Wholesale Prices, Retail Prices and the Lumpy Pass-Through of Alcohol Taxes (Preliminary and Incomplete- CITE WITH PERMISSION ONLY)

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Abstract

This paper examines the pass-through of taxation in the market for distilled spirits. By using detailed UPC level data from Nielsen Homescan, as well as state specific wholesale prices from the regulator in Connecticut we are able to measure the pass-through rate of taxation at both the wholesale and the retail level. We find that pass-through of taxes to wholesale prices is incomplete and approximately 70% while pass-through of taxation to retail prices is often excess of 100 and as high as 160%, consistent with other results on the pass-through of excise taxes for spirits. This over-shifting of the tax burden onto consumers is difficult to rationalize with profit maximizing firm behavior and log-concave demand (such as Linear Demand, Logit, or Probit). We offer an alternative explanation which incorporates dynamics in price adjustment, and shows that large pass-through rates are an artifact of small tax increases and lumpy price adjustment via $1.00 increments. When firms follow an (s, S) rule, this has implications for a policy where tax-increases minimize over-shifting behavior that generates additional deadweight loss per unit of government revenue.

Keywords: Excise Tax, Incidence, Market Power, Price Adjustment.

JEL Classification Numbers:

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1 Introduction

> *Hartford Courant: June 28, 2011*
> Michael Bradley, manager at Crazy Bruce's Discount Liquors, says consumers will see the cost of their favorite alcoholic beverages go up, especially distilled spirits. Gov. Dannel P. Malloy's tax package raised the excise tax 20 percent on all alcoholic beverages. The excise tax is paid by wholesalers, but consumers will see the increase reflected in the shelf price of wine, beer and spirits.
>
> The increase amounts to 40 cents for most 1.75-liter bottles of spirits, and much less for beer and wine. But wholesalers and retailers will add a markup on that higher excise tax, because it becomes part of their cost, Bradley says. On top of that, manufacturers are imposing their annual price increases at the same time.
>
> The result: The cost of a bottle will rise by about $1, Bradley says.

The pass-through of taxes and other cost shocks to retail prices has important implications ranging from the distributional impacts of taxes to the volatility of prices. We study the pass-through of alcohol taxes using mew and previously unused product level data form Nielsen Homescan data and wholesale prices from a state regulator to document four features of the pass-through of alcohol taxes. We interpret these stylized facts as evidence of pricing frictions and consider the implications for the efficiency and incidence of taxes on alcoholic beverages.

We think alcohol tax incidence is particularly important for several reasons. The first is that alcohol (along with gasoline and cigarettes) is one of the most heavily taxed commodities and the overall tax-burden can reach as high as 30-40% of the purchase price. The second is that alcohol taxes are extremely well-studied, for example, Wagenaar, Salois, and Komro (2009) perform a meta-analysis examining over 1,003 estimates. A smaller number of studies have examined the pass-through rate of alcohol taxes, but those that do usually find *over-shifting* of the tax or that the pass-through rate exceeds 100% and often as high as 150-200%. A pass-through rate of 150% would imply that when faced with a $1.00 additional tax, firms respond by increasing retail prices by $1.50; this might suggest not only are taxes paid exclusively by consumers, but paradoxically that firms may actually benefit from higher taxes. Finally, understanding the pass-through rate is important for current policy debates. Since the beginning of the Great Recession, six states have increased their alcohol taxes and more than 30 states have proposed increasing their alcohol taxes. Understanding the welfare tradeoffs associated with the tax increases is particularly relevant today.

We first document that alcohol taxes have differing pass-through rates depending on whether we examine store or state level price measures. Varying pass-through rates—ranging from as low as zero to well above unity—are a hallmark of the literature on tax pass-through. The studies of this literature vary as to the type and source of data collected: many of these studies have looked at either state average prices or price indices, though some have used product level scanner data. Table XX describes many of these studies. Examining clothing and personal care item price indices for cities in different states Poterba (1996) found that retail prices rise by approximately the amount of sales taxes. Examining a broader array of goods, Besley and Rosen (1999) could not reject that prices increased by roughly the amount of the sales tax for some goods (including Big Macs, eggs, Kleenex and interestingly, the game of Monopoly) but for more than half of the commodities they studied, taxes were passed on at rates that exceeded unity. Marion and Muehlegger (2011) find that though gasoline and diesel taxes are on average fully passed through to consumers, supply inelasticity lowers while low inventories raise pass-through rates. Studying temporary gas tax holidays, Doyle Jr. and Samphantharak (2008) find that while pass-through of the tax holiday happens within a week, the tax reduction is only partially passed-on to consumers. In their assessment of the incidence of cigarette taxes, Harding, Leibtag, and Lovenheim (2012) found that the excise taxes were less than fully passed through to consumers. DeCicca, Kenkel, and Liu (2013) could not reject full pass-through of cigarette taxes on average, but found that consumers who were willing to search for better prices by buying cartons rather than individual packs or crossing state borders to purchase in lower tax jurisdictions faced significantly less pass-through.

Several studies focus on the pass-through of alcohol taxes. Cook (1981) used price data for leading brands from *The Liquor Handbook* to calculate average yearly prices for each state. He found that the median ratio of price change (adjusted for the yearly median across states) to tax change for the 39 state-years that had tax changes was roughly 1.2. Pass-through studies that rely on indices or other aggregate price measures can potentially underestimate the pass-through as consumers shift towards lower pass-through products within an index category in reaction to the tax. Young and Bielinska-Kwapisz (2002) followed the prices of seven specific alcoholic beverage products and estimated pass-through rates ranging from 1.6 to 2.1. Exploiting Alaska's massive increase in alcohol taxes in 2002 (the taxes on alcoholic beverage more than doubled), Kenkel (2005) reported that the large tax increases were associated with pass-through rates ranging from 1.40 to 4.09 and between 1.47 to 2.1 for spirits products. These studies suggest that not all products experience the same pass-through rate even within a product category.

Pass-through has also been the subject of other literatures in economics. Trade and Macro economists examine pass-through to understand the extent to which cost shocks are dampened (or potentially multiplied) by firms. Nakamura and Zerom (2010) examine the pass-through of cost shocks in the coffee industry, finding that pass-through is incomplete with rates of approximately 23 percent. Further they found that pass-through is sluggish with the delay almost entirely attributable to pricing behavior at the wholesale rather than retail level. In their work aimed at uncovering the factors contributing to the inertia of local currency prices of traded goods despite exchange rate changes, Goldberg and Hellerstein (2013) find an average pass-through rate of just 7 percent. Generally these pricing dynamics are interpreted as a dampening of price volatility between wholesalers and retailers and indicate that firms smooth out shocks and adjust markups rather than passing shocks on to consumers, suggesting that firms may play an important role in reducing volatility within the economy. Microeconomic theory has linked pass-through to the curvature of the demand function, whereby observing the pass-through can inform researchers about which demand specifications are most realistic in particular applications. There has also been a recent theoretical literature in IO which has attempted to link cost pass-through to the price effects of mergers. Building on price theoretic work by Werden and Froeb (1994) and Farrell and Shapiro (2010) Jaffe and Weyl (2013) interpret mergers as increasing the opportunity cost of selling a product, and then use the pass-through to determine the extent of the price increase.

Estimated pass-through rates exceeding unity have been theoretically justified by the presence of imperfect competition among suppliers.[1]. We show that imperfect competition alone is not sufficient to generate over pass-through; demand must also be characterized by a log convex function not typically considered in these contexts. The implausibility of log convex demand suggests a different mechanism may be necessary to explain pass-through rate estimates exceeding one.

The second and third stylized facts that we establish describe features of the pricing behavior of firms. We document that for a wide range of retail products, including distilled spirits, nearly all prices end in \$0.99 increments. In Connecticut, YY percent and nationwide ZZ percent of spirits beverage UPCs feature prices that end in \$0.99. Next we show that even when the measured tax pass-through rate is large (≥ 1) a majority of products do not experience any price change at all; and those products which do experience a price change often change their prices by exactly \$1.00. Overall in Connecticut AA percent of price changes are in whole dollar increments. In July 2011when alcohol taxes were changed in Connecticut, whole dollar changes comprise BB percent of price changes.

The fourth and final fact that we document is that stores with relatively low prices for a given product are more likely to increase its price following the tax increase. The compression of the distribution of prices for a given spirits product reduces the scope for consumers to reduce the pass-through of taxes by shopping. More importantly, this variability amongst stores provides further evidence of heterogeneity in pass-through and suggests that prior work considering a uniform and smooth pass-through rate may be missing important frictions.

Motivated by these empirical facts we propose a somewhat different mechanism for pass-through than the previous literature has examined. The theory underlying pass-through involves smooth transmission of cost shocks to retail prices, and often assumes a homogenous treatment effect, or that the rate of pass-through is similar across products within a category. We suggest that patterns of pricing behavior play an important role in the rate of pass-through. While assuming that a 20 cent tax increase would lead to a 32 cent price increase might be correct on average; in practice it is not true for any products in the dataset. This heterogeneity of pass-through rates matters because the welfare implications when all products experience a 32 cent price increase are quite

[1] INSERT QUOTES FROM PAPERS HERE

different from the welfare implications where two-thirds of products experience no price change and one-third of products experience a \$1.00 price change. Heterogeneity in pass-through potentially allows consumers to minimize their surplus losses by shifting their consumption towards products for which prices do not change. Further, the lumpiness of price changes complicates the welfare calculation as the large price change means this re-allocation of consumers to products following the tax does not simply and smoothly “envelope” out.

We offer an alternative explanation which incorporates dynamics in price adjustment, and suggests that pass-through is a nonlinear function of the size of the cost-shock. Instead of directly measuring the average pass-through rate, which may be highly nonlinear and vary substantially across products; researchers should directly measure the probability of a \$1.00 price increase. We show that large pass-through rates are an artifact of small tax increases and lumpy price adjustment via \$1.00 increments; but that larger tax increases in the same market might lead to substantially smaller estimated pass-through rates. We believe this provides a partial explanation for the wide range of pass-through rates documented in the empirical literature. Furthermore, when firms follow an (s, S) rule, and do not adjust prices until they are sufficiently far from their profit maximizing price; the relationship between taxes and lost consumer surplus can be non-monotonic. We argue that states should be cognizant of this non-monotonicity when levying taxes, and should target tax-increases that lead to round number increases in the tax burden at the individual product level in order to maximize revenue collected per unit of lost consumer surplus.

More broadly an understanding of pass-through that accounts for pricing frictions may also have implications for the macro and trade literatures. If firms follow pricing rules that lead to infrequent but large full dollar price changes, these pricing frictions may provide one plausible explanation for the low and slow pass-through of cost shocks. The pricing frictions we document may both affect the incidence of taxes and have implications for the role of markups in dampening volatility of prices.

The paper proceeds as follows. Section 2 provides background on the alcoholic beverage industry and how it is taxed. In Section 3 we present a theoretical framework and show that market structure can only imply pass-through rates above one when demand is also log convex, suggesting that unusually demand characterizations are required to explain over pass-through when taxes are smoothly passed on to consumers through higher prices Section 4 describes the data. We document the pricing of spirits products and document our four facts in Section 5 and further assess their implications for the understanding of tax incidence and pricing rigidities. Section 6 concludes.

2 Alcohol Taxation and Industry Background

Alcoholic beverages carry unusually high taxes as products are subject to excise taxes at the federal, state and even local level with states and localities often levying both specific and ad valorem taxes.[2] In 2010, federal and state specific taxes raised \$15.5 billion in revenue on an industry in which production, distribution and retailing amount to roughly \$100 billion revenue. Federal taxes are levied as *specific* taxes determined by the alcohol content of a product with different rates for beer, wine and spirits products. Specifically, taxes are levied based on proof gallon—the fraction of a gallon of spirits at 100 proof of 50 percent alcohol by volume—content of product. We focus on distilled spirits, which carry the highest federal tax burden of \$13.50 per proof-gallon or roughly \$2.14 per 80 proof 750mL bottle, which is a common size and alcohol content for vodka and gin.

Though generally lower than federal taxes, states also levy excise taxes on alcohol. In Table 1 we report state taxes in the Northeast . Nationally nearly every state levies a specific tax on alcoholic beverages with spirits taxes in the Northeast ranging from \$1.10 for low-proof beverages in Massachusetts to \$7.44 in the case of New York City which levies an additional \$1.00 tax on top of the New York state tax. Some exceptions include New Hampshire, Pennsylvania and Vermont which employ fixed mark-up rules. All three of these states are *control* states where the state operates part or all of the distribution and retail tiers.[3] Control states are a minority of U.S. states; today only 18 states are control states with several considering privatization. In control states, also known as Alcohol Beverage Control (ABC) states, the alcoholic beverage markets are effectively run by a state monopolist. Control states have been the subject of recent empirical work examining the impact of state-run monopolies on entry patterns (Seim and Waldfogel 2013) and the effect of uniform markup rules as compared to third-degree price discrimination (Miravete, Seim, and Thurk 2014).

The majority of states in the U.S.—today the number stands at 31—are *license* states like Connecticut and the remaining states described by Table 1. In these license states where private businesses own and operate the distribution and retail tiers of the alcoholic beverage market, specific taxes are levied on wholesalers who are responsible for collecting taxes from purchasing retailers and remitting tax payments to the state tax authority. Nearly every state that allows for private retailing has instituted a *three-tier* system of alcohol distribution where the manufacture, distribution and sales of alcoholic beverages are vertically separated.[4]

License states often have ownership restrictions that govern not only cross-tier ownership, but also concentration with in a tier; most importantly, license states generally prohibit vertical integration, keeping the manufacturing, distribution and retailing tiers distinct. Prior work on license states has examined the stickiness of retail pricing using beer prices as an example (Goldberg and Hellerstein 2013) and the welfare effects of exclusivity arrangements in the beer industry in these

[2]Distillers, wholesaler and retailers are also subject to federal and state corporate taxes on profits.

[3]New Hampshire and Pennsylvania fully operate both the wholesale and retail tiers for all alcohol products while Vermont only controls the sale of spirits leaving the wholesaling and retailing of beer and wine to private firms.

[4]In many states these private businesses are subject to a number of retail regulations sometimes referred to as *blue laws*. These regulations govern everything from what kinds of stores can sell alcoholic beverages (specialty package stores, supermarkets, convenience stores), what times of day and days of week alcoholic beverages can be sold, and whether or not coupons or promotions are allowed.

states has been studied by Asker (2005). State-enforced vertical separation in the alcohol industry affects tax policy in two ways. First, it facilitates tax collection. Specific taxes are collected from wholesalers while ad valorem taxes are collected from retailers—the final point of sale. Second, mandated vertical separation creates multiple points of sale for taxes to impact pricing. If the manufacturing, wholesale and retail tiers were all perfectly competitive and frictionless, the statutory incidence of the tax—who remits the payments to the state—would be orthogonal to economic incidence—who ultimately bears the tax burden. The data we have gathered and combined provides a unique perspective on how firms at different points in this vertically separated industry react to and pass on tax increases.

In addition to specific taxes, many states also subject alcohol beverage sales to the state sales tax, an *ad valorem* tax proportionate the price of the product. Eight U.S. states do not subject alcoholic beverages to sales taxes; of the states listed in Table 1 only Massachusetts, New Hampshire and Vermont fall in that category.[5] Sales taxes are levied at the retail stage. Retailers are responsible for collecting these taxes from consumers and remitting tax payments to the state tax authority.

All of these taxes are of course levied in part to address the negative health and public safety externalizes of alcohol. However, governments also tax alcohol for the explicit purpose of raising revenue.[6] Regardless of the motivation, alcohol taxes may be at least partially passed on to consumers. The degree to which consumer prices rise in reaction to a tax determines the incidence and the ultimate equity impact of these taxes.

We examine how an increase in specific taxes in Connecticut was passed-through to wholesale and retail prices. In July 2011, Connecticut raised specific taxes on spirits with at least 7% alcohol content from $4.50 to $5.40 per proof gallon. For a 750mL 80 proof product, the state specific tax increased by $0.1427. This tax increase was statutorily levied on wholesalers; our data on prices wholesalers charge retailers and final retail prices allow us to track how the tax increase affects prices down the supply chain.

Because alcohol taxes are based on a product's ethanol content the small tax increase actually varies across products, helping us identify the effect of taxes on prices separate from factors affecting all products equally such as changes in transport costs. In addition, retailers (and wholesalers) were subjected to a *floor tax* on unsold inventory as of July 1, 2011, which also helps us measure the tax incidence.[7]

[5]Of these eight, Alaska, Delaware, Montana, New Hampshire and Oregon have no state sales tax. Vermont and and North Carolina are control states that do not levy an additional sales tax on off-premise sales but levy sales taxes on on-premise purchases. The only license states that do not levy sales taxes on alcohol are Alaska, Delaware and Massachusetts—of these only Massachusetts has a general retail sales tax.

[6]For example, in 2015 Governor Sam Brownback of Kansas proposed raising alcohol and tobacco taxes to help close the state's $648 million budget shortfall. For more details see http://www.kansas.com/news/politics-government/article6952787.html

[7]The floor tax meant that any product not in the hands of consumers would be subjected to the new tax rate rather than the old tax rate, and prevented retailers from evading the tax by placing large orders in advance of the tax increase. It did not, however, prevent consumers from stockpiling alcoholic beverages in advance of the tax increase.

3 Conceptual Framework

Studies of alcohol taxes generally find pass-through rates exceeding unity with Kenkel (2005) estimating a pass-through rate above four for one brand of spirits . Prior empirical studies have explained estimates exceeding one by appealing to the potential role of imperfect competition in helping firms raise prices to offset tax increases. We show below that over pass-through is not explained by imperfect competition alone. Instead we propose an alternative pass-through mechanism that contrasts with the prior literature's assumption of smooth and homogenous pass-through of taxes to consumer prices and instead focuses on the implications of pricing frictions.

3.1 Imperfect Competition and Pass-Through

Over pass-through has been rationalized by suggestions that markets where prices rise by more than the amount of the tax increase are characterized by imperfect competition.[8] Market power, however, is not alone sufficient to generate over pass-through. Consider a simple derivation of the pass-through rate for a monopolist facing downward sloping demand $Q(p)$ who sets the price p. Using the implicit function theorem, it is possible to consider the comparative static of how the optimal price p^* changes as we vary the constant marginal cost c of the monopolist. This derivation for the pass-through rate of dates back to the time of Cournot, but our derivation more closely follows that in Bulow and Pfleiderer (1983):

$$Q(p) + (p - c)Q'(p) = 0 \leftrightarrow (p - c) = -\frac{Q'(p)}{Q(p)} \equiv \mu(p)$$

Implicit differentiation w.r.t c (adding τ) yields:

$$\frac{dp}{dc} - 1 = \mu'(p)\frac{dp}{dc} \Rightarrow \rho = \frac{1}{1 - \mu'(p)}$$

The pass through rate ρ depends on:

$$\begin{aligned} \log Q' &= \frac{1}{Q}\frac{dQ}{dp} = -\frac{1}{\mu(p)} \\ \log Q'' &= \frac{\mu'(p)}{\mu(p)^2} \end{aligned}$$

[8] For example, Besley and Rosen (1999) state "An important implication of this literature is that in an imperfectly competitive market, varying degrees of shifting are possible in the long run. Indeed, even overshifting is a distinct possibility; i.e., the price of the taxed commodity can increase by more than the amount of the tax." DeCicca, Kenkel, and Liu (2013) also assert "The observed over-shifting in many goods markets is consistent with theoretical analyses of tax shifting under oligopoly and imperfect competition."; they also go on to say that market conditions other than perfect competition can lead potentially lead to both over and under pass-through.

Therefore $\rho > (<)1$ implies that the log-curvature of demand is $\mu' > (<)0$. It is well known that log-concavity is a sufficient (but not necessary) condition for profit maximization in the monopoly case.[9]

Most (though not all) demand models in the literature assume log-concavity of demand, because it implies globally declining marginal revenue curves. For example, demand systems described by multinomial Probit or multinomial Logit are log-concave and imply incomplete pass-through $\rho < 1$. Some forms of Frechet demand (as used in the Trade literature) as well as the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980) have parameter dependent pass-through rates and can rationalize pass through rates $\rho > 1$ as well as $\rho < 1$. Fabinger and Weyl (2013) extend the derivation of the pass-through rate to the case of symmetric imperfect competition so that $\rho = \frac{1}{1-(1-\theta)\cdot\mu'(p)}$ where θ is the Lerner conduct parameter. Anderson, De Palma, and Kreider (2001) provide results similar to those above for a Logit-CES model under differentiated products Bertrand competition that also produce over-shifting of taxes. Because CES demands generate fixed markups it is possible to generate a markup of 150% with a CES parameter of $\sigma = 3$, what is more difficult is explaining why taxes are marked up more than 100% when overall margins are small (as they are in distilled spirits).

A common explanation of $\rho > 1$ in the empirical literature is to attribute the effect to market power. It is worth pointing out that as $\theta \to 1$ we have that $\rho \to 1$ but whether it approaches 1 from the left or the right depends only on the sign of $\mu'(p)$ not the value of θ. In other words when tax increases lead to smooth price increases, over pass-through can only be explained by demand characterized by uncommonly used demand functions not the presence of market power alone.

3.2 Pass-Through with Lumpy Price Adjustments

Although log-convex demand combined with imperfect competition can explain over pass-through, we consider an alternative that may be more plausible, We explore the possibility that firms face re-pricing frictions with the implication that price adjustments may not be smoothly responding to cost shocks. We suggest that pricing frictions rather than imperfect competition help explain estimates of over pass-through of alcohol taxes, and more generally can help explain the variability of estimated pass-through rates.

As we document in Section XX the pricing patterns observed in the data suggest that pricing frictions are related to pricing conventions. In over 93 percent of product-months, prices end in \$0.99 and YY percent of price changes consist of changes in whole dollar increments (i.e. \$1.00,

[9] It is also worth noting that the above results are for a monopolist selling differentiated products under Bertrand competition. In other contexts, such as Cournot competition with free-entry it is possible to allow for pass-through rates in excess of one. This literature employs a conjectural variations approach and dates back to Katz and Rosen (1983). Seade (1985) demonstrated the possibility of profitable cost increases $\rho > 1$ in the Cournot with entry framework and generalized in later work by Hamilton (1999). It is not obvious that Cournot is a sensible framework to understand retail purchases of distilled spirits, however.

\$2.00, \$3.00, etc.). These pricing conventions appear to lead to large but infrequent price changes that determine observed average pass-through rates.

One way to rationalize firms' decisions to change prices in discrete \$1.00 increments, is to assume that firms follow a price setting (s, S) rule where they pay a menu-cost in order to adjust prices; or to assume that the demand function faced by firms is a step-function potentially arising from the left-digit bias of consumers (see Figure 3). Our goal is not to understand the origin of the \$0.99 pricing phenomenon, but rather just to understand the implications for understanding tax incidence and pass-through. Our goal is to characterize the decision rule of the individual retailers when it comes to setting prices, but we do not stipulate where the decision rule arises from.

We could imagine that the observed pricing decisions are the solution to some optimal dynamic program that the retailer solves:

$$V_j(p,x) = \max_p \pi_j(p,x) + \beta E[V_j(p',x')|(p,x)] - MC \cdot I[p \neq p']$$

where MC is the fixed marginal cost of adjusting prices. As such a firm may withstand cost shocks, including tax increases, without altering prices if the increase in value function from adjusted prices fails to exceed the marginal cost of price adjustment, MC. The range of prices, p', that are not sufficiently far from the current price, p, to justify the cost of adjustment, defines the zone of inaction. As shown by Figure 4 under such a scenario, a given tax change, represented by the rays from the origin, can generate very different estimates of pass-through depending on where the product's price is located in the zone of inaction at the time of the tax change. Pass-through would not even be monotonic in the tax change if firms follow such an (s, S) rule. The average pass-through rate over products in a category is determined by the share of products for which a price change is profit maximizing despite adjustment costs. Depending on previous costs shocks across products and the size of the tax increase, mean pass-through over all products could be either above or below one.

To simplify we could assume that retailers only choose among two options: $p_{j,t+1} = \{p_{j,t}, p_{j,t} + \$1.00\}$, which is partially supported by our descriptive work in the Section XX. If we wanted to estimate parameters of a dynamic model, we could consider the approach of Hotz and Miller (1993) or Bajari, Benkard, and Levin (2007) where the first step is to estimate the conditional choice probabilities or the policy function. We would begin by constructing an estimate for $Pr(\Delta p_{jt} = \$1.00|X)$ as flexibly as possible. The literature suggests a non-parametric frequency estimator when the dimension of the state space X is small, and a kernel estimator or flexible probit when the dimension of X is larger.

We document firm pricing behavior in Section XX that is consistent with price adjustment frictions and non-smooth pass-through and explore the implications for understanding pass-through. Large infrequent price changes also have implications for calculating the distributional impact of taxes. Because only some products experience price changes in reaction to a tax increase, the average pass-through rate overstates the surplus loss of consumers. Average pass-through rates belie significant heterogeneity; prices may not increase for a large share of products in a given category. Consumers can substitute away from products in a given category that experience price increases; here this allocation of consumers to products is not second order as suggested in Harberger (1964) and more recently generalized in Chetty (2009). We demonstrate the non-linearity of consumer surplus loss as a function of the tax change.

4 Data Description

In order to understand both the advantages and limitations of potential data sources, it is helpful to understand how alcohol beverages are sold and distributed within the United States. There are 18 *control states*, where the state has a monopoly on either the wholesale distribution or retailing of alcohol beverages (or both). In some control states, the monopoly applies to all forms of alcohol beverages, in others it applies to only distilled spirits (but not wine or beer), and in others it applies only to distilled spirits. In other control states (such as Maine and Vermont) the state nominally controls the distribution and sales of spirits but contracts with private firms. The other 32 states operate under a *license system*. License states follow a *three-tier system* where vertically separated firms engage in the manufacturer of alcohol beverages, distribution, and retail. Almost all states have restrictions that prevent distillers from owning wholesale distributors, or prevent wholesale distributors from owning bars or liquor stores. Several states have other restrictions on the number of retail licenses available, or the number of licenses a single chain retailer can own. States also differ on whether alcoholic beverages can be sold in supermarkets and convenience stores, or are relegated to stand alone liquor stores.

Our primary data source is the Kilts Center Nielsen Homescan Scanner dataset. These are weekly scanner data, which track prices and sales at the UPC (universal product code) level for a (non-random) sample of stores in all fifty states, though in practice we only have sufficient data from 34 states.[10] These weekly data are available from 2006-2012, and include data from both standalone liquor stores as well as from supermarkets and convenience stores. However, participation in the Nielsen dataset is voluntary, and not all stores participate. Supermarkets are much more likely to be included in the Homescan dataset than stand alone liquor stores, and larger chain stores are more likely to participate than smaller mom-and-pop stores. This leads to there being better coverage for states where spirits are sold in supermarkets. We provide more extensive analysis for the effect of the July 2011 tax-increase in the state of Connecticut, where we observe 34 (mostly larger) retailers.

We also gathered data on posted prices for each wholesaler and each product for the August

[10]We lack sufficient data from 15 states, many of which are control states (in bold): **Alabama**, Alaska, Hawaii, **Idaho**, Kansas, **Montana, New Hampshire, North Carolina**, Oklahoma, Oregon, **Pennsylvania**, Rhode Island, Tennessee, **Utah, Vermont, Virginia**.

2007 to August 2013 period from the Connecticut Department of Consumer Protection (DCP). Wholesalers agree to charge retailers these prices for the entire month, and are legally not allowed to provide quantity discounts or price discriminate.[11] Most of the 506 firms who have submitted prices to the state of Connecticut DCP since 2007, exclusively sell wine, or beer and wine; only 159 wholesale firms have ever sold distilled spirits. Among these 159 wholesale firms, the overwhelming majority sell primarily wine and distribute a single small brand of spirits. Only 18 wholesale firms have ever sold brands of distilled spirits that we observe in the Nielsen dataset, and more than 80% of sales come from just six major wholesalers.

There were two important considerations in the construction of our dataset. The first was how to match brands across competing wholesalers, or from wholesalers to Nielsen UPC's. Here we consolidate products so that a product is defined as brand-flavor-size such as *Smirnoff Orange Vodka 750mL*. Sometimes a "product" may aggregate over several UPC's, as changes in packaging can result in a new UPC. This most commonly arises with special promotional packaging such as a commemorative bottle, or as part of a holiday gift set. At other times, the change in UPC may be purely temporal in nature. A "product" may have one UPC for 2007 and 2008, but a different UPC in 2009 and 2010 if the packaging was redesigned. The third most common occurrence is that the same product may be available in both glass and plastic bottles at the same time. We rarely observe price differences for glass and plastic packaging within a product-month, so we also consolidate these UPCs. In total, these consolidations help us to construct a more balanced panel of products over time, and avoid gaps during holiday periods, or products going missing when packaging changes.

The second consideration is how to deal with the time component of our dataset. Our tax changes in Connecticut take effect July 1, 2011 and we observe (fixed) wholesale prices for each calendar month. The Nielsen scanner data are recorded weekly, and some weeks span two months. Another feature of Connecticut law is that temporary retail sales are not allowed, and retail "sales" must be registered with the DCP in advance. This makes it relatively easy for us to

An important consideration in the data construction is the level of aggregation used in the analysis. Because wholesale prices vary at the monthly level, we aggregate our retailer data to the store-week. In order to better mimic previous state-level analysis we also aggregate our data to the state-month level. When we aggregate across stores we use the sales weighted median price. We also construct price changes at both the retail and the wholesale level over different time horizons. For example, we compute 1 month, 2 month, 3 month, 6 month, and 12 month price changes. This lets us measure potential pass-through effects over different time horizons, and allows for the fact that pass-through may not happen instantaneously. Finally, because of how the Nielsen data are

[11] Connecticut is one of 12 states with a set of regulations known as *Post and Hold*, which mandates that all wholesalers post the prices they plan to charge retailers for the following month. Wholesalers must commit to charging these prices for the entire month (after a look-back period when wholesalers can view one another's initially posted prices and adjust their prices downwards without beating the lowest price for the product). For a detailed analysis of these regulations please see (Conlon and Rao 2014).

reported it is sometimes helpful to focus only on the subset of prices where we have consistent price information for the store-month (as opposed to a price change in the middle of the month). Later we mention when we restrict our prices to cases where we observe an unambiguous retail price

5 Desrciptive Evidence and Pass-Through

We begin by summarizing the price changes we observe around the time of the tax increase in July 2011. We report both retail and wholesale price changes at both the state, and individual store level in tables 3 and **??** respectively. At the retail level we see that there is a substantial price increase in both June and July, while at the wholesale level the price increase seems to take place only in the month of July. Moreover, we see that the overall magnitude of the price increase appears to be larger at the retail level (around 40 cents) than it is at the wholesale level (around $1.15 per case). Additionally we see similar effects when looking at the average price increase averaged across stores and products, or when averaging the state level median price across products. Later on in our regression analysis we will deal with other sources of variation including month of year effects and product specific trends more carefully.

The second fact we establish is that an overwhelming majority of retail prices, nearly 93% end in $0.99 and another 3% end in $0.49. We report the frequency of the cents part of the retail prices in Table 4, and perform a similar exercise for the wholesale prices in Table 5. The most common cents component of the wholesale price is $0.91, but that accounts for only 53% of all wholesale prices. One potential explanation for this phenomenon might be that consumers suffer from left-digit bias and are unable to process the cents component of price such as Lacetera, Pope, and Sydnor (2012). Another explanation might be that firms consider a smaller number of discrete price points for cost or information processing reasons.Whatever the source of these discrete price points, they are more common at the retail level than at the wholesale level.

We also show that the majority of price changes are in whole dollar increments by reporting a transition matrix which maps the cents part of the previous period price into the cents part of the current period price. We report these transitions only for periods where a price change occurred and report them in Tables 6 and **??**. We see that of 25,966 price changes 19,173 or almost 74% of them where from $0.99 to $0.99 endings; and 23,386 or 90% of new prices end in $0.99. Again, this suggests that firms do not smoothly pass on cost shocks but rather adjust prices in $1.00 increments.

In Figure 2 we demonstrate that there is a large degree of cross-sectional variation in the size of the tax increase. The source of this variation is that products differ in their size (750mL, 1L, or 1750mL) and their alcohol content (between 21% and 76%). This variation should be ideal to identify the pass-through rate.

We construct our pass-through regression specification similarly to the rest of the literature where j indicates products and t indicates time periods:

$$\Delta p_{jt} = \beta_0 + \rho \Delta \tau_{jt} + \beta_2 c_{jt} + B \Delta X_{jt} + \alpha_j + \gamma_t + \epsilon_{jt} \tag{1}$$

Here ρ represents the pass-through rate which is the parameter of interest. A value of $\rho = 1$ implies full or 100% pass-through, while a value $\rho > 1$ implies over-shifting of the tax burden and $\rho < 1$ indicates incomplete pass-through. We allow for product fixed effects α_j which in the differenced model have the interpretation of a product-specific time trend. We also allow for γ_t time fixed effects, here we allow for month of year fixed effects, and year fixed effects, but do not allow for month-year fixed effects. In some specifications we control for c_{jt} or the cumulative change in the wholesale price since the last price change. We do this for two reasons. First, it is helpful to understand if taxes are treated differently by firms than other changes to marginal cost. Second, we believe this cumulative cost increase may be an important determinant of the "initial conditions" of the retailer when the tax increase arrives. We would expect retailers that have recently increased prices, and thus have $c_{jt} = 0$ to be less affected by the tax increase; and retailers with large accumulated cost increases to be more likely to change prices in response to the tax increase.

We report our results using the state median prices in Table **??**. As a comparison we perform the same exercise but include all changes in wholesale prices (not just those induced by the tax in Table **??**. We try various specifications in each column where we include additional controls such as: product specific trends, the cumulative difference in wholesale prices since the previous retail price change in columns (1)-(4). In column (5) we report results for only those cases where the retailer changes his price. Finally in columns (6) and (7) we report difference-in-difference estimates using product level data for Florida and Texas.

We see several patterns emerge. The first is that over a one-month horizon we observe a pass through rate of approximately $\rho = [1.4, 1.5]$ that does not vary much with covariates indicating over-shifting of the tax. As we expand the window to two and three months we get estimates around $\rho = [1.0, 1.2]$ depending on the specification. We cannot rule out full pass-through or moderate amounts of overshifting. At the six month horizon, we do not have much power to measure the effect of the tax, in part because other costs have changed and prices may have adjusted for reasons we have not controlled for. The other important point is that conditional on a retail price change (5) we find an extremely large pass through rate that is always $\rho > 1$ and potentially $\rho > 2$. This is not surprising given the tendency of $1.00 price increases and the relatively small tax increases we observe in the data. In general, these results are consistent with the previous literature on pass-through of alcohol taxes which finds that taxes are over-shifted Kenkel (2005).

When we repeat this exercise using changes in the wholesale price instead of just changes in the tax rate (Table **??**), we find that the pass-through rate in the short-run is between 6-7% and increases to around 40% at one year or two years. This is more consistent with the results of slow and incomplete pass-through documented in the macro and trade literature by Nakamura and

Zerom (2010) and Goldberg and Hellerstein (2013) for coffee and beer.

We also run our pass-through regressions at the more granular store-month level. We report those results in Table **??**. Here we find a pass-through rate of around $\rho = [0.7, 0.8]$, so that pass through is incomplete though the estimated pass-through rate does not vary much with the time horizon and appears to be instantaneous. Again, if we estimate ρ conditional on retail stores with price changes we would measure a pass through rate of around 200%.

In one sense, we were able to successfully reproduce three facts from the existing pass-through literature: a) using state-product level data alcohol taxes appear to be overshifted and adjust quickly b) using state-level data pass-through of other cost shocks is slow and very small and c) using scanner data at the store level we observe incomplete pass through of around 75%. At the same time, we might worry that we used the same tax increase and data source and found three very different patterns of pass-through. These conflicting results are particularly problematic if we want to use estimates from the pass-through of tax increases to draw inferences about non-tax cost increases, such as an input price shock or a merger. Would we want to use the $\rho = 1.4$ or $\rho = 0.06$?

One explanation for our somewhat puzzling results is that they may be an artifact of both the lumpy adjustment of individual prices at the store level and the aggregation from the store level to the state level. We provide an example in Table 9. For Burnett's Vodka we see that 13 stores sell the product for \$14.99 in April and May and only one sells it for \$15.99. When the taxes increase in July, we see that 5 stores now sell the product for \$15.99 and only 6 sell it for \$14.99 and we see some intermediary prices (because of aggregation) for the other stores. By August of 2011, all 14 stores sell the product for \$15.99. Likewise for J&B Rare Whiskey we see 5 stores selling for \$36.99, 8 stores selling for \$39.99 and 2 stores selling for \$41.99 before the tax and by September we see 5 stores selling for \$38.99, 6 stores selling for \$39.99 and no stores selling below \$38.99.

These are meant to provide examples of a larger pattern that we observe in the data. When there is price dispersion across retailers selling an identical product during the same month, the lower priced retailers are more likely to raise their prices than the higher priced retailers. This can lead the sales-weighted state-level median price to appear to be more sensitive to the tax than the prices at individual stores, especially if the lower priced stores have greater sales volume. However, if retailers were able to smoothly pass-through the tax rather than change prices in discrete \$1.00 increments we would expect this aggregation effect to be smaller.

5.1 An (s, S) Rule for Price Setting

We may not want to use an estimate of $\rho = 1.4$ for welfare analysis even though it is theoretically possible that taxes increase the profitability of firms despite the fact that we rarely see firms lobby for higher taxes (Seade 1985). Likewise, we may not want to declare our store-month level estimate of the pass-through rate $\rho = 0.7$ to be the "true" estimate and other estimates to be "biased".

When firms adjust prices in discrete increments, such as \$1.00 the resulting pass-through rate may be highly nonlinear. We illustrate this phenomenon in Figure 4. Here we suppose that firms decide whether to increase price by \$1.00 or not given some decision rule. It might be that for a very small tax increase (red line) almost no price changes are induced and thus we measure the slope of that line ρ to be nearly zero. For a medium sized tax increase (purple line) we might just incur a large number of price changes and infer the slope of the line $\rho > 1$. Finally, for a larger tax increase (blue line), we might induce not many more price changes than the medium sized tax increase, but because of the larger tax increase find that the slope $\rho < 1$. Thus the pass-through rate we are likely to detect might depend on the size of the tax increase. Also, pre-existing conditions may also determine whether or not a retailer increases prices in response to a tax increase. For example, if the retailer has just changed his price he may be less likely to adjust prices in response to a tax increase; whereas a retailer who hasn't changed prices in many months may be more likely to change prices in response to a tax increase. Another important factor may be the degree to which wholesale prices have increased since the previous retail price change. A multi-product retailer may also want to adjust prices of similar products at the same time, or the optimal price of one product may change when the retailer changes the price of a close substitute.

One way to rationalize firms' decisions to change prices in discrete \$1.00 increments, is to assume that firms follow a price setting (s, S) rule where they pay a menu-cost in order to adjust prices; or to assume that the demand function faced by firms is a step-function potentially arising from the left-digit bias of consumers (see Figure 3). Our goal is not to understand the origin of the \$0.99 pricing phenomenon, but rather just to understand the implications for understanding tax incidence and pass-through. Our goal is to characterize the decision rule of the individual retailers when it comes to setting prices, but we do not stipulate where the decision rule arises from.

We could imagine that the observed pricing decisions are the solution to some optimal dynamic program that the retailer solves:

$$V_j(p, x) = \max_p \pi_j(p, x) + \beta E[V_j(p', x')|(p, x)] - MC \cdot I[p \neq p']$$

To simplify we could assume that retailers only choose among two options: $p_{j,t+1} = \{p_{j,t}, p_{j,t} + \$1.00\}$, which is partially supported by our descriptive work in the previous sections. If we wanted to estimate parameters of a dynamic model, we could consider the approach of Hotz and Miller (1993) or Bajari, Benkard, and Levin (2007) where the first step is to estimate the conditional choice probabilities or the policy function. We would begin by constructing an estimate for $Pr(\Delta p_{jt} = \$1.00|X)$ as flexibly as possible. The literature suggests a non-parametric frequency estimator when the dimension of the state space X is small, and a kernel estimator or flexible probit when the dimension of X is larger.

We begin with a simple probit estimator at the store-product-month level and report those results in Table 10. For all specifications we find that price changes are very responsive to the tax increase. Those results indicate that firms are more likely to adjust the prices of products with higher prices, or products with higher sales. This seems quite intuitive. In percentage terms a price increase from $7.99 to $8.99 is quite different from a price increase from $47.99 to $48.99. Likewise, it may be more important to price correctly on more popular products. The other potential state variable is the cumulative change in the wholesale price since the previous retail price change. This is meant to capture where in the (s, S) band of inaction the retailer is. As c_{jt} becomes larger it should be closer to the threshold of changing its price. This is not a perfect proxy, what we would like to actually observe is the distance between the retailer's current price and their "ideal" price but the hope is that c_{jt} should be correlated with the distance from the "ideal" price. If tax changes were like any other cost shock, we would expect the magnitude of the tax increase and the cumulative cost change to be about the same, instead we find that the tax effect is an order of magnitude larger. If we condition on products which did not change their price in the previous period, we find that the price and sales volume terms no longer have any explanatory power but the tax and cumulative wholesale price change terms are largely unaffected.

One explanation for the large discrepancy between the response to the tax change and the response to other wholesale price changes is that the tax change hits all products at the same time. In order to attempt to control for this we include an additional variable which captures the fraction of other products within the same category at the same store that also experience a price change that month. This may also capture other aspects of the retailers decision rule (if they adjust Rum prices every May and Whiskey prices every April). We report those results in Table **??**. We find that this additional control has a lot of explanatory power, and after we include it we find that there is no additional effect of the tax change beyond the wholesale cost change. Identification is questionable because our additional control is highly correlated with the timing of the tax-change. We should also state that this additional regressor is clearly endogenous. We do not want to causally interpret any of the parameters in Table **??**.

5.2 Description of Random Forest

[COMING SOON]

5.3 Counterfactual Experiments

We consider a counterfactual policy where instead of increasing taxes by $0.90 per proof gallon, Connecticut increases prices by $1.80 per proof gallon. For a large bottle of full-proof vodka this would represent a tax impact of approximately $0.84, and would not represent a cost increase of more than $1.00 for any product. Using our probit specification we find that only 24% of products at the 750mL size would see a $1.00 price increase under existing taxes and 27% would see a price increase under our counterfactual taxes. This effect is larger for the 1.75L sizes with 33% seeing a tax increase under the observed tax increase and 40% seeing a price increase in the counterfactual tax increase. We report these results in Table 13.

When we consider the welfare implications of the two tax increase we find that consumers are \$3,063 worse off under the observed tax increase and \$3,132 worse off under the counterfactual tax increase, because so few products increase in price when the tax doubles. Producers on the other hand are \$4,146 worse off under the observed tax increase but \$11,286 worse off under the counterfactual tax increase. This suggests that under the observed tax 73% is on the consumer side, but if the tax increase were doubled only 17% of the incidence would be borne by consumers. This also highlights why estimating a single pass-through parameter in order to calculate tax incidence can be very difficult.

If we compare the revenue raised per unit of deadweight loss, we find that doubling the tax increases the DWL by less than 2% since very few retail prices change in response to the additional taxes. However, the revenue raised almost doubles. Thus for only a small increase in the deadweight loss, we could bring in 98% more revenue than the existing tax.

What our model does not let us do is forecast outside the domain of a \$1.00 price increase. We cannot evaluate potential tax increases that might lead to \$2.00 and \$3.00 tax increases; especially since tax increases of this magnitude are rarely observed in practice (in Connecticut or otherwise).

6 Conclusion

We find that when retail price adjustments are discrete rather than continuous it can present difficulties in estimating the pass-through rate using traditional regression approaches because the resulting pass-through parameter is far from a constant treatment effect, but rather is a highly nonlinear function. Depending on the level of aggregation, the pre-existing market conditions (location within the band of inaction), and the size of the tax increase we find it is possible to recover pass-through rates between 0% and 200% using virtually the same data and identification strategy. While these results may appear to be quite negative, we propose a solution that is just as straightforward as the pass-through regressions which assume smooth and continuous pass-through. We recommend that instead, researchers estimate the probability of a unit price increase directly from the data, and use that to simulate counterfactual prices and welfare under various tax increases. If we interpret counterfactual pricing as a purely predictive exercise then we may want to use techniques from machine learning such as random forests which give us better out of sample predictive accuracy.

We also suggest that policy makers pay attention to round numbers when choosing tax increases. Because retailers may round up to the next dollar when setting prices, choosing tax increases that reflect \$1.00 increments at the unit sale level are likely to generate more revenue per unit of deadweight loss or lost consumer surplus than smaller tax increases that do not result in round increments.

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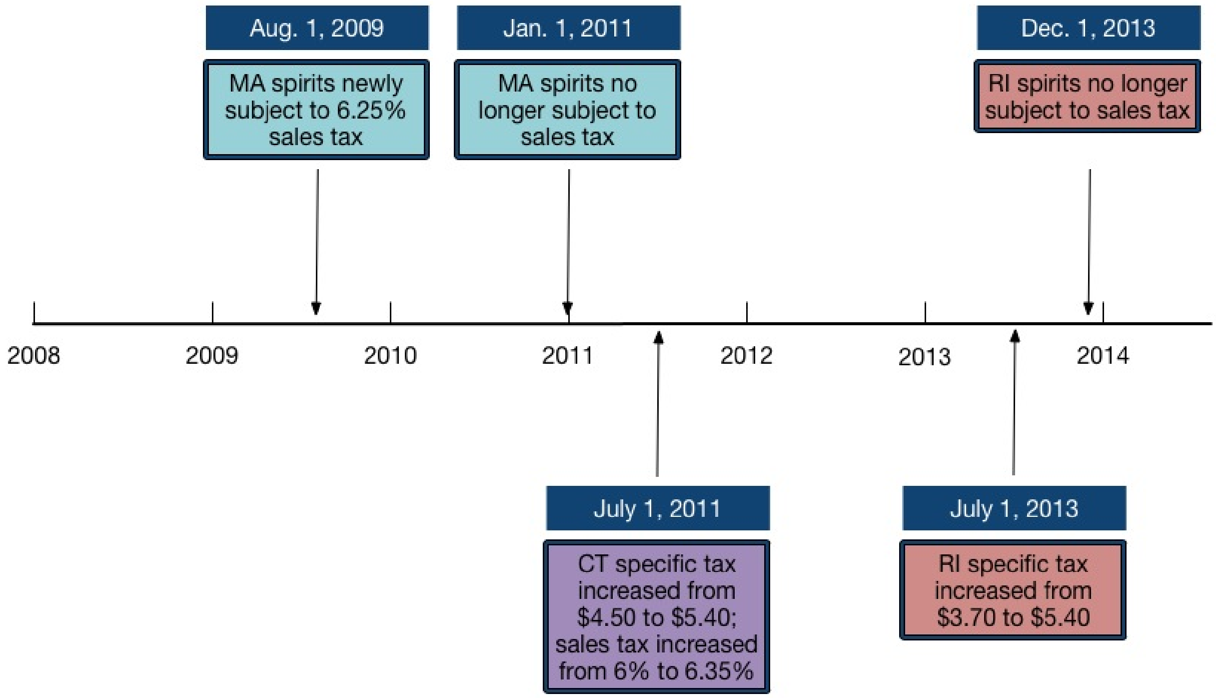

Figure 1: Timing of Alcohol Tax Changes in Connecticut and Neighboring States

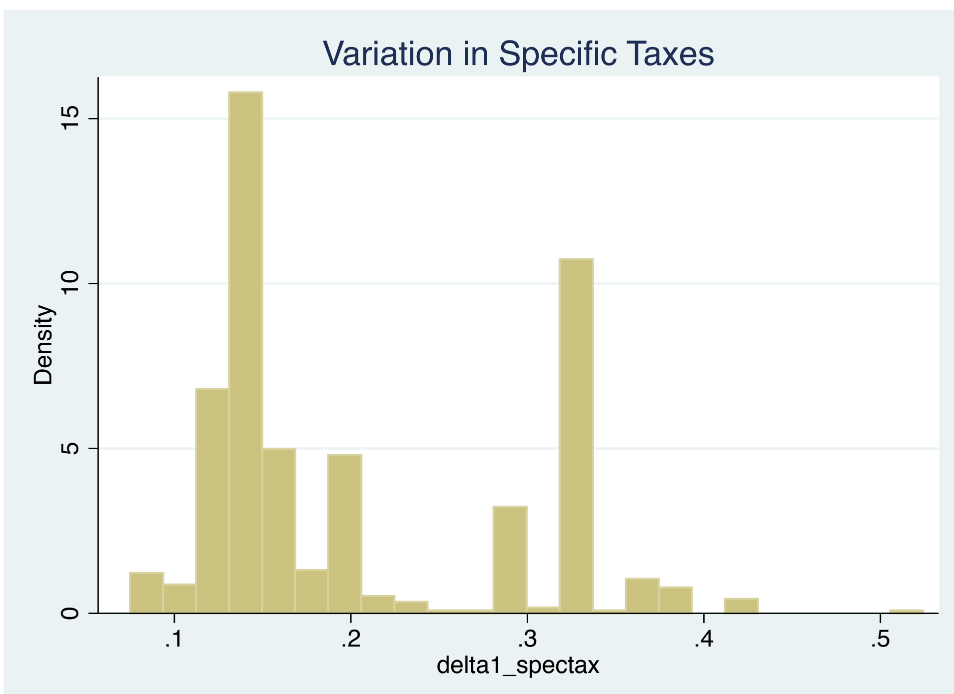

Figure 2: Magnitude of Tax Changes in Cross Section

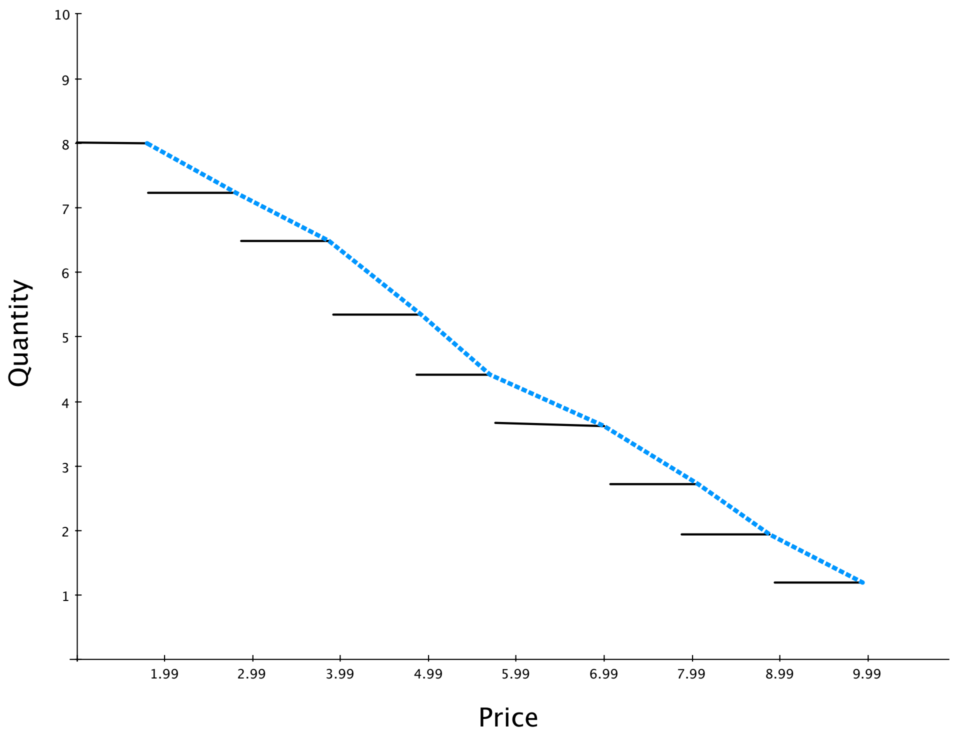

Figure 3: Perceived Demand as an (s, S) rule

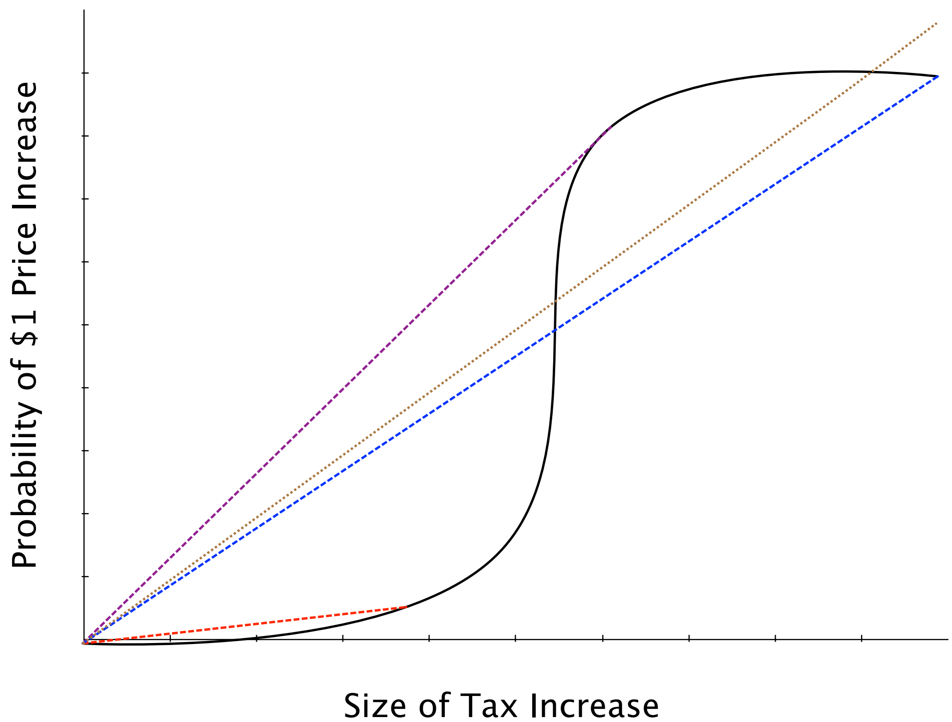

Figure 4: Probability of $1 Tax increase at different tax sizes

Table 1: Recent Changes in Distilled Spirits Taxes

State	Old Tax	New Tax	Effective Date	Notes
Connecticut	\$4.50/gal + 6% sales tax	\$5.40/gal + 6.35% sales tax	July 1, 2011	
Illinois	\$4.50/gal + 6.25% sales tax	\$8.55/gal + 6.25% sales tax	Sept 1, 2009	additional local sales tax
Kentucky	\$1.92/gal	\$1.92/gal + 6% sales tax	April 1, 2009	additional 11% wholesale tax
Maryland	\$1.50/gal + 6% sales tax	\$1.50/gal + 9% sales tax	July 1, 2011	
Massachusetts	\$4.05/gal	\$4.05/gal + 6.25% sales tax	September 1, 2009	Ended Jan 1, 2011
New Jersey	\$4.40/gal + 7% sales tax	\$5.50/gal + 7% sales tax	August 1, 2009	sales tax was 6% before 7/1/06
Rhode Island	\$3.75/gal + 7% sales tax	\$5.40/gal + 0% sales tax	December 1, 2013	

Table 2: Mean Change in Retail Price, Wholesale Price and Specific Tax, CT 2011 [State-Month] [NEED TO UPDATE]

	Retail Price		Wholesale Price		Specific Tax (\$)
Month	Monthly Change (\$)	Observations	Monthly Change (\$)	Observations	
1	0.079	509	0.426	846	0
2	0.110	502	-0.643	826	0
3	-0.272	502	0.285	809	0
4	-0.096	506	-0.083	832	0
5	0.269	512	0.086	857	0
6	0.096	509	-0.390	853	0
7	**0.131**	518	**1.157**	877	**0.204**
8	**0.284**	516	-0.338	875	0
9	0.092	513	0.306	866	0
10	-0.232	519	-0.478	877	0
11	-0.249	519	0.299	884	0
12	-0.022	524	-0.276	885	0

Note: Means are unweighted. The retail and wholesale means describe the same number of products; the number of wholesale observations exceeds the number of retail observations because multiple wholesalers sell the same product in some months.

Table 3: Mean Change in Retail Price, Wholesale Price and Specific Tax, CT 2011 [Store-Month] [NEED TO UPDATE]

	Retail Price		Wholesale Price		Specific Tax ($)
Month	Monthly Change ($)	Observations	Monthly Change ($)	Observations	
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2	0.110	502	-0.643	826	0
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4	-0.096	506	-0.083	832	0
5	0.269	512	0.086	857	0
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12	-0.022	524	-0.276	885	0

Note: Means are unweighted. The retail and wholesale means describe the same number of products; the number of wholesale observations exceeds the number of retail observations because multiple wholesalers sell the same product in some months.

Table 4: Cents Portion of Retail Prices CT 2008 - 2012 [Store-Month]

Cents	Obs	% of Total
99	268,720	92.61
49	8,930	3.08
59	4,917	1.69
93	1,382	0.48
69	1,041	0.36
95	851	0.29
79	577	0.20
89	385	0.13
Other	3,348	1.15
Total	290,151	

Note: Counts are unweighted.

Table 5: Cents Portion of Wholesale Prices (Top 20), CT 2008 - 2011 [State-Month] [NEED TO UPDATE]

Cents Portion of Retail Price	Frequency
91	23,841
41	5,320
16	1,335
74	1,321
58	1,302
24	1,220
79	1,059
99	988
66	787
8	774
49	457
29	451
21	438
61	393
33	349
11	340
51	305
71	303
31	255
4	231
Total	44,645
Percentage 91	0.534

Note: Counts are unweighted.

Table 6: Change in Cents Portion of Retail Prices, CT 2011 [Store-Month] where $\Delta P \neq 0$

	Current																				
Lag	11	24	29	33	39	45	49	53	55	59	65	69	75	79	85	88	89	93	95	99	Total
11	2		2						1											7	12
24		2				1	9					1	1						1	59	74
29			29			3	3					2		2						28	67
33							1	1										12		8	22
39						2	6			2		6								34	50
45					2	1	2			1			2						2	40	50
49		7	1		4	3	119		1	79	2	32	4	6	3	2		3	10	1,443	1,719
53				1														2		4	7
55							2			11			2	1	3				2	79	100
59						1	63	1	14	32	7	2	14	11	11		2	2	33	529	722
65							1			4			4		1				3	73	86
69			4						2	1		14		2					3	119	145
75		1	1			1	6		1	12			2		4				6	181	215
79							2			2				13					8	95	120
85							3		2	9	1				2			1	12	109	139
88							2					1								26	29
89							5								1			1		49	56
93				12			1	3		1	1							88	5	67	178
95		1		1			18	1	4	27	3	2	6	4	1			4	2	466	540
99	14	56	41	11	30	47	1,457	3	88	492	75	101	176	95	108	23	12	177	499	32,672	36,177
Total	16	67	78	25	36	59	1,700	9	113	673	89	161	211	134	134	25	14	290	586	36,088	40,508

Note: Table shows monthly transitions for cents portion of store-product prices where the product price changed at that store

Table 7: Pass-Through: Taxes to Retail Prices [State-Month]

	Full Sample			Δ Retail Price$\neq 0$		
Δ Retail Price	1m	2m	3m	1m	2m	3m
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Tax	1.473**	1.023***	1.165***	2.690***	1.347**	1.368**
	(0.612)	(0.395)	(0.400)	(1.024)	(0.535)	(0.568)
Cum Diff.	0.020**	0.029*	0.048***	0.028*	0.042*	0.068***
	(0.010)	(0.016)	(0.014)	(0.016)	(0.023)	(0.019)
Obs.	27,432	27,318	27,230	10,266	12,009	12,976
Product FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: All regressions are weighted by monthly Nielsen units and include month and year fixed effects.

Table 8: Pass-Through: Taxes to Retail Prices [Store-Month]

	Full Sample			Δ Retail Price$\neq 0$		
Δ Retail Price	1m	2m	3m	1m	2m	3m
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Tax	1.110***	1.125***	1.112***	1.822*	1.616**	1.647***
	(0.294)	(0.227)	(0.244)	(0.981)	(0.643)	(0.608)
Δ Tax	1.094***	1.090***	1.050***	1.852*	1.612***	1.653***
	(0.299)	(0.224)	(0.241)	(1.005)	(0.645)	(0.596)
Cum Diff.	0.043***	0.043***	0.059***	0.145***	0.102***	0.127***
	(0.007)	(0.007)	(0.009)	(0.025)	(0.021)	(0.024)
Observations	240,289	235,787	232,306	42,420	51,094	63,833
Product FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: All regressions are weighted by monthly Nielsen units and include month and year fixed effects.

Table 9: Price Frequency By Store and Product for 2011

	April	May	June	July	August	September
	Burnett's Vodka 1750mL @ 80PF					
14.99	13	13	9	6	0	0
15.49	0	0	0	1	0	0
15.59	0	0	0	1	0	0
15.62	0	0	0	1	0	0
15.66	0	0	1	0	0	0
15.74	0	0	1	0	0	0
15.99	1	1	3	5	14	14
	J and B Rare Whiskey 1750mL @ 86PF					
36.99	5	5	5	0	0	0
37.66	0	0	0	1	0	0
38.99	0	0	0	4	5	5
39.99	8	7	7	7	6	6
41.99	2	2	2	2	1	2

Table 10: Probability of Price Increase [Store-Month]

	Full Sample			Lag Δ Retail Price= 0		
Δ Retail Price	1m	2m	3m	1m	2m	3m
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Tax	2.087***	2.073***	1.984***	2.755***	2.800***	2.776***
	(0.311)	(0.284)	(0.283)	(0.364)	(0.372)	(0.363)
$\log(p_t)$	0.439***	0.378***	0.346***	0.355***	0.304***	0.273***
	(0.055)	(0.046)	(0.053)	(0.069)	(0.066)	(0.069)
$\log(q_{t-1})$	-0.114***	-0.051***	-0.025	-0.101***	-0.025	-0.001
	(0.013)	(0.013)	(0.017)	(0.017)	(0.016)	(0.020)
Δ Tax	2.070***	2.016***	1.891***	2.768***	2.710***	2.667***
	(0.318)	(0.284)	(0.280)	(0.384)	(0.371)	(0.358)
$\log(p_t)$	0.398***	0.301***	0.246***	0.232***	0.169**	0.144*
	(0.058)	(0.050)	(0.059)	(0.078)	(0.074)	(0.075)
$\log(q_{t-1})$	-0.114***	-0.051***	-0.025	-0.103***	-0.026	-0.001
	(0.013)	(0.014)	(0.017)	(0.017)	(0.016)	(0.020)
cum(Δ wholesale)	0.042***	0.070***	0.077***	0.117***	0.122***	0.108***
	(0.007)	(0.008)	(0.008)	(0.012)	(0.011)	(0.010)
Δ Tax	0.825**	0.848***	0.643**	1.695***	1.519***	1.392***
	(0.342)	(0.312)	(0.298)	(0.440)	(0.418)	(0.392)
$\log(p_t)$	0.312***	0.236***	0.170***	0.167**	0.113	0.078
	(0.057)	(0.052)	(0.060)	(0.080)	(0.077)	(0.078)
$\log(q_{t-1})$	-0.110***	-0.046***	-0.022	-0.100***	-0.021	0.004
	(0.013)	(0.012)	(0.016)	(0.017)	(0.016)	(0.020)
cum(Δ wholesale)	0.047***	0.070***	0.080***	0.120***	0.125***	0.111***
	(0.008)	(0.008)	(0.008)	(0.012)	(0.011)	(0.011)
Frac. PriceΔ	2.944***	2.771***	2.542***	2.504***	2.744***	2.525***
	(0.114)	(0.103)	(0.101)	(0.134)	(0.129)	(0.118)
Observations	236,338	228,315	221,206	172,415	166,801	161,458

Note: All regressions are weighted by monthly Nielsen units and include month and year fixed effects.

Table 11: Fit of Models

	Full Sample			During Tax Increase		
	0	1	Error	0	1	Error
	All available data					
0	166695	3011	1.77%	2401	0	0.00%
1	22528	11009	67.17%	1	1421	0.07%
	OOB error: 12.57%					
	Minus % of same store price changes and q_t					
0	167405	2301	1.36%	2399	2	0.08%
1	21295	12242	63.50%	12	1410	0.84%
	OOB error: 11.61%					
	Minus specific tax interaction					
0	167165	2541	1.50%	2400	1	0.04%
1	20741	12796	61.85%	6	1416	0.42%
	OOB error: 11.46%					
	Minus all data during tax period (Pure OOS)					
0	162561	2426	1.47%	2359	42	1.75%
1	21701	9489	69.58%	1242	180	87.34%
	OOB error: 11.35%					
	Probit (with all available regressors)					
0	113,386	80,186	41.42%	1,592	346	17.85%
1	17,906	14,639	55.02%	1,345	403	76.95%

Table 12: Model Fit for July 2011

		Pred 0	Pred 1	Total	Error
Probit	Actual 0	5,530	2,231	7,761	28.75%
	Actual 1	451	618	1,069	42.19%
Random Forest	Actual 0	4718	1	4719	0.02%
OOB 12.56%	Actual 1	4	2340	2344	0.17%
w/o % Price Changes	Actual 0	4535	184	4719	3.90%
OOB 12.59%	Actual 1	157	2187	2344	6.70%

Same Factors: Month and Year Dummies, Cumulative Wholesale Change, Dollar Portion of Price (log), lagged unit sales (log), Size, Proof.

Table 13: Counterfactual Probability of Price Change for Doubling a Tax

	Probit		Random Forest	
	$P(\Delta tax)$	$P(2 * \Delta tax)$	$P(\Delta tax)$	$P(2 * \Delta tax)$
750mL	24%	27%	28%	28%
1000mL	29%	33%	32%	35%
1750mL	33%	40%	41%	42%

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