Online Appendix for "Salience and Taxation with Imperfect Competition"

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Proofs

Proof of Lemma 1

Proof. Note that

$$\begin{aligned}
\epsilon_{Dt} &= \frac{dQ(p(t),t)}{dt}\frac{p+t}{Q(t)} \\
&= \frac{p+t}{Q(t)}\int \frac{\partial Q_i}{\partial p}(p(t),t) \quad \frac{dp}{dt}+\theta_i\Big)\, di \\
&= \frac{p+t}{Q(t)} \quad (\rho-1)\frac{\partial Q}{\partial p}+\int \frac{\partial Q_i}{\partial p}(p(t),t)\theta_i di\Big) \\
&= \frac{p+t}{Q(t)} \quad (\rho-1+\mathbb{E}(\theta_i))\frac{\partial Q}{\partial p}+Cov \quad \theta_i, \frac{\partial Q_i(p,t)}{\partial p}\Big)\Big) \\
&= -(\mathbb{E}(\theta_i)+\rho-1)\epsilon_D+\frac{p+t}{Q(t)}Cov\left(\theta_i, \frac{\partial Q_i(p,t)}{\partial p}\right)
\end{aligned}$$

Finally, under assumption 3, $\frac{\partial Q_i}{\partial p}(p(t),t)$ is constant in i and so $Cov\left(\theta_i, \frac{\partial Q_i(p,t)}{\partial p}\right)=0$ □

Proof of Proposition 1

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

$$CS_i=\int_0^{Q^i} wtp^i(s)ds-(p+t)Q^i$$

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

$$\begin{aligned}\frac{dCS^i}{dt} &= wtp^i(Q^i)\frac{dQ^i(p(t),t)}{dt} - \rho Q^i - (p+t)\frac{dQ^i(p(t),t)}{dt} \\ &= (p+\theta_i t)\frac{dQ^i(p(t),t)}{dt} - \rho Q^i - (p+t)\frac{dQ^i(p(t),t)}{dt} \\ &= -\rho Q^i - (1-\theta_i)t\frac{dQ^i(p(t),t)}{dt}\end{aligned}$$

where the second equality follows from the fact that $wtp^i(Q^i) = p + \theta_i(p,t)t$, then

$$\begin{aligned}\frac{dCS}{dt} &= \int \frac{dCS^i}{dt} di \\ &= -\rho\mathbb{E}(Q^i) - t\mathbb{E}\left((1-\theta_i)\frac{dQ^i(p(t),t)}{dt}\right) \\ &= -\rho Q - (1-\mathbb{E}(\theta_i))t\frac{dQ(p(t),t)}{dt} + tCov\quad \theta_i, \frac{dQ^i(p(t),t)}{dt}\Bigg)\end{aligned}$$

For the tax revenue, we have

$$\frac{dR}{dt} = Q + t\frac{dQ(p(t),t)}{dt}$$

For producer surplus, taking the derivative of $PS = pQ - Jc(q)$ with respect to t, we have

$$\begin{aligned}\frac{dPS}{dt} &= (\rho-1)Q + J(p - mc(q))\frac{dq}{dt} \\ &= (\rho-1)Q + \frac{\nu_q}{J\epsilon_D}\frac{dQ(p(t),t)}{dt}p \\ &= (\rho-1)Q - \frac{\nu_q}{J}Q\frac{dQ(p(t),t)}{dt}\frac{1}{\frac{\partial Q}{\partial p}} \\ &= (\rho-1)Q - \frac{\nu_q}{J}Q\frac{\int \frac{dQ_i(p(t),t)}{dt}di}{\frac{\partial Q}{\partial p}} \\ &= (\rho-1)Q - \frac{\nu_q}{J}Q\frac{\int \frac{\partial Q^i}{\partial p}\left(\frac{dp}{dt} + \theta_i\right)di}{\frac{\partial Q}{\partial p}} \\ &= (\rho-1)Q - \frac{\nu_q}{J}Q\left[\frac{dp}{dt} + \frac{\int \theta_i \frac{\partial Q^i}{\partial p}di}{\frac{\partial Q}{\partial p}}\right] \\ &= -\left(1 - \frac{\nu_q}{J}\right)[Q(1-\rho)] - \frac{\nu_q}{J}\left[Q\left(\mathbb{E}(\theta_i) + \frac{Cov\left(\theta_i, \frac{\partial Q^i}{\partial p}\right)}{\frac{\partial Q}{\partial p}}\right)\right]\end{aligned}$$

The second equality comes from the Lerner condition $\frac{p-mc(q)}{p} = \frac{\nu_q}{J\epsilon_D}$, and the fifth equation comes from$\frac{dQ^i(p(t),t)}{dt} = \frac{\partial Q^i}{\partial p}\left(\frac{dp}{dt} + \theta_i\right)$.

Also note that

$$\begin{aligned}\frac{dQ(p(t),t)}{dt} &= \int \frac{dQ^i(p(t),t)}{dt}di \\ &= \int \frac{\partial Q^i}{\partial p}\left(\frac{dp}{dt} + \theta_i\right)di \\ &= \mathbb{E}\left(\frac{\partial Q^i}{\partial p}\right)(\rho - 1 + \mathbb{E}(\theta_i)) + Cov\left(\theta_i, \frac{\partial Q^i}{\partial p}\right)\end{aligned}$$

Now, to obtain the formula for pass-through, from Lerner condition we have

$$p - mc(q) = -\frac{\nu_q}{J}\frac{Q}{\frac{\partial Q}{\partial p}}$$

Recall thar marginal surplus is $ms(Q) = -mwtp(Q)Q$. Furthermore, define $MS(Q,t) \equiv -\frac{Q}{\frac{\partial Q}{\partial p}(p(t),t)} = \frac{ms(Q)}{mwtp(Q(t))*\frac{\partial Q}{\partial p}(p(t),t)}$, then $MS(Q,0) = ms(Q)$. Let $MS_t = \frac{\partial MS}{\partial t}$, and let $\epsilon_{ms} = \frac{MS}{MS_Q Q}$, we have

$$p - mc(q) = \frac{\nu_q}{J}MS(Q,t)$$

Therefore

$$\begin{aligned}\frac{dp}{dt} &= \left(\frac{\nu_q}{J}MS_Q(Q,t) + \frac{mc'(q)}{J}\right)\frac{dQ(p(t),t)}{dt} + \frac{\nu_q}{J}MS_t \\ &= \left(\frac{\nu_q}{J}MS_Q(Q,t) + \frac{mc'(q)}{J}\right)\left(\frac{\partial Q}{\partial p}\left(\frac{dp}{dt} + \mathbb{E}(\theta_i)\right) + Cov\left(\theta_i, \frac{\partial Q^i}{\partial p}\right)\right) + \frac{\nu_q}{J}MS_t\end{aligned}$$

and

$$\frac{dp}{dt}\left[1 - \frac{\partial Q}{\partial p}\left(\frac{\nu_q}{J}MS_Q(Q,t) + mc'(Q)\right)\right] = \\ \left(\frac{\nu_q}{J}MS_Q(Q,t) + \frac{mc'(q)}{J}\right)\left(\frac{\partial Q}{\partial p}\left(\mathbb{E}(\theta_i)\right) + Cov\left(\theta_i, \frac{\partial Q^i}{\partial p}\right)\right) + \frac{\nu_q}{J}MS_t$$

Define $\epsilon_s \equiv \frac{mc(Q)}{mc'(Q)Q}$, then we have

$$\begin{aligned}
\rho &= \frac{dp}{dt} + 1 \\
&= 1 + \frac{\left(\frac{\nu_q}{J} ms'(Q) + \frac{mc'(q)}{J}\right)\left(\frac{\partial Q}{\partial p}\mathbb{E}(\theta_i) + Cov\left(\theta_i, \frac{\partial Q^i}{\partial p}\right)\right) + \frac{\nu_q}{J} MS_t}{1 - \frac{\partial Q}{\partial p}\left(\frac{\nu_q}{J} ms'(Q) + mc'(Q)\right)} \\
&= 1 + \left(\frac{1}{1 - \frac{\partial Q}{\partial p}\left(\frac{\nu_q}{J} ms'(Q) + \frac{mc'(q)}{J}\right)} - 1\right)\left(\mathbb{E}(\theta_i) + \frac{Cov\left(\theta_i, \frac{\partial Q^i}{\partial p}\right)}{\frac{\partial Q}{\partial p}}\right) \\
&+ \frac{\frac{\nu_q}{J} MS_t}{1 - \frac{\partial Q}{\partial p}\left(\frac{\nu_q}{J} ms'(Q) + \frac{mc'(q)}{J}\right)} \\
&= 1 - \left(1 - \frac{1}{1 + \frac{\epsilon_D \frac{p}{p+t} - \frac{\nu_q}{J}}{\epsilon_S} + \frac{\frac{\nu_q}{J}}{\epsilon_{ms}}}\right)\left(\mathbb{E}(\theta_i) + \frac{Cov\left(\theta_i, \frac{\partial Q^i}{\partial p}\right)}{\frac{\partial Q}{\partial p}}\right) \\
&+ \frac{\frac{\nu_q}{J} MS_t}{1 - \frac{\partial Q}{\partial p}\left(\frac{\nu_q}{J} ms'(Q) + \frac{mc'(q)}{J}\right)} \\
&= 1 - (1 - \omega)\left(\mathbb{E}(\theta_i) + \frac{Cov\left(\theta_i, \frac{\partial Q^i}{\partial p}\right)}{\frac{\partial Q}{\partial p}}\right) + \omega \frac{\nu_q}{J} MS_t
\end{aligned}$$

where $\omega = \frac{1}{1 + \frac{\epsilon_D \frac{p}{p+t} - \frac{\nu_q}{J}}{\epsilon_S} + \frac{\frac{\nu_q}{J}}{\epsilon_{ms}}}$.

Then we use

$$mc'(q)\frac{\partial Q}{\partial p} = \frac{J\epsilon_D - \nu_q}{\epsilon_S}$$

We have the incidence of the tax:

$$\begin{aligned}
I &= \frac{-\rho Q - (1 - \mathbb{E}(\theta_i))t\frac{dQ}{dt} + tCov\left(\theta_i, \frac{dQ^i(p(t),t)}{dt}\right)}{-\left(1 - \frac{\nu_q}{J}\right)[Q(1-\rho)] - \frac{\nu_q}{J}\left[Q\left(\mathbb{E}(\theta_i) + \frac{Cov\left(\theta_i, \frac{\partial Q^i}{\partial p}\right)}{\frac{\partial Q}{\partial p}}\right)\right]} \\
&= \frac{\rho + (1 - \mathbb{E}(\theta_i))\frac{t}{p+t}\epsilon_{Dt} - \frac{t}{Q}Cov\left(\theta_i, \frac{dQ^i(p(t),t)}{dt}\right)}{(1-\rho)\left(1 - \frac{\nu_q}{J}\right) + \frac{\nu_q}{J}\frac{\mathbb{E}\left(\theta_i \frac{\partial Q^i}{\partial p}\right)}{\mathbb{E}\left(\frac{\partial Q^i}{\partial p}\right)}}
\end{aligned}$$

The marginal excess burden of the tax is calculated by summing up the incidence on consumers, producers, and government. □

Derivation of Marginal Surplus Remark

Let $MS(Q,t) = \frac{ms(Q)}{mwtp(Q(t))*\frac{\partial Q}{\partial p}(p(t),t)}$, then $MS(Q,0) = ms(Q)$, and $MS(Q(t),t) = \frac{-mwtp(Q(t))Q(t)}{mwtp(Q(t))*\frac{\partial Q}{\partial p}(p(t),t)} = -\frac{Q(t)}{\frac{\partial Q}{\partial p}(p(t),t)}$. If $MS_t = \frac{\partial MS}{\partial t}$ then:

$$
\begin{aligned}
MS_t &= \frac{-ms(Q)}{\left(mwtp(Q(t)) * \frac{\partial Q}{\partial p}(p(t),t)\right)^2}\left(wtp''(Q(t))Q'(t) * \frac{\partial Q}{\partial p}(p(t),t) + wtp'(Q(t)) * \frac{\partial}{\partial t}\left(\frac{\partial Q}{\partial p}(p(t),t)\right)\right) \\
&= \frac{-ms(Q)}{\left(mwtp(Q(t)) * \frac{\partial Q}{\partial p}(p(t),t)\right)^2}\left(wtp''(Q(t))Q'(t) * \frac{\partial Q}{\partial p}(p(t),t) + wtp'(Q(t)) * \int \frac{\partial}{\partial t}\left(\frac{\partial Q_i}{\partial p}(p(t)+\theta_i t,0)\right) di\right) \\
&= \frac{-ms(Q)}{\left(mwtp(Q(t)) * \frac{\partial Q}{\partial p}(p(t),t)\right)^2} * \\
&\left(wtp''(Q(t))Q'(t) * \frac{\partial Q}{\partial p}(p(t),t) + wtp'(Q(t)) * \int \frac{\partial^2 Q_i}{\partial p^2}(p(t)+\theta_i t,0) * \left(\frac{dp}{dt}+\theta_i\right) di\right) \\
&= \frac{-Q}{mwtp(Q)\left(\frac{\partial Q}{\partial p}\right)^2}\left(wtp''(Q)\frac{\partial Q}{\partial p}\frac{dQ}{dt} + mwtp(Q)\left[\frac{dp}{dt}\int \frac{\partial^2 Q_i}{\partial p^2} di + \int\left(\frac{\partial^2 Q_i}{\partial p^2} * \theta_i\right) di\right]\right) \\
&= \frac{-Q}{mwtp(Q)\left(\frac{\partial Q}{\partial p}\right)^2}\left(wtp''(Q)\frac{\partial Q}{\partial p}\frac{dQ}{dt} + mwtp(q)\left[\frac{\partial^2 Q}{\partial p^2}\left(\frac{dp}{dt}+\bar{\theta}\right) + Cov\left(\frac{\partial^2 Q_i}{\partial p^2},\theta_i\right)\right]\right) \\
&\approx \frac{-Q}{\left(\frac{\partial Q}{\partial p}\right)^2} Cov\left(\frac{\partial^2 Q_i}{\partial p^2},\theta_i\right)
\end{aligned}
$$

Note that under Assumption 3 the second derivatives are 0 and so $MS_t = 0$. Also for the model with fixed θ it is easy to show that $wtp' = \left(\frac{\partial Q}{\partial p}\right)^{-1}$ implies $wtp''(Q)\frac{dQ}{dt} = -\frac{mwtp(Q)}{\frac{\partial Q}{\partial p}}\frac{\partial^2 Q}{\partial p^2}\left(\frac{dp}{dt}+\bar{\theta}\right)$ so $MS_t = 0$.

General model featuring both ad valorem and unit taxes

It is well known that ad valorem and unit taxes are not equivalent in imperfectly competitive markets (Delipalla and Keen 1992, Anderson, de Palma and Kreider 2001a, Adachi and Fabinger 2019). This section extends our results on incidence and excess burden in Proposition 3 to ad valorem taxes in the presence of salience effects. We consider the model of imperfect competition with both unit taxes and ad valorem taxes. The purpose of the model is to compare the incidence and welfare effects of these taxes and to forge a link with the empirical section which considers ad valorem taxes. For ease of exposition, we assume identical consumers and present the general expressions for ad valorem taxes in the presence of heterogeneous consumers that we calibrate in Section 6.

Let p denote the producer price and let $p(1+\tau)+t$ denote the price paid by consumers where τ is the ad valorem tax and t is the unit tax. Demand is given by $D(p,t,\tau)$ and assume that for $\tau > 0$ and $t > 0$, $D(p,0,0) > D(p,t,\tau) > D(p(1+\tau)+t,0,0)$. For any triple (p,t,τ) there exists $\theta_\tau(p,t,\tau)$ and $\theta_t(p,t,\tau)$ to be such that: $D(p,t,\tau) = D(p(1+\theta_\tau\tau)+\theta_t t,0,0)$. However following the literature and to simplify the setup assume θ_τ and θ_t are independent of the level of prices and tax rates. Equivalently we could define $\theta_\tau \equiv \frac{\frac{\partial D}{\partial \tau}}{\frac{\partial D}{\partial p}} \times \frac{1}{p}$ and $\theta_t \equiv \frac{\frac{\partial D}{\partial t}}{\frac{\partial D}{\partial p}}$ and assume they are constant with respect to prices and taxes.[1] Following the prior section, we extend the definition of willingness to pay to accommodate the ad valorem tax so that $wtp(Q) = p(1+\theta_\tau\tau)+\theta_t t$.

Let $\epsilon_D \equiv -\frac{\partial Q}{\partial p}\frac{p(1+\tau)+t}{Q}$, $\epsilon_D^* = \epsilon_D \frac{p}{p(1+\tau)+t}$ and define the pass-through rates for ad valorem and unit taxes respectively, as $\rho_\tau \equiv \frac{1}{p}\frac{\partial(p(1+\tau)+t)}{\partial \tau}$ and $\rho_t \equiv \frac{\partial(p(1+\tau)+t)}{\partial t}$. The following lemma shows how to identify θ_τ with commonly observable objects.

Lemma. ***A1****. Let $\epsilon_{D\tau} \equiv \frac{dQ}{d\tau}\frac{p(1+\tau)+t}{Q}$. The following relationship holds:*

$$\epsilon_{D\tau} = -\epsilon_D * \frac{p}{1+\tau}\left((1+\theta_\tau\tau)\,\rho_\tau + \theta_\tau - 1\right)$$

and

$$\theta_\tau = \frac{(1-\rho_\tau)\,p\epsilon_D - \epsilon_{D\tau}(1+\tau)}{(1+\tau\rho_\tau)\,p\epsilon_D}$$

Proof. See below. □

With Lemma 2 in hand, we can now state our main proposition for ad valorem taxes. Following the literature, we compare the pass-through rates and the marginal cost of public funds. A lower marginal cost of public funds indicates greater efficiency. We begin with the characterization of pass-through rates.

Proposition. ***A1.*** *In the symmetric model of imperfect competition, the pass-through rates for ad valorem and unit taxes are given respectively as:*

$$\rho_\tau = 1 - \frac{(1+\tau)\theta_\tau}{1+\theta_\tau\tau}\left(1 - \omega\frac{mc(q)}{p}\right)$$

$$\rho_t = 1 - \frac{(1+\tau)\theta_t}{1+\theta_\tau\tau}\,(1-\omega)$$

where $\omega = \frac{1}{1+\frac{(1+\theta_\tau\tau)\epsilon_D^* - \frac{\nu q}{J}}{\epsilon_S} + \frac{\nu q}{J}\frac{1}{\epsilon_{ms}}}$.

[1]Note that in the denominator of θ_τ and θ_t, the derivative is with respect to the first argument of D.

This implies that the two pass-through rates can be ranked based on the following:

$$\frac{\rho_\tau - 1}{\rho_t - 1} = \frac{\theta_\tau}{\theta_t} \frac{\omega \frac{mc}{p} - 1}{\omega - 1} = \frac{\theta_\tau}{\theta_t} \left(1 - \frac{\omega}{\omega - 1} \frac{\nu_q}{J \epsilon_D^*} \right)$$

Proof. See below. □

A first observation is that when $\theta_\tau = \theta_t$, if $mc < p$ then $\rho_\tau < \rho_t$ which is consistent with the literature (Delipalla and Keen 1992; Adachi and Fabinger 2019). Thus, if consumers underreact to ad valorem and unit taxes similarly, the pass-through rate is lower for ad valorem taxes. A new observation is that even under perfect competition starting from $p = mc$, ad valorem taxes imply a higher pass-through than unit taxes $\rho_t < \rho_\tau$ if and only if the consumers are more responsive to ad valorem taxes than unit taxes $\theta_\tau > \theta_t$.[2] Most of the available empirical evidence in the literature applies to sales taxes and thus, θ_τ. Our results stress the need for additional evidence on θ_t.

Next, we derive the marginal cost of public funds for an ad valorem tax and a unit tax which are defined as $MC_\tau \equiv -\frac{dW/d\tau}{dR/d\tau}$ and $MC_t \equiv -\frac{dW/dt}{dR/dt}$, respectively.

Proposition. *A2*. *Denote $wtp = p(1 + \theta_\tau \tau) + \theta_t t$ the perceived price by the consumer and $\epsilon_D^* = \epsilon_D \frac{p}{p(1+\tau)+t}$. The marginal cost of public funds for an ad valorem tax, τ, and a unit tax, t, may be expressed as:*

$$MC_\tau = \epsilon_D^* \frac{\frac{wtp-mc}{p}}{\frac{1+\tau\rho_\tau}{(1+\theta_\tau\tau)\rho_\tau+\theta_\tau-1} - \epsilon_D^*(\tau + \frac{t}{p})}$$

$$MC_t = \epsilon_D^* \frac{\frac{wtp-mc}{p}}{\frac{1+\tau\rho_t}{(1+\theta_\tau\tau)\rho_t+\theta_t-1} - \epsilon_D^*(\tau + \frac{t}{p})}$$

This implies the following:

$$\frac{MC_t}{MC_\tau} = \frac{\frac{1+\tau\rho_\tau}{(1+\theta_\tau\tau)\rho_\tau+\theta_\tau-1} - \epsilon_D^*(\tau + \frac{t}{p})}{\frac{1+\tau\rho_t}{(1+\theta_\tau\tau)\rho_t+\theta_t-1} - \epsilon_D^*(\tau + \frac{t}{p})}$$

In other words, the cost of ad-valorem taxes is lower than the cost of unit taxes ($MC_\tau < MC_t$) if and only if

$$\theta_\tau \left[1 - \frac{1 + \tau(1 + \theta_\tau - \theta_t)}{1 + \theta_\tau \tau} \quad \left. 1 - \omega \frac{mc}{p} \right) \right] < \theta_t \left[1 - \frac{1 + \tau}{1 + \theta_\tau \tau} (1 - \omega) \right]$$

Proof. See below. □

[2] As a basic matter of tax administration, this is relatively unlikely. Indeed, it has been suggested to us that the relative saliency of unit taxes appears to have played an important role in dictating the implementation details of recently-adopted beverage taxes.

It is instructive to consider the benchmark case where $\theta_\tau = \theta_t$. In this case, $MC_\tau < MC_t$ if and only if $p > mc$. Thus, as long as consumers respond symmetrically to ad valorem and unit taxes, then salience does not affect the well-known result that ad valorem taxes are more efficient than unit taxes under imperfect competition. Of course, if consumers are sufficiently more attentive to ad valorem taxes than unit taxes, then this result shows that ad valorem taxes can be more distortionary than unit tax.

Proof of Lemma A1

Proof. Observe

$$\begin{aligned}
\epsilon_{D\tau} &= \frac{dQ}{d\tau}\frac{p(1+\tau)+t}{Q} \\
&= -\epsilon_D * \left((1+\tau)\frac{dp}{d\tau} + p\right) \\
&= -\epsilon_D * \frac{p}{1+\tau}\left((1+\theta_\tau\tau)\left(\frac{1}{p}(1+\tau)\frac{\partial p}{\partial \tau} + 1\right) + \theta_\tau - 1\right) \\
&= -\epsilon_D * \frac{p}{1+\tau}\left((1+\theta_\tau\tau)\,\rho_\tau + \theta_\tau - 1\right)
\end{aligned}$$

Solving for θ_τ we obtain:

$$\theta_\tau = \frac{(1-\rho_\tau)\,p\epsilon_D - \epsilon_{D\tau}(1+\tau)}{(1+\tau\rho_\tau)\,p\epsilon_D}$$

□

Proof of Proposition A1

Proof. Note that

$$\frac{dp}{d\tau} = \frac{1}{1+\theta_\tau\tau}\left(mwtp(q)\frac{dq}{d\tau} - p\theta_\tau\right) \tag{1}$$

The first order condition with J symmetric products and conduct parameter ν_q is $p - mc(q) = -\frac{\nu_q}{J}\frac{mwtp(q)q}{1+\theta_\tau\tau}$, substitute $p = \frac{wtp(q)-\theta_t t}{1+\theta_\tau\tau}$ so we get $\frac{wtp(q)-\theta_t t}{1+\theta_\tau\tau} - mc(q) = -\frac{\nu_q}{J}\frac{mwtp(q)q}{1+\theta_\tau\tau}$ or $wtp(q) - \theta_t t - mc(q)\,(1+\theta_\tau\tau) = -\frac{\nu_q}{J}mwtp(q)q$. Taking thederivative with respect to τ, we have

$$mwtp(q)\frac{dq}{d\tau} - (1+\theta_\tau\tau)\,mc'(q)\frac{dq}{d\tau} - mc(q)\theta_\tau = -\frac{\nu_q}{J}\left(mwtp'(q)\frac{dq}{d\tau}q + mwtp(q)\frac{dq}{d\tau}\right)$$

Rearrange terms, we have

$$\left((1+\frac{\nu_q}{J})mwtp(q)-(1+\theta_\tau\tau)\,mc'(q)+\frac{\nu_q}{J}mwtp'(q)q\right)\frac{dq}{d\tau}=mc(q)\theta_\tau$$

And so

$$\begin{aligned}\frac{dq}{d\tau}&=\frac{mc(q)\theta_\tau}{(1+\frac{\nu_q}{J})mwtp(q)-(1+\theta_\tau\tau)\,mc'(q)+\frac{\nu_q}{J}mwtp'(q)q}\\&=\frac{\frac{mc(q)\theta_\tau}{mwtp(q)}}{(1+\frac{\nu_q}{J})-\frac{mc'(q)q}{mc(q)}\frac{mc(q)(1+\theta_\tau\tau)}{mwtp(q)q}+\frac{\nu_q}{J}\frac{mwtp'(q)}{mwtp(q)}q}\end{aligned}$$

Thus,

$$\frac{dq}{d\tau}=\frac{\theta_\tau\frac{mc(q)}{mwtp(q)}}{1+\frac{(1+\theta_\tau)\epsilon_D^*-\frac{\nu_q}{J}}{\epsilon_S}+\frac{\frac{\nu_q}{J}}{\epsilon_{ms}}}$$

Therefore,

$$\frac{dp}{d\tau}=\frac{\theta_\tau}{1+\theta_\tau\tau}\left(\frac{\frac{mc(q)}{p}}{1+\frac{(1+\theta_\tau)\epsilon_D^*-\frac{\nu_q}{J}}{\epsilon_S}+\frac{\frac{\nu_q}{J}}{\epsilon_{ms}}}-1\right)$$

And

$$\rho_\tau=\frac{\theta_\tau(1+\tau)}{1+\theta_\tau\tau}\left(\frac{\frac{mc(q)}{p}}{1+\frac{(1+\theta_\tau)\epsilon_D^*-\frac{\nu_q}{J}}{\epsilon_S}+\frac{\frac{\nu_q}{J}}{\epsilon_{ms}}}-1\right)+1$$

Similarly, we have

$$\frac{dp}{dt}=\frac{1}{1+\theta_\tau\tau}(mwtp(q)\frac{dq}{dt}-\theta_t)$$

The first order condition of monopoly is $p-mc(q)=-\frac{\nu_q}{J}\frac{mwtp(q)q}{1+\theta_\tau\tau}$, or $wtp(q)-\theta_t t-mc(q)\,(1+\theta_\tau\tau)=-\frac{\nu_q}{J}mwtp(q)q$. Taking the derivative w.r.t t we get:

$$\left(mwtp(q)-mc'(q)\,(1+\theta_\tau\tau)+\frac{\nu_q}{J}mwtp'(q)q+\frac{\nu_q}{J}mwtp(q)\right)\frac{dq}{dt}=\theta_t$$

And so

$$\frac{dq}{dt} = \frac{\theta_t}{mwtp(q) - mc'(q)\left(1+\theta_\tau\tau\right) + \frac{\nu_q}{J}mwtp'(q)q + \frac{\nu_q}{J}mwtp(q)}$$
$$= \frac{\frac{\theta_t}{mwtp(q)}}{1 - \frac{mc'(q)q}{mc(q)}\frac{(1+\theta_\tau\tau)mc(q)}{mwtp(q)q} + \frac{\frac{\nu_q}{J}\left(mwtp'(q)q+mwtp(q)\right)}{mwtp(q)}}$$

Thus,

$$\frac{dq}{dt} = \frac{\frac{\theta_t}{mwtp(q)}}{1 + \frac{(1+\theta_\tau)\epsilon_D^* - \frac{\nu_q}{J}}{\epsilon_S} + \frac{\frac{\nu_q}{J}}{\epsilon_{ms}}}$$

Therefore,

$$\frac{dp}{dt} = \frac{\theta_t}{1+\theta_\tau\tau}\left(\frac{1}{1 + \frac{(1+\theta_\tau)\epsilon_D^* - \frac{\nu_q}{J}}{\epsilon_S} + \frac{\frac{\nu_q}{J}}{\epsilon_{ms}}} - 1\right)$$

consumer price is

$$\rho_t = 1 + \frac{dp}{dt}(1+\tau) = 1 + \frac{(1+\tau)\theta_t}{1+\theta_\tau\tau}\left(\frac{1}{1 + \frac{(1+\theta_\tau)\epsilon_D^* - \frac{\nu_q}{J}}{\epsilon_S} + \frac{\frac{\nu_q}{J}}{\epsilon_{ms}}} - 1\right)$$

□

Proof of Proposition A2

Proof. Denote $wtp = p(1+\theta_\tau\tau) + \theta_t t$ the perceived price by the consumer and $\epsilon_D^* = \epsilon_D \frac{p}{p(1+\tau)+t}$. We have

$$\frac{dCS}{d\tau} = wtp(Q)\frac{dQ}{d\tau} - Q\frac{d(p(1+\tau)+t)}{d\tau} - \left(p(1+\tau)+t\right)\frac{dQ}{d\tau}$$
$$= -Q\frac{d(p(1+\tau)+t)}{d\tau} - \frac{dQ}{d\tau}\Big((1-\theta_\tau)p\tau + (1-\theta_t)t\Big)$$

$$\frac{dCS}{dt} = wtp(Q)\frac{dQ}{dt} - Q\frac{d(p(1+\tau)+t)}{dt} - (p(1+\tau)+t)\frac{dQ}{dt}$$
$$= -Q\frac{d(p(1+\tau)+t)}{dt} - \frac{dQ}{dt}\Big((1-\theta_\tau)p\tau + (1-\theta_t)t\Big)$$

$$\begin{aligned}\frac{dPS}{d\tau} &= \frac{d\Big((p-mc(q))q\Big)}{d\tau}\\ &= \frac{dp}{d\tau}q + \Big(p - mc(q)\Big)\frac{dq}{d\tau}\end{aligned}$$

$$\begin{aligned}\frac{dPS}{dt} &= \frac{d\Big((p-mc(q))q\Big)}{dt}\\ &= \frac{dp}{dt}q + \Big(p - mc(q)\Big)\frac{dq}{dt}\end{aligned}$$

$$\begin{aligned}\frac{dR}{d\tau} &= (\tau p + t)\frac{dQ}{d\tau} + Q\frac{d(\tau p + t)}{d\tau}\\ &= (\tau p + t)\frac{dQ}{d\tau} - \frac{p\tau}{\epsilon_D}\frac{dQ}{d\tau} - (1+\tau)\frac{p}{\epsilon_D\rho_\tau}\frac{dQ}{d\tau}\end{aligned}$$

$$\begin{aligned}\frac{dR}{dt} &= (\tau p + t)\frac{dQ}{dt} + Q\frac{d(\tau p + t)}{dt}\\ &= (\tau p + t)\frac{dQ}{dt} - \frac{p\tau}{\epsilon_D}\frac{dQ}{dt} - \frac{p}{\epsilon_D\rho_t}\frac{dQ}{d\tau}\end{aligned}$$

Therefore, we have

$$\begin{aligned}\frac{dW}{d\tau} &= \frac{dCS}{d\tau} + \frac{dPS}{d\tau} + \frac{dR}{d\tau}\\ &= (p(1+\theta_\tau\tau) + \theta_t t - mc(q))\,\frac{dQ}{d\tau}\end{aligned}$$

$$\frac{dW}{dt} = (p(1+\theta_\tau\tau) + \theta_t t - mc(q))\,\frac{dQ}{dt}$$

We also have

$$
\begin{aligned}
MC_\tau &= -\frac{\frac{dW}{d\tau}}{\frac{dR}{d\tau}} \\
&= -\frac{p(1+\theta_\tau \tau) + \theta_t t - mc(q)}{(\tau p + t) - \frac{p\tau}{\epsilon_D} - (1+\tau)\frac{p}{\epsilon_D \rho_\tau}} \\
&= \epsilon_D^* \frac{\frac{wtp - mc}{p}}{\frac{1+\tau\rho_\tau}{(1+\theta_\tau\tau)\rho_\tau + \theta_\tau - 1} - \epsilon_D^*(\tau + \frac{t}{p})}
\end{aligned}
$$

And

$$
\begin{aligned}
MC_t &= -\frac{\frac{dW}{dt}}{\frac{dR}{dt}} \\
&= -\frac{p(1+\theta_\tau \tau) + \theta_t t - mc(q)}{(\tau p + t) - \frac{p\tau}{\epsilon_D} - \frac{p}{\epsilon_D \rho_t}} \\
&= \epsilon_D^* \frac{\frac{wtp - mc}{p}}{\frac{1+\tau\rho_\tau}{(1+\theta_\tau\tau)\rho_\tau + \theta_\tau - 1} - \epsilon_D^*(\tau + \frac{t}{p})}
\end{aligned}
$$

□

Derivations for ad valorem tax with heterogeneous consumers used in the calibrations

For reference, we add the formulas to calculate the effect of increasing an ad-valorem tax on consumer surplus, and producer surplus in the presence of heterogenous consumers. We also derive the marginal excess burden and incidence formulas that we take to the data. Recall $\rho_\tau \equiv \frac{1}{p}\frac{\partial(p(1+\tau)+t)}{\partial \tau}$ and $D(p,t,\tau) = D(p(1+\theta_\tau\tau) + \theta_t t, 0, 0)$. Then

$$
\frac{dCS}{d\tau} = -pQ\rho_\tau - \frac{dQ}{d\tau}\Big((1-\mathbb{E}(\theta_\tau))p\tau + (1-\mathbb{E}(\theta_t))t\Big) + p\tau * Cov\left(\theta_{i\tau}, \frac{dQ_i}{dt}\right) + t * Cov\left(\theta_{it}, \frac{dQ_i}{dt}\right)
$$

$$
\frac{dPS}{d\tau} = -pQ * \left[\left(1-\frac{\nu_q}{J}\right)\left(\frac{1}{1+\tau}\right)[1-\rho_\tau] + \frac{\nu_q}{J} * \left(1 - \frac{\tau}{1+\tau}(1-\rho_\tau)\right)\left[\mathbb{E}(\theta_{i\tau}) + \frac{Cov\left(\theta_{i\tau}, \frac{\partial Q_i}{\partial p}\right)}{\frac{\partial Q}{\partial p}}\right]\right]
$$

If only there is no unit tax, then $\theta_t = t = 0$ and so:

$$
\frac{dCS}{d\tau} = -pQ\rho_\tau - \frac{dQ}{d\tau}\Big((1-\mathbb{E}(\theta_\tau))p\tau\Big) + p\tau * Cov\left(\theta_{i\tau}, \frac{dQ_i}{dt}\right)
$$

$$
\frac{dPS}{d\tau} = -pQ * \left[\left(1-\frac{\nu_q}{J}\right)\left(\frac{1}{1+\tau}\right)[1-\rho_\tau] + \frac{\nu_q}{J} * \left(1 - \frac{\tau}{1+\tau}(1-\rho_\tau)\right)\left[\mathbb{E}(\theta_{i\tau}) + \frac{Cov\left(\theta_{i\tau}, \frac{\partial Q_i}{\partial p}\right)}{\frac{\partial Q}{\partial p}}\right]\right]
$$

Furthermore, under assumption 1:

$$\frac{dCS}{d\tau} = -pQ\rho_\tau - \frac{dQ}{d\tau}\left((1-\mathbb{E}(\theta_{i\tau}))p\tau\right) + p\tau * \frac{\partial Q}{\partial p} Var\left(\theta_{i\tau}\right)$$

$$\frac{dPS}{d\tau} = -pQ * \left[\left(1-\frac{\nu_q}{J}\right)\left(\frac{1}{1+\tau}\right)[1-\rho_\tau] + \frac{\nu_q}{J} * \left(1 - \frac{\tau}{1+\tau}(1-\rho_\tau)\right)[\mathbb{E}(\theta_{i\tau})]\right]$$

From where, we can derive a formula for incidence:

$$I = \frac{\rho_\tau + (1-\mathbb{E}(\theta_{i\tau}))\frac{\tau}{Q}\frac{dQ}{d\tau} - \frac{\tau}{Q} * \frac{\partial Q}{\partial p} Var\left(\theta_{i\tau}\right)}{\left(1-\frac{\nu_q}{J}\right)\left(\frac{1}{1+\tau}\right)[1-\rho_\tau] + \frac{\nu_q}{J} * \left(1 - \frac{\tau}{1+\tau}(1-\rho_\tau)\right)\mathbb{E}(\theta_{i\tau})}$$

And so:

$$\frac{dW}{d\tau} = (p(1+\mathbb{E}(\theta_{i\tau})\tau) - mc(q))\,\frac{dQ}{d\tau} + p\tau * \frac{\partial Q}{\partial p} Var\left(\theta_{i\tau}\right)$$

Finally, for the empirical implementation we use the follwing variations:

$$I = \frac{\rho_\tau + (1-\mathbb{E}(\theta_{i\tau}))\frac{\tau}{1+\tau}\frac{dlog(Q)}{dlog(1+\tau)} - \frac{\tau}{p} * \frac{\partial log(Q)}{\partial log(p)} Var\left(\theta_{i\tau}\right)}{\left(1-\frac{\nu_q}{J}\right)\left(\frac{1}{1+\tau}\right)[1-\rho_\tau] + \frac{\nu_q}{J} * \left(1 - \frac{\tau}{1+\tau}(1-\rho_\tau)\right)\mathbb{E}(\theta_{i\tau})}$$

$$\frac{dW}{d\tau}\frac{1+\tau}{Q} = (p(1+\mathbb{E}(\theta_{i\tau})\tau) - mc(q))\,\frac{dlog(Q)}{dlog(1+\tau)} + \tau(1+\tau) * \frac{\partial log(Q)}{\partial log(p)} Var\left(\theta_{i\tau}\right)$$

We also have from previous sections:

$$\begin{aligned}
\frac{dq}{d\tau} &= \frac{\frac{(1+\theta\tau)(\rho_\tau-1)}{1+\tau} + p\theta}{mwtp(q)} \\
&= \frac{\frac{(1+\theta\tau)(\rho_\tau-1)}{1+\tau} + p\theta}{(1+\theta\tau)\frac{dp}{dq}} \\
&= \frac{\frac{(1+\theta\tau)(\rho_\tau-1)}{p(1+\tau)} + \theta}{(1+\theta\tau)\frac{dp}{dq}\frac{1}{p}} \\
&= q(\frac{\rho_\tau - 1}{p(1+\tau)} + \frac{\theta}{1+\theta\tau})\epsilon_D
\end{aligned}$$

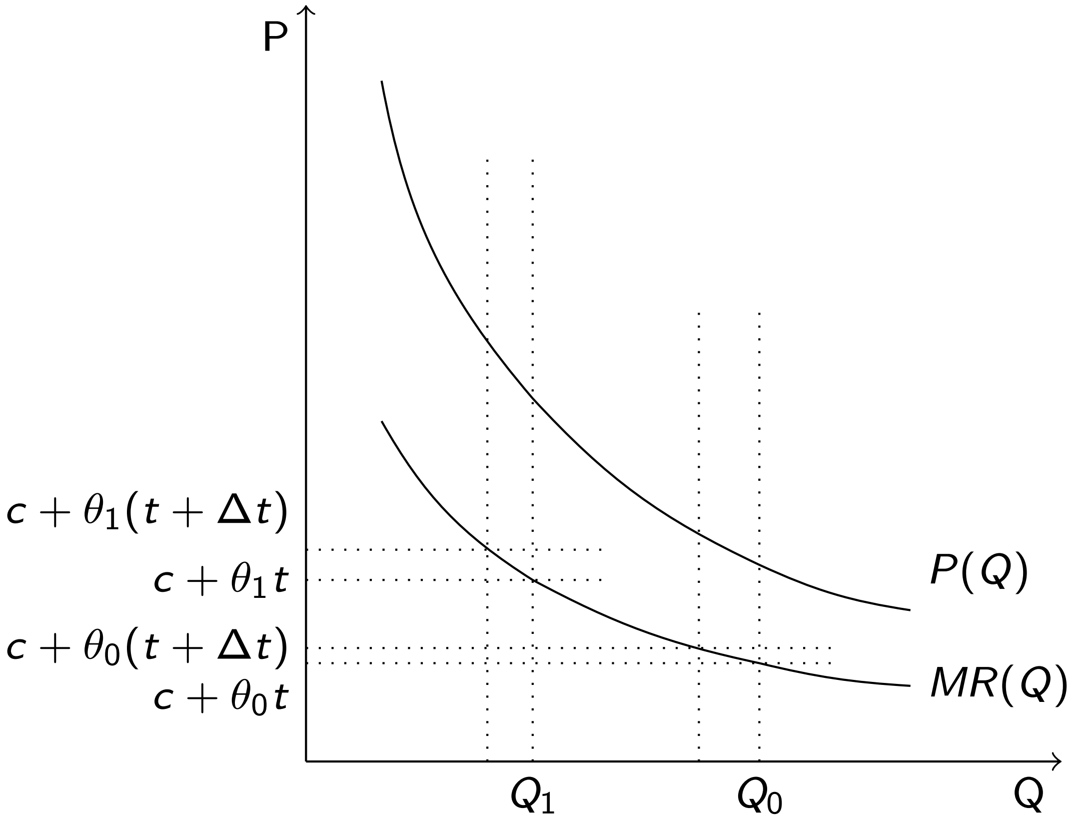
The generalized Lerner condition for ad valorem tax:

$$\frac{p - mc(q)}{p(1+\tau)} = \frac{\nu_q}{J\epsilon_D}$$

where $\epsilon_D \equiv -\frac{\partial D(p,\tau)}{\partial p}\frac{p(1+\tau)}{D}$.

Appendix Figures

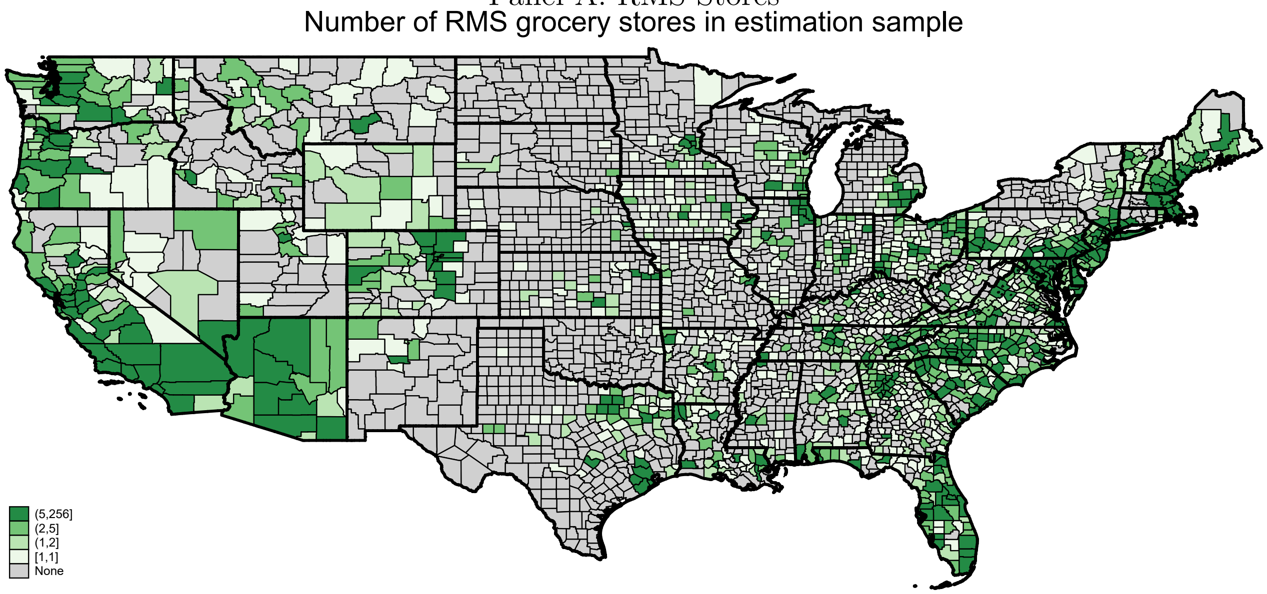
Figure OA.1: Pass-Through and Tax Salience in Monopoly



Notes: This figure shows that if the Marginal Revenue (MR) curve is flatter than the inverse demand curve, such as when $P(Q) = Q^{-1/\epsilon}$ for $\epsilon > 1$, then for $\theta_1 > \theta_0$, we have that $\theta_1 \Delta t > \theta_0 \Delta t$, which implies that $\Delta p/\Delta t$ will be higher if taxes are more salient.

Figure OA.2: Spatial distribution of stores and households

Panel A: RMS Stores



Panel B: HMS Households

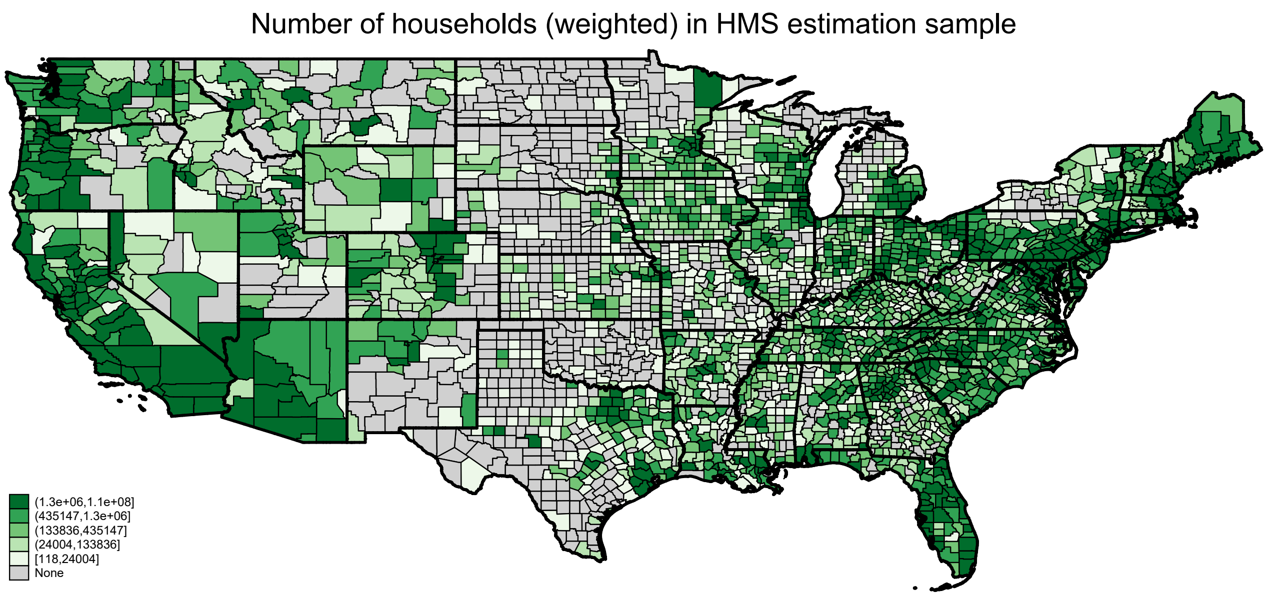


Figure OA.3: Cross-Sectional Variation in Sales Tax Rates

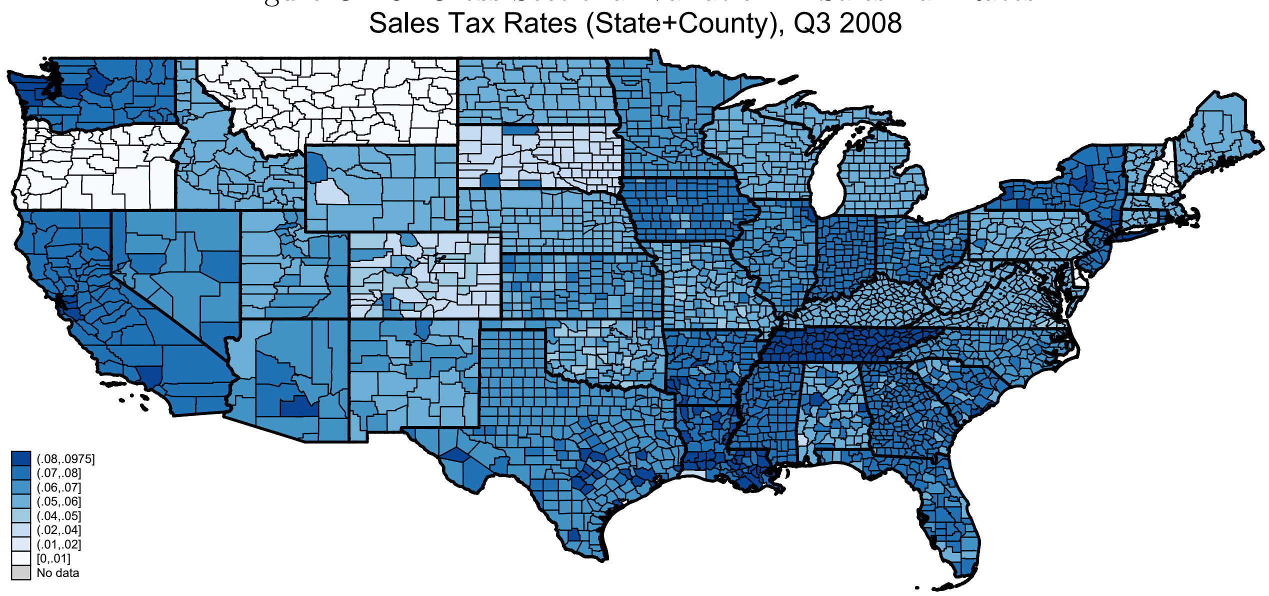


Figure OA.4: Cross-Sectional Variation in Sales Tax Exemption Status of Food Products

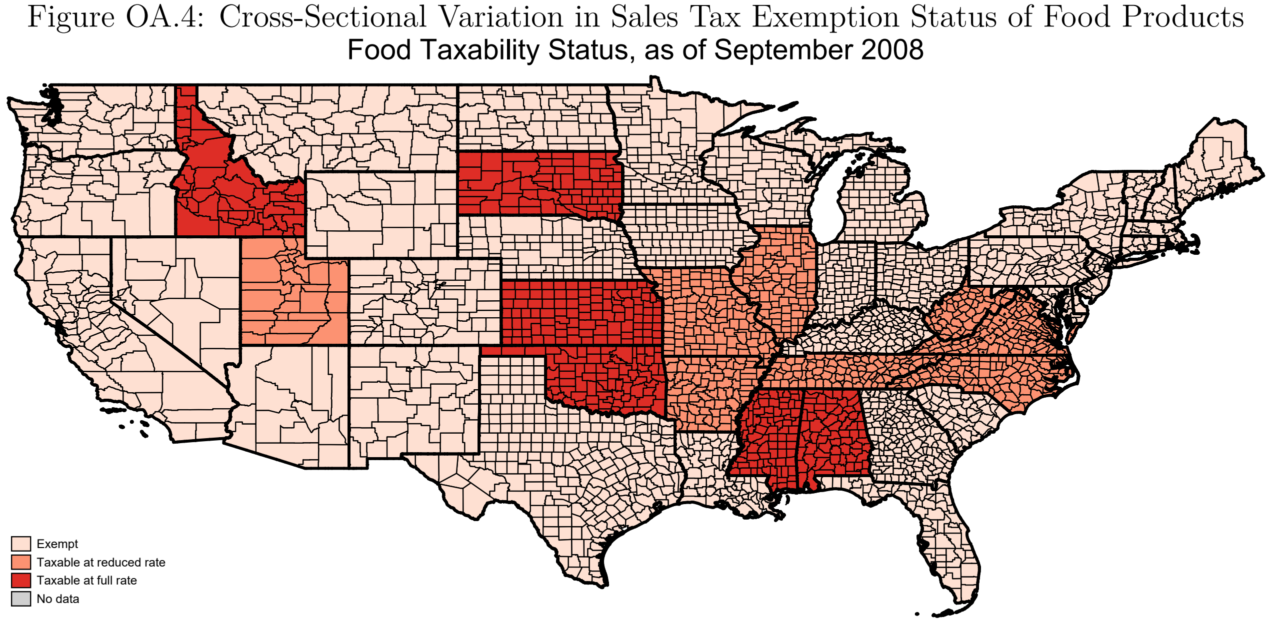


Figure OA.5: Changes in Sales Tax Rates

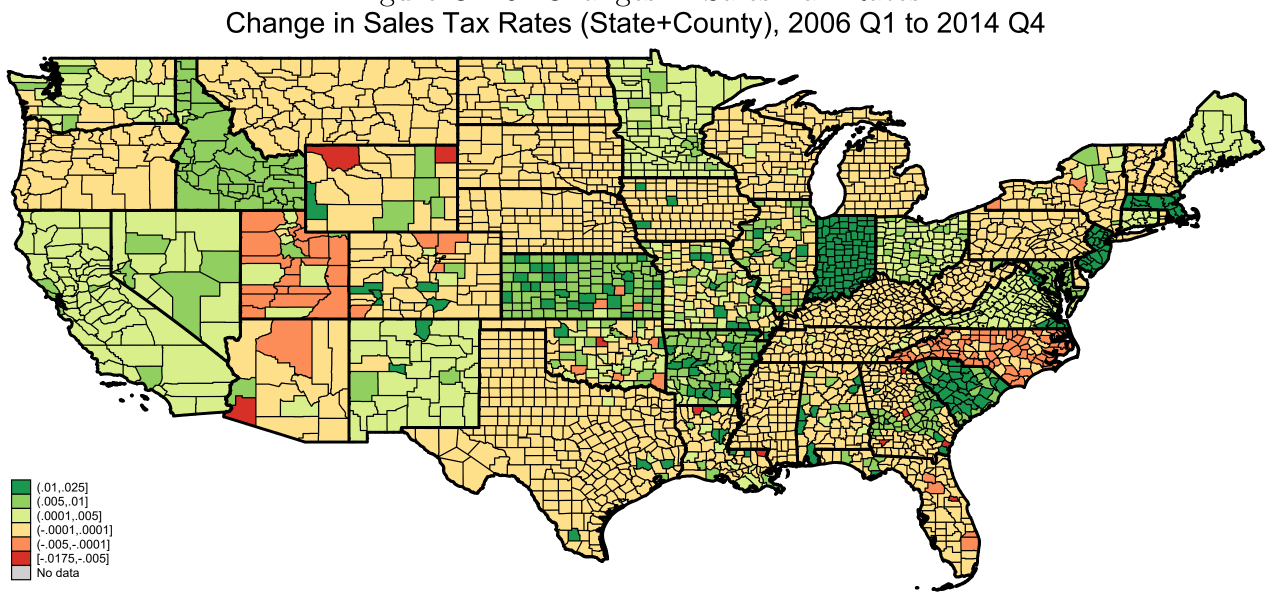
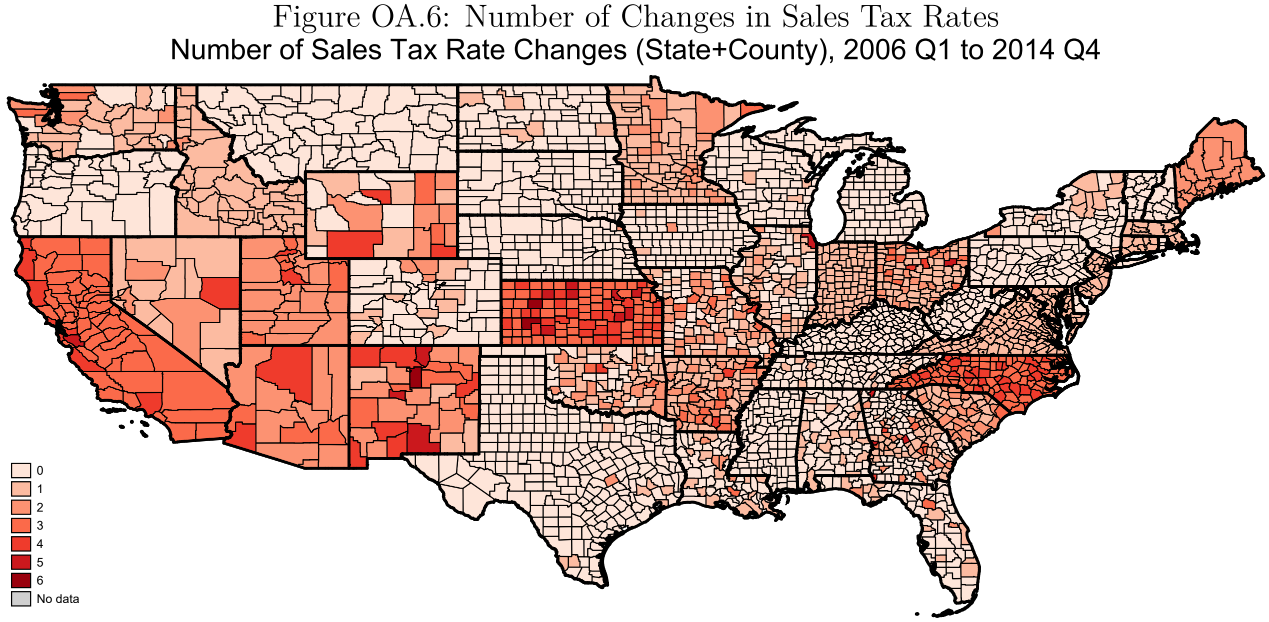


Figure OA.6: Number of Changes in Sales Tax Rates



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: 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/

Online Appendix Table OA.3
Variance Decomposition of Tax Rates

Sample:	Full Sample	County Border Pair Subsample	Full Sample
Weights:	Unweighted	Inverse of number of border-pairs	HMS-based weights
	(1)	(2)	(3)
Variance of log(1+τ)	0.0011	0.0010	0.0009
Standard deviation of log(1+τ)	0.0327	0.0313	0.0304
Standard deviation within:			
Store × Module cells	0.0041	0.0049	0.0041
Module × State × Year-Quarter cells	0.0041		0.0040
Module × Border Pair × Year-Quarter cells		0.0113	
Fraction of variance within:			
Store × Module cells	1.5%	2.5%	1.8%
Module × State × Year-Quarter cells	1.6%		1.7%
Module × Border Pair × Year-Quarter cells		13.0%	

Notes: This table reports variance decomposition of the tax rate variable in the RMS data.

Online Appendix Table OA.4

OLS and Instrumental Variables Estimates of the Effects of Sales Taxes on Prices and Quantity

Sample:	County Border Pair Sample **[OLS Estimates from Table 2]**		County Border Pair Sample **[Instrumental Variables Estimates]**	
Dependent variable:	Price	Quantity	Price	Quantity
	(1)	(2)	(3)	(4)
$\log(1 + \tau_{mcn})$	0.980	-0.649	0.952	-0.574
	(0.016)	(0.084)	(0.017)	(0.090)
First-stage coefficient for $\log(1 + \tau_{msn})$			0.988	
			(0.001)	
First stage F-statistic			486,509	
Specification:				
Store × Module fixed effects	y	y	y	y
Module × Border Pair × Year-Quarter fixed effects	y	y	y	y
N (observations)	33,749,257	33,749,257	33,749,208	33,749,208

Notes: Columns (1) and (2) replicate the estimates of the OLS effects of sales taxes on quantity and prices reported in Table 2, column (2) (Panel A and Panel B). In columns (3) and (4), we report 2SLS estimates from instrumenting the county-level module-specific sales tax rates with the associated average 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, with both measures available each quarter (n). One observation is a module in a store in a given quarter. Consumer prices $p(1+\tau)$ 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. All standard errors in this table are clustered at the state-module level and are reported in parentheses.

Online Appendix Table OA.5
Heterogeneous Pass-Through by Market Concentration

Dependent variable:	Consumer prices	
	(1)	(2)
$\log(1+\tau_{mcn})$	0.970	0.965
	(0.046)	(0.046)
$\log(1+\tau_{mcn})$ × normalized HHI_{mcs}		-0.045
		(0.035)
Specification:		
Store × Module fixed effects	y	y
Module × State × Year-Quarter fixed effects	y	y
N	53,987,131	53,987,131

Notes: This table reports estimates of pass-through heterogeneity as a function of market concentration. The normalized HHI is defined at the module-by-county level as $nHHI_{mc} = (H_{mc} - 1/J_{mc})/(1-1/J_{mc})$, where J_{mc} is the number of UPCs in the module-county market mc, and H_{mc} is the sum of squared market shares over all UPCs in market mc. In the regression, the normalized HHI is standardized to be mean zero and unit variance. All standard errors in this table are clustered at the state-module level and are reported in parentheses.

Online Appendix Table OA.6

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)	(9)	(10)	(11)	(12)
Leave-me-out chain average log(*p*)	0.970			-1.115			0.964			-1.128		
	(0.002)			(0.026)			(0.003)			(0.026)		
Leave-county-out chain average log(*p*)		0.952			-1.099			0.951			-1.104	
		(0.003)			(0.026)			(0.003)			(0.026)	
Index based on UPC-level leave-me-out chain average log(p)			0.983			-1.009			0.976			-1.032
			(0.002)			(0.024)			(0.003)			(0.023)
Specification:												
Store × Module fixed effects	y	y	y	y	y	y	y	y	y	y	y	y
Module × State × Year-Quarter fixed effects	y	y	y	y	y	y						
Module × Border Pair × Year-Quarter fixed effects							y	y	y	y	y	y
N	53,987,430	53,982,244	53,984,835	53,987,430	53,982,244	53,984,835	33,749,257	33,739,322	33,746,805	33,749,257	33,739,322	33,746,805

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 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 (6), 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 (7) to (12), the sample is restricted to stores in border counties, and observations are weighted by the inverse of the number of times a store appears in the data. In columns (7) to (12), the regression model includes module-by-store and module-by-quarter-by-pair fixed effects, where pairs denote pairs of contiguous counties. In columns (1), (4), (7) and (10) the independent variable is the chain average log price leaving store r out. In columns (2), (5), (8), and (11) the independent variable is the chain average log price leaving all stores in county c out. In the remaining columns, the dependent variable is a regression-adjusted price index where each UPCs price is a leave-me-out chain average price.

Online Appendix Table OA.7

Store-level Estimates of Pass-Through, Tax Elasticity, Price Elasticity of Demand, and Tax Salience

Sample:	**Low-price modules**	**High-price modules**
Weights:	Unweighted	Unweighted
	(1)	(2)
Panel A: Reduced-form OLS Estimates of the Effects of Sales Taxes on Consumer Prices and Quantity		
$d\log(p(1+\tau))/d\log(1+\tau)$ [pass-through]	0.969	0.970
	(0.065)	(0.064)
$d\log(Q)/d\log(1+\tau)$ [tax elasticity]	-0.829	-0.713
	(0.218)	(0.314)
Panel B: 2SLS Estimates of the Price Elasticity of Demand		
$d\log(Q)/d\log(p)$	-1.079	-1.221
	(0.024)	(0.048)
Panel C: "Plug-in" Estimate of Tax Salience Parameter		
θ_τ	0.771	0.595
Average tax rate, τ	0.038	0.034
Average price (in $)	3.14	6.84
Specification:		
Store × Module fixed effects	y	y
Module × State × Year-Quarter fixed effects	y	y
Module × Border Pair × Year-Quarter fixed effects		
N	27,716,660	26,270,770

Notes: This table reports estimates of the effects of sales taxes, of the price elasticity of demand, and of the tax salience parameter. All standard errors in this table are clustered at the state-module level and are reported in parentheses. In column (1), the sample is restricted to modules for which the average, unconditional price is below the median, where the median is calculated separately for food and nonfood products. In column (2), the sample is restricted to modules with average prices above the median.

Online Appendix Table OA.8

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						
$\log(1+\tau_{mrn})$	-0.775	-0.030	-0.834	-0.649	-0.020	-0.669
	(0.187)	(0.046)	(0.186)	(0.084)	(0.016)	(0.083)
Implied effect on quantity		-0.804			-0.649	
Panel B: Reduced-form OLS Estimates of the Effects of the Price Instrument						
z_{mrn}	-1.115	0.970	-0.333	-1.128	0.964	-0.340
	(0.026)	(0.002)	(0.025)	(0.026)	(0.002)	(0.024)
Implied effect on quantity		-1.303			-1.304	
Panel C: "Plug-in" Estimate of the Tax Salience Parameter						
$E[\theta]$		0.625			0.501	
Specification:						
Store × Module 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

Notes: This table replicates the key parameters reported in Table 2, but uses 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 n 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. All standard errors in this table are clustered at the state-module level and are reported in parentheses.

Online Appendix Table OA.9
Robustness to Local Trends

Sample:	Full Sample		
	(1)	(2)	(3)
Panel A: Reduced-form OLS Estimates of the Effects of Sales Taxes on Consumer Prices and Quantity			
$d\log(p(1+\tau))/d\log(1+\tau)$	0.970	0.939	0.941
	(0.046)	(0.036)	(0.036)
$d\log(Q)/d\log(1+\tau)$	-0.775	-0.499	-0.328
	(0.187)	(0.165)	(0.164)
Panel B: 2SLS Estimates of the Price Elasticity of Demand			
$d\log(Q)/d\log(p)$	-1.150	-1.073	-1.007
	(0.027)	(0.030)	(0.030)
Panel C: "Plug-in" Estimate of the Tax Salience Parameter			
θ_τ	0.680	0.509	0.372
Specification:			
Store × Module fixed effects	y	y	y
Module × Year-Quarter fixed effects		y	y
Module × State × Year-Quarter fixed effects	y		
Module × County × Linear time trend		y	
Module × Store × Linear time trend			y
N	53,895,446	53,994,252	53,994,252

Notes: This table reports estimates of the effects of sales taxes, of the price elasticity of demand, and of the tax salience parameter. In Panel A, the independent variable is quarterly sales tax rate of module m in county c in state s. One observation is a module in a store in a given quarter. Consumer prices $p(1+\tau)$ are tax inclusive. The Retail Scanner data is restricted to modules above the 80th percentile of the national distribution of sales. In Panel B, the reported coefficients are 2SLS estimates of the effect of consumer prices on quantity sold, where prices are instrumented with leave-self-out chain-level average prices. In Panel C, we report the estimate of the tax salience parameter. All standard errors in this table are clustered at the state-module level and are reported in parentheses. The sample includes our full sample of stores. In columns (1), the regression model includes module-by-store and module-by-quarter-by-state fixed effects. In column (2), the regression model includes module-by-store and module-by-quarter fixed effects, as well as county-module specific time trends. In column (3), the regression model includes module-by-store and module-by-quarter fixed effects, as well as store-module specific time trends.

Online Appendix Table OA.10

Store-level Estimates of Pass-Through, Tax Elasticity, Price Elasticity of Demand, and Tax Salience

Sample:	Full Sample	**Excluding alcohol and tobacco**
Weights:	Unweighted	Unweighted
	(1)	(2)
Panel A: Reduced-form OLS Estimates of the Effects of Sales Taxes on Consumer Prices and Quantity		
$d\log(p(1+\tau))/d\log(1+\tau)$ [pass-through]	0.970	0.974
	(0.046)	(0.046)
$d\log(Q)/d\log(1+\tau)$ [tax elasticity]	-0.775	-0.815
	(0.187)	(0.184)
Panel B: 2SLS Estimates of the Price Elasticity of Demand		
$d\log(Q)/d\log(p)$	-1.150	-1.136
	(0.027)	(0.027)
Panel C: "Plug-in" Estimate of Tax Salience Parameter		
θ_τ	0.680	0.718
Average tax rate, τ	0.036	0.036
Specification:		
Store × Module fixed effects	y	y
Module × State × Year-Quarter fixed effects	y	y
Module × Border Pair × Year-Quarter fixed effects		
N	53,987,430	52,404,504

Notes: This table reports estimates of the effects of sales taxes, of the price elasticity of demand, and of the tax salience parameter. All standard errors in this table are clustered at the state-module level and are reported in parentheses. In column (1), 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 column (2), the sample excludes alcoholic beverages and tobacco products, which are subject to excise taxes.

Online Appendix Table OA.11

Household-Level Estimates of Cross-Store Substitution

Dependent variable:	Total quantity	Quantity at IV stores only	Total quantity	Quantity at IV stores only
	log	log	levels	levels
	(1)	(2)	(3)	(4)
Panel A: 2SLS Estimates of the Effects of Sales Taxes on Quantity				
$\log(1+\tau)$	-0.355	-0.598	-12.22	-19.97
	(0.231)	(0.248)	(6.606)	(4.603)
Panel B: 2SLS Estimates of the Price Elasticity of Demand				
$\log(p)$	-1.113	-1.553	-15.28	-20.98
	(0.0101)	(0.0109)	(0.228)	(0.155)
Mean dependent variable			12.53	5.058
Specification:				
Household × Module fixed effects	y	y	y	y
Module × State × Year-Quarter fixed effects	y	y	y	y
N	27,957,026	27,957,026	51,346,211	51,346,211

Notes: This table reports estimates of the effects of sales taxes and prices on quantity demanded. In columns (1) and (2), the sample is restricted to cells with non-zero purchases at RMS stores. In column (1) the dependent variable is the log of the total quantity purchased at any store, whereas in column (2) the dependent variable is the log of the total quantity purchased at RMS stores only. In columns (3) and (4), the sample is expanded to include all observations with any purchase, but the dependent variables are now in levels to keep zeros when examining purchases at RMS stores. All standard errors in this table are clustered at the state-module level and are reported in parentheses.

Online Appendix Table OA.12

Alternative Estimates of Tax and Price Elasticities, Mixed-Effects Model

Independent variable (*x*):	Taxes (1)	Prices (3)
Panel A: Variance of the Price and Tax Elasticities (Random Coefficients)		
Average coefficient	-0.396	-1.375
Sample variance of empirical Bayes predictions	0.099	0.002
Panel B: Variance of First-Stage Coefficients (Random Coefficients)		
Average coefficient	0.564	0.218
Sample variance of empirical Bayes predictions	0.000	0.002
Panel C: Variance of the Tax Salience Parameter		
Var(θ_τ)	0.051	
N	51,346,211	51,346,211

Notes: This table reports estimates of the variance of random coefficients from mixed-effects models. Panel A reports the average price and tax elasticities as well as the sample variance of the associated empirical Bayes predictions of the random coefficients. Panel B reports the average first-stage coefficient for the price and tax instruments as well as the sample variance of the associated empirical Bayes predictions of the random coefficients. The mixed-effects models allow for random coefficients across household-year cells. Observations are weighted using Nielsen's projection factors in order to obtain national representativeness.

Online Appendix Table OA.13

Calibration of Incidence and Marginal Excess Burden Formulas

[Table 5 Using RMS Full Sample Estimates]

	(1)	(2)	(3)
Panel A: Inputs and Intermediate Estimates Needed in Calibration			
Inputs:			
Average tax rate, τ		0.036	
Price elasticity, $\tilde{\epsilon}_D \equiv \partial\log(Q)/\partial\log(p(1+\tau))$		-1.150	
Tax pass-through, $\rho_\tau \equiv d\log(p(1+\tau))/d\log(1+\tau)$		0.970	
Tax elasticity, $\tilde{\epsilon}_{D\tau} \equiv d\log(Q)/d\log(1+\tau)$		-0.775	
Intermediate estimates:			
Implied estimate of $v_q/(J\epsilon_{ms})$		0.025	
Implied markup $(p-mc)/p$		0.019	
Implied estimate of v_q/J		0.022	
($v_q/J = 0$ is perfect competition, $v_q/J = 1$ is perfect collusion)			
Tax salience:			
Tax salience parameter, θ_τ		0.680	
Heterogeneity in θ_τ, $(1/p)\mathrm{Var}(\theta_\tau)$	0.000	0.051	0.218
Panel B: Incidence and Marginal Excess Burden Formulas			
Incidence (I)			
$I \equiv (dCS/d\tau)/(dPS/d\tau)$	22.270	22.321	22.486
$= (\rho_\tau(1+\tau) + (1-\theta_\tau)\tau\tilde{\epsilon}_{D\tau} + \tau(1+\tau)\tilde{\epsilon}_D(1/p)\mathrm{Var}(\theta_\tau)) / ((1-v/J)(1-\rho_\tau)+(v/J)\theta_\tau(1+\tau\rho_\tau))$			
Marginal Excess Burden ($d\tilde{W}/d\tau$)			
$d\tilde{W}/d\tau = ((p-mc)/p + \theta_\tau\tau)\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\mathrm{Var}(\theta_\tau)$	-0.034	-0.036	-0.043
Panel C: Decomposition of the Deviation Between General Formula and Harberger Formula			
Harberger formula (assuming perfect competition and full salience), $d\tilde{W}/d\tau = \tau\tilde{\epsilon}_{D\tau}$	-0.028	-0.028	-0.028
Imperfect salience only, $d\tilde{W}/d\tau = \theta_\tau\tau\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\mathrm{Var}(\theta_\tau)$	-0.019	-0.021	-0.028
Decomposition of deviation (as % of difference b/w Harberger and general formula)	-154%	-84%	3%
Imperfect competition only, $d\tilde{W}/d\tau = ((p-mc)/p + \tau)\tilde{\epsilon}_{D\tau}$	-0.043	-0.043	-0.043
Decomposition of deviation (as % of difference b/w Harberger and general formula)	254%	184%	97%

Notes: This table reports calibrations of the tax incidence and marginal excess burden formulas. The results of these calibrations are shown in Panel B. Panel A presents the value of the input parameters taken from Tables 2 through 4, as well as estimates of intermediate parameters (see main text for details). Panel C presents a decomposition of the deviation between the general formula calibrated in Panel B and a standard Harberger analysis. In column (1), we assume no heterogeneity in salience across consumers; in column (2) we allow for heterogeneity in the tax salience parameter by calibrating the variance of θ_τ using the estimate reported in Table 4. In column (3), we consider the special case of consumers being either fully attentive or fully inattentive to taxes.

Online Appendix Table OA.14

Calibration of Incidence and Marginal Excess Burden Formulas

[Table 5 Using RMS County Border Pair Sample Estimates]

	(1)	(2)	(3)
Panel A: Inputs and Intermediate Estimates Needed in Calibration			
Inputs:			
Average tax rate, τ		0.034	
Price elasticity, $\tilde{\epsilon}_D \equiv \partial\log(Q)/\partial\log(p(1+\tau))$		-1.170	
Tax pass-through, $\rho_\tau \equiv d\log(p(1+\tau))/d\log(1+\tau)$		0.980	
Tax elasticity, $\tilde{\epsilon}_{D\tau} \equiv d\log(Q)/d\log(1+\tau)$		-0.649	
Intermediate estimates:			
Implied estimate of $v_q/(J\epsilon_{ms})$		0.021	
Implied markup $(p-mc)/p$		0.015	
Implied estimate of v_q/J		0.018	
($v_q/J = 0$ is perfect competition, $v_q/J = 1$ is perfect collusion)			
Tax salience:			
Tax salience parameter, θ_τ		0.556	
Heterogeneity in θ_τ, $(1/p)\text{Var}(\theta_\tau)$	0.000	0.051	0.247
Panel B: Incidence and Marginal Excess Burden Formulas			
Incidence (I)			
$I \equiv (d\text{CS}/d\tau)/(d\text{PS}/d\tau)$	33.669	33.742	34.021
$= (\rho_\tau(1+\tau) + (1-\theta_\tau)\tau\tilde{\epsilon}_{D\tau} + \tau(1+\tau)\tilde{\epsilon}_D(1/p)\text{Var}(\theta_\tau)) \,/\, ((1-v/J)(1-\rho_\tau)+(v/J)\theta_\tau(1+\tau\rho_\tau))$			
Marginal Excess Burden ($d\tilde{W}/d\tau$)			
$d\tilde{W}/d\tau = ((p-mc)/p + \theta_\tau\tau)\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\text{Var}(\theta_\tau)$	-0.022	-0.024	-0.032
Panel C: Decomposition of the Deviation Between General Formula and Harberger Formula			
Harberger formula (assuming perfect competition and full salience), $d\tilde{W}/d\tau = \tau\tilde{\epsilon}_{D\tau}$	-0.022	-0.022	-0.022
Imperfect salience only, $d\tilde{W}/d\tau = \theta_\tau\tau\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\text{Var}(\theta_\tau)$	-0.012	-0.014	-0.022
Decomposition of deviation (as % of difference b/w Harberger and general formula)	-	-365%	4%
Imperfect competition only, $d\tilde{W}/d\tau = ((p-mc)/p + \tau)\tilde{\epsilon}_{D\tau}$	-0.032	-0.032	-0.032
Decomposition of deviation (as % of difference b/w Harberger and general formula)	-	465%	96%

Notes: This table reports calibrations of the tax incidence and marginal excess burden formulas. The results of these calibrations are shown in Panel B. Panel A presents the value of the input parameters taken from Tables 2 through 4, as well as estimates of intermediate parameters (see main text for details). Panel C presents a decomposition of the deviation between the general formula calibrated in Panel B and a standard Harberger analysis. In column (1), we assume no heterogeneity in salience across consumers; in column (2) we allow for heterogeneity in the tax salience parameter by calibrating the variance of θ_τ using the estimate reported in Table 4. In column (3), we consider the special case of consumers being either fully attentive or fully inattentive to taxes.

Online Appendix Table OA.15

Calibration of Incidence and Marginal Excess Burden Formulas

[Sensitivity of Table 5 to Alternative Values of Elasticity of Inverse Marginal Surplus]

	(1)	(2)	(3)	(4)	(5)
Panel A: Inputs and Intermediate Estimates Needed in Calibration					
Inputs:					
Average tax rate, τ			0.024		
Price elasticity, $\tilde{\epsilon}_D \equiv \partial\log(Q)/\partial\log(p(1+\tau))$			-1.375		
Tax pass-through, $\rho_\tau \equiv d\log(p(1+\tau))/d\log(1+\tau)$			0.968		
Tax elasticity, $\tilde{\epsilon}_{D\tau} \equiv d\log(Q)/d\log(1+\tau)$			-0.396		
ϵ_{ms} (assume $1/\epsilon_D$ in col (1), sensitivity analysis in (2)-(5))	0.727	**0.400**	**0.600**	**1.000**	**1.200**
Intermediate estimates:					
Implied estimate of $v_q/(J\epsilon_{ms})$	0.070	0.084	0.075	0.062	0.057
Implied markup $(p - mc)/p$	0.037	0.024	0.033	0.045	0.049
Implied estimate of v_q/J	0.051	0.034	0.045	0.062	0.068
($v_q/J = 0$ is perfect competition, $v_q/J = 1$ is perfect collusion)					
Tax salience:					
Tax salience parameter, θ_τ			0.313		
Heterogeneity in θ_τ, $(1/p)\mathrm{Var}(\theta_\tau)$			0.051		
Panel B: Incidence and Marginal Excess Burden Formulas					
Incidence (I)					
$I \equiv (dCS/d\tau)/(dPS/d\tau)$	21.126	23.663	21.942	19.828	19.132
$= (\rho_\tau(1+\tau) + (1-\theta_\tau)\tau\tilde{\epsilon}_{D\tau} + \tau(1+\tau)\tilde{\epsilon}_D(1/p)\mathrm{Var}(\theta_\tau))/((1-v/J)(1-\rho_\tau)+(v/J)\theta_\tau(1+\tau\rho_\tau))$					
Marginal Excess Burden ($d\tilde{W}/d\tau$)					
$d\tilde{W}/d\tau = ((p-mc)/p + \theta_\tau\tau)\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\mathrm{Var}(\theta_\tau)$	-0.019	-0.014	-0.018	-0.022	-0.024
Panel C: Decomposition of the Deviation Between General Formula and Harberger Formula					
Harberger formula (assuming perfect competition and full salience), $d\tilde{W}/d\tau = \tau\tilde{\epsilon}_{D\tau}$	-0.009	-0.009	-0.009	-0.009	-0.009
Imperfect salience only, $d\tilde{W}/d\tau = \theta_\tau\tau\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\mathrm{Var}(\theta_\tau)$	-0.005	-0.014	-0.014	-0.014	-0.014
Decomposition of deviation (as % of difference b/w Harberger and general formula)	-49%	89%	53%	34%	29%
Imperfect competition only, $d\tilde{W}/d\tau = ((p-mc)/p + \tau)\tilde{\epsilon}_{D\tau}$	-0.024	-0.019	-0.022	-0.027	-0.029
Decomposition of deviation (as % of difference b/w Harberger and general formula)	149%	199%	159%	137%	133%

Notes: This table reports calibrations of the tax incidence and marginal excess burden formulas. The results of these calibrations are shown in Panel B. Panel A presents the value of the input parameters taken from Tables 2 through 4, as well as estimates of intermediate parameters (see main text for details). Panel C presents a decomposition of the deviation between the general formula calibrated in Panel B and a standard Harberger analysis. In all columns, we assume no heterogeneity in salience across consumers.

Online Appendix Table OA.16

Calibration of Incidence and Marginal Excess Burden Formulas

[Table 5 Using Alternative Calibration of τ]

	(1)	(2)	(3)
Panel A: Inputs and Intermediate Estimates Needed in Calibration			
Inputs:			
Average tax rate, τ		**0.052**	
Price elasticity, $\tilde{\epsilon}_D \equiv \partial\log(Q)/\partial\log(p(1+\tau))$		-1.375	
Tax pass-through, $\rho_\tau \equiv d\log(p(1+\tau))/d\log(1+\tau)$		0.968	
Tax elasticity, $\tilde{\epsilon}_{D\tau} \equiv d\log(Q)/d\log(1+\tau)$		-0.396	
Intermediate estimates:			
Implied estimate of $v_q/(J\epsilon_{ms})$		0.070	
Implied markup $(p - mc)/p$		0.037	
Implied estimate of v_q/J		0.051	
($v_q/J = 0$ is perfect competition, $v_q/J = 1$ is perfect collusion)			
Tax salience:			
Tax salience parameter, θ_τ		0.305	
Heterogeneity in θ_τ, $(1/p)\text{Var}(\theta_\tau)$	0.000	0.048	0.212
Panel B: Incidence and Marginal Excess Burden Formulas			
Incidence (I)			
$I \equiv (d\text{CS}/d\tau)/(d\text{PS}/d\tau)$	21.483	21.565	21.842
$= (\rho_\tau(1+\tau) + (1-\theta_\tau)\tau\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\text{Var}(\theta_\tau)) / ((1-v/J)(1-\rho_\tau)+(v/J)\theta_\tau(1+\tau\rho_\tau))$			
Marginal Excess Burden ($d\tilde{W}/d\tau$)			
$d\tilde{W}/d\tau = ((p-mc)/p + \theta_\tau\tau)\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\text{Var}(\theta_\tau)$	-0.021	-0.025	-0.037
Panel C: Decomposition of the Deviation Between General Formula and Harberger Formula			
Harberger formula (assuming perfect competition and full salience), $d\tilde{W}/d\tau = \tau\tilde{\epsilon}_{D\tau}$	-0.021	-0.021	-0.021
Imperfect salience only, $d\tilde{W}/d\tau = \theta_\tau\tau\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\text{Var}(\theta_\tau)$	-0.006	-0.010	-0.022
Decomposition of deviation (as % of difference b/w Harberger and general formula)	-	-265%	10%
Imperfect competition only, $d\tilde{W}/d\tau = ((p-mc)/p + \tau)\tilde{\epsilon}_{D\tau}$	-0.035	-0.035	-0.035
Decomposition of deviation (as % of difference b/w Harberger and general formula)	-	365%	90%

Notes: This table reports calibrations of the tax incidence and marginal excess burden formulas. The results of these calibrations are shown in Panel B. Panel A presents the value of the input parameters taken from Tables 2 through 4, as well as estimates of intermediate parameters (see main text for details). The average tax rate is based on taxable products alone. Panel C presents a decomposition of the deviation between the general formula calibrated in Panel B and a standard Harberger analysis. In column (1), we assume no heterogeneity in salience across consumers; in column (2) we allow for heterogeneity in the tax salience parameter by calibrating the variance of $\theta\tau$ using the estimate reported in Table 4. In column (3), we consider the special case of consumers being either fully attentive or fully inattentive to taxes.