# Online Appendix for "Salience and Taxation with Imperfect Competition"

Kory Kroft, Jean-William P. Laliberté, René Leal-Vizcaíno, and Matthew J. Notowidigdo

December 2020

## Proofs

### Proof of Lemma 1

*Proof.* Note that

$$\begin{aligned}
\epsilon_{Dt} &= \frac{dD(p(t),t)}{dt}\frac{p+t}{q(t)} \\
&= \frac{p+t}{q(t)}\int \frac{\partial D_i}{\partial p}(p(t),t)\left(\frac{dp}{dt}+\theta_i\right)di \\
&= \frac{p+t}{q(t)}\left((\rho-1)\frac{\partial D}{\partial p}+\int \frac{\partial D_i}{\partial p}(p(t),t)\theta_i di\right) \\
&= \frac{p+t}{q(t)}\left((\rho-1+\mathbb{E}(\theta_i))\frac{\partial D}{\partial p}+Cov\left(\theta_i,\frac{\partial D_i(p,t)}{\partial p}\right)\right) \\
&= -(\mathbb{E}(\theta_i)+\rho-1)\epsilon_D+\frac{p+t}{q(t)}Cov\left(\theta_i,\frac{\partial D_i(p,t)}{\partial p}\right)
\end{aligned}$$

Finally, under assumption 1 $\frac{\partial D_i}{\partial p}(p(t),t)$ is constant in $i$ and so $Cov\left(\theta_i,\frac{\partial D_i(p,t)}{\partial p}\right)=0$ □

### Proof of Proposition 1

*Proof.* Let the market be perfect competition. Consumer surplus can be expressed as

$$CS_i=\int_0^{q_i} wtp_i(s)ds-(p+t)q_i$$

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

$$\begin{aligned}\frac{dCS_i}{dt} &= wtp_i(q_i)\frac{dq_i}{dt} - \rho q_i - (p+t)\frac{dq_i}{dt} \\ &= (p+\theta_i t)\frac{dq_i}{dt} - \rho q_i - (p+t)\frac{dq_i}{dt} \\ &= -\rho q_i - (1-\theta_i)t\frac{dq_i}{dt}\end{aligned}$$

where the second equality follows from the fact that $wtp_i(q_i) = p + \theta_i t$, then

$$\begin{aligned}\frac{dCS}{dt} &= \int \frac{dCS_i}{dt} di \\ &= -\rho \mathbb{E}(q_i) - t\mathbb{E}\left((1-\theta_i)\frac{dq_i}{dt}\right) \\ &= -\rho q - (1 - \mathbb{E}(\theta_i))t\frac{dq}{dt} + tCov\left(\theta_i, \frac{dq_i}{dt}\right)\end{aligned}$$

For the tax revenue, we have

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

For producer surplus, we have

$$\frac{dPS}{dt} = -(1-\rho)q$$

Note that

$$\begin{aligned}\frac{dq}{dt} &= \int \frac{dq_i}{dt} di \\ &= \int \frac{\partial D_i}{\partial p}\left(\frac{dp}{dt} + \theta_i\right) di \\ &= \mathbb{E}\left(\frac{\partial D_i}{\partial p}\right) * (\rho - 1 + \mathbb{E}(\theta_i)) + Cov\left(\theta_i, \frac{\partial D_i}{\partial p}\right)\end{aligned}$$

Then we have

$$\begin{aligned}\rho &= \frac{dp}{dt} + 1 \\ &= 1 - \left(1 - \frac{1}{1 + \frac{\epsilon_D}{\epsilon_S}\frac{p}{p+t}}\right)\left(\mathbb{E}(\theta_i) + \frac{Cov\left(\theta_i, \frac{\partial D_i}{\partial p}\right)}{\frac{\partial D}{\partial p}}\right) \\ &= 1 - (1-\omega)\left(\mathbb{E}(\theta_i) + \frac{Cov\left(\theta_i, \frac{\partial D_i}{\partial p}\right)}{\frac{\partial D}{\partial p}}\right)\end{aligned}$$

where $\omega = \frac{1}{1+\frac{\epsilon_D}{\epsilon_S}\frac{p}{p+t}}$

Using Lemma 1, we have

$$\begin{aligned}I &= \frac{-\rho q - (1 - \mathbb{E}(\theta_i))t\frac{dq}{dt} + tCov\left(\theta_i, \frac{dq_i}{dt}\right)}{-(1-\rho)q} \\ &= \frac{\rho}{1-\rho} + \frac{1 - \mathbb{E}(\theta_i)}{1-\rho}\frac{t}{p+t}\epsilon_{Dt} - \frac{t}{q(1-\rho)}Cov\left(\theta_i, \frac{dq_i}{dt}\right)\end{aligned}$$

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

**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

$$\begin{aligned}
\frac{dPS}{dt} &= \frac{dp}{dt}q + [p - mc(q)]\frac{dq}{dt} \\
&= (\rho - 1)q - mwtp(q)q\frac{dq}{dt} \\
&= (\rho - 1)q - q\frac{\int \frac{dq_i}{dt} di}{\frac{\partial D}{\partial p}} \\
&= (\rho - 1)q - q\frac{\int \frac{\partial D_i}{\partial p}\left(\frac{dp}{dt} + \theta_i\right) di}{\frac{\partial D}{\partial p}} \\
&= (\rho - 1)q - q\left[\frac{dp}{dt} + \frac{\int \theta_i \frac{\partial D_i}{\partial p} di}{\frac{\partial D}{\partial p}}\right] \\
&= -q\left(\mathbb{E}(\theta_i) + \frac{Cov\left(\theta_i, \frac{\partial D_i}{\partial p}\right)}{\frac{\partial D}{\partial p}}\right)
\end{aligned}$$

Recall thar marginal surplus is $ms(q) = -mwtp(q)q$. Furthermore, define $MS(q,t) = -\frac{q}{\frac{\partial D}{\partial p}(p(t),t)} = \frac{ms(q)}{mwtp(q(t)) * \frac{\partial D}{\partial p}(p(t),t)}$, 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

$$p - mc(q) = MS(q,t)$$

Therefore

$$\begin{aligned}
\frac{dp}{dt} &= \left(MS_q(q,t) + mc'(q)\right)\frac{dq}{dt} + MS_t \\
&= \left(MS_q(q,t) + mc'(q)\right)\left(\frac{\partial D}{\partial p}\left(\frac{dp}{dt} + \mathbb{E}(\theta_i)\right) + Cov\left(\theta_i, \frac{\partial D_i}{\partial p}\right)\right) + MS_t
\end{aligned}$$

Then we have

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

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

The incidence of the tax is then:

$$\begin{aligned}
I &= \frac{-\rho q - (1 - \mathbb{E}(\theta_i))t\frac{dq}{dt} + tCov\left(\theta_i, \frac{dq_i}{dt}\right)}{-q * \left(\mathbb{E}(\theta_i) + \frac{Cov\left(\theta_i, \frac{\partial D_i}{\partial p}\right)}{\frac{\partial D}{\partial p}}\right)} \\
&= \frac{\epsilon_D}{\frac{p+t}{q}\mathbb{E}\left(\theta_i \frac{\partial D_i}{\partial p}\right)}\left(\rho + (1 - \mathbb{E}(\theta_i))\frac{t}{p+t}\epsilon_{Dt} - \frac{t}{q}Cov\left(\theta_i(p,t), \frac{dq_i}{dt}\right)\right)
\end{aligned}$$

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

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

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

**Proof of Proposition 3**

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

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

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

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

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

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

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:

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

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

**Proof of Lemma 2**

*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 $\theta_\tau$ 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 4**

*Proof.* Note that

$$\frac{dp}{d\tau} = \frac{1}{1+\theta_\tau\tau}(mwtp(q)\frac{dq}{d\tau} - p\theta_\tau) \tag{A1}$$

The first order condition with $J$ symmetric products and conduct parameter $\nu_q$ 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 $\tau$, 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

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

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

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

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 5**

*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

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

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

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

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

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

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

Therefore, we have

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

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

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 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

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

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

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

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

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

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:

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

And so:

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

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

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

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

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

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:
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 | 0.977 | -0.594 |
| | (0.016) | (0.084) | (0.017) | (0.093) |
| First-stage coefficient for $\log(1+\tau_{ms})$ | | | 1.011 | |
| | | | (0.002) | |
| First stage F-statistic | | | 413,454 | |
| *Specification:* | | | | |
| Store × Module fixed effects | y | y | y | y |
| Module × Border Pair × Year-Quarter fixed effects | y | y | 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: 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 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. 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.

Online Appendix Table OA.4: 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($p$) | 0.969 | | | -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) | |
| Index based on UPC-level leave-me-out chain average log(p) | | | 0.981 | | | -1.062 | | | 0.975 | | | -1.086 |
| | | | (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 | 53,895,446 | 53,890,260 | 53,892,855 | 53,895,446 | 53,890,260 | 53,892,855 | 33,749,157 | 33,739,222 | 33,746,705 | 33,749,157 | 33,739,222 | 33,746,705 |

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. 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 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 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.5: 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 | | | |
| $d\log(p(1+\tau))/d\log(1+\tau)$ | 0.961 | 0.926 | 0.928 |
| | (0.045) | (0.036) | (0.036) |
| $d\log(Q)/d\log(1+\tau)$ | -0.668 | -0.507 | -0.336 |
| | (0.185) | (0.165) | (0.164) |
| Panel B: 2SLS Estimates of the Price Elasticity of Demand | | | |
| $d\log(Q)/d\log(p)$ | -1.202 | -1.127 | -1.064 |
| | (0.027) | (0.030) | (0.030) |
| Panel C: "Plug-in" Estimate of the Tax Salience Parameter | | | |
| $\theta_\tau$ | 0.575 | 0.507 | 0.376 |
| 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 | 53,902,268 | 53,902,268 |

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.6

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** | | | | | | |
| $\log(1+\tau)_{mrn}$ | -0.668 | -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** | | | | | | |
| $z_{mrn}$ | -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** | | | | | | |
| $E[\theta]$ | | 0.552 | | | 0.491 | |
| *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 |
| 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 2, 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 $n$ 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.

Online Appendix Table OA.7
Calibration of Incidence and Marginal Excess Burden Formulas
**[Table 3 Using County Border Pair Sample Estimates]**

| | (1) | (2) |
|---|---|---|
| **Panel A: Inputs and Intermediate Estimates Needed in Calibration** | | |
| Inputs: | | |
| Average tax rate, $\tau$ | 0.036 | |
| Price elasticity, $\tilde{\epsilon}_D \equiv \partial\log(Q)/\partial\log(p)$ | **-1.223** | |
| Tax pass-through, $\rho_\tau \equiv d\log(p(1+\tau))/d\log(1+\tau)$ | **0.986** | |
| Tax elasticity, $\tilde{\epsilon}_{D\tau} \equiv d\log(Q)/d\log(1+\tau)$ | **-0.665** | |
| Intermediate estimates: | | |
| Implied estimate of $v_q/(J\epsilon_{ms})$ | 0.016 | |
| Implied markup $(p - mc)/p$ | 0.011 | |
| Implied estimate of $v_q/J$ | 0.013 | |
| ($v_q/J = 0$ is perfect competition, $v_q/J = 1$ is perfect collusion) | | |
| Tax salience: | | |
| Tax salience parameter, $\theta_\tau$ | 0.528 | |
| Heterogeneity in $\theta_\tau$, $(1/p)\text{Var}(\theta_\tau)$ | 0.00 | 0.20 |
| **Panel B: Incidence and Marginal Excess Burden Formulas** | | |
| Incidence ($I$) | | |
| $I \equiv (d\text{CS}/d\tau)/(d\text{PS}/d\tau)$ | 48.475 | 48.021 |
| $= (\rho_\tau(1+\tau) + (1-\theta_\tau)\tau\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\text{Var}(\theta_\tau)) / ((1-v/J)(1-\rho_\tau)+(v/J)\theta_\tau(1+\tau\rho_\tau))$ | | |
| Marginal Excess Burden ($d\tilde{W}/d\tau$) | | |
| $d\tilde{W}/d\tau = ( (p-mc)/p + \theta_\tau\tau)\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\text{Var}(\theta_\tau)$ | -0.020 | -0.029 |
| **Panel C: Decomposition of the Deviation Between General Formula and Harberger Formula** | | |
| Harberger formula (assuming perfect competition and full salience), $d\tilde{W}/d\tau = \tau\tilde{\epsilon}_{D\tau}$ | -0.024 | -0.024 |
| Imperfect salience only, $d\tilde{W}/d\tau = \theta_\tau\tau\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\text{Var}(\theta_\tau)$ | -0.013 | -0.022 |
| Decomposition of deviation (as % of difference b/w Harberger and general formula) | 262% | -45% |
| Imperfect competition only, $d\tilde{W}/d\tau = ( (p-mc)/p + \tau)\tilde{\epsilon}_{D\tau}$ | -0.031 | -0.031 |
| Decomposition of deviation (as % of difference b/w Harberger and general formula) | -162% | 145% |

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 Table 2 column (1), 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 salience parameter by calibrating the variance of $\theta$.

Online Appendix Table OA.8: Calibration of Incidence and Marginal Excess Burden Formulas
**[Sensitivity of Table 3 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, $\tau$ | | | 0.036 | | |
| Price elasticity, $\tilde{\epsilon}_D \equiv \partial\log(Q)/\partial\log(p)$ | | | -1.202 | | |
| Tax pass-through, $\rho_\tau \equiv d\log(p(1+\tau))/d\log(1+\tau)$ | | | 0.961 | | |
| Tax elasticity, $\tilde{\epsilon}_{D\tau} \equiv d\log(Q)/d\log(1+\tau)$ | | | -0.668 | | |
| $\epsilon_{ms}$ (assume $1/\epsilon_D$ in col (1), sensitivity analysis in (2)-(5)) | 0.832 | **0.400** | **0.600** | **1.000** | **1.200** |
| Intermediate estimates: | | | | | |
| Implied estimate of $v_q/(J\epsilon_{ms})$ | 0.041 | 0.052 | 0.046 | 0.037 | 0.034 |
| Implied markup $(p-mc)/p$ | 0.028 | 0.017 | 0.023 | 0.031 | 0.034 |
| Implied estimate of $v_q/J$ | 0.034 | 0.021 | 0.028 | 0.037 | 0.041 |
| ($v_q/J = 0$ is perfect competition, $v_q/J = 1$ is perfect collusion) | | | | | |
| Tax salience: | | | | | |
| Tax salience parameter, $\theta_\tau$ | | | 0.575 | | |
| Heterogeneity in $\theta_\tau$, $(1/p)\text{Var}(\theta_\tau)$ | | | 0.00 | | |
| **Panel B: Incidence and Marginal Excess Burden Formulas** | | | | | |
| Incidence ($I$) | | | | | |
| $I \equiv (d\text{CS}/d\tau)/(d\text{PS}/d\tau)$ | 17.051 | 19.489 | 18.129 | 16.473 | 15.932 |
| $= (\rho_\tau(1+\tau) + (1-\theta_\tau)\tau\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\text{Var}(\theta_\tau))/((1-v/J)(1-\rho_\tau)+(v/J)\theta_\tau(1+\tau\rho_\tau))$ | | | | | |
| Marginal Excess Burden ($d\tilde{W}/d\tau$) | | | | | |
| $d\tilde{W}/d\tau = ((p-mc)/p + \theta_\tau\tau)\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\text{Var}(\theta_\tau)$ | -0.033 | -0.025 | -0.029 | -0.035 | -0.037 |
| **Panel C: Decomposition of the Deviation Between General Formula and Harberger Formula** | | | | | |
| Harberger formula (assuming perfect competition and full salience), $d\tilde{W}/d\tau = \tau\tilde{\epsilon}_{D\tau}$ | -0.024 | -0.024 | -0.024 | -0.024 | -0.024 |
| Imperfect salience only, $d\tilde{W}/d\tau = \theta_\tau\tau\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\text{Var}(\theta_\tau)$ | -0.014 | -0.014 | -0.014 | -0.014 | -0.014 |
| Decomposition of deviation (as % of difference b/w Harberger and general formula) | -119% | -765% | -199% | -97% | -81% |
| Imperfect competition only, $d\tilde{W}/d\tau = ((p-mc)/p + \tau)\tilde{\epsilon}_{D\tau}$ | -0.043 | -0.036 | -0.039 | -0.045 | -0.047 |
| Decomposition of deviation (as % of difference b/w Harberger and general formula) | 219% | 865% | 299% | 197% | 181% |

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 Table 2 column (1), 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.

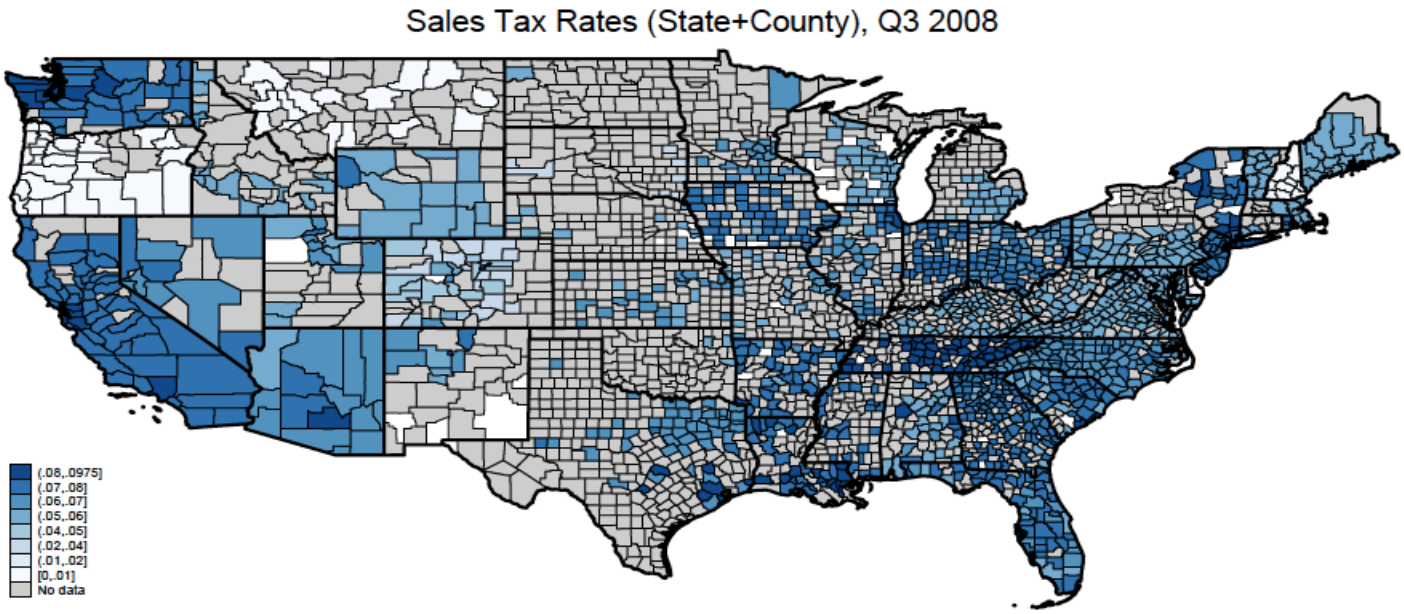
Online Appendix Table OA.9: Counterfactual Scenarios Adjusting Tax Salience and Market Structure

**[Table 4 Allowing for Heterogeneity in Tax Salience]**

| Tax salience parameter, $\theta_\tau$: | Imperfect salience, $\theta_\tau = 0.575$ | Counterfactual scenarios: Imperfect salience, $\theta_\tau = 0.575$ | | Counterfactual scenarios: Full salience, $\theta_\tau = 1.00$ | | |
|---|---|---|---|---|---|---|
| Market structure (conduct parameter, $v_q/J$): | Imperfect competition, $v_q/J = 0.034$ | Perfect competition, $v_q/J = 0$ | Imperfect competition, $v_q/J = 0.068$ | Imperfect competition, $v_q/J = 0.034$ | Perfect competition, $v_q/J = 0$ | Imperfect competition, $v_q/J = 0.068$ |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Panel A: Inputs and Intermediate Estimates Needed to Calibrate Formulas** | | | | | | |
| Inputs: [constant parameters] | | | | | | |
| Average tax rate, $\tau$ | | | 0.036 | | | |
| Price Elasticity, $\tilde{\epsilon}_D \equiv \partial \log(Q)/\partial \log(p)$ | | | -1.202 | | | |
| Intermediate estimates: | | | | | | |
| Implied estimate of $v_q/(J\epsilon_{ms})$ | 0.041 | 0.000 | 0.082 | 0.041 | 0.000 | 0.082 |
| Implied markup $(p - mc)/p$ | 0.028 | 0.000 | 0.057 | 0.028 | 0.000 | 0.057 |
| **Panel B: Counterfactual Tax Responses and Implied Incidence and Marginal Excess Burden** | | | | | | |
| Counterfactual reponses: | Baseline estimates | Counterfactual responses | | | | |
| Tax Pass-Through, $\rho_\tau \equiv d\log(p(1+\tau))/d\log(1+\tau)$ | 0.961 | 1.000 | 0.924 | 0.933 | 1.000 | 0.869 |
| Tax Elasticity, $\tilde{\epsilon}_{D\tau} \equiv d\log(Q)/d\log(1+\tau)$ $= \tilde{\epsilon}_D(\rho_\tau - 1 + \theta_\tau/(1+\tau\theta_\tau))(1+\tau)$ | -0.668 | -0.701 | -0.607 | -1.118 | -1.202 | -1.039 |
| Incidence ($I$) | | | | | | |
| $I \equiv (dCS/d\tau)/(dPS/d\tau)$ $= (\rho_\tau(1+\tau)+(1-\theta_\tau)\tau\tilde{\epsilon}_{D\tau}-\tau(1+\tau)\tilde{\epsilon}_D(1/p)\mathrm{Var}(\theta_\tau))/((1-v/J)(1-\rho_\tau)+(v/J)\theta_\tau(1+\tau\rho_\tau))$ | 17.051 | $\infty$ | 8.536 | 9.640 | $\infty$ | 4.674 |
| Marginal Excess Burden ($d\tilde{W}/d\tau$) | | | | | | |
| $d\tilde{W}/d\tau = ((p-mc)/p + \theta_\tau\tau)\tilde{\epsilon}_{D\tau} - \tau(1+\tau)\tilde{\epsilon}_D(1/p)\mathrm{Var}(\theta_\tau)$ | -0.042 | -0.023 | -0.056 | -0.072 | -0.043 | -0.097 |

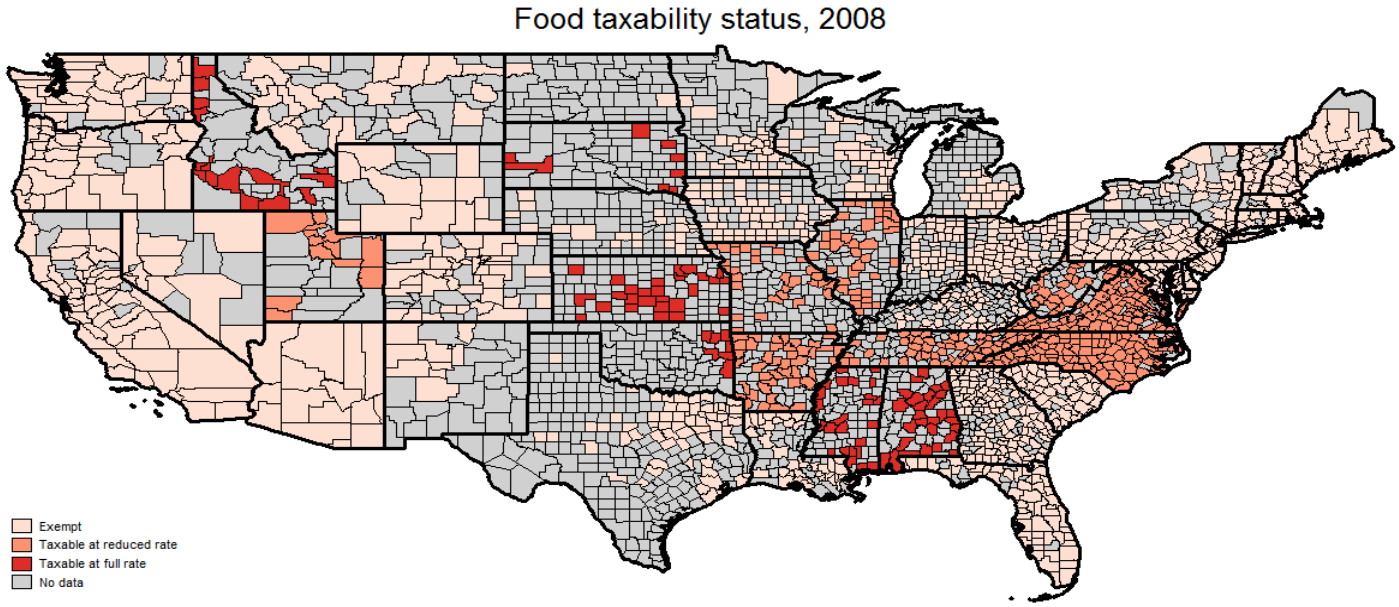
Notes: This table reports calibrations of the tax incidence and marginal excess burden formulas for different counterfactual assumptions about tax salience and market structure. **Columns (1)-(3) allow for heterogeneity in salience parameter following column (2) of Table 3.** Panel A shows the parameters that are held constant across scenarios as well as the implied markup (given assumed market structure that determines the degree of competition). Panel B shows the counterfactual responses to tax changes for each scenario, which can be compared to the empirical estimates in column 1 (based on Table 2). Lastly, Panel B reports the incidence and marginal excess burden. Column (1) reports results using the baseline estimates of salience and conduct parameter from Table 3, and the remaining columns report counterfactual results assuming different values of the tax salience parameter and the conduct parameter. Columns (1)-(3) use the baseline estimate of the tax salience parameter, and columns (4)-(6) assume taxes are fully salient. Columns (2) and (5) assume perfect competition, while columns (3) and (6) assume a conduct parameter that is double the baseline estimate from Table 3.

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



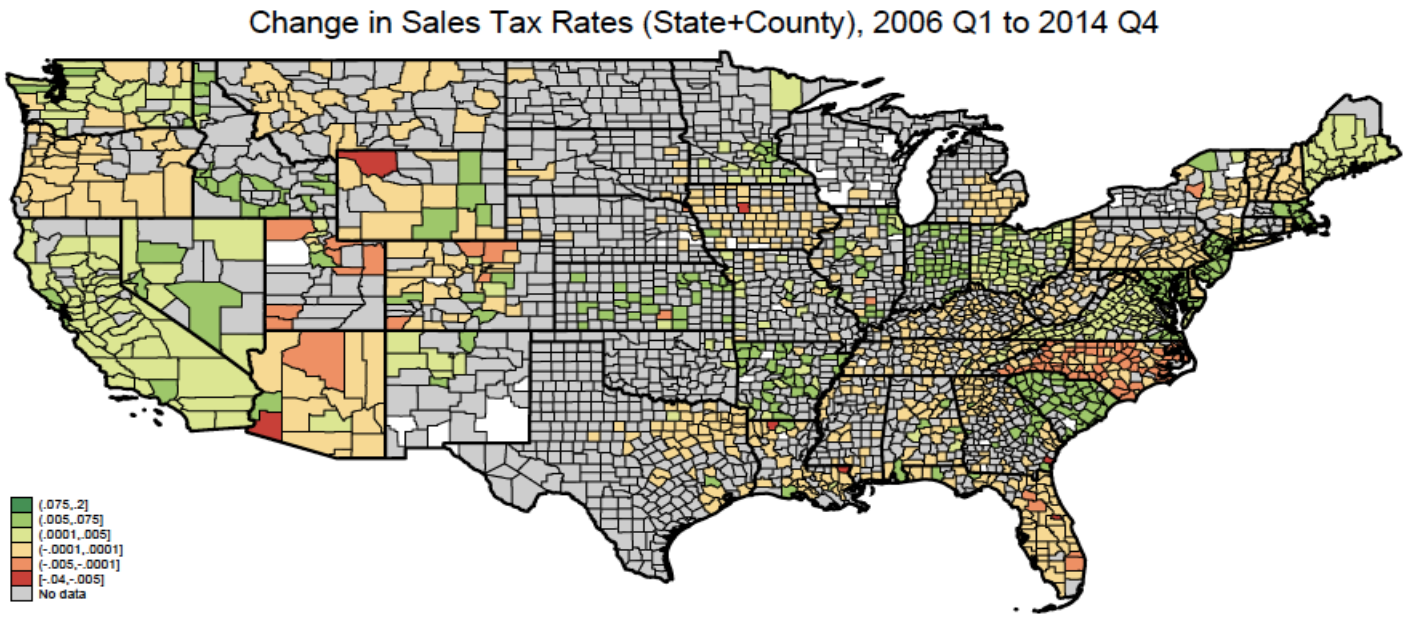

Notes: 'No data' indicates counties for which no grocery store sales were recorded in Nielsen's Retail Scanner data in 2008.

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



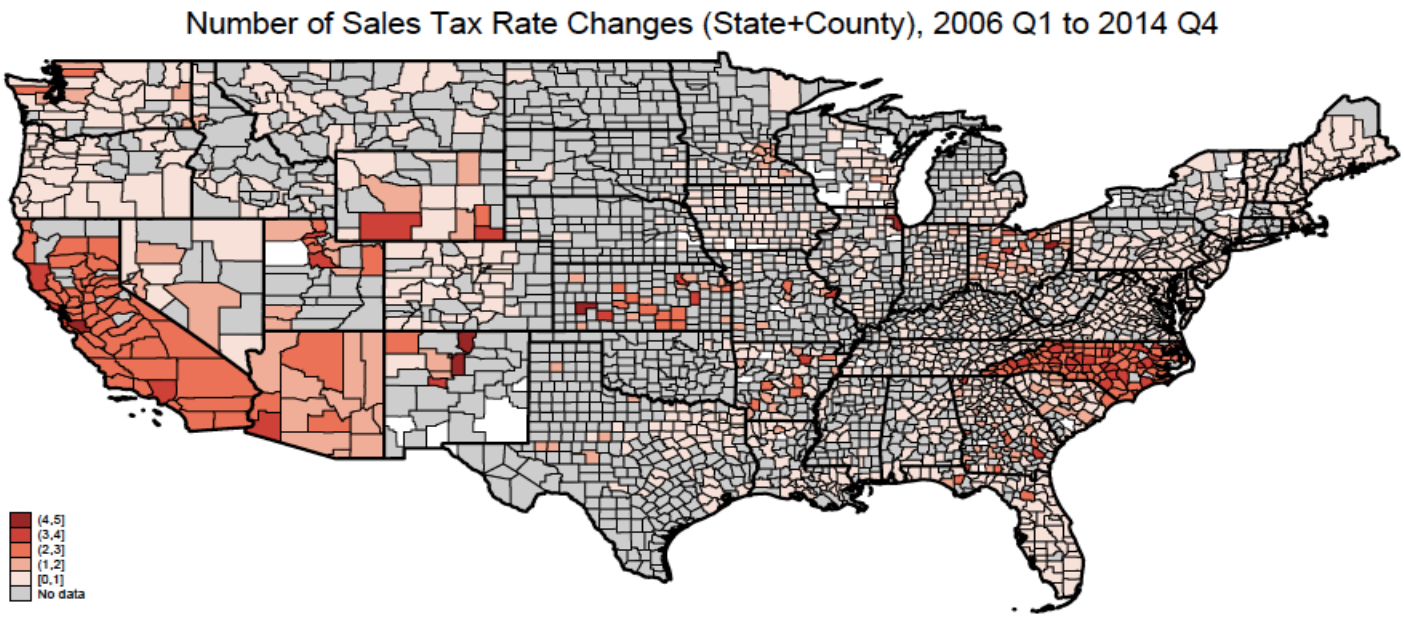

Notes: 'No data' indicates counties for which no grocery store sales were recorded in Nielsen's Retail Scanner data in 2008.

Online Appendix Figure OA.3: Changes in Sales Tax Rates




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

Online Appendix Figure OA.4: Number of Changes in Sales Tax Rates




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