 2011, the state of Connecticut increased the volumetric tax levied on wholesalers from $\tau_{jt} = \$1.18/L$ to $\tau_{jt} = \$1.43/L$. This provides both some useful variation in τ_{jt} that serves as an instrument for p_{jt} (in z_{jt}^D), and is consistent with a long literature in public finance exploiting changes in excise tax rates to instrument for prices. It also enables us to compute a quasi-experimental estimate of the aggregate elasticity of demand for spirits $\varepsilon^{AGG} \approx -0.41$.[44] We require that our estimated system of demand and supply match this aggregate elasticity as an additional moment of the form:

$$\mathbb{E}_t\left[\varepsilon^{AGG} + 1 - \frac{\sum_j s_{jt}(\mathbf{p}\cdot 1.01;\theta)}{\sum_j s_{jt}(\mathbf{p};\theta)}\right] = 0. \tag{15}$$

In words, we require that when we increase the prices of all products by 1%, the total sales decrease by ε^{AGG} percent. We expect this moment to be most informative about the nesting parameter ρ which governs the extent to which consumers respond to higher prices by substituting from one vodka to another vodka or to a product from another category (including the outside good).

In addition to the moments from (aggregate) supply and demand, we augment these with moments formed from the decisions of individual panelists in the NielsenIQ data. These micro-

[43] We've experimented with additional supply moments of the form $\mathbb{E}[\omega_{jt}\, z_{jt}^s] = 0$, but they seem to have little to impact on the parameter estimates.

[44] We provide more details in the appendix on our estimated aggregate elasticity. A meta-analysis in Wagenaar et al. (2009) reported the mean elasticity for the spirits category to be $\varepsilon^{AGG} \approx -0.29$.

moments (Petrin, 2002; Berry et al., 2004) are constructed by evaluating interactions of product characteristics with consumer demographics (conditional on purchase). We employ the following four types of micro-moments:

$$\begin{aligned}
&\mathbb{P}\left[\text{Income}_i \in \text{bin}_k \mid Purchase\right] \\
&\mathbb{P}\left[\text{Income}_i \in \text{bin}_k \mid 750mL\right] \\
&\mathbb{P}\left[\text{Income}_i \in \text{bin}_k \mid 1750mL\right] \\
&\mathbb{E}\left[p^w_{jt} \mid \text{Income}_i \in \text{bin}_k \text{ and } Purchase\right]
\end{aligned} \tag{16}$$

That is, we match the average price paid (per liter) conditional on purchase for each of the five income "quintiles". We also match the probability that the buyer of a generic liter of spirits or a 750mL/1750mL bottle falls into each income "quintile". Each of these moments is meant to be informative about a particular parameter in Π (the interactions of consumer preferences with income "quintiles"). These are not necessarily the "ideal" form for micro-moments, but we found that they can be reliably constructed from the NielsenIQ panelist data without making additional assumptions. We estimate a *separate set of moments for each year* in the panelist data from 2007-2013.

We also need to estimate $g(y_i)$, the distribution of household income for the state of Connecticut. This appears both in the calculation of market shares (11) and the micro-moments (16). The NielsenIQ Panelist data doesn't report exact levels of household income, but rather reports it in discrete ranges. We assign income y_i into a set of discrete "quintile" bins: {< \$25k, \$25k-\$45k \$45k-\$70k, \$70k-\$100k, ≥ \$100k}. Because Connecticut is a high-income state, and NielsenIQ top codes income at \$100k, we have that 29% of households are in our top "quintile" while only 8.5% are in the bottom "quintile". As one might expect, household incomes decline during Great Financial Crisis, then rise slowly over time. We examine the possibility of including other consumer demographics in y_i. We don't see enough Black or Hispanic households purchasing spirits in Connecticut to accurately estimate micro-moments on these sub-populations. The age of the head of household doesn't seem vary in a meaningful way with any of the product characteristics in our data, and education is highly correlated with income.[45]

Estimation takes place in `PyBLP` (Conlon and Gortmaker, 2020). We use all four sets of moments: demand $\mathbb{E}[\Delta\xi_{jt}\, z^d_{jt}] = 0$; supply $\mathbb{E}[\omega_{jt}] = 0$; aggregate elasticity ε^{AGG}, and the micro-moments. For the demand side, we need to choose instruments z^d_{jt}. Here the obvious instruments are the excluded cost variables: p^m_{jt} (the manufacturer price), τ_{jt} the per-liter excise tax (which changes in July 2011). In addition, we follow the recipe in Gandhi and Houde (2019) and construct instruments based on differences in exogenous product characteristics $d_{jkt} = \left|x_{jt} - x_{kt}\right|$. We interact these

[45]See Conlon et al. (2021) for an in depth examination of interaction between household demographics and purchases of sin goods.

distances with dummies for each product category, and use the local variant which constructs $z_{jt}^{GH} = \sum_k \mathbb{I}\left[d_{jk,t} < a\right]$ where a is one standard deviation of $d_{jk,t}$ when x_{jt} is discrete.

In words, these instruments convey, "How many other 750mL flavored vodkas are available?" or "How many other similar proof whiskies are for sale?". These are meant to capture the "crowding" of the product space over time.[46] An important characteristic not typically in x_{jt} are the manufacturer (upstream) prices p_{jt}^m. This allows us to ask: "How many other 750mL Vodkas with manufacturer prices between \$35-\$39 per liter are available?".

The identification argument here is somewhat different from the "classic" BLP setup in Berry et al. (1995); Nevo (2001), which relies primarily on "characteristics of other goods" varying across markets in the aggregate moments $\mathbb{E}[z_{jt}^D \, \Delta\xi_{jt}] = 0$. Instead, we rely largely on our auxillary moments: matching average markups to recover the price sensitivity $\overline{\alpha}$, the aggregate elasticity ε^{AGG} to recover the nesting parameter ρ, the levels of the micro-moments to recover the demographic interactions Π, and cross market variation in the micro-moments to recover the unobserved heterogeneity Σ. In a sense, our identification strategy more closely follows the "identification from micro-data" argument in Berry and Haile (2022).

We estimate the parameters $\theta = [\theta_1, \theta_2]$ using 2-step GMM, and then use these estimated parameters to construct a feasible approximation to the optimal instruments Chamberlain (1987) following the recipe in Conlon and Gortmaker (2020) and Berry et al. (1999).[47] We then re-estimate the problem a second time using 2-step GMM and report those estimates for both the full model, and several restricted models.

5.4. Parameter Estimates

We report our estimated parameters for the full model in Table 3. The parameters themselves are not easily interpretable, though we can see some obvious patterns. At higher income levels, consumers become less price sensitive (as one might expect), but also the intercept for all spirits products declines. This is important as it implies that higher income consumers don't purchase all of the alcohol, but instead purchase similar quantities at higher prices. We see less of a discernible pattern for the large format (handle) size 1750mL other than all consumers prefer this to the other two sizes (the more ubiquitous 750mL or somewhat rare 1L sizes). Our fixed effects are at the brand level (e.g. *Smirnoff Vodka 80 Proof*), so different sizes share the same ξ_j term, but may be differ in the 1750mL dummy.

We estimate the average markups (under the PH system) to have an IQR of $(20.5\%, 25.9\%)$ with a median of 23.3% across all products and markets. In the data, the IQR is $(18.8\%, 27.6\%)$ with a median of 23.3% suggesting that these are matched quite well, though our predictions are

[46] In the data we see more US Whiskey products entering and fewer flavored rum products.

[47] With initial estimates of $\widehat{\theta}_2$, we solve (7) for $\hat{\boldsymbol{\eta}}$ at $\mathbf{mc} = \mathbf{p^m} + \tau$ and $\boldsymbol{\xi} = 0$ in order to recover $\hat{\mathbf{p}}$ and $\hat{\mathbf{s}}(\hat{\mathbf{p}})$ and then compute the relevant components of the Jacobian for the demand moments: $\mathbb{E}\left[\frac{\partial \xi_{jt}}{\partial \theta} \mid \mathbf{z_t}, \widehat{\theta}_2\right]$ and supply moments $\mathbb{E}\left[\frac{\partial \eta_{jt}}{\partial \theta} \mid \mathbf{z_t}, \widehat{\theta}_2\right]$.

somewhat less dispersed.

In order to rationalize these markups, our model estimates an IQR for own-price elasticities between $(-5.77, -4.70)$ with a median of -5.11. We also report product level own-price elasticities in Figure 6 for the final period in our data. We see that less expensive products tend to have more elastic demand, particularly for the larger 1.75L bottles. Additionally Figure 6 reports the outside good diversion ratio which tells us: conditional on leaving a product, how likely is a consumer to switch to the no-purchase option? We see that diversion to the outside good declines steeply with prices. Taken together these suggest that when we raise prices at the lower end of the price distribution consumers are more likely to substitute away from drinking (more than 30% of switchers), while when we raise prices at the higher end, they are more likely to switch to another product (or to simply pay more for their preferred product) with fewer than 20% of switchers choosing the outside option. This is important for the welfare results of counterfactual tax policies, because raising prices at the lower end of the price distribution will be more effective at getting consumers to substitute away from ethanol consumption (but also raise less revenue).

Our estiamated own-price elasticities tend to be a little more elastic than in previous studies that do not impose the supply side restriction (Miravete et al., 2020, 2018).[48] However, we still obtain relatively inelastic demand at the aggregate level. We estimate that a 1% increase in the price of all products would lead to a reduction in demand of $\widehat{\varepsilon}^{AGG} = -0.34$ (the targeted value was $\varepsilon^{AGG} = -0.41$). Part of the challenge is to match both the level of markups, and the aggregate elasticity using a single nesting parameter $\widehat{\rho} = 0.47$. In an ideal world, we might have quasi-experimental estimates of aggregate elasticities at the category level rather than just the overall level, however we only observe a single (uniform across categories) tax change in our data.

Perhaps the best way to validate our demand model is to examine the predicted substitution patterns. For several top products, we compute the diversion ratio from that product to its closest substitutes and report both the name and diversion ratios in Table 4. For the most part products appear to compete with similarly priced products within the same category. For example, Dubra Vodka (1.75L), the least expensive product in our sample, appears to compete most closely with the other discount vodka brands (Popov, Sobieski, Gray's Peak, and Latitutde) as well as Smirnoff vodkda (a mid-range vodka and the best selling product overall). Belvedere (a super premium vodka) appears to compete with Ketel One, Grey Goose, Absolut, and Tito's (other premium vodkas). Because of the nesting structure, we see that Captain Morgan's competes primarily with Bacardi Rum's and Beefeater Gin competes largely with other gins (as well as Smirnoff vodka).

[48] If we did not try to match the level of markups, we would estimate significantly *less elastic* demand. Increasing the wholesaling cost wc_{jt} leads to smaller markups and even *more elastic* demand.

6. Welfare Under Counterfactual Policies

6.1. Comparison to Social Planner's Problem

We consider the problem of a social planner who observes demand $\mathbf{Q}(\mathbf{p})$, and sets the prices $p_j \in \mathbf{p}$ of all products to maximize social surplus subject to two additional constraints: a minimum level of revenue $\overline{R}$, and a maximum level of externalities arising from ethanol consumption $\overline{E}$. We write the social planner's Lagrangian:

$$\mathcal{L}(\mathbf{p}) = CS(\mathbf{Q}(\mathbf{p})) - C(\mathbf{Q}(\mathbf{p})) + \lambda_r(\mathbf{p} \cdot \mathbf{Q}(\mathbf{p}) - C(\mathbf{Q}(\mathbf{p})) - \overline{R}) - \lambda_e(E(\mathbf{Q}(\mathbf{p})) - \overline{E}). \tag{17}$$

The Lagrange multiplier λ_r measures the social value of an additional dollar of revenue, while λ_e measures the shadow cost of an extra unit of external damage caused by alcohol consumption. This nests the well-known *Ramsey problem.* A common (though by no means necessary) assumption is that the externality is *atmospheric*, or that it depends only on total ethanol consumption and not the source of the ethanol nor the identity of the consumer, such that $E(\mathbf{q}(\mathbf{p})) = \sum_j e_j \cdot q_j(\mathbf{p})$.[49]

Written in terms of the own-price demand elasticity, ϵ_{jj}, and the diversion ratio, D_{jk}[50], the planner's resulting first-order condition yields the price rule

$$p_j = \frac{|\epsilon_{jj}|}{|\epsilon_{jj}| - \frac{\lambda_r}{1+\lambda_r}} \left(mc_j + \frac{\lambda_e}{1+\lambda_r} e_j + \sum_{k \neq j} D_{jk} \left[p_k - mc_k - \frac{\lambda_e}{1+\lambda_r} e_k \right] \right) \tag{18}$$

The first term functions like the usual inverse elasticity rule Lerner markup with $\frac{\lambda_r}{1+\lambda_r} = \theta$ behaving like a conduct parameter where $\theta = 0$ corresponds to the perfectly competitive solution and $\theta = 1$ corresponds to the monopoly solution. The first two terms in parentheses, $mc_j + \frac{\lambda_e}{1+\lambda_r} e_j$, represent the effective marginal cost. When $\lambda_e > 0$, the marginal cost of production, mc_j, is augmented by the marginal external damage, e_j. The final term, $\sum_{k \neq j} D_{jk} \left[p_k - mc_k - \frac{\lambda_e}{1+\lambda_r} e_k \right]$, represents the *opportunity cost* of selling j, which is that fraction of consumers D_{jk} who switch to k as the price of j rises multiplied by the price less marginal cost (adjusted for the externality). Trading off these opportunity costs is a distinguishing feature of the multi-product Ramsey problem. Absent any revenue constraint, $\lambda_r = 0$, the first best solution to the planner's problem is to set prices at their Pigouvian rates $p_k = c_k + \lambda_e e_k$. More generally, for any revenue level and external damage (λ_r, λ_e) the Ramsey solution in (18) will maximize social surplus or minimize deadweight loss.

Recall that the decentralized solution for oligopolistic firms under PH solves the problem in

[49] This assumption would be violated if for example, if tequila generates more externalities per unit of ethanol than vodka or if 1750mL bottles generate more externalities *per liter* than 750mL bottles. Recent work by Griffith et al. (2019) shows that if consumer preferences across beer, wine and spirits are correlated with their marginal externality of alcohol consumption, taxes that vary across categories will more effectively address the external damage of alcohol consumption.

[50] Antitrust practitioners will recognize D_{jk} as the diversion ratio from j to k given by $D_{jk} = \frac{\partial q_k}{\partial p_j} / \left| \frac{\partial q_j}{\partial p_j} \right|$.

(4) instead. The main difference is that the PH first-order conditions effectively set $\lambda_e = 0$ and $\lambda_r \to \infty$ as in the monopoly problem. An additional wedge arises because the *opportunity cost* depends on the term γ_k^f / γ_j^f which measures the relative market shares of k and j for the pivotal seller of j. The Ramsey solution would set this to be unity for all (j, k) whereas the PH solution will set $\gamma_k^f = 0$ for products not distributed by the pivotal seller of j, and may set $\gamma_k^f / \gamma_j^f > 1$ for others.

In general, the Ramsey solution, which entails setting a different effective price (or tax rate) for each product p_j, serves as a benchmark to which other simpler tax instruments can be compared. We don't think of this as being technologically feasible for a state alcohol regulator (except perhaps a control state monopolist), but rather we can understand how close to the Ramsey solution a particular tax instrument can get.

6.2. Counterfactual Policies

Our welfare analysis focuses on what would happen if PH were replaced with a competitive market for wholesale distribution in all products, and existing state volumetric excise taxes were replaced with a single tax instrument.[51] Because our demand estimates reflect derived demand at the *wholesale level* and abstract away from retail pricing, our notion of Marshallian consumer surplus corresponds to the joint welfare of both retailers (bars, restaurants, and liquor stores) as well as households. When we report distributional analysis, this is based on the types of products purchased by households at different income levels in retail environments (liquor stores).

We consider two scenarios (which we treat as bounds) for how the upstream distiller/manufacturers react to a more competitive wholesale market. In the first scenario, we hold manufacturer prices fixed. This makes sense if distiller/manufacturers are pricing regionally and can't price discriminate across wholesalers in Connecticut and those in Massachusetts, New York, or New Jersey. In the second scenario, we allow for multi-product distiller/manufacturers (e.g. Bacardi, Diageo) to adjust prices. This scenario requires estimates not only of *manufacturer prices* which we observe, but *manufacturer marginal costs* which we do not. However, we are able to back those $\mathbf{c_m}$ out of the manufacturer first order condition:[52]

$$\mathbf{p^m} - \mathbf{c_m} = \left[\mathcal{H}_m \odot \left(\frac{\partial\,\mathbf{p^w}}{\partial\,\mathbf{p^m}}(\mathbf{p^w}, \kappa)\right)^T \Delta(\mathbf{p^w})\right]^{-1} \mathbf{s}(\mathbf{p^w}). \tag{19}$$

This requires knowledge of the manufacturer ownership matrix $\mathcal{H}_m$ (which we observe) and the

[51] While most large products are sold by multiple wholesale firms who could compete until $P = MC$, several products have a single wholesale distributor. Even though that distributor might have market power in the distribution of that product, our counterfactuals treat distribution as perfectly competitive. The assumption is that a manufacturer would have an incentive to seek a second wholesale distributor in the counterfactual world, even though they don't in the PH world.

[52] Recall that $\mathbf{p}$ is wholesale price, $\mathbf{m}$ is manufacturer price and market shares $\mathbf{s}(\mathbf{p})$. See the appendix to Miller and Weinberg (2017) for a derivation.

manufacturer-wholesale price pass-through matrix, which we can estimate from the demand system. In the counterfactual world, with competitive wholesaling, the pass-through matrix reduces to the identity matrix plus any ad valorem taxes $\frac{\partial \mathbf{p}}{\partial \mathbf{m}} = I_J \cdot (1 + \tau_r)$, while the effective marginal cost becomes the production cost $\mathbf{c_m} + \tau$ where τ are any per unit taxes.

The second challenge from (18) is that we can calculate the total level of ethanol consumption $E(\mathbf{q}(\mathbf{p})) = \overline{E}$, but don't know the externality associated with ethanol consumption λ_e. Rather than take a stand on the externality, we consider three policy targets: (a) keeping ethanol consumption fixed at the existing level $\overline{E}$; (b) increasing ethanol consumption by 10%; (c) reducing ethanol consumption by 10%.

Table 5 describe the policies alternatives to the PH system that we consider: (a) a volumetric tax (similar to the one Connecticut uses currently); (b) an ethanol specific tax (similar to the one used by the federal government); (c) and *ad-valorem* tax (similar to the general sales tax); (d) a price floor per unit of ethanol (similar to that enacted in Scotland and examined by Griffith et al. (2021)); (e) a product specific (Ramsey) tax subject to either a revenue or aggregate ethanol constraint; and (f) a profit-maximizing mononpoly (similar to the market structure in Maine). Under each of our policy alternatives, we do not change the baseline federal excise tax, which we treat as part of m_j, but replace the existing state volumetric tax with the policy alternative.

6.3. Welfare Results

We start by plotting prices under single-instrument tax policy alternatives that leave aggregate ethanol consumption unchanged from the *status quo* policy of PH. Figure 7 shows how prices under the volumetric tax, ethanol tax, sales tax, minimum price and the addition of a new sales tax to existing volumetric taxes, compare to prices under PH.

Product prices that lie below the black 45 degree line denote products that are less expensive under the alternative policy than under PH, while prices above the line are more expensive under the alternative policy. The most obvious difference is that very low marginal cost products are generally more expensive under the alternative policies. Profit maximizing wholesalers tend to set very low markups on the least expensive and most elastically demanded products. These are also the products where there is the most substitution to the outside good, and what makes PH ineffective as a tool to discourage ethanol consumption.

Beyond this are several notable patterns. First, minimum prices reduce aggregate ethanol consumption by raising the price of 80-proof products to roughly \$17 per liter (and by definition lower all other prices since these products now sell at marginal cost). Second, there is little difference between taxing volume and taxing ethanol content, since the bulk of products are around 80 proof (40% alcohol by volume).[53] These taxes effectively add a fixed $\tau = \$5.26$ (per liter) or $\tau = \$12.87$ (per liter of ethanol) to each product, which leads to higher prices at the low end of the market,

[53] In part this is because we excluded liqueurs and cordials from our analysis.

and lower prices at the high end of the market (because PH markups are generally increasing in marginal costs). Third, sales tax instruments, whether in combination with the existing volumetric tax or without, generally lead to higher prices for much of the quality distribution. In part this stems from the fact that the marginal costs at the low end of the distribution are quite low, and to raise those prices sufficiently requires very high sales tax rates (86% without existing excise taxes, and 47.5% with existing excise taxes) which exceed the typical markups under PH (around 23%).

Because all price distributions yield the same amount of overall ethanol consumption, it should be clear that the volumetric and ethanol taxes (along with minimum unit prices) are likely to yield significant benefits to consumers (particularly those that prefer high-end products).

As described above, governments tax alcohol with dual objectives: to curb alcohol consumption and to raise revenue for the state. In the first panel of Table 7, we report the welfare implications of alternative tax policies which hold ethanol consumption fixed. Under the PH system, the state collects excise taxes on the total volume of spirits sold by wholesalers, but the bulk of the revenue collected is in the form of wholesaler profits. By eliminating the wholesale profits and raising taxes, our alternative policies increase tax revenue from (257% for ethanol taxes to 420% for sales taxes) while holding consumption fixed. The exception is the ethanol price floor policy. Under this policy, the state loses the existing excise tax revenue, and we (generously) assume collects the difference between the marginal cost and the minimum unit price.[54] However, at a minimum unit price of approximately \$16.80/L there is little demand for products that sell at prices below Smirnoff Vodka, and facing flat prices consumers substitute to higher quality products so that little tax revenue is ultimately collected. In terms of our Ramsey benchmarks, we see that the sales tax collects nearly as much revenue as the revenue maximizing Ramsey prices, but leaves consumers somewhat worse off (and worse off than they would be under PH). Likewise, the minimum unit price increases consumer surplus by nearly as much as the consumer surplus maximizing Ramsey prices with the same ethanol constraint.

The subsequent panels of Table 7 consider a 10% reduction and increase in ethanol consumption respectively. We see that a volumetric tax of $\$6.35/L$, could reduce ethanol consumption by 10% but still increase consumer surplus, while raising tax revenue by nearly 300%. Likewise, a similarly sized ethanol tax of \$12.87/L (of pure ethanol) could slightly increase consumer surplus (by 2.1%) while increase tax revenue by 288%. However, these policies have unequal distributional consequences with households earning less than \$45k ending up worse off on average, while households earning above \$45k ending up better off. However, this implies a win-win situation for somewhat more modest reductions in overall ethanol consumption. That is it is possible to substantially increase consumer surplus and tax revenue, while reducing ethanol consumption by as much as 8% without making any income group worse off.

Even with a 10% increase in overall ethanol consumption, the sales tax still leaves consumers

[54]In practice this seems unlikely as wholesalers or manufacturers would likely raise prices and collect the additional revenue.

worse 7.2% off than the existing PH system. However, we see that a sales tax of 37% applied to the existing excise taxes would leave consumers 1.6% better off on average. The highest income households, who consume the most expensive products would still be slightly worse off than under the status quo PH policy. This provides some insight as to why in control states like Pennsylvania with fixed markup rules, they also employ volumetric taxes (Miravete et al., 2018, 2020). Sales taxes (or fixed markups) on their own are not an efficient way (in terms of consumer surplus) to discourage consumption.

Our choices of taxes which held ethanol consumption at existing levels or considered changes of $\pm 10\%$ were somewhat arbitrary. Instead, we can compute the welfare impacts of our alternative policy instruments at all possible levels. This allows us to map out the policy frontier in terms of: consumer surplus, tax revenue, and ethanol consumption (external damage) in Figure 8.

We use stars to indicate the same aggregate ethanol consumption as the PH baseline while + and x indicate aggregate consumption levels 10% above/below baseline respectively. We denote competitive pricing without taxes (P = MC) and PH pricing; we indicate the revenue raised by PH both with and without counting the profits that accrue to wholesalers under PH. (One can imagine either using the tax revenue raised by alternative policies to compensate the wholesalers, or auctioning off the rights to be a wholesaler to raise tax revenue.)

One obvious takeaway is that if we eliminated PH, and existing excise taxes, the resulting perfectly competitive wholesaling equilibrium would increase consumer surplus by almost 47%. However, it would nearly double the overall consumption of ethanol (and completely eliminate any tax revenue). This seems unlikely to be the preferred outcome of any social planner.

PH lies within the policy frontier for both panels. The right panel shows that for any level of ethanol consumption, ethanol taxes, and volumetric taxes generate significantly higher consumer surplus (around 8%) when compared to PH policies. However, even these policies are a significant distance from the frontier of the Ramsey prices which maximize consumer surplus for a given level of ethanol. This is because these simple tax instruments fail to account for cross-price elasticities. There is little welfare benefit in raising taxes on premium products. These consumers largely switch to lower priced products rather than substituting away from spirits altogether. Thus volumetric or ethanol taxes on premium products tend to reduce consumer surplus without discouraging much additional ethanol consumption. Here the Ramsey price frontier looks very much like the minimum unit price used by Scotland and studied in Griffith et al. (2021).

In the left panel of Figure 8, we see that the existing PH policy is far from the frontier of maximizing consumer surplus or government tax revenue. This is true even if we include the profits of wholealers in our revenue calculation. It is easily dominated by volumetric and ethanol taxes (even with a 10% reduction in overall ethanol consumption). We also see that sales taxes get surprisingly close to the Ramsey frontier of maximizing consumer surplus for a given level of revenue generation. We also see that the minimum unit prices (assuming that the state even collects the difference between the price floor and the marginal cost) are nearly as ineffective at raising revenue as a planner which puts no weight on revenue in their objective function.

7. Conclusions

We show that the post and hold system employed by Connecticut is not effective at discouraging consumption of ethanol or raising tax revenues when compared to simple, commonly used tax instruments.

By tracing out the surface of potential Ramsey prices for a social planner who maximizes consumer surplus subject to a revenue constraint (and ignores external damage from spirits consumption) and a social planner who cares only about maximizing consumer surplus for a given level of spirits consumption (but ignores tax revenue), we show that *ad valorem* sales taxes (or fixed markup rules as in Miravete et al. (2020)) are a relatively effective way to raise revenue, but a poor way to discourage consumption, while minimum ethanol unit prices (Griffith et al., 2021) are an extremely effective way to discourage consumption but raise little to no revenues.

However, we show that commonly employed taxes on either volume of distilled spirits or ethanol content are able to raise significant amounts of revenue while still discouraging consumption of ethanol. As an example, we show it is possible to increase tax revenues by 266% or around $160M in additional tax collections each year (from a base of $60M) while increasing consumer surplus by 6.7% simply by replacing the PH system with competitive wholesale distribution and raising existing volumetric taxes. Likewise, it is possible to increase (average) consumer surplus while decreasing overall ethanol consumption by 10% while increasing tax collections by $178M per year.

This seemingly "free lunch" arises because firms with market power may face substantially different incentives than a social planner. When products are differentiated, relying on firms with market power to provide "second-best" regulation of externalities may be far from optimal. In our case this arises because consumers care about product quality, and firms with market power set the effective "tax" on product quality too high and the effective "tax" on externalities too low, and significantly distort the choices of infra-marginal consumers.

References

Anderson, T. W. and H. Rubin (1949): "Estimation of the Parameters of a Single Equation in a Complete System of Stochastic Equations," *The Annals of Mathematical Statistics*, 20, 46–63.

Asker, J. (2016): "Diagnosing Foreclosure due to Exclusive Dealing," *The Journal of Industrial Economics*, 64, 375–410.

Backus, M., C. Conlon, and M. Sinkinson (2021a): "Common Ownership and Competition in the Ready-to-Eat Cereal Industry," Working Paper 28350, National Bureau of Economic Research.

——— (2021b): "Common Ownership in America: 1980–2017," *American Economic Journal: Microeconomics*, 13, 273–308.

Berry, S., J. Levinsohn, and A. Pakes (1995): "Automobile Prices in Market Equilibrium," *Econometrica*, 63, 841–890.

——— (1999): "Voluntary Export Restraints on Automobiles: Evaluating a Trade Policy," *American Economic Review*, 89, 400–430.

——— (2004): "Differentiated Products Demand Systems from a Combination of Micro and Macro Data: The New Car Market," *Journal of Political Economy*, 112, 68–105.

Berry, S. T. and P. A. Haile (2014): "Identification in Differentiated Products Markets Using Market Level Data," *Econometrica*, 82, 1749–1797.

——— (2022): "Nonparametric Identification of Differentiated Products Demand Using Micro Data," Tech. Rep. arXiv:2204.06637, arXiv.

Brenkers, R. and F. Verboven (2006): "Liberalizing A Distribution System: The European Car Market," *Journal of the European Economic Association, MIT Press*, 4, 216–251.

Bresnahan, T. F. (1987): "Competition and Collusion in the American Automobile Industry: The 1955 Price War," *The Journal of Industrial Economics*, 35, 457–482.

Chamberlain, G. (1987): "Asymptotic efficiency in estimation with conditional moment restrictions," *Journal of Econometrics*, 34, 305–334.

Conlon, C. and J. Gortmaker (2020): "Best practices for differentiated products demand estimation with PyBLP," *The RAND Journal of Economics*, 51, 1108–1161.

Conlon, C., N. L. Rao, and Y. Wang (2021): "Who Pays Sin Taxes? Understanding the Overlapping Burdens of Corrective Taxes," Working Paper 29393, National Bureau of Economic Research.

Conlon, C. T. and N. L. Rao (2020): "Discrete Prices and the Incidence and Efficiency of Excise Taxes," *American Economic Journal: Economic Policy*, 12, 111–143.

Cooper, J. C. and J. D. Wright (2012): "Alcohol, Antitrust, and the 21st Amendment: An Empirical Examination of Post and Hold Laws," *International Review of Law and Economics*, 32, 379–392.

Duarte, M., L. Magnolfi, S. Mikkel, and C. Sullivan (2021): “Testing Firm Conduct,” .

Gandhi, A. and J.-F. Houde (2019): “Measuring Substitution Patterns in Differentiated-Products Industries,” Working Paper 26375, National Bureau of Economic Research.

Griffith, R., M. O’Connell, and K. Smith (2019): “Tax design in the alcohol market,” *Journal of Public Economics*, 172, 20 – 35.

——— (2021): “Price floors and externality correction,” .

Grigolon, L. and F. Verboven (2013): “Nested Logit or Random Coefficients Logit? A Comparison of Alternative Discrete Choice Models of Product Differentiation,” *Review of Economics and Statistics*.

Hansen, B., K. Miller, B. Seo, and C. Weber (2020): “Taxing the potency of sin goods: evidence from recreational cannabis and liquor markets,” *National Tax Journal*, 73, 511–544.

Hinnosaar, M. (2016): “Time inconsistency and alcohol sales restrictions,” *European Economic Review*, 87, 108–131.

Hollenbeck, B. and R. Z. Giroldo (2021): “Winning Big: Scale and Success in Retail Entrepreneurship,” *Marketing Science*.

Hollenbeck, B. and K. Uetake (2021): “Taxation and market power in the legal marijuana industry,” *The RAND Journal of Economics*, 52, 559–595.

Illanes, G. and S. Moshary (2020): “Market Structure and Product Assortment: Evidence from a Natural Experiment in Liquor Licensure,” Working Paper 27016, National Bureau of Economic Research.

Jaffe, S. and E. G. Weyl (2013): “The First-Order Approach to Merger Analysis,” *American Economic Journal: Microeconomics*, 5, 188–218, publisher: American Economic Association.

Kingston, S. (2011): *Greening EU Competition Law and Policy*, Antitrust and Competition Law, Cambridge: Cambridge University Press.

Levy, D. T., L. M. Sánchez-Romero, C. E. Douglas, and D. T. Sweanor (2021): “An Analysis of the Altria-Juul Labs Deal: Antitrust and Population Health Implications,” *Journal of Competition Law & Economics*, 17, 458–492.

Linklaters, S. (2020): “92 percent of businesses call for changes to competition rules to boost climate change collaboration | Deals | About Us | Linklaters,” .

Miller, N. H., G. Sheu, and M. C. Weinberg (2021): “Oligopolistic Price Leadership and Mergers: The United States Beer Industry,” *American Economic Review*, 111, 3123–3159.

Miller, N. H. and M. C. Weinberg (2017): “Understanding the Price Effects of the MillerCoors Joint Venture,” *Econometrica*, 85, 1763–1791.

Miravete, E. J., K. Seim, and J. Thurk (2018): “Market Power and the Laffer Curve,” *Econometrica*, 86, 1651–1687.

——— (2020): "One Markup to Rule Them All: Taxation by Liquor Pricing Regulation," *American Economic Journal: Microeconomics*, 12, 1–41.

Myerson, R. B. (1978): "Refinements of the Nash equilibrium concept," *International Journal of Game Theory*, 7, 73–80.

Nevo, A. (2000): "Mergers with Differentiated Products: The Case of the Ready-to-Eat Cereal Industry," *The RAND Journal of Economics*, 31, 395–421.

——— (2001): "Measuring Market Power in the Ready-to-Eat Cereal Industry," *Econometrica*, 69, 307–342.

Petrin, A. (2002): "Quantifying the Benefits of New Products: The Case of the Minivan," *Journal of Political Economy*, 110, 705–729, publisher: The University of Chicago Press.

Saffer, H. and M. Gehrsitz (2016): "The effect of post-and-hold laws on alcohol consumption," *International Review of Law and Economics*, 45, 63–71.

Sass, T. (2005): "The competitive effects of exclusive dealing: Evidence from the U.S. beer industry," *International Journal of Industrial Organization*, 23, 203–225.

Sass, T. and D. S. Saurman (1993): "Mandated Exclusive Territories and Economic Efficiency: An Empirical Analysis of the Malt-Beverage Industry," *Journal of Law and Economics*, 36, 153–77.

Schinkel, M. P. and L. Treuren (2020): "Green Antitrust: (More) Friendly Fire in the Fight against Climate Change," SSRN Scholarly Paper ID 3749147, Social Science Research Network, Rochester, NY.

Seim, K. and J. Waldfogel (2013): "Public Monopoly and Economic Efficiency: Evidence from the Pennsylvania Liquor Control Board's Entry Decisions," *American Economic Review*, 103, 831–862.

Selten, R. (1975): "Reexamination of the Perfectness Concept for Equilibrium Points in Extensive Games," *International Journal of Game Theory*, 4, 25–55.

Seo, B. (2019): "Firm Scope and the Value of One-Stop Shopping in Washington State's Deregulated Liquor Market," SSRN Scholarly Paper ID 2863094, Social Science Research Network, Rochester, NY.

Thomas, D. (2019): "License Quotas and the Inefficient Regulation of Sin Goods: Evidence From the Washington Recreational Marijuana Market," SSRN Scholarly Paper ID 3312960, Social Science Research Network, Rochester, NY.

Treasury, U. (2022): "Competition in the Markets for Beer, Wine, and Spirits," .

Villas-Boas, S. B. (2007): "Vertical Relationships between Manufacturers and Retailers: Inference with Limited Data," *The Review of Economic Studies*, 74, 625–652, publisher: [Oxford University Press, Review of Economic Studies, Ltd.].

Wagenaar, A. C., M. J. Salois, and K. A. Komro (2009): "Effects of beverage alcohol price and tax levels on drinking: a meta-analysis of 1003 estimates from 112 studies," *Addiction (Abingdon, England)*, 104, 179–190.

Table 1: Summary Statistics: Wholesale and Manufacturer Price Connecticut Q3 2007 - Q2 2013

					Manufacturer		Wholesaler		Retailer	
	# Obs	Share	Proof	% Flavored	Price	Margin	Price	Margin	Price	Margin
Gin	59	7.4	87.07	0.02	11.15	2.99	16.21	3.79	18.72	2.34
Rum	147	17.5	73.63	0.21	10.17	2.54	15.08	3.65	17.60	2.52
Tequila	92	4.9	80.04	0.00	15.17	4.14	22.05	5.60	28.51	4.70
Vodka	208	44.8	79.19	0.15	10.73	2.68	15.42	3.42	18.05	2.54
NA Whiskey	127	15.2	81.80	0.00	11.59	3.11	17.41	4.54	20.08	2.76
UK Whiskey	102	10.2	80.79	0.00	18.36	4.31	25.04	5.41	28.15	3.12
750mL	310	20.1	79.05	0.18	16.44	4.17	23.57	5.85	28.32	4.74
1L	174	23.2	79.32	0.12	13.80	3.71	19.92	4.85	24.85	4.35
1.75L	251	56.7	79.55	0.08	9.32	2.26	13.53	2.94	14.91	1.36
All	735	100.0	79.40	0.11	11.79	2.98	17.03	3.97	19.82	2.71

Note: The table above describes manufacturer, wholesale and retail prices and margins for 735 of 1,365 products (used in our estimation procedure) by category and size. The number of products corresponds to brand-size combinations, such as Smirnoff Vodka-750mL or Tanqueray Gin-1L. All averages are weighted by total liters sold. *Share* describes the share of total liters sold. The average *Proof* and percentage *Flavored* is reported. The average prices and margins are reported on a *per liter* basis.
The *Manufacturer Margin* is the difference between the manufacturer price the estimated manufacturer marginal cost from the demand and supply model (net of Federal excise taxes). All other columns in this table are observed rather than estimated.
Retail Margin is the difference between the retail price and the wholesale price.
Wholesale Margin is the difference between the wholesale and manufacturer price plus state excise tax.
Federal alcohol excise taxes of $2.85 per liter of 80 proof spirits are levied on manufacturers. Connecticut state alcohol taxes, which are remitted by wholesalers, were raised from $1.18 to $1.42 per liter regardless of proof in July 2011.
Source: Harmonized Price and Quantity Data (top 750 products, average price under $60 per liter).

Table 2: Manufacturer Summary

	# Obs	Share	750mL	1L	1.75L	Manufacturer Price	Manufacturer Lerner	Wholesaler Price	Wholesaler Lerner	Retailer Price	Retailer Lerner
Diageo	155	32.7	0.16	0.21	0.63	11.75	0.30	17.00	0.23	19.26	0.11
Bacardi	48	14.2	0.21	0.34	0.45	14.30	0.23	20.03	0.23	22.63	0.11
Pernod	68	14.2	0.20	0.33	0.47	15.03	0.24	20.74	0.21	23.96	0.13
Jim Beam	102	8.3	0.18	0.23	0.59	9.59	0.26	14.55	0.24	17.56	0.14
Brown Forman	32	5.2	0.23	0.30	0.47	14.83	0.28	22.49	0.28	26.01	0.13
Skyy	26	2.9	0.27	0.06	0.67	11.18	0.20	16.00	0.21	18.58	0.13
Constellation Brands	6	2.8	0.19	0.11	0.71	7.43	0.26	12.45	0.29	14.37	0.13
Constellation	24	2.1	0.05	0.12	0.83	4.91	0.25	8.09	0.22	9.72	0.14
Star Industries	16	2.1	0.13	0.29	0.58	4.67	0.26	7.88	0.24	9.53	0.17
Imperial	6	2.1	0.19	0.10	0.71	5.72	0.26	9.16	0.23	12.16	0.24
MHW	44	2.0	0.41	0.16	0.43	11.68	0.22	16.97	0.23	20.77	0.17
Black Prince	7	2.0	0.10	0.29	0.62	3.97	0.28	5.93	0.11	7.15	0.17
Heaven Hill	21	1.5	0.18	0.05	0.77	6.65	0.21	10.12	0.20	12.05	0.15
White Rock	8	1.3	0.24	0.00	0.76	7.04	0.21	10.53	0.21	13.48	0.21
William Grant	17	1.3	0.22	0.12	0.65	10.40	0.24	16.02	0.25	18.62	0.11
Other	36	1.0	0.42	0.16	0.42	9.57	0.22	13.86	0.21	18.34	0.23
Remy-Cointreau	16	1.0	0.35	0.13	0.52	18.09	0.20	24.74	0.20	28.94	0.15
US Distributors	6	0.8	0.23	0.00	0.77	7.02	0.20	9.47	0.11	14.52	0.33
Sazerac	20	0.7	0.34	0.24	0.42	9.92	0.24	14.52	0.20	18.69	0.22
Moet Hennessy	10	0.6	0.41	0.37	0.22	24.35	0.21	31.02	0.17	37.43	0.17
LuxCo	19	0.6	0.17	0.38	0.45	7.13	0.24	10.97	0.23	14.60	0.23
MS Walker	10	0.2	0.08	0.48	0.45	5.33	0.22	7.32	0.09	10.99	0.25
McCormick	7	0.2	0.07	0.56	0.37	5.09	0.28	7.59	0.17	11.96	0.23
Proximo	3	0.1	1.00	0.00	0.00	20.02	0.24	29.27	0.26	37.64	0.21
Duggans	2	0.1	0.00	0.26	0.74	8.00	0.20	12.93	0.28	15.30	0.15
Infinium	1	0.0	0.00	0.00	1.00	5.54	0.22	8.84	0.24	10.78	0.17
Castle Brands	1	0.0	1.00	0.00	0.00	11.86	0.21	16.79	0.21	22.03	0.23

Note: The table above summarizes product shares, prices and Lerner markups by manufacturer for 735 of 1,365 products (used in our estimation procedure). The number of products corresponds to brand-size combinations, such as Smirnoff Vodka-750mL or Tanqueray Gin-1L. All averages are weighted by total liters sold. *Share* describes the share of total liters sold by each manufacturer. Average prices and Lerner markups are reported on a *per liter* basis.

Manufacturer Markup is the difference between the manufacturer price and the lowest price among products in the same category and bottle size (with the minimum constrained by the federal tax on the product) scaled by the manufacturer price; the constructed input price is meant to proxy the base costs of production and is used only here to provide a sense of the allocation of margins along the different tiers of the spirits market in Connecticut. This constructed manufacturer input cost is not used in any of the subsequent analysis.

Retail Lerner is the difference between the retail price and the wholesale price scaled by the retail price.

Wholesale Lerner is the difference between the wholesale and manufacturer price plus state excise tax scaled by the wholesale price.

Federal alcohol excise taxes of $2.85 per liter of 80 proof spirits are levied on manufacturers. Connecticut state alcohol taxes, which are remitted by wholesalers, were raised from $1.18 to $1.42 per liter regardless of proof in July 2011.

Source: Harmonized Price and Quantity Data (top 750 products, average under $60 per liter).

Table 3: Parameter Estimates: Full Model

Π	Const	Price	1750mL
Below \$25k	2.746	-0.779	0.152
	(0.205)	(0.058)	(0.066)
\$25k-\$45k	0.174	-0.508	0.433
	(0.213)	(0.061)	(0.108)
\$45k-\$70k	0.000	-0.516	0.831
	(0.000)	(0.060)	(0.098)
\$70k-\$100k	-0.429	-0.807	0.162
	(0.209)	(0.058)	(0.116)
Above \$100k	-2.200	-1.940	0.076
	(0.236)	(0.053)	(0.102)
Σ^2			
Price	0.000	0.520	0.705
	(0.089)	(0.028)	(0.049)
1750mL	0.000	0.705	2.512
	(0.091)	(0.049)	(0.576)
Nesting Parameter ρ		0.467	
		(0.028)	
Fixed Effects		Brand+Quarter	
Model Predictions	25%	50%	75%
Own Elasticity	-5.772	-5.114	-4.702
Aggregate Elasticity	-0.352	-0.339	-0.333
Observed Wholesale Markup (PH)	0.188	0.233	0.276
Predicted Wholesale Markup (PH)	0.205	0.233	0.259

Source: Authors' calculations

Table 4: Best Substitutes: Diversion Ratios 2013 Q2

	Median Price	% Substitution		Median Price	% Substitution
Capt Morgan Spiced 1.75 L			**Cuervo Gold 1.75 L**		
Bacardi Superior Lt Dry Rum 1.75 L	12.52	16.02	Don Julio Silver 1.75 L	22.81	7.05
Bacardi Dark Rum 1.75 L	12.52	3.32	Sauza Especial Tequila Gold 1.75 L	15.38	2.89
Lady Bligh Spiced V Island Rum 1.75 L	9.43	2.60	Cuervo Gold 1.0 L	21.32	2.59
Smirnoff 1.75 L	11.85	2.25	Cuervo Silver 1.75 L	18.33	2.50
Mount Gay Eclipse 1.75 L	18.23	2.08	Smirnoff 1.75 L	11.85	2.49
Absolut Vodka 1.75 L			**Beefeater Gin 1.75 L**		
Smirnoff 1.75 L	11.85	10.14	Tanqueray 1.75 L	17.09	15.27
Skyy Vdk Dom 1.75 L	12.52	3.35	Gordons 1.75 L	11.19	4.82
Svedka 1.75 L	13.09	3.30	Seagrams Gin 1.75 L	10.23	3.26
Tito'S Vdk Dom 1.75 L	15.09	3.07	Bombay 1.75 L	21.95	2.61
Smirnoff Raspberry Vodka 1.75 L	10.23	2.25	Gilbey Gin 1.75 L	9.30	2.56
Dubra Vdk Dom 80P 1.75 L			**Belvedere Vodka 1.75 L**		
Popov Vodka 1.75 L	7.66	7.94	Absolut Vodka 1.75 L	15.94	9.74
Smirnoff 1.75 L	11.85	4.91	Smirnoff 1.75 L	11.85	6.28
Sobieski Poland 1.75 L	9.09	3.93	Ktl1 Vdk Im 1.75 L	20.71	4.09
Grays Peak Vdk Dom 1.75 L	9.16	3.62	Tito'S Vdk Dom 1.75 L	15.09	3.31
Wolfschmidt 1.75 L	6.92	2.46	Svedka 1.75 L	13.09	2.58

Note: We compute the diversion ratio for a small price change $D_{j\to k} = \frac{\partial q_k}{\partial q_j} / \left|\frac{\partial q_j}{\partial q_j}\right|$.
There are 636 products available in our final period.
The product with the largest overall share is Smirnoff Vodka (80 Proof, 1.75L) with $s_{jt} = 1.2\%$ or 4.38% of sales.
Source: Authors' calculations

Table 5: Counterfactual Policies to Limit Ethanol Consumption

Policy	Product Prices
Sales Tax	$p_{jt} = mc_{jt} \cdot (1+\tau_r)$
Volumetric Tax	$p_{jt} = mc_{jt} + \tau_v$
Ethanol Tax	$p_{jt} = mc_{jt} + \tau_e \cdot ABV_{jt}$
Revenue+Volume Taxes	$p_{jt} = (mc_{jt} + \tau_0) \cdot (1+\tau_r)$
Minimum Unit Price	$p_{jt} = \max\{mc_{jt}, \tau_u \cdot ABV_{jt}\}$
Ramsey-Revenue	$\mathbf{p}(\overline{R}) = \arg\max_{\mathbf{p}\geq\mathbf{mc}} CS(\mathbf{p})$ s.t. $(\mathbf{p}-\mathbf{mc})\cdot\mathbf{q}(\mathbf{p}) > \overline{R}$
Ramsey-Ethanol	$\mathbf{p}(\overline{E}) = \arg\max_{\mathbf{p}\geq\mathbf{mc}} CS(\mathbf{p})$ s.t. $ABV\cdot\mathbf{q}(\mathbf{p}) \leq \overline{E}$
Ramsey-Full Problem	$\mathbf{p}(\overline{R}, E_0) = \arg\max_{\mathbf{p}\geq\mathbf{mc}} CS(\mathbf{p})$ s.t. $(\mathbf{p}-\mathbf{mc})\cdot\mathbf{q}(\mathbf{p}) > \overline{R}$ and $ABV\cdot\mathbf{q}(\mathbf{p}) = E_0$
Monopoly	$\mathbf{p} = \arg\max_{\mathbf{p}} (\mathbf{p}-\mathbf{mc})\cdot\mathbf{q}(\mathbf{p})$

Note: We examine eight policy alternatives to PH. In all counterfactuals PH pricing is replaced with taxes levied on a competitive wholesale market. *Sales* levies a single-rate sales tax (τ_r) on all spirits products to achieve the desired aggregate ethanol consumption level. Similarly, *Volume* and *Ethanol* model the impact of volumetric (τ_v) and ethanol-based (τ_e) taxes set to limit ethanol consumption. We also consider a policy which retains Connecticut's existing volumetric tax (τ_0) and layers on a sales tax. A *Minimum Price* enforces a floor based on ethanol content ($\tau_u \cdot ABV_{jt}\}$) but otherwise prices products competitively.
Finally, we examine the impacts of Ramsey prices where individual product prices are set to maximize consumer surplus while meeting different constraints. The first set of Ramsey prices are set to generate a required revenue (regardless of ethanol consumption). The second set of Ramsey prices are set to cap aggregate ethanol consumption (regardless of revenue generated). The final set of Ramsey prices generate required revenue while limiting aggregate ethanol consumption to the level under PH.

Table 6: Distributional Impacts of Counterfactual Policies

		% Change in CS					
No Change in Ethanol	% Total Revenue	% Overall	Below $25k	$25k-$45k	$45k-$70k	$70k-$100k	Above $100k
Ramsey (Ethanol)	-0.6	22.2	15.4	23.0	27.1	38.3	21.9
Minimum Price	12.7	21.6	12.9	21.5	24.3	34.5	22.5
Ethanol	272.2	7.4	4.2	7.2	7.5	11.7	7.9
Volume	279.1	6.4	2.6	5.3	5.2	9.5	7.4
Revenue+Volume	365.7	-5.5	-1.8	-3.4	-3.6	-5.1	-7.1
Ramsey (Revenue)	375.7	-7.0	-4.7	-5.9	-6.2	-9.2	-7.7
Revenue	386.6	-13.2	-4.5	-8.7	-8.5	-13.9	-16.6
-10% Ethanol							
Ramsey (Ethanol)	22.8	15.2	8.0	11.5	14.5	26.2	16.5
Minimum Price	47.1	14.5	5.3	10.1	11.2	21.6	17.2
Ethanol	301.2	0.6	-3.7	-3.2	-4.7	0.0	2.9
Volume	308.6	-0.5	-5.5	-5.3	-7.1	-2.3	2.3
Revenue+Volume	396.3	-13.8	-10.2	-15.0	-16.7	-17.9	-14.1
Ramsey (Revenue)	406.6	-15.5	-13.8	-17.9	-19.8	-22.4	-14.6
Revenue	407.1	-21.0	-12.6	-19.9	-21.1	-25.8	-23.2
+10% Ethanol							
Ramsey (Ethanol)	-13.7	28.1	21.4	33.3	38.3	48.2	26.4
Minimum Price	-12.7	27.7	19.6	32.2	36.6	45.8	26.9
Ethanol	239.7	13.8	11.6	17.8	20.0	23.2	12.4
Volume	245.9	13.0	10.3	16.1	17.9	21.3	12.1
Revenue+Volume	327.1	2.6	6.4	8.4	10.0	8.1	-0.3
Ramsey (Revenue)	339.7	0.8	3.8	6.0	7.5	3.6	-1.6
Revenue	358.4	-5.3	3.3	2.8	4.6	-1.6	-10.1

Note: The table above reports estimates of the impacts of the counterfactual policy alternatives described in Table 5 on tax revenue collected, overall consumer surplus and the distribution of consumer surplus across the five income bins. All effects are reported in percentage changes relative to the PH baseline. The top panel describes the impact of alternative policies that limit ethanol consumption to the same aggregate level as under PH while panels B and C report the effects of alternative policies that reduce and increase ethanol consumption by 10%, respectively.
Our revenue is calculated as the additonal tax revenue raised by the state compared to the existing excise tax collections.

Table 7: Reducing Overall Ethanol Consumption (Volumetric Taxes)

	No Change to Ethanol			No Change to Overall CS			No Change to CS by Income		
	Base	$wc = 1$	p^m	Base	$wc = 1$	p^m	Base	$wc = 1$	p^m
% Δ Ethanol	-0.00	-0.00	0.00	-9.30	-9.25	-8.67	-3.13	-3.20	-3.86
% Δ Tax Revenue	279.05	209.52	246.33	306.61	243.41	269.71	288.70	221.62	257.08
% Δ Manufacturer Profit	17.76	17.76	35.18	9.57	9.61	28.61	15.03	14.97	32.29
% Δ Total CS	6.40	6.40	5.93	0.01	0.04	0.02	4.28	4.23	3.33
% Δ CS by Income									
Below \$25k	2.58	2.58	3.09	-4.96	-4.92	-3.93	0.08	0.02	0.00
\$25k-\$45k	5.34	5.34	5.42	-4.55	-4.50	-3.81	2.01	1.93	1.31
\$45k-\$70k	5.22	5.22	5.42	-6.28	-6.23	-5.33	1.32	1.23	0.61
\$70k-\$100k	9.55	9.55	9.90	-1.49	-1.43	-0.38	5.84	5.76	5.33
Above \$100k	7.42	7.42	6.46	2.72	2.74	2.14	5.88	5.85	4.58
Tax per Liter	5.45	4.45	4.98	6.45	5.44	5.83	5.77	4.78	5.35

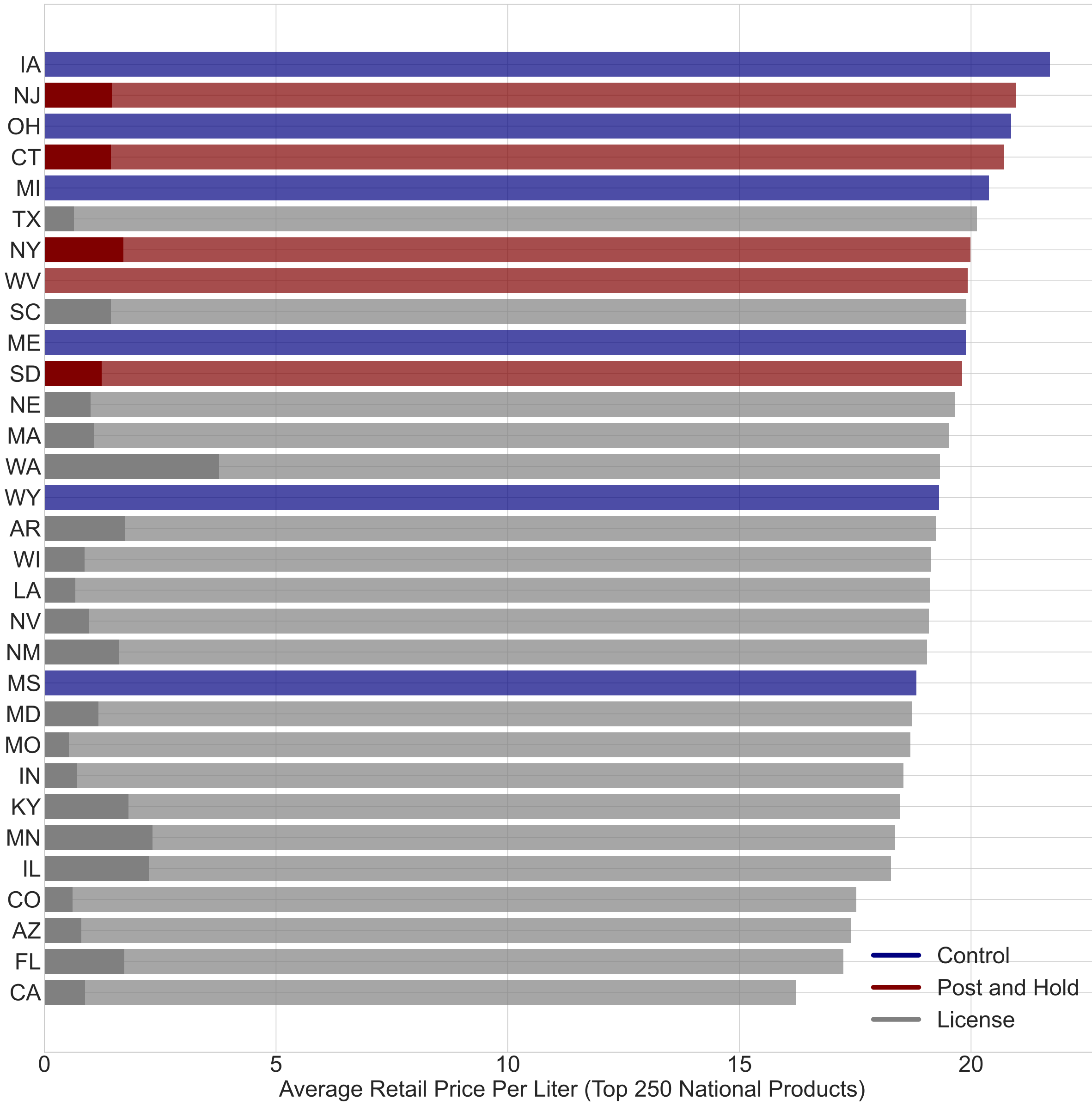
Note: The table above reports welfare estimates for the impacts of a counterfactual volumetric tax under three scenarios: (a) no change in overall ethanol consumption (b) minimizing ethanol consumption without reducing aggregate consumer surplus (c) minimizing ethanol consumption without reducing consumer surplus for any income bin.

In addition to the base model which sets the marginal cost of wholesaling to be zero and holds manufacturer prices fixed (Base), we allow for a \$1 per liter wholesaling cost ($wc = 1$), or we allow manufacturers to endogenously set prices (p^m) in response to counterfactual taxes but with perfectly competitive wholesaling.

Manufacturer profits increase even when prices are held fixed because absent PH, consumers substitute to higher margin/quality products.

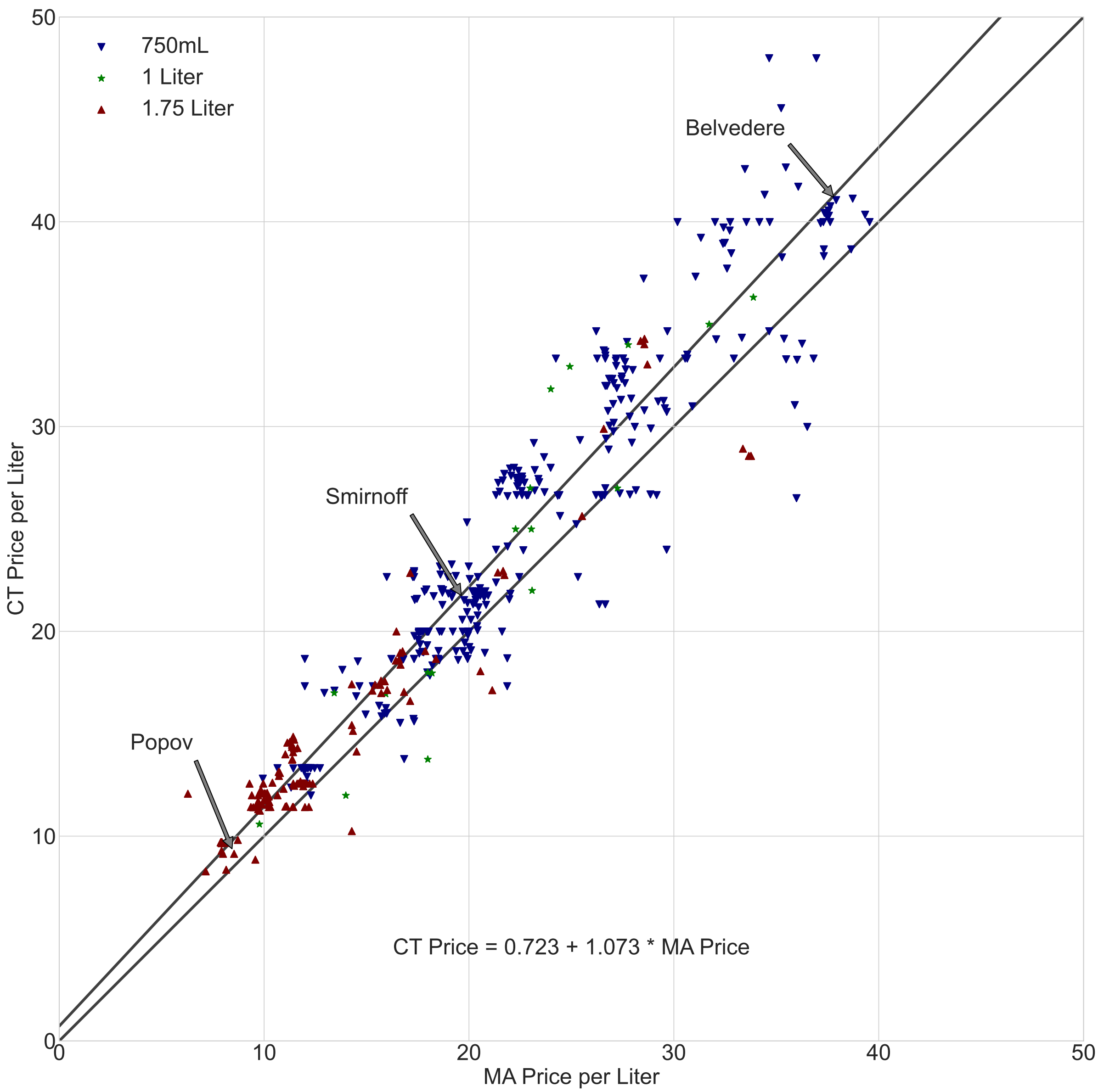
Existing volumetric taxes are \$1.43/L.

Figure 1: Price Indices by State, National Consumption Bundle (2013)



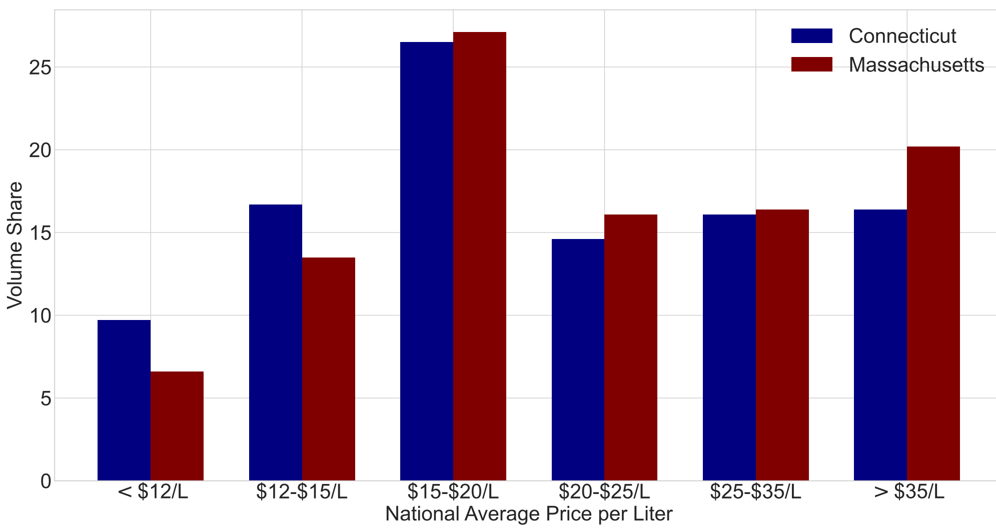
Note: The figure above plots the average retail price by state of the 250 best-selling products nation-wide. Retail prices in each state are weighted by the product's share within the top 250 national bundle by volume. As such, sales weights are constant across states so that the indices reflect only the differences in prices for the national bundle. License states such as Rhode Island and Delaware where we lack data describing sales of at least 1,000 products are excluded. Control states are shaded in blue, post and hold states in red and license states without post and hold regulations in grey. Darkly shaded bars on the left indicate state excise tax levied on the national bundle in license states (control states generally do not levy taxes on top of state markups).
Source: NielsenIQ Scanner Dataset.

Figure 2: Retail Prices for Vodka Products in Connecticut vs. Massachusetts (2013)

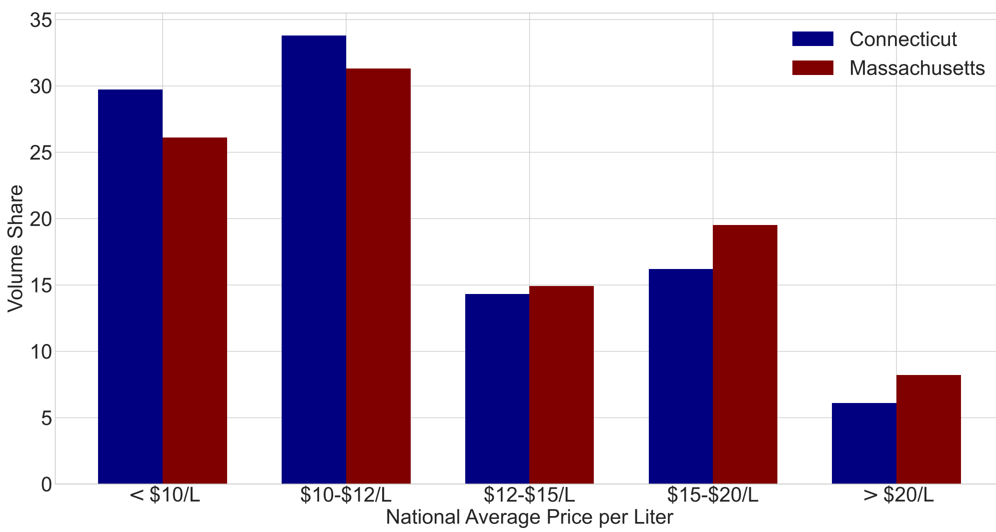


Note: The figure above compares the retail prices of individual products in Connecticut and the neighboring state of Massachusetts. Massachusetts prices are plotted on the x-axis and Connecticut prices are plotted on the y-axis with each dot representing brand-size combination, for example Smirnoff is a 750mL bottle. Prices are converted into dollars per liter and different colored markers denote 750mL (blue), 1000mL (green) and 1750mL (red) products. The dashed line plots the linear best fit and its coefficients are reported. The 45 degree line, corresponding to equal prices in Connecticut and Massachusetts, is shown as well.
Source: NielsenIQ Scanner Dataset.

Figure 3: Vodka Consumption in Connecticut and Massachusetts by National Price Per Liter (2013)



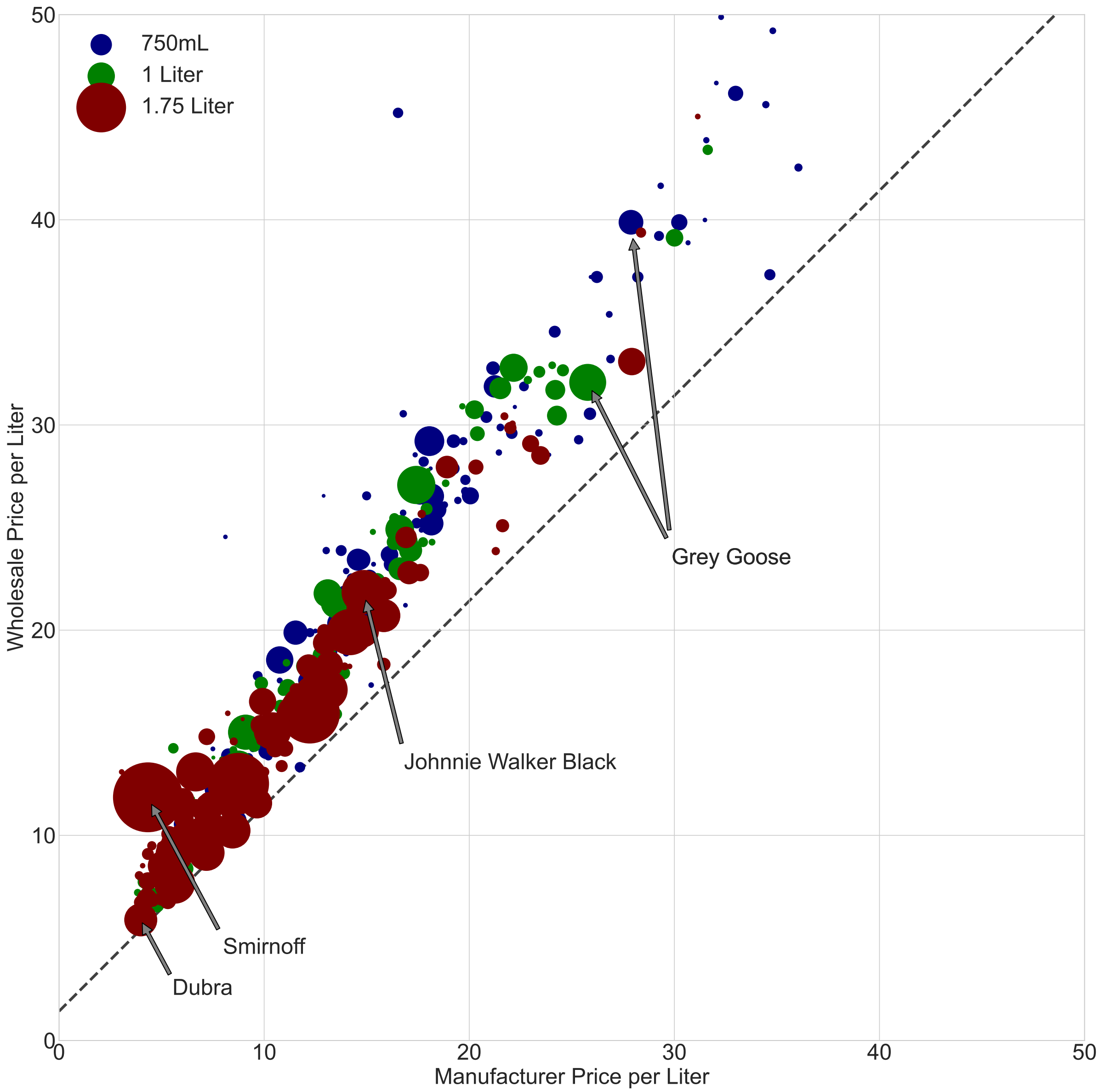
(a) 750mL Products



(b) 1.75L Products

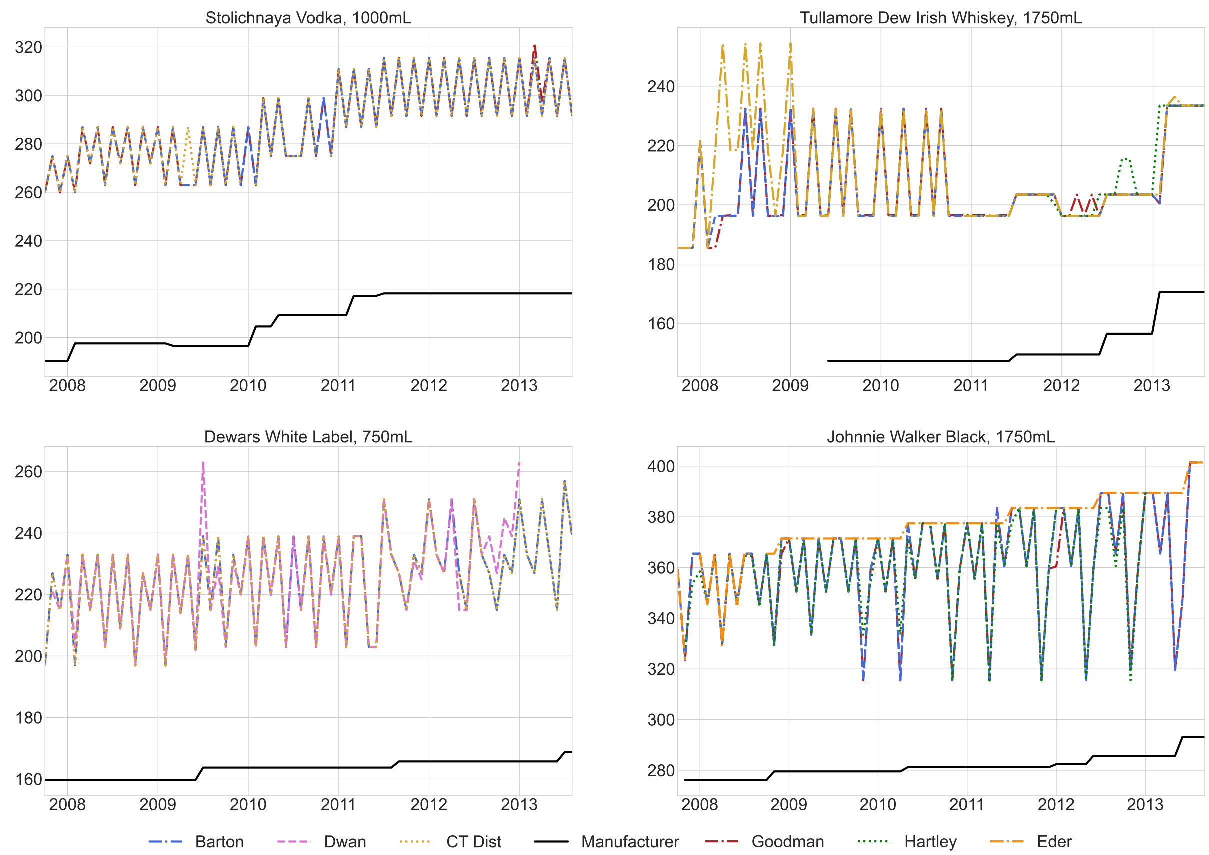
Note: The charts above show the share of vodka consumption by volume in Connecticut and Massachusetts for 750mL and 1.75L products by national price per liter category. A product's national price category is determined using the average price per liter across all Nielsen markets outside of Connecticut designated market areas. For products only sold in Connecticut or Massachusetts the state price is used in place of the national price to calculate price per liter.
Source: NielsenIQ Scanner Data. All of 2013.

Figure 4: Manufacturer and Wholesale Prices Q2 2013



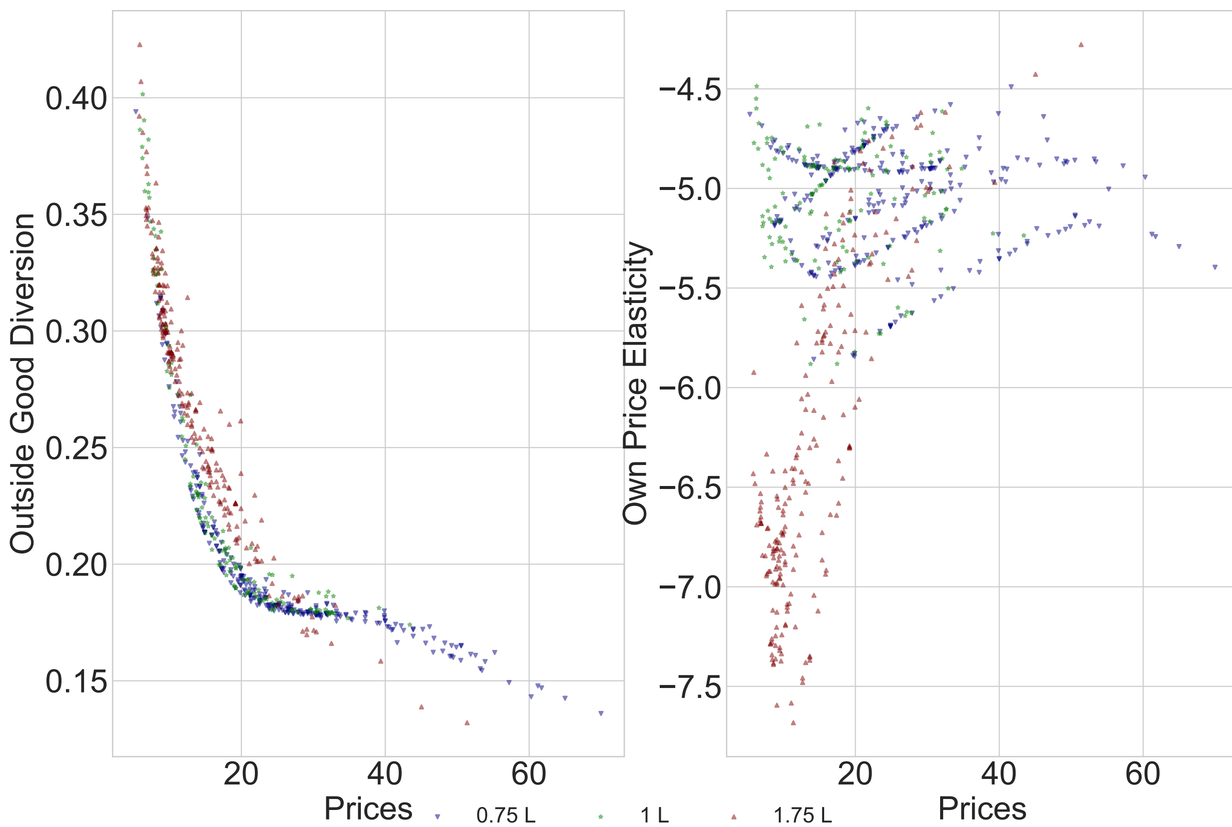
Note: The figure above plots the manufacturer price against wholesale price, capturing how the ratio of wholesale to manufacturer prices rises with manufacturer price. Prices are converted into dollars per liter and different colored markers denote 750mL (blue), 1000mL (green) and 1750mL (red) products. Marker sizes are proportional to quarterly sales totals. The 45 degree line, corresponding to zero wholesale markup, is shown as well.
Source: Harmonized Price and Quantity Data. Period from 2013-04-01 to 2013-06-30.

Figure 5: Case Price by Wholesaler and Manufacturer Price, Four Top Selling Products



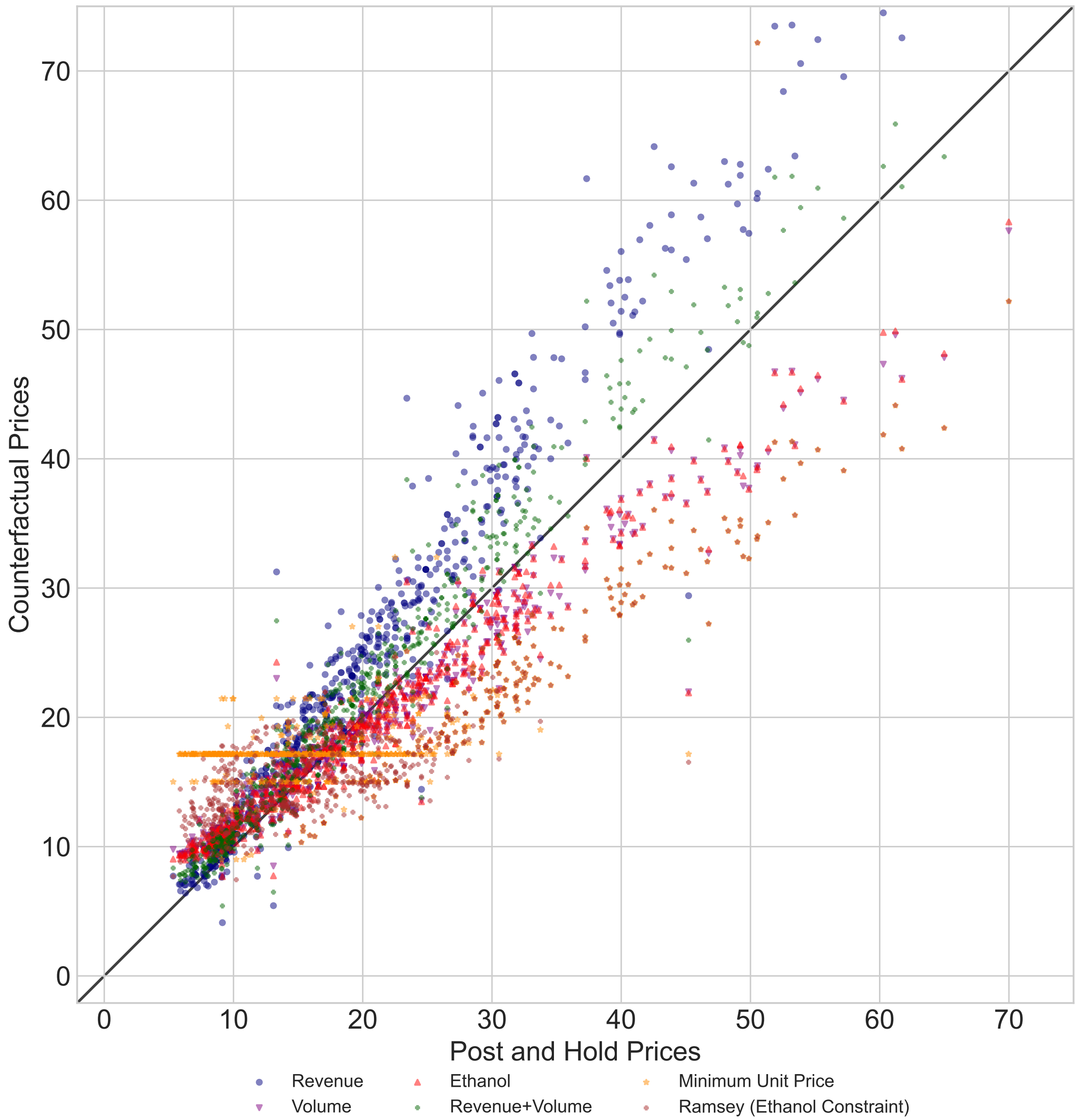
Note: The figure above plots monthly wholesale prices as well as the manufacturer price for four popular products between October 2007 and August 2013. Three wholesalers offer Stolichnaya Vodka, 1000mL (Goodman, Barton and CT Dist) and Dewars White Label, 750mL (Barton, CT Dist and Dwan), while four wholesalers sell Tullamore Dew, 1750mL (Barton, CT Dist, Goodman and Hartley) and Johnnie Walker Black, 1750mL (Barton, Eder, Goodman and Dwan) over the period. Prices offered by these distinct wholesalers overlap in the vast majority of months. While we might expect correlated wholesale price increases when manufacturer prices rise, which we observe, prices also exhibit considerable month-to-month changes between manufacturer price adjustments that happen in lockstep across wholesalers.
Source: Harmonized Price and Quantity Data. Period from 2013-04-01 to 2013-06-30.

Figure 6: Estimated Own Elasticities and Diversion to the Outside Good



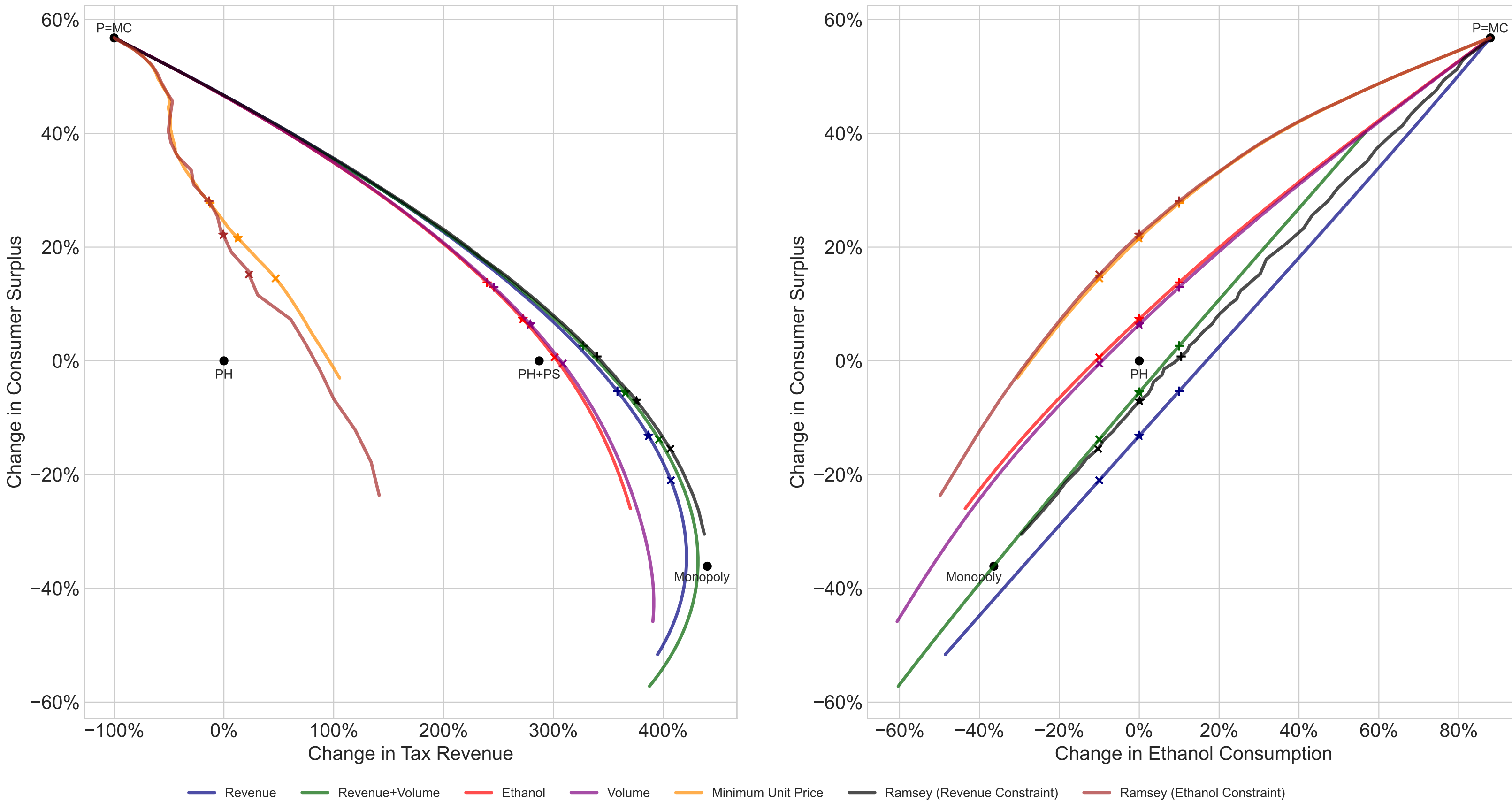
Note: Each observation is a product in 2013Q2. The figure above plots product prices under PH against diversion to the outside good. $D_{j\to 0} = \frac{\partial s_0}{\partial p_j} / \left|\frac{\partial s_j}{\partial p_j}\right|$ or the own price elasticity $e_{jj} = \frac{\partial s_j}{\partial p_j} \cdot \frac{p_j}{s_j}$.

Figure 7: Prices Under PH vs. Other Policy Alternatives



Note: The figure above plots product prices under PH against prices under our counterfactual policy alternatives. In each of our counterfactual scenarios we consider a tax rate that would keep the overall level of ethanol fixed at the status quo. Our taxes follow the definitions in Table 5, and are levied on a competitive market (with the exception of "Both" which applies sales taxes to existing manufacturer costs and excise taxes). The solid black 45 degree line illustrates prices unchanged from PH.

Figure 8: Consumer Surplus vs. Tax Revenue and Ethanol Consumption Under Alternative Policies



Note: The figure above plots the change tax revenue (left panel) and ethanol consumption (right panel) against the change in consumer surplus for each of the policy alternatives to PH detailed in Table 5 that we consider. The frontiers trace the trade-off between consumer surplus and tax revenue or ethanol consumption for each policy instrument. Stars indicate an aggregate ethanol consumption level equal to total ethanol under PH while x denotes 10% more and less ethanol consumption (in the left panel higher ethanol consumption corresponds to less tax revenue). We also mark competitive prices without taxes (denoted by P = MC), and PH pricing. In the left panel we indicate the revenue generate by existing excise taxes under PH pricing as well as the sum of tax revenue and wholesale profits generated by PH.

A. Additional Theoretical Results

B. Empirical Implementation Details

B.1. Recovering Manufacturer Marginal Costs

This part builds on Jaffe and Weyl (2013) and Appendix E from Miller and Weinberg (2017) and almost exactly follows the implementation in Backus et al. (2021a); Conlon and Gortmaker (2020). The wrinkle here is that we observe the manufacturer prices $\mathbf{p^m}$ which simplify matters considerably, and we have the addition of the existing excise tax τ_0, which we show does not create any new issues.

We write the manufacturer's first order conditions as:

$$\mathbf{p^m} = \mathbf{mc^m} + \left(\mathcal{H}_M \odot \left(\frac{\partial \mathbf{p^w}}{\partial \mathbf{p^m}} \cdot \Omega(\mathbf{p^w})\right)\right)^{-1} \mathbf{s}(\mathbf{p^w}) \tag{manuf FOC}$$

This requires that we estimate the pass-through matrix $\frac{\partial \mathbf{p^w}}{\partial \mathbf{p^m}}$.

In order to do so, we re-examine the wholealers' problem: a system of J first order conditions and J prices $\mathbf{p^w}$, with manufacturer prices $\mathbf{p^m}$ and wholesaling costs (including taxes) τ_0 serving as parameters:[55]

$$f(\mathbf{p^w}, \mathbf{p^m}, \tau_0) \equiv \mathbf{p^w} - \underbrace{(\mathbf{p^m} + \tau_0)}_{=\mathbf{mc^w}} - (\underbrace{\mathcal{H}_{PH}(\kappa) \odot \Omega(\mathbf{p^w})}_{\equiv \Delta(\mathbf{p^w})})^{-1} \mathbf{s}(\mathbf{p^w}) = 0 \tag{wholesale FOC}$$

Where $\Delta(\mathbf{p^w}) \equiv \mathcal{H}_{PH} \odot \Omega(\mathbf{p^w})$ is the PH augmented matrix of demand derivatives.

We differentiate the wholesalers' system of FOC's with respect to p_l, to get the $J \times J$ matrix with columns l given by:

$$\frac{\partial f(\mathbf{p^w}, \mathbf{p^m}, \tau_0)}{\partial p_l^w} \equiv e_l - \Delta^{-1}(\mathbf{p^w}) \left[\mathcal{H}_{PH} \odot \frac{\partial\, \Omega(\mathbf{p^w})}{\partial\, p_l^w}\right] \Delta^{-1}(\mathbf{p^w})\, \mathbf{s}(\mathbf{p^w}) - \Delta^{-1}(\mathbf{p^w})\, \frac{\partial \mathbf{s}(\mathbf{p^w})}{\partial p_l^w}. \tag{Col L}$$

The complicated piece is the demand Hessian: a $J \times J \times J$ tensor with elements (j,k,l), $\frac{\partial^2 s_j}{\partial p_k^w \partial p_l^w} = \frac{\partial^2 \mathbf{s}}{\partial \mathbf{p^w} \partial p_l^w} = \frac{\partial\, \Omega(\mathbf{p^w})}{\partial\, p_l^w}$.

We can follow Jaffe and Weyl (2013) and apply the multivariate IFT. The multivariate IFT says that for some system of J nonlinear equations $f(\mathbf{p^w}, \mathbf{p^m}, \tau_0) = [F_1(\mathbf{p^w}, \mathbf{p^m}, \tau_0), \ldots, F_J(\mathbf{p^w}, \mathbf{p^m}, \tau_0)] =$

[55] Because the marginal costs are additively separable we can also define the system as $f(\mathbf{p}, 0, 0) + \mathbf{c} + \tau_0 = 0$.

$[0, \ldots, 0]$ with J endogenous variables $\mathbf{p^w}$ and J exogenous parameters $\mathbf{p^m}$.

$$\frac{\partial \mathbf{p^w}}{\partial \mathbf{p^m}} = -\begin{pmatrix} \frac{\partial F_1}{\partial p^w_1} & \cdots & \frac{\partial F_1}{\partial p^w_J} \\ \cdots & \cdots & \cdots \\ \frac{\partial F_J}{\partial p^w_1} & \cdots & \frac{\partial F_J}{\partial p^w_J} \end{pmatrix}^{-1} \cdot \underbrace{\begin{pmatrix} \frac{\partial F_1}{\partial p^m_k} \\ \cdots \\ \frac{\partial F_J}{\partial p^m_k} \end{pmatrix}}_{=-\mathbb{I}_J} \tag{PTR}$$

Because the system of equations is additive in $\mathbf{p^m}$ and τ_0 this simplifies dramatically $\frac{\partial f(\mathbf{p^w}, \mathbf{p^m}, \tau_0)}{\partial \mathbf{p^m}} = -\mathbb{I}_J$. The pass-through matrix (PTR) is merely the inverse of the matrix whose columns are defined in (Col L).

Implmentation Notes:

1. PyBLP method `compute_passthrough()` will deliver (PTR) (this is very time consuming).
2. PyBLP method `compute_demand_jacobians()` will deliver $\Omega(\mathbf{p^w})$.
3. $\mathcal{H}_m$ is the ownership matrix at the manufacturer level (ie: 1's if both products are owned by Diageo, Bacardi, etc.).
4. $\mathbf{s_t}$ are observed shares and we can plug into (manuf FOC) to get $\mathbf{mc^m}$.
5. Because $\mathbf{mc^m}$ is backed out of (manuf FOC) it is the combination of production costs and federal excise taxes. We never need to separate the two for any counterfactuals.

B.2. Micro Moments

B.2.1. Demographic Interactions

In `PyBLP` Conlon and Gortmaker (2020), all micro moments take the following form, where we match $\overline{v}_m$ with the model simulated analogue. We use the same number of Monte Carlo draws in each market t so that $w_{it} = \frac{1}{I}$ and the general formula simplifies:

$$v_{mt} = \frac{\sum_{i \in I_t} \sum_{j \in J_t \cup \{0\}} s_{ijt} w_{d_m ijt} v_{mijt}}{\sum_{i \in I_t} \sum_{j \in J_t \cup \{0\}} s_{ijt} w_{d_m ijt}}$$

Where $w_{d_m ijt}$ are the survey weights and v_{mijt} is the value. We match the following moments:

1. $w_{dijt} = 1\{j \neq 0\}$ and $v_{mijt} = 1\{\text{Income}_i \in \text{bin}_k\}$ for each market $t \in T$ and "inside" goods only. This allows us to match:

$$\mathbb{P}\left[\text{Income}_i \in \text{bin}_k \mid Purchase\right]$$

2. $w_{dijt} = 1\left\{j \neq 0, x_j = 750mL\right\}$ and $v_{mijt} = 1\{\text{Income}_i \in \text{bin}_k\}$ for each market $t \in T$ and "inside" goods only. This allows us to match:

$$\mathbb{P}\left[\text{Income}_i \in \text{bin}_k \mid 750mL\right]$$

3. $w_{dijt} = 1\left\{j \neq 0, x_j = 1750mL\right\}$ and $v_{mijt} = 1\{\text{Income}_i \in \text{bin}_k\}$ for each market $t \in T$ and "inside" goods only. This allows us to match:

$$\mathbb{P}\left[\text{Income}_i \in \text{bin}_k \mid 1750mL\right]$$

4. $w_{dijt} = 1\left\{j \neq 0, \text{Income}_i \in \text{bin}_k\right\}$ and $v_{mijt} = p^w_{jt}$ for each market $t \in T$ and "inside" goods only. This allows us to match:

$$\mathbb{E}\left[p^w_{jt} \mid \text{Income}_i \in \text{bin}_k \text{ and } Purchase\right]$$

We match a different set of values for each income bin. To avoid colinearity (probabilities sum to one) we exclude the middle income bin for the first three sets of moments. We match a different set of moments for each *year* from 2007-2013, rather than each *market* (a quarter). This is because the NielsenIQ Household Panelist data samples different households each year.

These moments are straightforward to calculate from the NielsenIQ Household Panelist data, and don't require any other data sources beyond the NielsenIQ data. The exception is that for each product, NielsenIQ reports the *retail price* and we must find the corresponding *wholesale price* because the model is defined in terms of *Wholesale Demand*.

B.2.2. Aggregate Elasticity

To capture aggregate elasticity we set $w_{dijt} = 1\left\{j \neq 0, t \in T\right\}$ and $v_{mijt} = \frac{\hat{s}^*_{ijt}(\mathbf{p}(1+\tau), \widehat{\theta})}{\hat{s}_{ijt}(\mathbf{p}, \widehat{\theta})}$ and only use "inside goods" and average over all markets t:

$$v_m(\theta) = \frac{\sum_{t \in T} \sum_{i \in I_t} \sum_{j \in J_t} s_{ijt}(\theta) \cdot v_{mijt}}{\sum_{t \in T} \sum_{i \in I_t} \sum_{j \in J_t} s_{ijt}(\theta)} \approx \frac{1 - \frac{1}{T} \sum_t \hat{s}^*_{0t}(\mathbf{p}(1+\tau), \widehat{\theta})}{1 - \frac{1}{T} \sum_t s_{0t}(\theta)} = \frac{\sum_t \hat{Q}^*_t(\mathbf{p}(1+\tau), \widehat{\theta})}{\sum_t Q_t(\theta)} = 1 + \varepsilon_{agg}.$$

This approximation is valid when $\hat{s}^*_{ijt}(\mathbf{p}, \widehat{\theta}) \approx s_{ijt}(\mathbf{p}, \theta)$. In practice, this requires an initial consistent estimate (just like two-step GMM or approximations to the optimal instruments), and that we evaluate the model at values of θ which generate choice probabilities close to those generated by our initial choice of $\widehat{\theta}$.

While this seems a bit non-standard, this enables us to incorporate the aggregate elasticity as a "micro moment" in the `PyBLP` software.

[Describe DID estimator here.]

C. Robustness Tests

C.1. Allowing for Wholesaling Costs

We might worry that the main results are driven by our assumption that in the absence of post and hold policies, that the wholesaler tier becomes perfectly competitive. A reasonable concern is that wholesaling is not costless, and unless wholesalers charge a markup above manufacturer prices, they may not be able to cover the costs of hiring drivers, and operating warehouses. To alleviate these concerns, we set $\mathbf{mc^w} = \mathbf{p^m} + 1$, so that the wholeslaer incurs an additional cost of of \$1 per liter. We think this is reasonable, as it is in line with the wholesaler margins on the lowest margin items.[56]

Qualitatively the patterns in Figure 8 in the main text, and Figure 9 which allows for the \$1 per liter wholesaling cost, are nearly identical. The relative ranking of various tax instruments, and most importantly the fact that post and hold is clearly dominated by alternative taxes on a competitive market remains the same. Quantitatively, the somewhat higher cost means that the overall level of additional tax revenue that can be generated is reduced slightly, such that we can never increase revenue by more than 400%. The resulting equilibrium prices are highly similar, the main difference being that rather than capturing all of that as additional tax revenue, some must be used to cover the wholesaler costs.

[56]We obtain similar results if we consider larger wholesaleing costs of $\mathbf{mc^w} = \mathbf{p^m} + 2$ or $\mathbf{mc^w} = \mathbf{p^m} + 3$.

Figure 9: Consumer Surplus vs. Tax Revenue and Ethanol Consumption Under Alternative Policies with $\mathbf{c^w} = 1$

Note: The figure above plots the change tax revenue (left panel) and ethanol consumption (right panel) against the change in consumer surplus for each of the policy alternatives to PH detailed in Table 5 that we consider. The frontiers trace the trade-off between consumer surplus and tax revenue or ethanol consumption for each policy instrument. Stars indicate an aggregate ethanol consumption level equal to total ethanol under PH while x denotes 10% more and less ethanol consumption (in the left panel higher ethanol consumption corresponds to less tax revenue). We also mark competitive prices without taxes (denoted by P = MC), and PH pricing. In the left panel we indicate the revenue generate by existing excise taxes under PH pricing as well as the sum of tax revenue and wholesale profits generated by PH.