Online Appendix for "Salience and Taxation with Imperfect Competition"

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1 Proofs

Proof of Lemma 1

Proof. Note that

$$(\theta + \rho - 1)\frac{t}{p}\epsilon_D = -\frac{t}{p}\left(\theta + \frac{dp}{dt}\right)\frac{p}{mwtp(q)q} = -\frac{t}{q}\frac{1}{mwtp(q)}\frac{d(p+\theta t)}{dt} = -\epsilon_{Dt}$$

□

Proof of Proposition 1

Proof. Consumer surplus can be expressed as

$$CS = \int_0^q wtp(s)ds - (p+t)q$$

Given $\rho \equiv 1 + \frac{dp}{dt}$, we have

$$\begin{aligned}\frac{dCS}{dt} &= wtp(q)\frac{dq}{dt} - \rho q - (p+t)\frac{dq}{dt} \\ &= (p+\theta t)\frac{dq}{dt} - \rho q - (p+t)\frac{dq}{dt} \\ &= -\rho q - (1-\theta)t\frac{dq}{dt}\end{aligned}$$

where the second equality follows from the fact that $wtp(q) = p + \theta t$.

Next, producer surplus can be expressed as

$$PS = pq - c(q)$$

Differentiating this expression with respect to t:

$$\begin{aligned}\frac{dPS}{dt} &= \frac{dp}{dt}q + [p - mc(q)]\frac{dq}{dt} \\ &= -(1-\rho)q\end{aligned}$$

where the last line follows since $p = mc(q)$ under perfect competition.

Government revenue is $R = tq$ which implies that:

$$\frac{dR}{dt} = q + t\frac{dq}{dt}$$

By taking derivative of willingness-to-pay with respect to the tax and using the fact that $wtp(q) = p + \theta t = mc(q) + \theta t$, we have:

$$mwtp(q)\frac{dq}{dt} = mc'(q)\frac{dq}{dt} + \theta$$

Therefore,

$$\begin{aligned}\frac{dq}{dt} &= \frac{\theta}{mwtp(q) - mc'(q)} \\ &= -\frac{\theta\frac{q}{p}}{\frac{1}{\epsilon_D} + \frac{1}{\epsilon_S}}\end{aligned}$$

where $\epsilon_D = -\frac{wtp(q)-\theta t}{wtp'(q)q}$ and $\epsilon_S = \frac{c'(q)}{c''(q)q}$. We also have $\rho = \frac{d(p+t)}{dt} = mwtp(q)\frac{dq}{dt} + (1-\theta)$. Substitute $\frac{dq}{dt}$ with the equation above, we get:

$$\begin{aligned}\rho &= -mwtp(q)\frac{\theta\frac{q}{p}}{\frac{1}{\epsilon_D} + \frac{1}{\epsilon_s}} + (1-\theta) \\ &= \theta\frac{\frac{1}{\epsilon_D}}{\frac{1}{\epsilon_D} + \frac{1}{\epsilon_s}} + (1-\theta) \\ &= 1 - \frac{\theta\epsilon_D}{\epsilon_S + \epsilon_D}\end{aligned}$$

Using Lemma 1, the incidence of the tax can be expressed as:

$$\begin{aligned} I &= \frac{-\rho q - (1-\theta)t\frac{dq}{dt}}{-(1-\rho)q} \\ &= \frac{\rho}{1-\rho} + \frac{1-\theta}{1-\rho}\epsilon_{Dt} \\ &= \frac{1-\theta}{\theta} + \frac{\epsilon_S}{\theta\epsilon_D} - (1-\theta)\frac{t}{p}\epsilon_S \end{aligned}$$

where we have used the fact that $\epsilon_{Dt} \equiv \frac{t}{q}\frac{dq}{dt}$.

Finally, marginal excess burden is:

$$\begin{aligned} \frac{dW}{dt} &= -\rho q - (1-\theta)t\frac{dq}{dt} - (1-\rho)q + q + t\frac{dq}{dt} \\ &= \theta t\frac{dq}{dt} \end{aligned}$$

□

Proof of Proposition 2

Proof. Let the firm be a monopoly in the market. The incidence of a tax on consumers is the same as in the perfect competitive market, since the incidence does not depend on the firm's behavior. Similarly, the incidence on the government is the same as in the perfect competitive market.

Using Lerner's rule, we have in monopoly that $p - mc(q) = -mwtp(q)q$. The incidence on the producer is then

$$\begin{aligned} \frac{dPS}{dt} &= \frac{dp}{dt}q + [p - mc(q)]\frac{dq}{dt} \\ &= (\rho - 1)q - mwtp(q)q\frac{dq}{dt} \\ &= (\rho - 1)q + (1 - \theta - \rho)q \\ &= -\theta q \end{aligned}$$

Using the first-order condition of the monopoly problem and taking the derivative with repect to t, we get

$$\begin{aligned}
\frac{dq}{dt} &= \frac{\theta}{2mwtp(q) + mwtp'(q)q - mc'(q)} \\
&= \frac{\theta \frac{1}{mwtp(q)}}{1 + \frac{mwtp(q)+mwtp'(q)q}{mwtp(q)} - \frac{mc'(q)q}{mc(q)}\left(\frac{p+mwtp(q)q}{mwtp(q)q}\right)} \\
&= \frac{\theta \frac{1}{mwtp(q)}}{1 + \frac{1}{\epsilon_{ms}} + \frac{\epsilon_D - 1}{\epsilon_s}} \\
&= \frac{\theta \frac{1}{mwtp(q)}}{1 + \frac{1}{\epsilon_{ms}} + \frac{\epsilon_D - 1}{\epsilon_s}}
\end{aligned}$$

Substituting into the expression of ρ, we have

$$\begin{aligned}
\rho &= mwtp(q)\frac{dq}{dt} + (1-\theta) \\
&= \frac{\theta}{1 + \frac{1}{\epsilon_{ms}} + \frac{\epsilon_D - 1}{\epsilon_s}} + 1 - \theta
\end{aligned}$$

Combining with the result from Lemma 1, the incidence of the tax is then:

$$\begin{aligned}
I &= \frac{-\rho q - (1-\theta)t\frac{dq}{dt}}{-\theta q} \\
&= \frac{\rho}{\theta} + \frac{1-\theta}{\theta}\epsilon_{Dt} \\
&= \frac{1-\theta}{\theta} + \left(1 - (1-\theta)\,\frac{t}{p}\epsilon_D\right)\frac{1}{1 + \frac{\epsilon_D - 1}{\epsilon_S} + \frac{1}{\epsilon_{ms}}}
\end{aligned}$$

The marginal excess burden of the tax is:

$$\begin{aligned}
\frac{dW}{dt} &= -\rho q - (1-\theta)t\frac{dq}{dt} - \theta q + q + t\frac{dq}{dt} \\
&= \theta t\frac{dq}{dt} + (1 - \rho - \theta)q \\
&= (p - mc(q) + \theta t)\,\frac{dq}{dt}
\end{aligned}$$

□

Proof of Proposition 3

Proof. Let the market be **symmetric imperfect competition with J products** $j = 1, \ldots, J$ and the market conduct parameter $\nu_p = \frac{\partial p_k}{\partial p_j}$ $(k \neq j)$**.**

Analogous to the perfect competition, we have

$$\frac{dCS}{dt} = -\rho Q - (1-\theta)t\frac{dQ}{dt}$$

We also have

$$\frac{dR}{dt} = Q + t\frac{dQ}{dt}$$

The producer surplus can be expressed as

$$PS = pQ - Jc(q)$$

Taking the derivative of PS with respect to t, we get the incidence on producers:

$$\begin{aligned}
\frac{dPS}{dt} &= (\rho - 1)Q + J(p - mc(q))\frac{dq}{dt} \\
&= (\rho - 1)Q + \frac{\nu_q}{\epsilon_D}\frac{dq}{dt}p \\
&= (\rho - 1)Q - \nu_q Q mwtp(Q)\frac{dq}{dt} \\
&= -Q\left(\theta\frac{\nu_q}{J} + (1-\rho)\left(1 - \frac{\nu_q}{J}\right)\right)
\end{aligned}$$

The second equality comes from the Lerner condition $\frac{p-mc(q)}{p} = \frac{\nu_q}{J\epsilon_D}$. The last equality comes from the relationship $mwtp(Q)\frac{dQ}{dt} = \rho - (1-\theta)$.

We also have

$$\frac{dQ}{dt} = \frac{\theta\frac{1}{mwtp(Q)}}{1 + \frac{\epsilon_D - \frac{\nu_q}{J}}{\epsilon_S} + \frac{\frac{\nu_q}{J}}{\epsilon_{ms}}}$$

Therefore,

$$\begin{aligned}
\rho &= mwtp(Q)\frac{dQ}{dt} + (1-\theta) \\
&= 1 - \theta + \frac{\theta}{1 + \frac{\epsilon_D - \frac{\nu_q}{J}}{\epsilon_S} + \frac{\frac{\nu_q}{J}}{\epsilon_{ms}}}
\end{aligned}$$

Using the result from Lemma 1, the incidence of the tax can be written as:

$$
\begin{aligned}
I &= \frac{-\rho Q - (1-\theta)t\frac{dQ}{dt}}{-Q\left(\theta\frac{\nu_q}{J} + (1-\rho)\left(1-\frac{\nu_q}{J}\right)\right)} \\
&= \frac{\frac{1-\theta}{\theta} + \frac{1}{1+\frac{\nu_q/J}{\epsilon_{ms}}+\frac{\epsilon_D-\nu_q/J}{\epsilon_s}} + \frac{1-\theta}{\theta}\epsilon_{Dt}}{1-\frac{1-\nu_q/J}{1+\frac{\nu_q/J}{\epsilon_{ms}}+\frac{\epsilon_D-\nu_q/J}{\epsilon_s}}} \\
&= \frac{\frac{1-\theta}{\theta} + \frac{1}{1+\frac{\nu_q/J}{\epsilon_{ms}}+\frac{\epsilon_D-\nu_q/J}{\epsilon_s}}(1-(1-\theta)\frac{t}{p}\epsilon_D)}{1-\frac{1-\nu_q/J}{1+\frac{\nu_q/J}{\epsilon_{ms}}+\frac{\epsilon_D-\nu_q/J}{\epsilon_s}}} \\
&= \frac{\frac{1-\theta}{\theta}(1+\frac{\nu_q/J}{\epsilon_{ms}}+\frac{\epsilon_D-\nu_q/J}{\epsilon_s}) + (1-(1-\theta)\frac{t}{p}\epsilon_D)}{\frac{\nu_q}{J}(1+\frac{1}{\epsilon_{ms}}-\frac{1}{\epsilon_s})+\frac{\epsilon_D}{\epsilon_S}} \\
&= \frac{1-\theta}{\theta} + \frac{1+(1-\frac{\nu_q}{J})(\frac{1-\theta}{\theta}) - (1-\theta)\frac{t}{p}\epsilon_D}{\frac{\nu_q}{J}+\frac{\epsilon_D-\frac{\nu_q}{J}}{\epsilon_S}+\frac{\frac{\nu_q}{J}}{\epsilon_{ms}}}
\end{aligned}
$$

The marginal excess burden of the tax is

$$
\begin{aligned}
\frac{dW}{dt} &= -\rho Q - (1-\theta)t\frac{dQ}{dt} - Q\left(\theta\frac{\nu_q}{J} + (1-\rho)\left(1-\frac{\nu_q}{J}\right)\right) + Q + t\frac{dQ}{dt} \\
&= \theta t\frac{dQ}{dt} + (1-\rho-\theta)\frac{\nu_q}{J}Q \\
&= \left(p - c'(q) + \theta t\right)\frac{dQ}{dt}
\end{aligned}
$$

□

2 Ad valorem taxes

Let p denote the producer price, $p(1+t)$ denote the price paid by consumers and $D(p,t)$ be the quantity demanded. Following Chetty, Looney and Kroft (2009) we permit prices and taxes to have different effects. Assume that for $t>0$, $D(p,0)>D(p,t)>D(p(1+t),0)$, and assume linearity for the tax effect, then the basic building block for ad valorem taxes is the relationship $wtp(Q)=p(1+\theta t)$, from which we observe $\theta=\frac{\frac{\partial D}{\partial t}\frac{1}{Q}}{\frac{p}{mwtp(Q)Q}}=-\frac{\frac{\partial D}{\partial t}\frac{1}{Q}}{\epsilon_D}$.

Let $\tilde{\rho}\equiv\frac{1}{p}\frac{dp(1+t)}{dt}=\frac{dlog(p(1+t))}{dlog(1+t)}=\frac{dlog(p)}{dlog(1+t)}+1$, $\epsilon_D\equiv-\frac{p}{mwtp(q)q}$, $\epsilon_S=\frac{c'(q)}{c''(q)q}$.

Lemma. ***(Lemma 1 for ad valorem taxes)*** *Let* $\tilde{\epsilon}_{Dt}\equiv\frac{dlog(Q)}{dlog(1+t)}=\frac{1+t}{t}\epsilon_{Dt}$. *The following relationship holds:*

$$\tilde{\epsilon}_{Dt}=\tilde{\epsilon}_D\left(\tilde{\rho}-1+\frac{\theta(1+t)}{1+\theta t}\right) \tag{A1}$$

and

$$\theta=\frac{(1-\tilde{\rho})\,\tilde{\epsilon}_D+\tilde{\epsilon}_{Dt}}{(1+t\tilde{\rho})\,\tilde{\epsilon}_D-t\tilde{\epsilon}_{Dt}}$$

where $\tilde{\epsilon}_D=\frac{dlog(Q)}{dlog(p)}=-\epsilon_D*(1+\theta t)$.

Proof. Observe

$$\begin{aligned}\tilde{\epsilon}_{Dt}&\equiv\frac{dlog(Q)}{dlog(1+t)}\\&=-\epsilon_D\frac{1+t}{p}\left((1+\theta t)\frac{dp}{dt}+\theta p\right)\\&=-\epsilon_D\left((1+\theta t)(\tilde{\rho}-1)+\theta(1+t)\right)\\&=\tilde{\epsilon}_D\left(\tilde{\rho}-1+\frac{\theta}{1+\theta t}(1+t)\right)\end{aligned}$$

Solving for θ we obtain:

$$\theta=\frac{(1-\tilde{\rho})\,\tilde{\epsilon}_D+\tilde{\epsilon}_{Dt}}{(1+t\tilde{\rho})\,\tilde{\epsilon}_D-t\tilde{\epsilon}_{Dt}}$$

□

Proposition. ***(Proposition 3 for ad valorem taxes)*** *The incidence on consumers, producers, government, the pass-through rate and the marginal excess burden under* ***symmetric***

imperfect competition *may be expressed as:*

$$\frac{dCS}{dt} = -\tilde{\rho}pQ - (1-\theta)tp\frac{dQ}{dt} \tag{A2}$$

$$\frac{dPS}{dt} = -\frac{pQ}{1+t}\left(\left(1-\frac{\nu_q}{J}\right)(1-\tilde{\rho}) + \frac{\nu_q}{J}\theta\left(1+t\tilde{\rho}\right)\right) \tag{A3}$$

$$\frac{dR}{dt} = \frac{d(tpQ)}{dt} \tag{A4}$$

$$\tilde{\rho} \equiv \frac{dlog(p(1+t))}{dlog(1+t)} = \frac{1+t}{1+\theta t}\left(\frac{\theta\left(1-\frac{\nu_q}{J\epsilon_D}\right)}{1+(1+\theta t)\left(\frac{\epsilon_D-\frac{\nu_q}{J}}{\epsilon_S}+\frac{\frac{\nu_q}{J}}{\epsilon_{ms}}\right)} - \theta\right) + 1 \tag{A5}$$

$$I = \frac{\tilde{\rho}(1+t) + (1-\theta)t\tilde{\epsilon}_{Dt}}{\left(1-\frac{\nu_q}{J}\right)(1-\tilde{\rho}) + \frac{\nu_q}{J}\theta\left(1+t\tilde{\rho}\right)} \tag{A6}$$

$$\frac{dW}{dt} = \left(p(1+\theta t) - mc(q)\right)\frac{dQ}{dt} \tag{A7}$$

Finally note:

$$\tilde{\rho} = \frac{1+t}{(1+\theta t)^2}\left(\left(\rho_{unit-tax} - 1 + \theta\right)\left(1-\frac{\nu_q}{J\epsilon_D}\right) - \theta(1+\theta t)\right) + 1$$

when $\theta = 1$ and $t = 0$ then:

$$\tilde{\rho} = \left(1-\frac{\nu_q}{J\epsilon_D}\right)\rho_{unit-tax}$$

Proof. Consumer surplus can be expressed as

$$CS = \int_0^Q wtp(s)ds - p(1+t)Q$$

Given $\tilde{\rho} \equiv \frac{1}{p}\frac{dp(1+t)}{dt}$ and $wtp(Q) = p(1+\theta t)$, we have

$$\begin{aligned}\frac{dCS}{dt} &= wtp(q)\frac{dQ}{dt} - \tilde{\rho}pQ - p(1+t)\frac{dQ}{dt} \\ &= -\tilde{\rho}pQ - (1-\theta)tp\frac{dQ}{dt}.\end{aligned}$$

We also have

$$\frac{dR}{dt} = \frac{d(tpQ)}{dt}$$

Let the market be **symmetric imperfect competition with J products** $j = 1, \ldots, J$ and the market conduct parameter $\nu_p = \frac{\partial p_k}{\partial p_j}$ $(k \neq j)$**.** The producer surplus can be expressed as

$$PS = pQ - Jc(q)$$

Taking the derivative of PS with respect to t, we get the incidence on producers:

$$\begin{aligned}
\frac{dPS}{dt} &= Q\frac{dp}{dt} + (p - c'(q))\frac{dQ}{dt} \\
&= Q\frac{dp}{dt} + p\frac{\nu_q}{J\epsilon_D}\frac{dQ}{dt} \\
&= Q\frac{dp}{dt} - Q\frac{\nu_q}{J}\left((1+\theta t)\frac{dp}{dt} + \theta p\right) \\
&= Q\left(\frac{dp}{dt}\left(1 - \frac{\nu_q}{J}\right) - \frac{\nu_q}{J}\left(\theta p + \theta t\frac{dp}{dt}\right)\right) \\
&= -\frac{pQ}{1+t}\left(\left(1 - \frac{\nu_q}{J}\right)(1-\tilde{\rho}) + \frac{\nu_q}{J}\theta\left(1 + t\tilde{\rho}\right)\right)
\end{aligned}$$

The second equality comes from the Lerner condition $\frac{p-mc(q)}{p} = \frac{\nu_q}{J\epsilon_D}$. The third equality comes from the equivalence $mwtp(Q)\frac{dQ}{dt} = (1+\theta t)\frac{dp}{dt} + \theta p$. The first order condition of the firm is:

$$wtp(Q) + \frac{\nu_q}{J}ms(Q) = (1+\theta t)mc(q) \tag{A8}$$

where $ms(Q) = -Qmwtp(Q)$. From where:

$$\frac{dQ}{dt} = \frac{\frac{\theta}{wtp'(Q)}\left(mc(q)\right)}{1 + (1+\theta t)\left(\frac{\epsilon_D - \frac{\nu_q}{J}}{\epsilon_S} + \frac{\frac{\nu_q}{J}}{\epsilon_{ms}}\right)} = \frac{\theta * \frac{mc(q)}{mwtp(Q)}}{1 + (1+\theta t)\left(\frac{\epsilon_D - \frac{\nu_q}{J}}{\epsilon_S} + \frac{\frac{\nu_q}{J}}{\epsilon_{ms}}\right)}$$

so from lemma A1 we obatin:

$$\frac{dp}{dt} = \frac{1}{1+\theta t}\left(\frac{\theta p\left(1 - \frac{\nu_q}{J\epsilon_D}\right)}{1 + (1+\theta t)\left(\frac{\epsilon_D - \frac{\nu_q}{J}}{\epsilon_S} + \frac{\frac{\nu_q}{J}}{\epsilon_{ms}}\right)} - \theta p\right)$$

and therefore:

$$\tilde{\rho} \equiv \frac{1}{p}\frac{dp(1+t)}{dt} = \frac{1+t}{1+\theta t}\left(\frac{\theta\left(1 - \frac{\nu_q}{J\epsilon_D}\right)}{1 + (1+\theta t)\left(\frac{\epsilon_D - \frac{\nu_q}{J}}{\epsilon_S} + \frac{\frac{\nu_q}{J}}{\epsilon_{ms}}\right)} - \theta\right) + 1$$

Next, incidence follows directly from $I = \frac{\frac{dCS}{dt}}{\frac{dPS}{dt}}$.
Finally, the marginal excess burden of the tax is

$$\begin{aligned}
\frac{dW}{dt} &= -\rho Q - (1-\theta)tp\frac{dQ}{dt} + Q\left(\frac{dp}{dt}\left(1 - \frac{\nu_q}{J}\right) - \frac{\nu_q}{J}\left(\theta p + \theta t\frac{dp}{dt}\right)\right) + \frac{d(tpQ)}{dt} \\
&= \frac{dQ}{dt}(tp - (1-\theta)tp) + Q\left(p + (1+t)\frac{dp}{dt} - \rho - \frac{\nu_q}{J}\left(\theta p + (1+\theta t)\frac{dp}{dt}\right)\right) \\
&= \frac{dQ}{dt}(\theta tp) + Q\left(-\frac{\nu_q}{J}\left(\theta p + (1+\theta t)\frac{dp}{dt}\right)\right) \\
&= \frac{dQ}{dt}(\theta tp) + Q\left(-\frac{\nu_q}{J}mwtp(Q)\frac{dQ}{dt}\right) \\
&= \frac{dQ}{dt}(\theta tp) + Q\left(-\frac{p - mc(q)}{p}\epsilon_D mwtp(Q)\frac{dQ}{dt}\right) \\
&= (p - mc(q) + \theta tp)\frac{dQ}{dt}
\end{aligned}$$

□

3 Data Appendix

3.1 Nielsen Retail Scanner Data

We obtained the Nielsen scanner data from the Kilts Marketing Data Center at the University of Chicago Booth School of Business. The micro data records weekly prices and quantities by product at the barcode level (Universal Product Code, UPC) for over 35,000 stores from approximately 90 retail chains across the United States (except for Hawaii and Alaska), covering the years 2006-2014.[1] Each store, geolocated at the county level, is assigned one of five possible store types ("channels"), and can be matched with its parent chain.[2] Products are organized in a hierarchical structure: There are over 2.5 million different UPCs, which are categorized into approximately 1,200 *product-module*s. Each module is then assigned to one of roughly 120 *product-groups*, which in turn is part of one of 10 broader *product-departments*. Table A1 shows a few examples of UPCs included in the retail data.

The Retail Scanner dataset's coverage of total US sales volume varies across locations and store-types. For instance, it covers more than half of the total sales volume of US grocery stores, but only 2 percent of sales in convenience stores. We restrict our focus to grocery stores for several reasons. First, while there is a large number of grocery store retail chains in the data (70), there are too few different chains for other store types, precluding the use of an instrumental variable based on uniform pricing within chains for these stores. Second, the distribution of stores by store-type varies substantially across locations. Focusing on one store type ensures that compositional differences across regions are not driving our results based on sales tax variation. We further impose several sample restrictions. To implement our instrumental variable approach, we only include stores that are assigned to the same retail chain throughout the $2006 - 2014$ period, that are present in the data for at least two years, and that belong to retail chains that were associated with the same parent company throughout the period. In terms of the set of products, we only keep modules sold in all 48 continental states. We restrict the sample to the top selling modules that rank above the 80th percentile of total US sales in the distributions of food and non-food modules. These 198 modules account for almost 80% of the total value of sales in grocery stores in the scanner data.

[1] Products without a barcode such as random weight meat, fruits, and vegetables are not included in the data set.

[2] The five channels are grocery, drug, mass merchandise, convenience and liquor stores. Each store and each parent chain has a unique identifier. Retail chain names are confidential and unknown to researchers.

From the scanner data, we construct a store-module-level panel data set where the unit of observation is at the store-module-year-quarter level. Most of the time-variation in tax rates occurs via changes in sales tax rates, which affect most modules within a store the same way, and most tax rate changes occur either on January 1 or July 1.

Prices We measure the consumer price for each module-store-year-quarter combination by $p_{mr\tau}(1+t_{mcs\tau})$ where $p_{mr\tau}$ is pre-tax price and m = module, r = store, τ = year-quarter, c = county and s = state. Module-store-year-quarter pre-tax prices $p_{mr\tau}$ are module-store-year-quarter fixed effects extracted from a UPC-level regression of log prices on UPC fixed effects and store-module-year-quarter fixed effects. This accounts for compositional differences in the set of UPCs sold in the module in a given store at a point in time (Handbury and Weinstein 2015).

Quantity To measure output $Q_{mr\tau}$, we create a price-weighted quantity index by aggregating UPC-level expenditures within store-module-year-quarter cells, fixing each UPC's price at its national average. Specifically, we aggregate revenue $Q_{jmr\tau} = q_{jmr\tau} \times \bar{p}_{j\tau}$ across all UPCs to the module-store-year-quarter level, where $q_{jmr\tau}$ is the quantity of product (UPC) j sold in store r at time τ and $\bar{p}_{j\tau}$ is the national average price of that product at that time.

In Table OA.5, we consider an alternative method for obtaining the effect of sales taxes on quantity. In Panel A, we report the effect of sales taxes on pre-tax prices $p_{mr\tau}$ as well as on total expenditures $\sum_j R_{jmr\tau} = \sum_j (q_{jmr\tau} \times p_{jmr\tau})$. The effect on expenditures captures both the effect on prices and on quantity. We then back out the implied effect on quantity by substracting the effect on prices (column (2)) from the effect on expenditures (columns (3)). These estimates are very similar to those where we directly use our measure of quantity as the dependent variable.

3.2 US Sales Tax Exemptions and Rates

The second source of data we use is a hand-collected monthly panel of local (county and state) sales tax *rates* and state-level *exemptions*, which vary at the product-module level, covering the years 2006-2014. All sources used to input the exemption status of products are listed in Table OA.8. In general, exemptions are set by states and are module-specific.[3] The

[3]There are a handful of exceptions to this. Colorado, for example, allows each county to decide whether to subject food to the county-level portion of the sales tax rate.

general rule of thumb is that food products are tax-exempt and non-food products are taxable. However, there are important exceptions to this rule. First, several states tax food at the full rate or a reduced rate. Second, in a few states, food products are exempt from the state-level portion of the total sales tax rate, but remain subject to the county-level sales tax. Third, in some cases where food is tax-exempt, there is a tax that applies at the product-module level. For example, prepared foods are subject to sales taxes in many states. Finally, some states exempt some non-food products from sales taxes. Our final tax exemption database is at the county-module-month level, however it should be noted that changes in exemptions over time are very rare during our sample period. For tax rates, we collected monthly state-level and county-level rates.[4]

There are several possible sources of measurement error in our sales tax rates. First, we do not incorporate county-level exemptions or county-specific sales surtaxes that apply to specific products or modules, although our understanding is that these cases are uncommon. Second, there may be measurement error coming from our exemption definitions and how we assigned a taxability status to each module, which in some cases required a subjective judgment based on interpreting the text of the state sales tax law. While the bulk of the variation in taxes occurs at the module level or higher, there are some instances where taxability varies within module. For example, in New York, fruit drinks are tax exempt as long as they contain at least 70% real fruit juice, but are subject to the sales tax otherwise. Therefore, some products in Nielsen's module "Fruit Juice- Apple", may or may not be taxed in New York, but all are considered eligible for the sales tax exemption in our database since we cannot readily identify the real fruit juice content.[5]

As a final step, we merge the effective sales tax rates to the Nielsen scanner data. This requires aggregating the sales tax data to the level of the scanner data. We use the rate effective at the mid-point of each quarter (February for quarter 1, May for quarter 2, etc) and then merge the sales tax rates to the scanner data by product-module, county and time. Our final sample includes 8,652 grocery stores, and contain price, output and variety for 198 modules in 1,460 counties.

[4]Some cities and other localities also impose an additional local sales tax rate. We do not incorporate rates that apply to areas smaller than counties.

[5]In cases where it is impossible to tell whether the majority of products in a given module are subject to the tax or not, we code the statutory tax rate as missing. This results in excluding less than 3% of the observations in our sample.

3.3 Descriptive Statistics

Table OA.2 presents the tax status of the top selling food and non-food modules in our sample. Modules such as soft drinks, ice cream, and candy are taxed in some states that generally exempt food, like Connecticut, Florida, and Wisconsin. Additionally, several non-food modules are exempt from taxes. For example, toilet tissue and diapers are exempt in New Jersey and Pennsylvania and magazines are tax-exempt in Maine, Massachusetts, New York and Oklahoma.

Figure OA.1 shows the cross-sectional distribution of the total sales tax rate (state + county) in September 2008. There is substantial cross-sectional variation in sales tax rates ranging from zero in Montana, Oregon, New Hampshire and Delaware to a maximum rate of 9.75 percent in Tennessee. To estimate the causal effects of sales taxes, we rely on the panel structure of our data spanning the 2006-2014 period. All regression models control for module fixed effects interacted with store fixed effects, so that we are only exploiting variation within store-by-module cells in sales tax rates over time. In practice, since tax exemptions rarely change during our sample period, our identifying variation comes primarily from state-level and county-level changes in sales tax rates.

In Figure OA.2, we present visual evidence on the distribution of food tax exemptions across states. In general we see that food taxability status is spatially correlated. For example, most states that tax food are located in the South or in the Midwest.

3.4 Instrumental variable construction

We construct an instrument that is equal to the average log pre-tax price across all stores in the same chain excluding store r:

$$z_{mr\tau} = \frac{\sum_{x \in f} \log(p_{mr\tau}) - \log(p_{mr\tau})}{N_{f,\tau} - 1}$$

where f denotes the retail chain to which store r belongs and $N_{f,\tau}$ is the number of stores in chain f at time τ. This variable is used as an instrumental variable for module-store average prices at a given point in time based on chain-level pricing decisions. As described in the main text, this is a valid instrument under the assumption that chain-specific prices predict store prices, but are not correlated with unobserved store-level demand factors (DellaVigna and Gentzkow 2019).

A threat to the validity of this instrument is that there may be correlated demand shocks

across stores within chains. To address this, we continue to include store-by-module fixed effects in all of our specifications. The inclusion of module fixed effects accounts for the fact that more expensive modules may reflect chains responding to strong demand for these modules. Intuitively, our identification is coming from differences in relative prices across modules and chains. To the extent that this variation is driven by differences in product-specific marginal costs across chains, differences in distribution costs across chains (such as supply-sourcing costs), or differences in bargaining power across chains, then we can consistently estimate our reduced-form elasticities of interest, since these supply-side instruments will identify the average price elasticity of demand. Intuitively, this approach requires that chains select store locations based on overall demand (across modules), but not module-specific demand. In Table OA.7, we report the reduced-form relationships between this instrument and price and quantity. For robustness, we present corresponding estimates based on an alternative instrument that is equal to the average log pre-tax price across all stores in the same chain excluding all stores located in county c.

Kroft et al. (2020) also use chain-level instrument but the construction of the instrument in this paper is more tightly connected to a specific theoretical model of consumer demand. Additionally the instrument is cross-sectional, while the instrument here is similar to the tax variation in that it exploits within-store, over-time variation in the "uniform pricing" instrument. Reassuringly, we find a module-level price elasticity of demand that is similar using both approaches.

3.5 Robustness of Calibration of Incidence and Welfare Formulas

Table OA.3 reports all of the results in Table 2 using the county border pair subsample instead of the full sample of counties. Since the reduced-form effects are fairly similar, it is not surprising that the incidence and welfare results are broadly similar, although the difference between the Harberger formula and the full welfare formula allowing for imperfect competition and tax salience is reduced somewhat. This is because using the county border pair results we find that the attenuating effect of the tax salience parameter largely offsets the increase in magnitude of welfare change due to imperfect competition. In Table OA.4, we show senstivity to alternative values of the elasticity of marginal surplus. In the main results in Table 2, we assume that this elasticity if equal to the inverse of the price elasticity of demand. Alternative functional form assumptions would lead to different relationships between these parameters. Since we do not have sufficient data to estimate this elasticity directly, we instead

show sensitivty across different values of this parameter. Varying this parameter by roughly 50 percent in either direction does not change the main qualitative conclusions from our main results – that the incidence largely falls on consumers, the incidence is actually increasing in the tax salience parameter, and Harberger formula understates the welfare change.and OA.4.

References

1. DellaVigna, Stefano and Matthew Gentzkow (2019). "Uniform Pricing in US Retail Chains," *The Quarterly Journal of Economics*, 134(4): 2011-2084.
2. Handbury, Jessie, and David E. Weinstein (2015), "Goods Prices and Availability in Cities," *Review of Economic Studies*, 82(1): 258-296.
3. Kroft, Kory, Jean-William P. Laliberté, René Leal-Vizcaíno and Matthew J. Notowidigdo (2020), "A New Empirical Method for Valuing Product Variety". Working Paper.

Online Appendix Table OA.1: Examples of Universal Product Codes (UPC)

UPC Description	Module Description	Group Description	Department Description	Brand Description	Multi	Size	Units
M&M PLN DK CH HDY-M HDY	CANDY-CHOCOLATE-SPECIAL	CANDY	DRY GROCERY	M&M MARS M&M PLAIN	1	12.6	OZ
M&M PLN CH/TY SHREK 2 HL	CANDY-CHOCOLATE-SPECIAL	CANDY	DRY GROCERY	M&M MARS M&M PLAIN	1	1.75	OZ
M&M PLN CH DSP STAR WARS	CANDY-CHOCOLATE-SPECIAL	CANDY	DRY GROCERY	M&M MARS M&M PLAIN	1	1.06	OZ
R SSY E-C MSE AP CHFN	COSMETICS-EYE SHADOWS	COSMETICS	HEALTH & BEAUTY CARE	REVLON STAR STYLE	1	0.17	OZ
R SSY E-S PWD SQN	COSMETICS-EYE SHADOWS	COSMETICS	HEALTH & BEAUTY CARE	REVLON STAR STYLE	1	0.05	OZ
AXE AR R TWIST	DEODORANTS - COLOGNE TYPE	DEODORANT	HEALTH & BEAUTY CARE	AXE	1	4	OZ
CTL BR EGGS A LG	EGGS-FRESH	EGGS	DAIRY	CTL BR	1	12	CT
CTL BR B-E JMB	EGGS-FRESH	EGGS	DAIRY	CTL BR	1	12	CT
COKE CLS R CL NB 6P	SOFT DRINKS - CARBONATED	CARBONATED BEVERAGES	DRY GROCERY	COCA-COLA CLASSIC R	6	8	OZ
COKE CLS R CL CN &	SOFT DRINKS - CARBONATED	CARBONATED BEVERAGES	DRY GROCERY	COCA-COLA CLASSIC R	1	12	OZ
GPC 2 UL L M F UT 85 P -.30	CIGARETTES	TOBACCO & ACCESSORIES	NON-FOOD GROCERY	GPC	1	20	CT
GPC 2 UL L M F UT 85 C -2.00	CIGARETTES	TOBACCO & ACCESSORIES	NON-FOOD GROCERY	GPC	10	20	CT

Source: Nielsen's Retail Scanner Data.

Online Appendix Table OA.2: Sales Tax Exemptions

Panel A: Food Modules

Module	Avg. Mkt. Share	States taxing all food	State taxing module at reduced rate	State taxing module at full rate (but otherwise exempt food)
DAIRY - MILK	3.04%	AL, ID, KS, MS, OK, SD	AR, IL, MO, NC, TN,UT,VA,WV	
SOFT DRINKS - CARBONATED	2.88%	AL, ID, KS, MS, OK, SD	AR, IL, MO, TN,UT,VA	CA, CT, FL, IA, IN, KY, MD, ME, MN, NC, ND, NJ, NY, OH, PA, RI, TX, WA, WI, WV
BAKERY - BREAD - FRESH	2.19%	AL, ID, KS, MS, OK, SD	IL, MO, TN,UT,VA, WV	
CEREAL - READY TO EAT	1.93%	AL, ID, KS, MS, OK, SD	AR, IL, MO, NC, TN,UT,VA,WV	
SOFT DRINKS - LOW CALORIE	1.62%	AL, ID, KS, MS, OK, SD	AR, IL, MO, TN,UT,VA	CA, CT, FL, IA, IN, KY, MD, ME, MN, NC, ND, NJ, NY, OH, PA, RI, TX, WA, WI, WV
WATER-BOTTLED	1.42%	AL, ID, KS, MS, OK, SD	AR, IL, MO, NC, TN,UT,VA,WV	LA, MD, ME, MN, NY
ICE CREAM - BULK	1.22%	AL, ID, KS, MS, OK, SD	AR, IL, MO, NC, TN,UT,VA,WV	FL, MD
COOKIES	1.21%	AL, ID, KS, MS, OK, SD	AR, IL, MO, NC, TN,UT,VA,WV	
CANDY-CHOCOLATE	0.64%	AL, ID, KS, MS, OK, SD	AR, IL, MO, UT,VA,WV	CT, FL, IA, IN, KY, MD, ME, MN, NC, ND, NJ, NY, RI, TN, TX, WI

Panel B: Non-Food Modules

Module	Avg. Mkt. Share	State with no sales tax	State exempting module	State taxing module at reduced rate
WINE - DOMESTIC	2.11%	DE, MT, NH, OR	PA, KS, KY, MA	
CIGARETTES	1.70%	DE, MT, NH, OR	CO, MN, OK	
TOILET TISSUE	1.07%	DE, MT, NH, OR	PA, NJ	
DETERGENTS - LIQUID	0.75%	DE, MT, NH, OR		
PAPER TOWELS	0.66%	DE, MT, NH, OR	NJ	
RUM	0.54%	DE, MT, NH, OR	PA, KS, KY, MA	
DISPOSABLE DIAPERS	0.50%	DE, MT, NH, OR	MA, MN, NJ, PA, VT	IL
MAGAZINES	0.41%	DE, MT, NH, OR	MA, ME, NY, OK	
CAT FOOD - DRY TYPE	0.35%	DE, MT, NH, OR		
COLD REMEDIES - ADULT	0.28%	DE, MT, NH, OR	CT, FL, MD, MN, NJ, NY, PA, TX, VA, VT	IL
DOG & CAT TREATS	0.25%	DE, MT, NH, OR		
ALE	0.25%	DE, MT, NH, OR	PA, KS, KY, MA	
DOG FOOD - WET TYPE	0.23%	DE, MT, NH, OR		
FACIAL TISSUE	0.22%	DE, MT, NH, OR	NJ	
TOOTH CLEANERS	0.22%	DE, MT, NH, OR	PA	IL

Notes: Average market shares are calculated at the store-level for the year 2008.

Online Appendix Table OA.3: Calibration of Incidence and Marginal Excess Burden Formulas

[County Border Pair Sample Estimates]

	Using plug-in estimate of tax salience parameter	Assuming full salience (θ=1), but using same markup from (1)	Assuming full salience (θ=1), but re-calibrating markup
	(1)	(2)	(3)
Panel A: Incidence and Marginal Excess Burden Formulas			
Incidence (I)			
General formula (imperfect salience, imperfect competition):			
$(\rho(1+t) + (1-\theta)t\epsilon_{D,t+1}) / (\theta(v/J)(1+t\rho) + (1-\rho)(1-v/J))$	48.434	37.924	48.749
Incidence under perfect competition (for $0 < \theta \leq 1$)	∞	∞	∞
Marginal Excess Burden ($d\tilde{W}/dt$)			
General formula (salience, imperfect competition):			
$d\tilde{W}/dt = [\ (p-mc)/p + \theta(t)\ ] * d\log(Q)/d\log(1+t)$	-0.019	-0.029	-0.026
Harberger/Chetty-Looney-Kroft formulas (perfect competition):			
$d\tilde{W}/dt = \theta * t * d\log(Q)/d\log(1+t)$	-0.012	-0.022	
Panel B: Inputs and Intermediate Estimates Needed to Calibrate Formulas			
Inputs:			
Average tax rate, t	0.034	0.034	0.034
Price Elasticity, $d\log(Q)/d\log(p)$	**-1.223**	**-1.223**	**-1.223**
Tax Pass-Through, $d\log(p(1+t))/d\log(1+t)$	**0.986**	**0.986**	**0.986**
Tax Elasticity, $d\log(Q)/d\log(1+t)$	**-0.650**	**-0.650**	**-0.650**
Tax Salience Parameter, θ			
Implied "Plug-In" Estimate of θ	0.537		
Assuming full salience (θ = 1)		1.000	1.000
Intermediate estimates:			
Implied estimate of $v/(J * \epsilon_{ms})$	0.015		0.008
Implied markup $(p-mc)/p$, which equals $v/(J * \epsilon_D)$	0.010		0.006
Implied estimate of v/J	0.013		0.007
($v/J = 0$ is perfect competition, $v/J = 1$ is perfect collusion)			

Notes: This table reports calibrations of the tax incidence and marginal excess burden formulas. The results of these calibrations are shown in Panel A. Panel B presents the value of the input parameters taken from Table 1 column (1), as well as estimates of intermediate parameters. In column (1), the incidence and marginal excess burden formulas are implemented with no restrictions. In column (2), we use estimates of the markup based on the tax salience parameter reported in column (1), but assume full salience elsewhere in the formulas. In column (3), full salience is assumed throughout, including when calculating the markup.

Online Appendix Table OA.4: Calibration of Incidence and Marginal Excess Burden Formulas

[Sensitivity to Alternative Values of Elasticity of Marginal Surplus]

	Using plug-in estimate of tax salience parameter				
	(1)	(2)	(3)	(4)	(5)
Panel A: Incidence and Marginal Excess Burden Formulas					
Incidence (I)					
General formula (imperfect salience, imperfect competition):					
$(\rho(1+t) + (1-\theta)t\epsilon_{D,t+1}) / (\theta(v/J)(1+t\rho) + (1-\rho)(1-v/J))$	17.051	19.492	18.131	16.473	15.931
Incidence under perfect competition (for $0 < \theta \leq 1$)	∞	∞	∞	∞	∞
Marginal Excess Burden ($d\tilde{W}/dt$)					
General formula (salience, imperfect competition):					
$d\tilde{W}/dt = [\ (p-mc)/p + \theta(t)\ ] * d\log(Q)/d\log(1+t)$	-0.033	-0.025	-0.029	-0.035	-0.036
Harberger/Chetty-Looney-Kroft formulas (perfect competition):					
$d\tilde{W}/dt = \theta * t * d\log(Q)/d\log(1+t)$	-0.014	-0.014	-0.014	-0.014	-0.014
Panel B: Inputs and Intermediate Estimates Needed to Calibrate Formulas					
Inputs:					
Average tax rate, t	0.036	0.036	0.036	0.036	0.036
Price Elasticity, $d\log(Q)/d\log(p)$	-1.202	-1.202	-1.202	-1.202	-1.202
Tax Pass-Through, $d\log(p(1+t))/d\log(1+t)$	0.961	0.961	0.961	0.961	0.961
Tax Elasticity, $d\log(Q)/d\log(1+t)$	-0.668	-0.668	-0.668	-0.668	-0.668
Tax Salience Parameter, θ					
Implied "Plug-In" Estimate of θ	0.586	0.586	0.586	0.586	0.586
Assuming full salience ($\theta = 1$)					
Intermediate estimates:					
Implied estimate of $v/(J * \epsilon_{ms})$	0.040	0.051	0.045	0.037	0.034
ϵ_{ms} (assume $1/\epsilon_D$ in col (1), sensitivity analysis in (2)-(5))	0.832	**0.400**	**0.600**	**1.000**	**1.200**
Implied markup $(p-mc)/p$, which equals $v/(J * \epsilon_D)$	0.028	0.017	0.023	0.031	0.034
Implied estimate of v/J	0.033	0.020	0.027	0.037	0.040
($v/J = 0$ is perfect competition, $v/J = 1$ is perfect collusion)					

Notes: This table reports calibrations of the tax incidence and marginal excess burden formulas. The results of these calibrations are shown in Panel A. Panel B presents the value of the input parameters taken from Table 1 column (1), as well as estimates of intermediate parameters. Each column reports results from a different assumed value of the elasticity of marginal surplus. Column (1) reproduces the results from Table 2 where the elasticity of marginal surplus is assumed to be the inverse of the price elasticity of demand. In columns (2) to (5), the elasticity of marginal surplus is calibrated using values ranging from 0.4 to 1.2.

Online Appendix Table OA.5: Reduced-form OLS Estimates of the Effects of Sales Taxes on Quantity and Expenditure

Sample:	Full Sample			County Border Pair Sample		
Dependent variable:	Quantity	Pre-tax price	Expenditure	Quantity	Pre-tax price	Expenditure
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Reduced-form OLS Estimates of the Effects of Sales Taxes						
$\log(1 + t_{mrcsr})$	-0.668	-0.0388	-0.741	-0.650	-0.014	-0.667
	(0.185)	(0.045)	(0.183)	(0.084)	(0.016)	(0.083)
Implied effect on quantity		-0.702			-0.653	
Panel B: Reduced-form OLS Estimates of the Effects of the Price Instrument						
z_{mrcst}	-1.165	0.969	-0.351	-1.179	0.964	-0.359
	(0.026)	(0.002)	(0.0249)	(0.026)	(0.002)	(0.024)
Implied effect on quantity		-1.320			-1.323	
Panel C: "Plug-in" Estimate of the Tax Salience Parameter						
θ		0.571			0.508	
Specification:						
Store × Module fixed effects	y	y	y	y	y	y
Module × Year-Quarter fixed effects	y	y	y	y	y	y
Module × State × Year-Quarter fixed effects	y	y	y			
Module × Border Pair × Year-Quarter fixed effects				y	y	y
N (observations)	53,895,446	53,895,446	53,895,446	33,749,157	33,749,157	33,749,157
N (modules)	198	198	198	198	198	198
N (stores)	8,652	8,652	8,652	2,714	2,714	2,714
N (counties)	1,460	1,460	1,460	468	468	468
N (county-modules)	277,398	277,398	277,398	88,249	88,249	88,249

Notes: This table replicates the key parameters reported in Table 1, but using an alternative measure of quantity. Here, we report separately the effects of sales taxes (Panel A) and the effects of the price instrument (Panel B) on total expenditures on module m in store r at time t and on pre-tax prices. We then report the difference between the effect on expenditure and on prices as an alternative measure of the effect on quantity. Panel C reports the associated value of the tax salience parameter. The Retail Scanner data is restricted to modules above the 80th percentile of the national distribution of sales. All standard errors in this table are clustered at the state-module level and are reported in parentheses. In columns (1) to (3), the sample includes our full sample of stores and the regression model includes module-by-store and module-by-quarter-by-state fixed effects. In columns (4) to (6), the sample is restricted to stores in border counties. Observations are weighted by the inverse of the number of times a store appears in the data. The regression model includes module-by-store and module-by-quarter-by-pair fixed effects, where pairs denote pairs of contiguous counties.

Online Appendix Table OA.6:
OLS and Instrumental Variables Estimates of the Effects of Sales Taxes on Prices and Quantity

Sample:	County Border Pair Sample		County Border Pair Sample **[Instrumental Variables Estimates]**	
Dependent variable:	Price	Quantity	Price	Quantity
	(1)	(2)	(3)	(4)
$\log(1+\tau_{mcs})$	0.986	-0.650	0.965	-0.775
	(0.016)	(0.084)	(0.029)	(0.191)
Specification:				
Store × Module fixed effects	y	y	y	y
Module × Year-Quarter fixed effects	y	y	y	y
Module × State × Year-Quarter fixed effects	y	y		
Module × Border Pair × Year-Quarter fixed effects			y	y
N (observations)	33,749,157	33,749,157	33,749,157	33,749,157
N (modules)	198	198	198	198
N (stores)	2,714	2,714	2,714	2,714
N (counties)	468	468	468	468
N (county-modules)	88,249	88,249	88,249	88,249

Notes: This table replicates the estimates of the effects of sales taxes on quantity and prices reported in Table 1, column (2), but using instrumenting county-level module-specific sales tax rates with the associated state-level sales tax rate. The independent variable is quarterly sales tax rate of module m in county c in state s and the instrument is is quarterly sales tax rate of module m in state s. One observation is a module in a store in a given quarter. For the effect of sales taxes on consumer prices, the p-value for a test of full pass-through (coefficient equal to one) is reported in square brackets. Consumer prices $p(1+t)$ are tax inclusive. The Retail Scanner data is restricted to modules above the 80th percentile of the national distribution of sales. The sample is restricted to stores in border counties. Observations are weighted by the inverse of the number of times a store appears in the data. The regression model includes module-by-store and module-by-year-quarter-by-pair fixed effects, where pairs denote pairs of contiguous counties.

Online Appendix Table OA.7: Reduced-form OLS Estimates of the Effects of Chain Instrument on Prices and Quantity

Sample:	Full Sample				County Border Pair Sample			
Dependent variable:	Price		Quantity		Price		Quantity	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Leave-me-out chain average log(p)	0.969		-1.165		0.964		-1.179	
	(0.002)		(0.026)		(0.003)		(0.026)	
Leave-county-out chain average log(p)		0.951		-1.148		0.951		-1.155
		(0.003)		(0.026)		(0.003)		(0.026)
Specification:								
Store × Module fixed effects	y	y	y	y	y	y	y	y
Module × Year-Quarter fixed effects	y	y	y	y	y	y	y	y
Module × State × Year-Quarter fixed effects	y	y	y	y				
Module × Border Pair × Year-Quarter fixed effects					y	y	y	y
N	53,895,446	53,890,260	53,895,446	53,890,260	33,749,157	33,739,222	33,749,157	33,739,222

Notes: This table reports estimates of the reduced-form effect of price instruments on consumer prices and quantity sold. One observation is a module in a store in a given quarter. Consumer prices p(1+t) are tax inclusive. The Retail Scanner data is restricted to modules above the 80th percentile of the national distribution of sales. All standard errors in this table are clustered at the state-module level and are reported in parentheses. In columns (1) to (4), the sample includes our full sample of stores and the regression model includes module-by-store and module-by-quarter-by-state fixed effects. In columns (5) to (8), the sample is restricted to stores in border counties. Observations are weighted by the inverse of the number of times a store appears in the data. The regression model includes module-by-store and module-by-quarter-by-pair fixed effects, where pairs denote pairs of contiguous counties. In odd-numbered columns, the independent variable is the chain average log price leaving store r out. In even-numbered columns, the independent variable is the chain average log price leaving all stores in county c out.

Online Appendix Table OA.8: Sources of sales tax exemption information

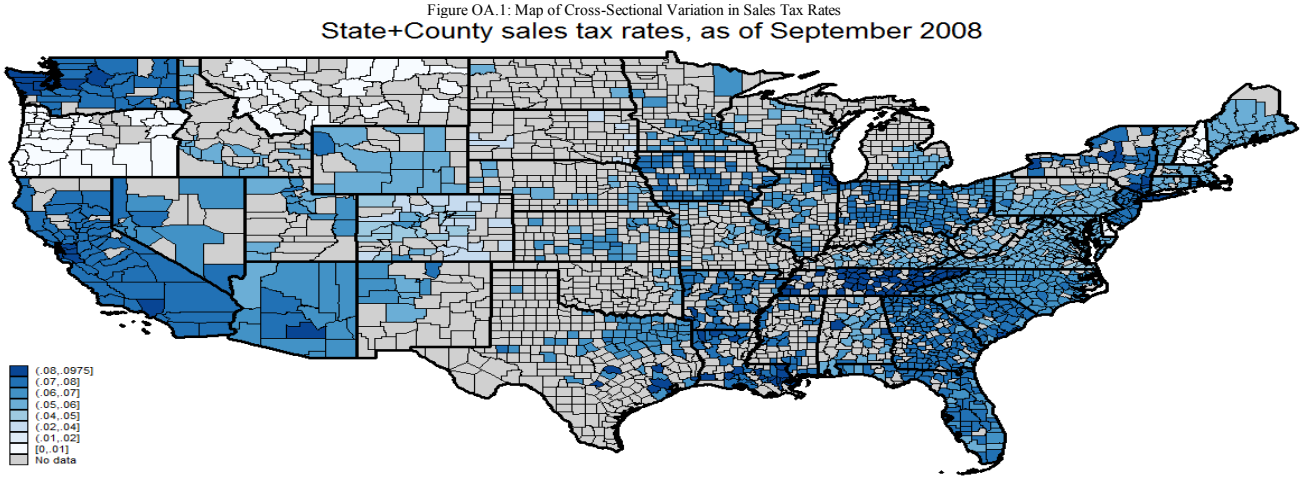
State	URLs	Type of Document
AL	http://revenue.alabama.gov/salestax/rules/810-6-5-.02.pdf	Laws and Regulations
AL	http://www.alabamaadministrativecode.state.al.us/docs/rev/810-6-3.pdf	Laws and Regulations
AL	http://revenue.alabama.gov/publications/business-taxes/sales/Sales_Tax--Sales_Tax_Brochure.pdf	Brochure
AZ	http://www.azleg.state.az.us/ArizonaRevisedStatutes.asp?Title=42	Laws and Regulations
AZ	http://www.azsos.gov/public_services/Title_15/15-05.htm	Laws and Regulations
AZ	https://www.azdor.gov/Portals/0/TPTRates/08012016RateTable.pdf	Table
AZ	https://www.azdor.gov/Portals/0/Brochure/575.pdf	Brochure
AR*	http://www.lexisnexis.com/hottopics/arcode/Default.asp	Laws and Regulations
AR*	http://www.dfa.arkansas.gov/offices/policyAndLegal/Documents/et2008_3.pdf	Laws and Regulations
AR*	http://www.dfa.arkansas.gov/offices/policyAndLegal/Documents/et2007_3.pdf	Laws and Regulations
AR*	http://www.dfa.arkansas.gov/offices/exciseTax/salesanduse/Documents/SalesTaxExemptionsFY2011.pdf	Brochure
CA	http://www.boe.ca.gov/lawguides/business/current/btlg/business-taxes-law-guide.html	Laws and Regulations
CA	https://www.boe.ca.gov/pdf/pub31.pdf	Brochure
CA	https://www.boe.ca.gov/pdf/pub27.pdf	Brochure
CA	https://www.boe.ca.gov/pdf/pub61.pdf	Brochure
CO	https://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=4753	Laws and Regulations
CO	http://codes.findlaw.com/co/title-39-taxation/co-rev-st-sect-39-26-707.html	Laws and Regulations
CO	https://www.colorado.gov/pacific/sites/default/files/DR1002.pdf	Brochure
CO	https://www.colorado.gov/pacific/sites/default/files/Sales04.pdf	Brochure
CT	http://www.cga.ct.gov/2011/pub/chap219.htm	Laws and Regulations
CT	https://www.cga.ct.gov/2011/rpt/2011-R-0238.htm	Brochure
CT	http://www.ct.gov/drs/cwp/view.asp?A=1514&Q=563394	Brochure
CT	http://www.ct.gov/drs/cwp/view.asp?a=1511&q=267404	Brochure
DE	http://revenue.delaware.gov/services/current_bt/taxtips/grocery.pdf	Brochure
FL	http://www.leg.state.fl.us/statutes/index.cfm?App_mode=Display_Statute&URL=0200-0299/0212/0212ContentsIndex.html	Laws and Regulations
FL	https://www.flrules.org/gateway/ChapterHome.asp?Chapter=12A-1	Laws and Regulations
FL	http://floridarevenue.com/Forms_library/current/dr46nt.pdf	Brochure
GA*	http://www.lexisnexis.com/hottopics/gacode/Default.asp	Laws and Regulations
GA*	http://garules.elaws.us/rule/560-12-2	Laws and Regulations
GA*	https://dor.georgia.gov/sites/dor.georgia.gov/files/related_files/document/LATP/Bulletin/2016%20List%20of%20Sales%20and%20Use%20Tax%20Exemptions.pdf	Brochure
ID	http://adminrules.idaho.gov/rules/current/35/0102.pdf	Laws and Regulations
ID	http://www.legislature.idaho.gov/idstat/Title63/T63CH36.htm	Laws and Regulations
ID	https://tax.idaho.gov/pubs/EBR00012_07-01-2001.pdf	Brochure
ID	https://tax.idaho.gov/pubs/EBR00016_03-23-2015.pdf	Brochure
IL	ftp://www.ilga.gov/JCAR/AdminCode/086/08600130sections.html	Laws and Regulations
IL	http://www.revenue.state.il.us/publications/Bulletins/2010/FY-2010-01.PDF	Brochure
IL	http://www.revenue.state.il.us/Publications/Pubs/Pub-117.pdf	Brochure
IN*	http://codes.findlaw.com/in/title-6-taxation/	Laws and Regulations
IN*	http://www.in.gov/legislative/iac/20080827-IR-045080658NRA.xml.pdf	Brochure
IA*	https://www.legis.iowa.gov/law/iowaCode/chapters?title=X	Laws and Regulations
IA*	http://law.justia.com/codes/iowa/2013/titlex/subtitle1/chapter423	Laws and Regulations
IA*	https://tax.iowa.gov/iowa-sales-tax-food	Brochure
KS*	http://kansasstatutes.lesterama.org/Chapter_79/	Laws and Regulations
KS*	http://rvpolicy.kdor.ks.gov/Pilots/Ntrntpil/IPILv1x0.NSF/$$ViewTemplate%20for%20Regulations%20Only?OpenForm	Laws and Regulations
KS*	http://www.ksrevenue.org/pdf/pub1510.pdf	Brochure
KY*	http://www.lrc.ky.gov/Statutes/chapter.aspx?id=37663	Laws and Regulations
KY*	http://www.lrc.ky.gov/kar/TITLE103.HTM	Laws and Regulations
KY*	http://revenue.ky.gov/Documents/AppendixN_CandyProduct91114.pdf	Brochure
KY*	http://revenue.ky.gov/News/Publications/Pages/Sales-Tax-Facts.aspx	Brochure
LA	http://www.legis.state.la.us/lss/lss.asp?folder=121	Laws and Regulations
LA	http://www.doa.louisiana.gov/osr/lac/61v01/61v01.doc	Laws and Regulations
LA	http://www.rev.state.la.us/Miscellaneous/FoodExemptionFlyer.pdf	Brochure
LA	http://revenue.louisiana.gov/Publications/R-1002(01-17)%20FINAL.pdf	Brochure

ME	http://www.mainelegislature.org/legis/statutes/36/title36ch0sec0.html	Laws and Regulations
ME	http://www.maine.gov/revenue/salesuse/Bull1220160101v2.pdf	Brochure
ME	http://www.maine.gov/revenue/salesuse/Bull2720160101v2.pdf	Brochure
MD	http://www.lexisnexis.com/hottopics/mdcode/	Laws and Regulations
MD	http://www.dsd.state.md.us/COMAR/title_search/Title_List.aspx	Laws and Regulations
MD	http://taxes.marylandtaxes.com/Resource_Library/Tax_Publications/Tax_Tips/Business_Tax_Tips/bustip5.pdf	Brochure
MA	https://malegislature.gov/Laws/GeneralLaws/PartI/TitleIX/Chapter64H	Laws and Regulations
MA	http://www.mass.gov/dor/individuals/taxpayer-help-and-resources/tax-guides/salesuse-tax-guide.html	Brochure
MI*	http://w3.lara.state.mi.us/orrsearch/948_2010-012TY_AdminCode.pdf	Laws and Regulations
MI*	https://www.michigan.gov/documents/treasury/RAB_2009-8_Food_for_Human_Consumption_Oct_09_299470_7.pdf	Brochure
MN*	https://www.revisor.mn.gov/statutes/?id=297A.67	Laws and Regulations
MN*	http://www.revenue.state.mn.us/businesses/sut/factsheets/FS102A.pdf	Brochure
MN*	http://www.revenue.state.mn.us/businesses/sut/factsheets/FS102B.pdf	Brochure
MN*	http://www.revenue.state.mn.us/businesses/sut/factsheets/FS102C.pdf	Brochure
MN*	http://www.revenue.state.mn.us/businesses/sut/factsheets/FS102D.pdf	Brochure
MN*	http://www.revenue.state.mn.us/businesses/sut/factsheets/FS117A.pdf	Brochure
MN*	http://www.revenue.state.mn.us/businesses/sut/factsheets/FS117F.pdf	Brochure
MS	http://www.lexisnexis.com/hottopics/mscode/	Laws and Regulations
MS	http://www.sos.ms.gov/admincodesearch/default.aspx	Laws and Regulations
MS	https://www.dor.ms.gov/Laws-Rules/Documents/Part%20IV%20Sales%20and%20Use%20Tax%2092216.pdf	Laws and Regulations
MS	http://www.dor.ms.gov/Business/Pages/Sales-Tax-Exemptions.aspx	Brochure
MO	http://www.moga.mo.gov/mostatutes/stathtml/14400000301.html	Laws and Regulations
MT	https://revenue.mt.gov/home/individuals/businesses_otherinformation#Sales%20Tax	Brochure
NE*	http://www.revenue.nebraska.gov/legal/regs/slstaxregs.html	Laws and Regulations
NE*	http://www.nebraskalegislature.gov/laws/browse-chapters.php?chapter=77	Laws and Regulations
NE*	http://www.revenue.nebraska.gov/info/6-432.pdf	Brochure
NE*	http://www.revenue.nebraska.gov/info/6-437.pdf	Brochure
NV*	http://www.leg.state.nv.us/NRS/NRS-372.html	Laws and Regulations
NV*	http://www.leg.state.nv.us/NAC/NAC-372.html	Laws and Regulations
NV*	https://tax.nv.gov/FAQs/Sales_Tax_Information___FAQ_s/	Brochure
NH	https://www.revenue.nh.gov/assistance/tax-overview.htm	Brochure
NJ*	http://law.justia.com/codes/new-jersey/2009/title-54/54-32b	Laws and Regulations
NJ*	http://www.state.nj.us/treasury/taxation/pdf/pubs/sales/su4.pdf	Brochure
NJ*	http://www.state.nj.us/treasury/taxation/pdf/ssutfood.pdf	Brochure
NM	http://www.nmcpr.state.nm.us/nmac/_title03/T03C002.htm	Laws and Regulations
NM	http://public.nmcompcomm.us/nmpublic/gateway.dll/?f=templates&fn=default.htm	Laws and Regulations
NM	http://realfile.tax.newmexico.gov/FYI-105%20-%20Gross%20Receipts%20&%20Compensating%20Taxes%20-%20An%20Overview.pdf	Brochure
NM	http://www.zillionforms.com/2016/P668403604.PDF	Brochure
NY	http://codes.findlaw.com/ny/tax-law/tax-sect-1105.html	Laws and Regulations
NY	https://govt.westlaw.com/nycrr/Document/I50f2201ecd1711dda432a117e6e0f345?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)	Laws and Regulations
NY	https://www.tax.ny.gov/pdf/publications/sales/pub840.pdf	Brochure
NY	https://www.tax.ny.gov/pdf/publications/sales/pub750.pdf	Brochure
NY	https://www.tax.ny.gov/pdf/memos/sales/m11_3s.pdf	Brochure
NY	https://www.tax.ny.gov/pdf/memos/sales/m06_6s.pdf	Brochure
NY	https://www.tax.ny.gov/pdf/tg_bulletins/sales/b11_525s.pdf	Brochure
NY	https://www.tax.ny.gov/pdf/tg_bulletins/sales/b14_103s.pdf	Brochure
NY	https://www.tax.ny.gov/pdf/tg_bulletins/sales/b11_160s.pdf	Brochure
NY	https://www.ny.gov/sites/ny.gov/files/atoms/files/GuideForTaxableandExemptPropertyandServices.pdf	Brochure
NC*	http://www.ncga.state.nc.us/gascripts/Statutes/StatutesTOC.pl?Chapter=0105	Laws and Regulations
NC*	http://www.dornc.com/practitioner/sales/bulletins/toc.html	Laws and Regulations
NC*	http://www.dornc.com/taxes/sales/foodnotice6-06.pdf	Brochure
ND*	http://law.justia.com/codes/north-dakota/2013/title-57/chapter-57-39.2	Laws and Regulations
ND*	https://www.nd.gov/tax/data/upfiles/media/gl-22062.pdf?20170414121353	Brochure

OH*	http://codes.ohio.gov/orc/5739	Laws and Regulations
OH*	http://www.tax.ohio.gov/portals/0/sales_and_use/information_releases/st200401.pdf	Brochure
OK*	http://law.justia.com/codes/oklahoma/2006/os68.html	Laws and Regulations
OK*	https://www.ok.gov/tax/documents/rule6509.pdf	Laws and Regulations
OK*	https://www.ou.edu/controller/fss/dwnload/SalesTax%20GeneralFAQs.pdf	Brochure
OR	http://landru.leg.state.or.us/ors/	Laws and Regulations
OR	http://arcweb.sos.state.or.us/pages/rules/oars_100/oar_150/150_tofc.html	Laws and Regulations
PA	http://www.pacode.com/secure/data/061/061toc.html	Laws and Regulations
PA	http://www.revenue.pa.gov/FormsandPublications/FormsforBusinesses/Documents/Sales-Use%20Tax/rev-717.pdf	Brochure
RI*	http://www.tax.ri.gov/regulations/FINAL%20REGS%202009/FoodandFoodIngredientsRegFinal%20v2%2002122010.pdf	Laws and Regulations
RI*	http://law.justia.com/codes/rhode-island/2010/title44/chapter44-18/	Laws and Regulations
RI*	http://www.tax.ri.gov/regulations/salestax/11-60.pdf	Laws and Regulations
RI*	http://www.tax.state.ri.us/streamlined/candy_soft_diet.php	Brochure
SC	http://www.scstatehouse.gov/code/t12c036.php	Laws and Regulations
SC	http://www.scstatehouse.gov/coderegs/c117.php	Laws and Regulations
SC	https://dor.sc.gov/resources-site/lawandpolicy/Advisory%20Opinions/RR06-5.pdf	Laws and Regulations
SC	https://dor.sc.gov/resources-site/publications/Publications/Sales%20and%20Use%20Tax%20Manual%202015%20Edition-Web.pdf	Brochure
SC	http://media.clemson.edu/procurement/2011SalesTaxSeminarManual_May.pdf	Brochure
SD*	http://legis.sd.gov/Statutes/Codified_Laws/DisplayStatute.aspx?Type=Statute&Statute=10-45	Laws and Regulations
SD*	http://dor.sd.gov/taxes/business_taxes/publications/pdfs/stguide2014.pdf	Brochure
SD*	http://dor.sd.gov/Publications/2013_Session_Presentations/PDFs/SummaryofStateSalesTaxExemptions0113.pdf	Brochure
TN*	http://www.lexisnexis.com/hottopics/tncode/	Laws and Regulations
TN*	https://www.tnumc.org/wp-content/uploads/2016/04/TN-Sales-Tax-booklet-2013.pdf	Brochure
TN*	https://revenue.support.tn.gov/hc/en-us/article_attachments/202401125/Notice__13-05.pdf	Brochure
TX	http://www.statutes.legis.state.tx.us/	Laws and Regulations
TX	https://comptroller.texas.gov/taxes/publications/96-280.pdf	Brochure
TX	https://comptroller.texas.gov/taxes/publications/94-155.pdf	Brochure
TX	https://comptroller.texas.gov/taxes/audit/docs/convenience-manual.pdf	Brochure
UT*	http://le.utah.gov/UtahCode/chapter.jsp?code=59	Laws and Regulations
UT*	http://www.tax.utah.gov/sales/food-rate	Brochure
UT*	http://www.tax.utah.gov/forms/pubs/pub-25.pdf	Brochure
VT*	http://www.leg.state.vt.us/statutes/sections.cfm?Title=32&Chapter=233	Laws and Regulations
VT*	http://www.state.vt.us/tax/pdf.word.excel/legal/regs/SU.finals.11012010.pdf	Laws and Regulations
VT*	http://tax.vermont.gov/sites/tax/files/documents/SalesTaxTaxable%26ExemptFS.pdf	Brochure
VA	http://law.lis.virginia.gov/vacode/title58.1/chapter6/	Laws and Regulations
VA	http://lis.virginia.gov/000/reg/TOC23010.HTM#C0210	Laws and Regulations
VA	https://www.tax.virginia.gov/laws-rules-decisions/rulings-tax-commissioner/05-78	Brochure
VA	https://www.tax.virginia.gov/sites/default/files/inline-files/TB%2013-5%20Nonprescription%20Drugs.pdf	Brochure
WA*	http://apps.leg.wa.gov/rcw/default.aspx?cite=82.08	Laws and Regulations
WA*	http://apps.leg.wa.gov/WAC/default.aspx?cite=458-20	Laws and Regulations
WA*	http://dor.wa.gov/Docs/Pubs/SpecialNotices/2012/sn_12_SoftDrinks.pdf	Brochure
WA*	http://dor.wa.gov/Docs/Pubs/SpecialNotices/2010/sn_10_WaterCandyGumTaxRepeal.pdf	Brochure
WA*	http://dor.wa.gov/content/aboutus/statisticsandreports/stats_ExemptionStudy.aspx	Brochure
WV*	http://www.legis.state.wv.us/wvcode/Code.cfm?chap=11&art=1	Laws and Regulations
WV*	http://tax.wv.gov/Documents/TSD/tsd300.pdf	Brochure
WV*	http://tax.wv.gov/Documents/TSD/tsd419.pdf	Brochure
WV*	http://tax.wv.gov/Documents/TSD/tsd420.pdf	Brochure
WI*	https://docs.legis.wisconsin.gov/statutes/statutes/77/III/51	Laws and Regulations
WI*	https://www.revenue.wi.gov/DOR%20Publications/pb220.pdf	Brochure
WY*	http://www.lexisnexis.com/hottopics/wystatutes/	Laws and Regulations
WY*	http://revenue.wyo.gov/home/rules-and-regulations-by-chapter	Laws and Regulations
WY*	http://revenue.wyo.gov/FoodExemption.pdf?attredirects=0	Brochure

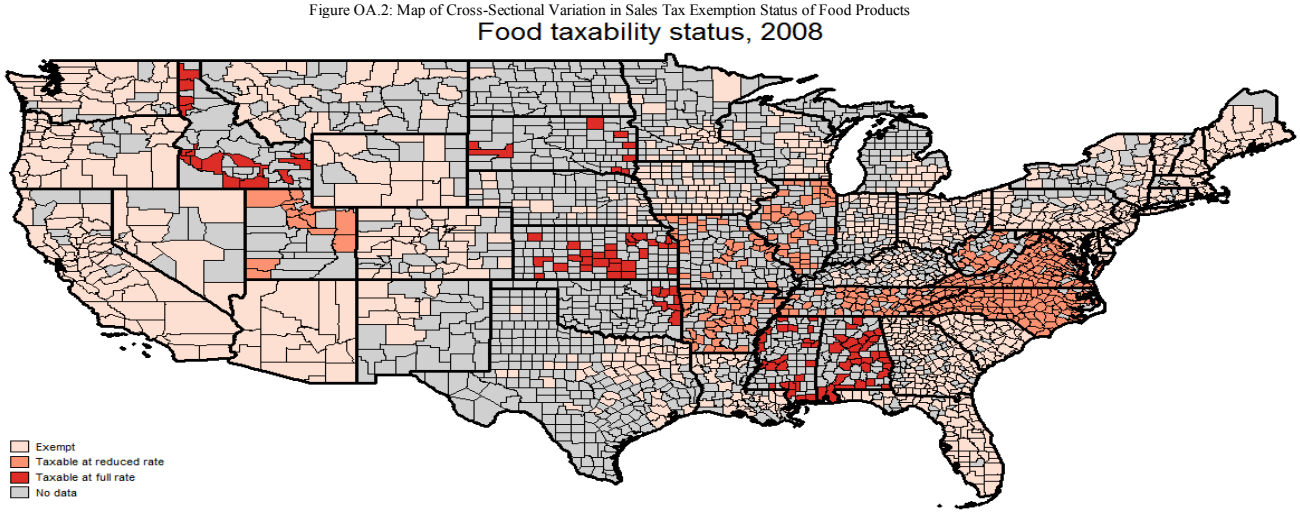
* States indexed participate in the Streamlined Sales Tax Project (SSTP): http://www.streamlinedsalestax.org/

Figure OA.1: Map of Cross-Sectional Variation in Sales Tax Rates



Note: 'No data' indicates counties for which no grocery store sales were recorded in Nielsen's Retail Scanner data in 2008.

Figure OA.2: Map of Cross-Sectional Variation in Sales Tax Exemption Status of Food Products



Note: 'No data' indicates counties for which no grocery store sales were recorded in Nielsen's Retail Scanner data in 2008.