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

Christopher T. Conlon* Nirupama S. Rao†

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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.

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*cconlon@columbia.edu, Columbia University Department of Economics. 1132 International Affairs Building. 420 W 118th St New York, NY.

†nirupama.rao@nyu.edu, Robert F. Wagner School of Public Service, New York University. 295 Lafayette St New York, NY.

1 Introduction

Pass-through, or the extent to which cost shocks are reflected in retail prices is an important concept which cuts across fields in economics. Pass-through a long history in public economics and tells whether taxes are paid by consumers or by various firms in the supply chain. That literature has long accepted that the physical incidence (which side of the market remits the tax payment) is largely irrelevant, and instead the relative elasticities of consumers and firms determines the allocation of the tax burden. Trade and Macro economists have used pass-through to understand the extent to which cost shocks are dampened (or potentially multiplied) by firms. If firms are slow to respond to cost shocks, and only partially pass them on to consumers, then firms may play an important role in reducing the 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. Recent efforts in Industrial Organization have linked the pass-through of cost shocks to the potential price effects of mergers.

A major appeal of the pass-through rate as an economic object is that it is transparent and easy to understand both theoretically and empirically. Pass-through emerges as a treatment effect on an experiment where: taxes are raised, input prices or exchange rates fluctuate, or other cost shocks are observed. One can simply look at prices before and after a new tax is implemented within a simple regression framework in order to estimate the pass-through rate. There is in fact a large literature that does just this, yet the resulting pass-through rates vary tremendously depending on: the market studied, the time horizon, the level of aggregation in the data, and the nature of the shock (taxes, commodity prices, exchange rates, etc.). In practice some studies have reported virtually no pass-through at all, while others have reported pass-through rates in excess of 100%.

Our study examines the pass-through rate for alcohol taxes. We think this 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 1,100 studies. 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.

Motivated by our empirical setting, 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 document that for a wide range of retail products, including distilled spirits, nearly all prices end in \$0.99 increments. We also show that even when the measured 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. 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 matters because the welfare implications when all products experience a 32 cent price increase are quite 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.

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; 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.

2 Literature Review

Given the centrality of tax incidence to understanding the distributional impact of taxes, unsurprisingly many prior studies have analyzed the how prices are affected by taxes and alcohol taxes in particular have been the subject of a number of empirical studies. In general, these studies vary as to the type and source of data collected: most studies have looked at either state level average prices or price indices, though some have used product level scanner data; studies have examined transitory increases in commodity prices or exchange rates, or more permanent increases in sales or excise taxes.

Poterba (1996) studied clothing price indices for cities in different states and found that retail prices rise by approximately the amount of sales taxes. Examining a broader array of goods, Besley and Rosen (1999) found that prices increase 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 the pass-through of gasoline taxes is less than one while the pass-through of diesel taxes is greater than one.

Numerous studies have focuses 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. Young and Bielinska-Kwapisz (2002) followed the prices of three 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 passthrough rates ranging from 1.47 to 2.1.

More broadly, the way in which producers pass on marginal cost shocks has been the subject of a growing literature in macroeconomics and trade. Nakamura and Zerom (2010) examined 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.

There has also been a recent 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) 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 Jaffe and Weyl (2013).

3 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. 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. Alcohol 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.[1] Regardless of

[1] 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

the motivation, these taxes are partially passed on to consumers. The degree to which consumer prices rise in reaction to a tax determines the ultimate equity impact of these taxes.

Federal taxes are levied as *specific* taxes that are determined by the alcohol content of each product with different rates for beer, wine and spirits. Specific taxes are levied on the pure ethanol content rather than revenues or volume. In the US these taxes are at the unit of a proof gallon or gallon of spirits at 100 proof or 50 alcohol by volume. 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, we report those taxes in Table 1. In Connecticut the tax rate is $4.50 per proof gallon prior to the tax increase and $5.40 per proof gallon after. Nearly every state levies a specific tax on all alcoholic beverages with spirits taxes ranging from $1.10 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.[2] 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). Where the wholesale tier is private, specific taxes are levied on wholesalers who are responsible for collecting taxes from purchasing retailers and remitting tax payments to the state tax authority.

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.[3] 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.

Control states are a minority of U.S. states; today only 18 states are control states with several considering privatization. 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 license states, private businesses own and operate the distribution and retail tiers of the alcoholic beverage market. 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 sep-

[2]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.

[3]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.

arated.[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 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 particular, we examine the consequences of an increase in Connecticut's specific tax in July 2011. Connecticut increased its specific tax 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. What also helps to measure the incidence was that retailers (and wholesalers) were subjected to a *floor tax* on unsold inventory as of July 1, 2011. This means 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.

4 Theoretical Framework

There is a large literature which seeks to measure either the elasticity of alcohol demand with respect to a) taxes or b) prices. In fact, various meta-analyses (Wagenaar, Salois, and Komro 2009) have reported over 1000 elasticities some of which use aggregate level data on overall alcohol sales, and others which use individual data and survey data on micro-level consumption. A framework that makes easier to categorize the literature might be the following:

$$\frac{\partial Q_{st}(P_{st})}{\partial \tau_{st}} = \frac{\partial Q_{st}(P_{st})}{\partial P_{st}} \cdot \frac{\partial P_{st}(P_{st})}{\partial \tau_{st}} \tag{1}$$

[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.

One approach might be to measure the responsiveness of quantity of alcohol purchased/consumed to changes in the tax rate directly $\frac{\partial Q_{st}(P_{st})}{\partial \tau_{st}}$. In fact, this is the approach that is suggested in Harberger (1964) and more recently generalized in Chetty (2009). This arises by considering a utilitarian social welfare function (ignoring potential negative externalities associated with alcohol consumption) where we aggregate over individuals i, and totally differentiating with respect to the tax:

$$\begin{aligned} W(t) &= \left\{ \sum_{i=1}^{N} \max_{x^i} [u^i(x^i) + Y^i - t x_1^i - p x_1^i] \right\} + \left\{ \max_x p(x) - c(x) \right\} t \sum_{i=1}^{N} x_1^i \\ &= \left\{ \sum_{i=1}^{N} \max_{x^i} [u^i(x^i) + Y^i - t x_1^i] - c(x) \right\} + t \sum_{i=1}^{N} x_1^i \\ \Rightarrow \frac{dW(t)}{dt} &= -\sum_{i=1}^{N} x_1^i + \sum_{i=1}^{N} x_1^i + t \sum_{i=1}^{N} \frac{d x_1^i}{dt} = t \frac{d x_1(t)}{dt} \end{aligned}$$

This implies that to measure the excess welfare burden of the tax, one needs only consider the elasticity of consumption of the good x_1 with respect to a specific tax t_1, because inframarginal allocations are second-order due to the Envelope Conditions of each agent i being satisfied. This implies that the marginal deadweight loss is measured by $\frac{\partial Q_{st}(P_{st})}{\partial \tau_{st}}$. Here, a typical design might be to collect aggregate data on the consumption of spirits at the state s year t level and run a panel regression as follows:

$$Q_{st} = \alpha^{\tau} \tau_{st} + \beta x_{st} + \gamma_s + \gamma_t + \varepsilon_{st} \tag{2}$$

In such a regression γ would represent the state and year fixed effects, x_{st} would typically contain time-varying demographic variables at the state level (population density, income, age distribution, education level, etc.), and the maintained assumption would be that changes in the tax τ_{st} were exogenous. Identification would also require that the marginal treatment effect (MTE) of an additional unit of tax to have the same effect across states. While pre-existing differences in preferences might be captured in γ_s, we might worry that differences in market structure would not be fully captured only by the level of consumption γ_s but also in how consumption responds to the tax α^{τ}. More explicitly, we expect the pass-through rate $\frac{\partial P_{st}(P_{st})}{\partial \tau_{st}}$ to vary across states with the corresponding market structure.[5]

A second approach is to estimate the price elasticity as $\frac{\partial Q_{st}(P_{st})}{\partial P_{st}}$. In this approach, one worries about the endogeneity of price, and a common tactic is to instrument for price using changes in sales or excise taxes. Much of the literature related to alcohol has focused on whether demand in fact slopes downwards, and whether demand is elastic or inelastic, $\frac{P_{st}}{Q_{st}} \cdot \frac{\partial Q_{st}(P_{st})}{\partial P_{st}} \lesseqgtr -1$. Approaches

[5]In fact, there is some evidence that license states and control states face different elasticities (Trolldal and Ponicki 2005).

often differ in how the prices and quantities are constructed, but estimation usually follows a 2SLS analogue of (2). Many studies related to alcohol (though not all) use aggregate data at the state level, rather than brand level data. One potential advantage of brand level data is that excise taxes vary with proof and size and thus shift prices around differentially within a state. After recovering the slope of demand, one either needs an estimate or an assumption regarding the pass-through rate $\rho \equiv \frac{\partial P_{st}(P_{st})}{\partial \tau_{st}}$ in order to make statements about the potential excess burden of taxation. As an example, if the true passthrough rate would be zero, there would be no change in the prices of goods, taxes would be born entirely by firms, and hence no reduced consumption from additional taxation. Many studies measure the elasticity of quantity with respect to price and assume that taxes are fully passed on to consumers $\rho = 1$.

The third term in (1), $\rho \equiv \frac{\partial P_{st}(P_{st})}{\partial \tau_{st}}$ represents the pass-through rate of taxation. While it is possible to measure the excess burden of taxation from $\frac{\partial Q_{st}(P_{st})}{\partial \tau_{st}}$ directly, ρ is required in order to apportion the incidence of taxation between consumers and firms. Fabinger and Weyl (2013) derive an expression which relates the passthrough rate to the incidence of taxation under symmetric imperfect competition:

$$I \equiv \frac{\frac{dCS}{dt}}{\frac{dPS}{dt}} = \frac{\rho}{1-(1-\theta)\rho}$$

where $\theta = 1$ corresponds to monopoly, and $\theta = 0$ corresponds to perfect competition, similar to the conduct parameter of the Lerner index.[6] Under monopoly, a larger pass-through rate implies more of the burden of taxation is born by consumers. A pass-through rate $\rho > 1$ implies that more than 100% of the burden is born by consumers.

It is important to point out that given equation (1) if you observe two of: the price elasticity, the tax elasticity, or the pass-through rate you should in theory be able to measure the third.

4.1 Monopoly Pass-Through and Overshifting

We 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):

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

[6] Much like the conduct parameter literature, intermediate values of $0 < \theta < 1$ can be difficult to interpret when products are differentiated and firms are asymmetric.

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:

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

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.

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 overshifting 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.

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.

5 Data Description

Our empirical investigation of the pass-through of taxation in the alcoholic beverage industry makes use of data from several different sources. We gathered data on posted prices for each wholesaler and each product for the August 2007 to August 2013 period from the Connecticut Department of Consumer Protection (DCP). These are the prices that wholesalers agree to charge retailers for the entire month.[7] We draw retail price data from the product-level data from the Kilts Center Nielsen Homescan Scanner dataset (Nielsen Homescan). These data describe weekly prices and sales at the UPC level for 34 (mostly larger) retail liquor stores in Connecticut. In our analysis we also use retail price data for other states from this dataset.

The Nielsen dataset provides quantity data for purchases in the 34 establishments tracked. For a fuller picture of quantities sold we draw on a proprietary data source. We merge our wholesale price and Nielsen Homescan retail price and quantity data with data we obtained from the Distilled Spirits Council of the United States (DISCUS).[8] The DISCUS data tracks monthly shipments from spirits manufacturers to distributors at the shipment level.[9]

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. DISCUS data only track shipments from its members, which are the largest distillers or spirits manufacturers.[10] Thus, the DISCUS data only describe shipments to 18 Connecticut wholesalers. These 18 firms, however, include all of the major distributors in Connecticut, and account for over 80% of sales by volume.

Lastly, we use the *2012 Liquor Handbook*, provided by The Beverage Information Group. The Liquor Handbook tracks aggregate shipments and consumption at the brand and state level. It tracks information like national market shares of spirits brands by category (Vodka, Rum, Blended Whisky, etc.), and relative consumption of states across spirits categories.

An important consideration in the data construction is the level of aggregation used in the

[7] 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 more details on these regulations please see (Conlon and Rao 2014).

[8] A major challenge in constructing our final dataset was matching products across the three datasets we use. As the wholesale price data, the Nielsen data and the DISCUS shipment data come from unrelated sources, there is no single set of product identifiers. The products instead had to be matched by product name.

[9] Shipments from distillers to wholesalers do not necessarily happen for every product in every month, for lower volume products, shipments are often quarterly. Thus, we smooth the shipment data. Details on the precise smoothing procedure can be found in the Appendix of (Conlon and Rao 2014).

[10] DISCUS members represent the vast majority of spirits sales. 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. Large non-DISCUS distillers include Heaven Hill Distillery and Ketel One Vodka.

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 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

6 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 2 and 3 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 7. 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:

$$\Delta p_{jt} = \beta_0 + \rho \Delta \tau_{jt} + \beta_2 c_{jt} + B \Delta X_{jt} + \alpha_j + \gamma_t + \epsilon_{jt} \quad (3)$$

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 8. As a comparison we perform the same exercise but include all changes in wholesale prices (not just those induced by the tax in Table 9. 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 9), 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 11. 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 14. 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.

6.1 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 15. 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 16. 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 16.

6.2 Description of Random Forest

[COMING SOON]

6.3 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 19.

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).

7 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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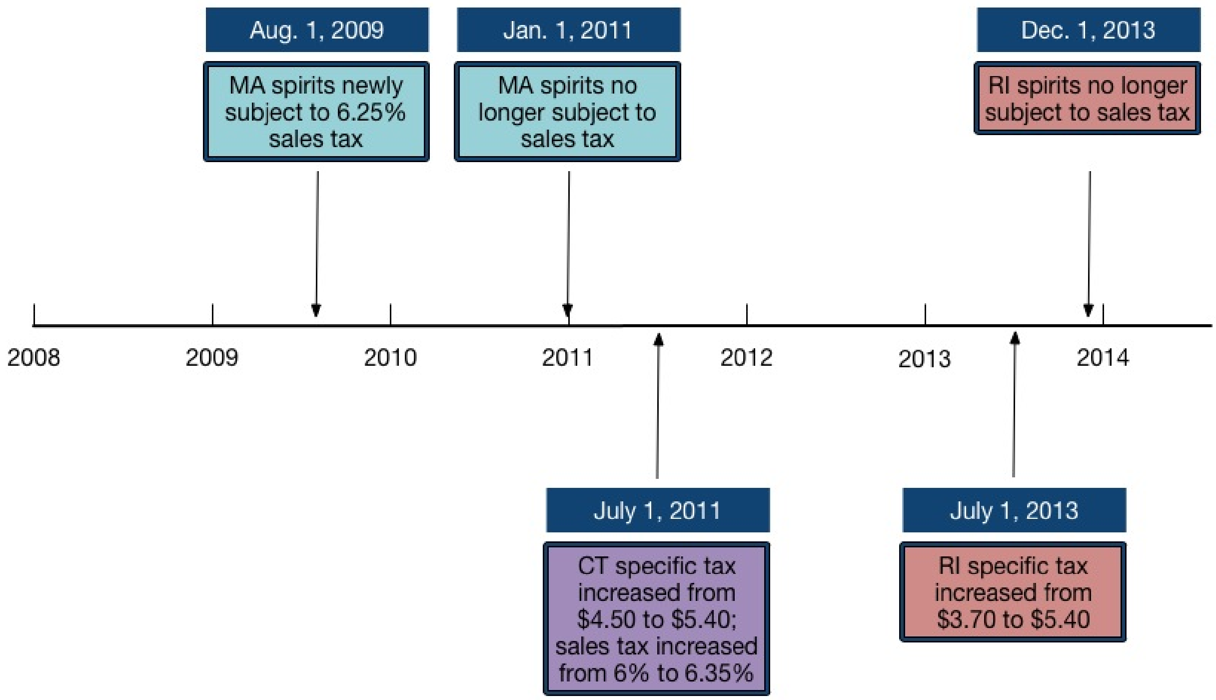

Figure 1: Timing of Alcohol Tax Changes in Connecticut and Neighboring States

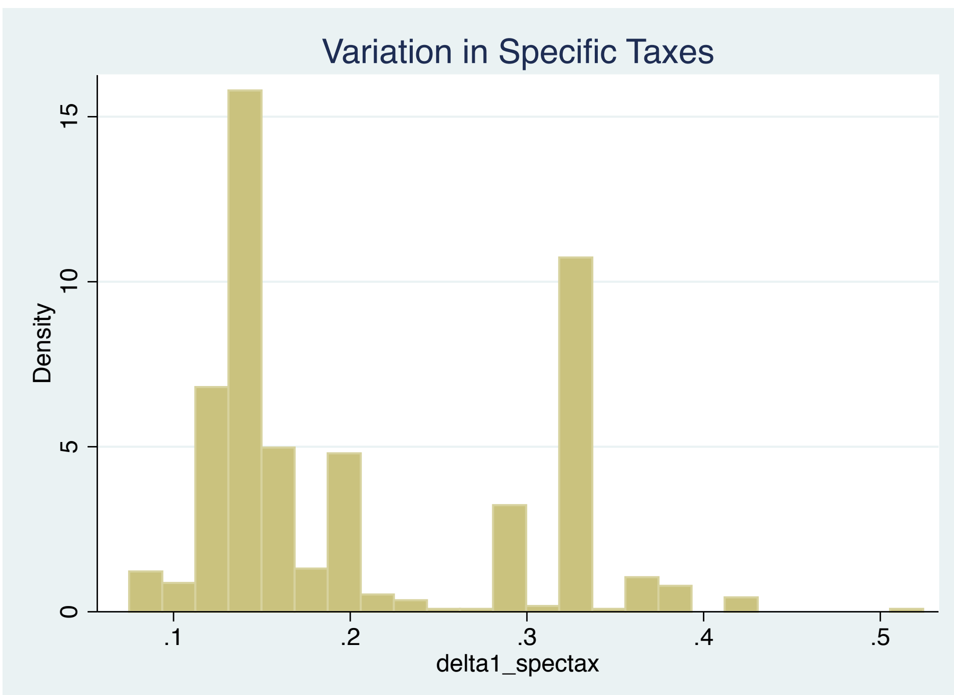

Figure 2: Magnitude of Tax Changes in Cross Section

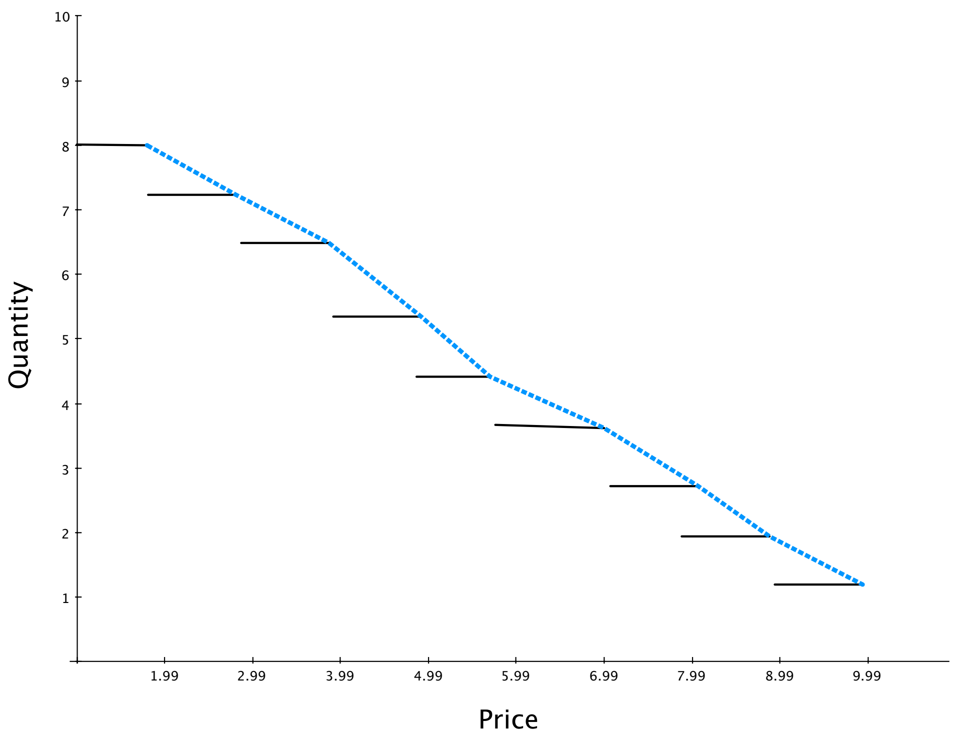

Figure 3: Perceived Demand as an (s, S) rule

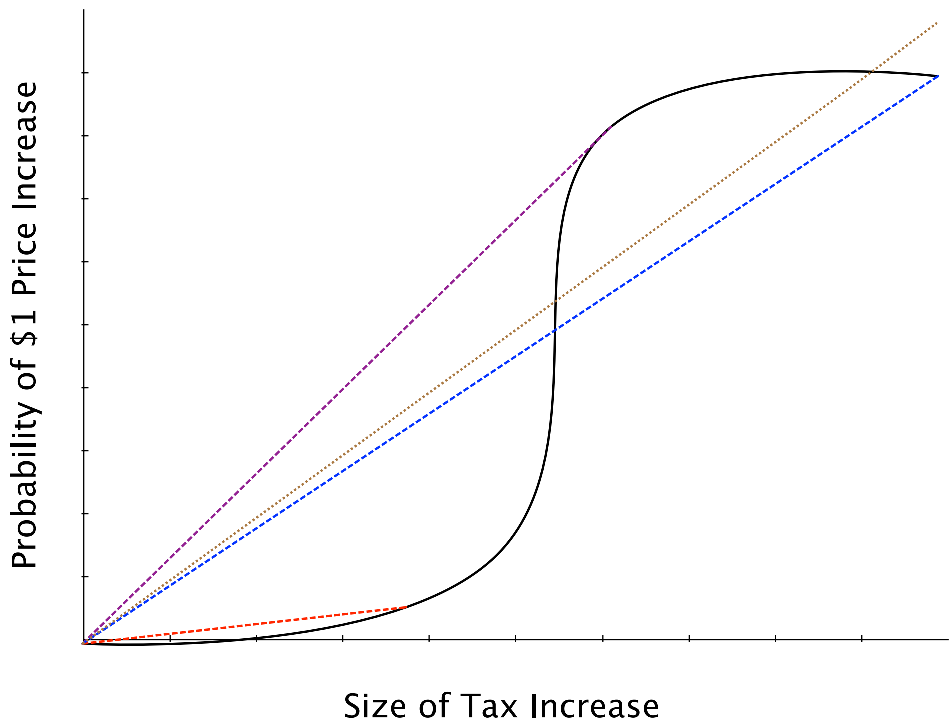

Figure 4: Probability of $1 Tax increase at different tax sizes

Table 1: Comparison of State Alcohol Taxes (per gallon)

	Still Wine	Sparkling Wine	Beer	Distilled Spirits	State Sales Tax
Connecticut	$0.72 under 21%	$1.80	0.24	$5.40 for 7% or more	6.35%
	$10.80 21% or more			$2.46 for less than 7%	
Maine	$0.60 150.5% and less	$1.25	$0.35	markup + $1.25	7%
	15.5% or more sold by state				
Massachusetts	$0.55	$0.70	$0.11	$4.05 if over 15%	repealed
				$1.10 if under 15%	
New Hampshire	66% markup	61% markup	$0.30	47.5% markup	no sales tax
New Jersey	$0.875	$0.875	$0.12	$5.50	7%
New York	$0.30	$0.30	$0.14	$6.44 24% or more	4%
				$2.54 less than 24%	
New York City	$0.30	$0.30	$0.26	$7.44 24% or more	4%
				$3.54 less than 24%	4%
Pennsylvania	30% markup + 18%	30% markup + 18%	0.08	30% markup + 18%	6%
Rhode Island	$0.60	$0.75	$0.10	$3.75	7%
Vermont	0.55	0.55	0.27	markup + 25%	on-premise

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

	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 Prices, CT 2011 [Store-Month]

	Retail Price, All Stores		Retail Price, Stores where $min\_price = max\_price$	
Month	Monthly Change ($)	Observations	Monthly Change ($)	Observations
1	0.026	4,625	0.130	3,835
2	0.166	4,247	0.254	3,804
3	-0.111	4,033	0.049	3,564
4	-0.019	4,243	0.157	3,598
5	0.128	4,396	0.209	3,867
6	0.037	4,348	0.150	3,589
7	**0.177**	4,584	**0.286**	3,315
8	**0.225**	4,548	**0.314**	4,038
9	-0.007	4,287	0.093	3,818
10	-0.050	4,271	0.108	3,669
11	-0.173	4,397	-0.009	3,866
12	-0.076	4,746	0.039	4,287

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 (Top 20), CT 2008 - 2011 [Store-Month], $min\_price = max\_price$

Cents Portion of Retail Price	Frequency
99	232,719
49	7,758
59	4,220
93	1,200
69	919
79	458
95	427
89	365
39	191
45	175
75	150
29	120
11	102
85	85
55	84
65	72
88	72
24	62
33	53
53	49
Total	250,127
Percentage 99	0.930

Note: Counts are unweighted. Total refers to all price observations, not just the top 20 listed here.

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

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. Total refers to all price observations, not just the top 20 listed here.

Table 6: Mean Change in Retail Price, Wholesale Price and Specific Tax, 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		1				1		3	1										22	30
24		2	1			1	28		1	2	1	1	2					1	1	275	316
29			18			3	10			9		4	1	1						76	122
33				1				1		3						2		16		36	59
39		2				2	8		1	2	1	6		1	1	2				149	175
45					1	2	2	1	1	2	3		2		1	1	1	1	2	109	129
49		36	6	1	11	8	109	4	2	62	1	31	7	9	5	6	5	4	18	2,014	2339
53	1			1	1		3		1						1	1		4		27	40
55			1	1			2			12		1	3	1	1	1			4	131	158
59	2	2	9	2	1	2	36	1	14	21	11	1	20	16	12	1	5	2	34	551	743
65	1	1					3			8			3						4	95	115
69		1	5						4	2	2	12		3		1	1		2	154	187
75		4				1	5		5	14	1		5		5	1	2	1	9	197	250
79	1	1	1		1	1	6		2	6	1			10	1	1	2	1	2	248	285
85	1						9		1	11		1	3	1	3	1	1	2	14	153	201
88	1		1	2			3			1	1	1	1				1	1	1	67	81
89							5			3	1		1	1			1	3	2	107	124
93				13			3	4	1	2	1		1	1	1	1		93	7	91	219
95	1	2		1	1	1	19	2	11	25	4	1	13	7	4		2	7	9	504	614
99	24	255	81	43	144	113	2,031	29	120	563	102	130	204	230	177	56	63	189	597	26,155	31306
Total	34	306	124	65	160	134	2283	42	167	749	130	189	266	281	212	75	84	325	706	31161	37493

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

Table 7: Mean Change in Retail Price, Wholesale Price and Specific Tax, CT 2011 [Store-Month] where $\Delta P \neq 0$ and $min_price = max_price$

	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		1							1										18	22
24		1					18			1		1	1						1	215	238
29			13			2	6			8		4		1						68	102
33								1		2								15		32	50
39						1	8			2		6								97	114
45					1	1	2		1	2			1					1		92	101
49		6	1		1	3	71		1	52		16		5	2	2		2	4	1,663	1829
53				1			2											1		18	22
55							2			9		1	1	1					3	122	139
59	1					1	27		8	16	3	1	4	8	4		1		14	457	545
65							2			6			2						1	83	94
69			3						2			11		2						132	150
75		1				1	4		1	13			1		1				5	182	209
79		1					2			4				8					2	202	219
85							6		1	10								1	1	137	156
88			1				1											1		55	58
89							5			2				1				1		96	105
93				11			2	3		1				1				72	3	80	173
95							15		5	23	1	1	8	6				4	2	464	529
99	3	27	14	7	16	21	836	3	48	351	38	55	68	46	43	12	9	120	221	19,173	21111
Total	6	36	33	19	18	30	1009	7	67	503	42	96	86	79	50	14	10	218	257	23386	25966

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

Table 8: Pass-Through: Taxes to Retail Prices [State-Month] (NEW)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Δ_R	Δ_R	Min CD	All CD	$\Delta_R \neq 0$	CT, FL	CT, FL, TX
One Month							
Δ Tax	1.459**	1.475**	1.473**	1.453**	2.692***	0.895	0.885
	(0.612)	(0.617)	(0.612)	(0.605)	(1.039)	(0.671)	(0.640)
Cum Diff.			0.020**				
			(0.010)				
Obs.	27,432	27,432	27,432	27,432	10,266	55,583	83,749
Two Months							
Δ Tax	0.980**	1.032**	1.023***	1.020***	1.608**	0.937*	0.942*
	(0.400)	(0.405)	(0.395)	(0.394)	(0.637)	(0.521)	(0.509)
Cum Diff.			0.029*				
			(0.016)				
Obs.	27,318	27,318	27,318	27,318	10,335	55,392	83,457
Three Months							
Δ Tax	1.095***	1.191***	1.165***	1.169***	1.873***	1.941***	1.901***
	(0.397)	(0.411)	(0.400)	(0.411)	(0.509)	(0.530)	(0.509)
Cum Diff.			0.048***				
			(0.014)				
Obs.	27,230	27,230	27,230	27,230	10,308	55,213	83,180
Six Months							
Δ Tax	0.192	0.425	0.382	0.345	0.154	2.773***	2.592***
	(0.609)	(0.632)	(0.639)	(0.671)	(0.791)	(0.676)	(0.653)
Cum Diff.			0.063***				
			(0.019)				
Obs.	26,947	26,947	26,947	26,947	10,182	54,665	82,356
Product FE	No	Yes	Yes	Yes	Yes	Yes	Yes

Note: All regressions are weighted by monthly Nielsen units. All regressions include year, month, and where applicable state and state-by-year fixed effects.

Table 9: Pass-Through: Wholesale to Retail Prices [State-Month] (NEW)

	(1) Δ_R	(2) Trend	(3) CD	(4) Δ_R	(5) Trend	(6) CD
One Month (22,717 Obs.)						
Δ Wholesale	0.064***	0.064***	0.064***	0.065***	0.065***	0.065***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)
Δ Wholesale * $1(\Delta Tax \neq 0)$				-0.045	-0.043	-0.044
				(0.046)	(0.047)	(0.047)
Two Months (22,574 Obs.)						
Δ Wholesale	0.149***	0.146***	0.145***	0.153***	0.149***	0.148***
	(0.023)	(0.024)	(0.024)	(0.025)	(0.026)	(0.026)
Δ Wholesale * $1(\Delta Tax \neq 0)$				-0.043	-0.038	-0.040
				(0.041)	(0.042)	(0.042)
Three Months (22,451 Obs.)						
Δ Wholesale	0.078***	0.077***	0.076***	0.075***	0.073***	0.073***
	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)	(0.011)
Δ Wholesale * $1(\Delta Tax \neq 0)$				0.071***	0.074***	0.072***
				(0.024)	(0.024)	(0.024)
Six Months (21,089 Obs.)						
Δ Wholesale	0.232***	0.219***	0.217***	0.231***	0.218***	0.216***
	(0.028)	(0.027)	(0.027)	(0.035)	(0.034)	(0.034)
Δ Wholesale * $1(\Delta Tax \neq 0)$				0.006	0.005	0.006
				(0.063)	(0.065)	(0.067)
Twelve Months (18,350 Obs.)						
Δ Wholesale	0.457***	0.399***	0.397***	0.521***	0.462***	0.457***
	(0.051)	(0.045)	(0.046)	(0.043)	(0.040)	(0.041)
Δ Wholesale * $1(\Delta Tax \neq 0)$				-0.145***	-0.139***	-0.135***
				(0.052)	(0.047)	(0.046)
24 Months (13,337 Obs.)						
Δ Wholesale	0.545***	0.401***	0.399***	0.550***	0.400***	0.396***
	(0.063)	(0.041)	(0.041)	(0.059)	(0.047)	(0.047)
Δ Wholesale * $1(\Delta Tax \neq 0)$				-0.008	0.001	0.004
				(0.070)	(0.050)	(0.050)

Note: All regressions are weighted by monthly Nielsen units. All regressions include year and month fixed effects. Columns (3) and (6) include the Cum Diff regressor but the coefficient is not reported.

Table 10: Pass-Through: Taxes to Retail Prices [Store-Month], $min\_price = max\_price$

	(1) Δ_R	(2) Δ_R	(3) Min CD	(4) All CD	(5) $\Delta_R \neq 0$	(6) CT, FL	(7) CT, FL, TX
One Month							
Δ Tax	0.383***	0.438***	0.411***	0.394***	1.156*	0.141	0.162
	(0.136)	(0.136)	(0.141)	(0.144)	(0.597)	(0.143)	(0.142)
Cum Diff.			0.038***				
			(0.006)				
Obs.	189,924	189,924	189,924	189,924	27,547	3,562,979	4,113,245
Two Months							
Δ Tax	0.795***	0.886***	0.842***	0.837***	1.051**	0.307	0.357
	(0.255)	(0.255)	(0.259)	(0.262)	(0.442)	(0.265)	(0.262)
Cum Diff.			0.043***				
			(0.007)				
Obs.	188,210	188,210	188,210	188,210	42,201	3,510,882	4,053,887
Three Months							
Δ Tax	0.633**	0.754**	0.692**	0.676**	0.930**	0.001	0.059
	(0.296)	(0.304)	(0.308)	(0.307)	(0.463)	(0.271)	(0.270)
Cum Diff.			0.051***				
			(0.008)				
Obs.	186,718	186,718	186,718	186,718	42,061	3,474,913	4,012,944
Six Months							
Δ Tax	0.210	0.480	0.411	0.339	0.646	-0.339	-0.328
	(0.358)	(0.364)	(0.365)	(0.370)	(0.428)	(0.346)	(0.344)
Cum Diff.			0.044***				
			(0.014)				
Obs.	183,291	183,291	183,291	183,291	41,905	3,385,471	3,911,121
Product FE	No	Yes	Yes	Yes	Yes	Yes	Yes

Note: All regressions are weighted by monthly Nielsen units. All regressions include year, month, and where applicable state and state-by-year fixed effects.

Table 11: Pass-Through: Taxes to Retail Prices [Store-Month]

	(1) Δ_R	(2) Δ_R	(3) Min CD	(4) All CD	(5) $\Delta_R \neq 0$	(6) CT, FL	(7) CT, FL, TX
One Month							
Δ Tax	0.759***	0.740***	0.722***	0.699***	2.023***	0.517**	0.553**
	(0.215)	(0.215)	(0.214)	(0.217)	(0.543)	(0.260)	(0.255)
Cum Diff.			0.034***				
			(0.006)				
Obs.	218,455	218,455	218,455	218,455	44,846	5,286,741	6,041,313
Two Months							
Δ Tax	0.724***	0.725***	0.701***	0.683***	2.022***	0.307	0.418
	(0.258)	(0.262)	(0.264)	(0.264)	(0.528)	(0.287)	(0.280)
Cum Diff.			0.033***				
			(0.007)				
Obs.	216,393	216,393	216,393	216,393	59,592	5,215,907	5,960,552
Three Months							
Δ Tax	0.904***	0.936***	0.907***	0.887***	1.899***	0.129	0.273
	(0.278)	(0.290)	(0.293)	(0.292)	(0.408)	(0.265)	(0.263)
Cum Diff.			0.033***				
			(0.007)				
Obs.	214,660	214,660	214,660	214,660	59,304	5,166,770	5,904,184
Six Months							
Δ Tax	0.614*	0.781**	0.753**	0.682*	1.184*	-0.035	0.149
	(0.348)	(0.367)	(0.368)	(0.367)	(0.651)	(0.313)	(0.312)
Cum Diff.			0.029**				
			(0.014)				
Obs.	210,900	210,900	210,900	210,900	58,937	5,043,742	5,763,137
Product FE	No	Yes	Yes	Yes	Yes	Yes	Yes

Note: All regressions are weighted by monthly Nielsen units. All regressions include year, month, and where applicable state and state-by-year fixed effects.

Table 12: Pass-Through: Taxes to Retail Prices [State-Month]

	Full Sample			Δ Retail Price≠ 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 13: Pass-Through: Taxes to Retail Prices [Store-Month]

	Full Sample			Δ Retail Price≠ 0		
Δ Retail Price	1m	2m	3m	1m	2m	3m
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Tax	0.411***	0.842***	0.692**	1.088*	1.380**	1.078
	(0.141)	(0.259)	(0.308)	(0.597)	(0.636)	(0.750)
Cum Diff.	0.038***	0.043***	0.051***	0.138***	0.093***	0.100***
	(0.006)	(0.007)	(0.008)	(0.022)	(0.018)	(0.018)
Obs.	189,924	188,210	186,718	27,547	41,211	49,804
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 14: 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 15: 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	1.150***	1.487***	1.219***	1.619***	1.533***	1.034***
	[0.356]	[0.422]	[0.386]	[0.357]	[0.537]	[0.315]
log(price)	0.256***	0.182**	0.147**	0.133	0.108	0.09
	[0.077]	[0.081]	[0.075]	[0.097]	[0.09]	[0.073]
log(units)	0.141***	0.131***	0.116***	-0.003	0.045	0.05
	[0.032]	[0.039]	[0.037]	[0.046]	[0.049]	[0.037]
cum(Δ wholesale)	0.037***	0.071***	0.082***	0.094***	0.100***	0.098***
	[0.009]	[-0.011]	[0.011]	[0.013]	[0.015]	[0.012]
Observations	186,840	182,283	177,917	139,180	134,105	123,860

Table 16: Probability of Price Increase [Store-Month] w/ other price changes

	Full Sample			Lag Δ Retail Price= 0		
Δ Retail Price	1m	2m	3m	1m	2m	3m
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Tax	0.589	0.651	0.196	1.197***	0.681	0.176
	[-0.385]	[-0.452]	[0.425]	[0.374]	[0.538]	[0.353]
log(price)	0.153*	0.092	0.061	0.072	0.058	0.031
	[0.084]	[0.089]	[0.081]	[0.102]	[0.096]	[0.077]
log(units)	0.129***	0.127***	0.114***	-0.009	0.048	0.052
	[0.03]	[0.039]	[0.035]	[0.045]	[0.049]	[0.033]
cum(Δ wholesale)	0.042***	0.072***	0.083***	0.099***	0.101***	0.098***
	[0.009]	[0.01]	[0.011]	[0.012]	[0.014]	[0.011]
Frac. PriceΔ	2.938***	2.451***	2.264***	2.512***	2.147***	2.209***
	-0.183	-0.165	-0.149	-0.144	-0.154	-0.124
Observations	186,840	182,283	177,917	139,180	134,105	123,860

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

Table 17: 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 18: 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 19: 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%

.