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SALIENCE AND TAXATION WITH IMPERFECT COMPETITION

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ABSTRACT

This paper studies commodity taxation in a model featuring heterogeneous consumers, imperfect competition, and tax salience. We derive new formulas for the incidence and marginal excess burden of commodity taxation, and we find that tax salience and market structure interact when considering tax incidence but do not directly interact when considering the marginal excess burden. We estimate the necessary inputs to the formulas by combining Nielsen Retail Scanner data from grocery stores in the US with detailed sales tax data. We calibrate our new formulas and conclude that the incidence of sales taxes on consumers is increasing in tax salience, and the marginal excess burden of taxation is larger than standard formulas that ignore imperfect competition and tax salience.

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1 Introduction

Standard welfare analysis of commodity taxation typically makes two key assumptions: (1) the product market is perfectly competitive and (2) consumers respond to taxes in the same way they respond to price changes. Several papers in public economics have relaxed the first assumption (see Auerbach and Hines 2002 for a review of this literature), but these papers have maintained the second assumption that taxes are fully salient. More recently, researchers have relaxed the second assumption, developing new theoretical and empirical tools to analyze the welfare effects of taxes when taxes are less salient than prices, but have maintained the assumption of perfect competition (Chetty, Looney, and Kroft 2009; Taubinsky and Rees-Jones 2018). If markets are characterized by imperfect competition and consumers misperceive taxes, however, neither of these approaches is likely to provide an accurate characterization of the welfare effects of commodity taxes.

This paper contributes to the behavioral public finance literature in several ways. First, we derive new formulas for the incidence and marginal excess burden of commodity taxes in a general model featuring imperfect competition and tax salience. These formulas lead to the key novel insight of this paper. Tax salience and market structure *interact* when considering tax incidence. In particular, we show that greater attention to taxes can increase the incidence on consumers under imperfect competition when the standard model of perfect competition predicts the opposite pattern. Thus, the standard intuition of how tax salience affects the incidence of taxation in perfectly competitive markets does not always carry over to imperfect competition. On the other hand, tax salience and imperfect competition do not directly interact when considering the efficiency cost of taxation, which means that tax salience affects the welfare cost of taxation in similar ways under perfect and imperfect competition.[1]

Second, we provide new estimates of the necessary inputs to our tax formulas using Nielsen Retail Scanner data covering grocery stores selling consumer goods in the US combined with county-

[1]As we describe in more detail below, this separability between salience and the degree of competition is conditional on the other sufficient statistics that determine the welfare effects of taxation, which themselves could vary with market structure and the degree of inattention to the tax. This contrasts with the incidence formula, where the tax salience and market structure parameters interact directly.

level and state-level sales tax data. We estimate the effect of taxes on consumer prices and quantity using a regression model that leverages variation in sales taxes within states and counties over time, and another regression model that focuses on differences between "border pair" counties located on opposite sides of a state border (Holmes 1998; Dube, Lester and Reich 2010). We also estimate the price of elasticity of demand based on an instrumental variable strategy where we exploit the "uniform pricing" across stores within retail chains (DellaVigna and Gentzkow 2019). Our estimates indicate nearly-complete pass-through of taxes onto consumer prices, and a tax elasticity of demand that is smaller in magnitude than the price elasticity of demand. We combine these estimates to provide a new estimate of tax salience, which is fairly similar to other estimates reported in the literature.

Lastly, we calibrate our new tax formulas using these empirical estimates. A novel feature of our approach is the use of our pass-through formula and the generalized Lerner index to calibrate the average markup, which enters in the marginal excess burden formula. Our calibration results show that accounting for imperfect competition and tax salience meaningfully changes the incidence and marginal excess burden of sales taxes. We find a lower incidence of taxes on consumers (as compared to perfect competition), and we find that increased attention to taxes leads to consumers bearing a *larger* share of the burden of the tax. Turning to welfare, Chetty, Looney and Kroft (2009) show that when consumers underreact to sales taxes, the standard Harberger formula exaggerates the true marginal excess burden of sales taxes. However, our new formula shows that this may no longer be the case under imperfect competition, since there is a pre-existing distortion coming from firms' market power. In fact, our calibration results suggest that even though consumers underreact to taxes, the Harberger formula nevertheless *understates* – rather than overstates – the marginal excess burden of sales taxes. Intuitively, this is because the markup scales one-for-one in the welfare formula, while the tax salience parameter scales with the tax rate, as in the perfectly competitive case. Overall, we interpret these results as revealing the importance of jointly accounting for tax salience and imperfect competition when analyzing the incidence and efficiency costs of commodity taxation, and our general formulas show how to incorporate these features in a unified framework.

Our paper is related to several streams of research. First, our paper builds on and contributes to the literature on taxation and imperfect competition (see, e.g., Seade 1987, Stern 1987, Delipalla and Keen 1992, Anderson, de Palma and Kreider 2001a, Anderson, de Palma and Kreider 2001b, Auerbach and Hines 2001, Weyl and Fabinger 2013, Hackner and Herzing 2016, Adachi and Fabinger 2018 and Miravete, Seim and Thurk 2018). Our paper innovates in several ways. First, we consider a general model of imperfect competition and do not impose a functional form for preferences or technology, similar to Weyl and Fabinger (2013).[2] Second, we permit consumers to underreact to taxes. Third, unlike most of the research in this area, we provide an empirical application that allows us to calibrate our new formulas. Our empirical analysis thus contributes to the literature studying sales taxes empirically (see, e.g., Besley and Rosen 1999, Einav et al. 2014, and Baker, Johnson, and Kueng 2018).

We also contribute to the behavioral public economics literature studying tax salience (Chetty, Looney and Kroft 2009, Goldin and Hominoff 2013, Allcott and Taubinsky 2015, Farhi and Gabaix 2017, Rees-Jones and Taubinsky 2018, Allcott, Lockwood and Taubinsky 2018, Bradley and Feldman 2019, and Morrison and Taubsinky 2020). We extend results on incidence and efficiency to settings with imperfect competition, and we highlight a new result under perfect competition which goes against the conventional wisdom. Specifically, we show that the pass-through rate is not sufficient to characterize tax incidence when there are pre-existing taxes in a market; one also requires independent estimates of tax salience and the tax elasticity of demand.

The remainder of the paper is organized as follows: Section 2 begins with a model of perfect competition. Section 3 extends the results to monopoly and the general model of imperfect competition. Section 4 discusses the data and the empirical results. Section 5 presents the calibration results. Section 6 concludes.

[2]Weyl and Fabinger (2013) only consider tax incidence. They do not consider the efficiency costs of taxation.

2 Perfect Competition

We are interested in characterizing the incidence and marginal excess burden effects of commodity taxation allowing for salience effects. Following Weyl and Fabinger (2013), we define the incidence of a unit tax t as $I=\frac{dCS/dt}{dPS/dt}$ and the marginal excess burden of the tax as $\frac{dW}{dt} = \frac{dCS}{dt}+\frac{dPS}{dt}+\frac{dR}{dt}$ where CS denotes consumer surplus, PS denotes producer surplus, R denotes government revenue, and $W = CS+PS+R$ denotes social welfare.[3]

Let p denote the producer price, $p+t$ denote the price paid by consumers and $D(p,t)$ and $S(p)$ be, respectively, quantities demanded and supplied. We assume that $D(p,t)$ is strictly decreasing in both arguments and continuous and $S(p)$ is strictly increasing and continuous. Our specification for demand permits prices and taxes to have different effects, following Chetty, Looney and Kroft (2009). We assume: (1) utility is quasilinear and taxes affect utility only through their effects on the chosen consumption bundle, so that $U = u(q) - (p+t)q$, where q is quantity demanded; and (2) in the absence of taxation, individuals perfectly optimize so that $p = u'(q)$ when $t = 0$. We define willingness to pay as $wtp(q) \equiv u'(q)$ and marginal willingness to pay as $mwtp(q) \equiv u''(q)$. Therefore, $D(p,0) = D(wtp(q),0) = q$. Assume that for $t > 0$, $D(p,0) > D(p,t) > D(p+t,0)$. By strict monotonicity and continuity, for all p and t there exists $\theta(p,t) \in (0,t)$ such that $D(p+\theta(p,t),0) = D(p,t)$.

For fixed t, we assume that if $D(p+\theta,0) = D(p,t)$ for some price p, then $D(p'+\theta,0) = D(p',t)$ for any other price p'. This implies that $\theta(p,t) = \theta(t)$. We further assume that $\theta(t)$ is linear and write it as $\theta(t) = \theta t$ which is without loss of generality on the shape of the original inverse demand curve $P(q) = u'(q) = wtp(q)$. This definition of θ satisfies $\theta = \frac{\frac{\partial D}{\partial t}}{\frac{\partial D}{\partial p}}$ which is how this parameter is defined in Chetty, Looney and Kroft (2009).

The equilibrium price, p, is determined by $D(p,t) = S(p)$. We denote the pass-through rate by $\rho \equiv 1+dp/dt$. We now introduce a lemma which turns out to be quite useful in deriving all of the

[3] As in Chetty, Looney and Kroft (2009), we consider a unit tax for our theoretical analysis and an ad valorem tax for the empirical analysis, since sales taxes are expressed as a percentage of price in the US. By focusing on unit taxes in the theoretical analysis, we can relate our formulas to the incidence formulas in Weyl and Fabinger (2013), who do not consider tax salience. The Appendix provides an analogous theoretical analysis for ad valorem taxes, and we use the ad valorem formulas in our calibrations since our empirical analysis is based on ad valorem sales taxes.

incidence formulas that we present in the paper.

Lemma 1. *Let the price elasticity of demand be given by* $\epsilon_D \equiv -\frac{wtp(q)-\theta t}{mwtp(q)q} = -\frac{p}{mwtp(q)q}$ *and let* $\epsilon_{Dt} \equiv \frac{t}{q}\frac{dq}{dt}$ *be the elasticity of equilibrium output* q *with respect to the tax* t*. Then the following relationship holds:*

$$-\epsilon_{Dt} = (\theta+\rho-1)\frac{t}{p}\epsilon_D$$

Proof. See Appendix. □

Note that ϵ_{Dt} need not equal $\frac{\partial D}{\partial t}\frac{t}{q}$; the latter holds pre-tax prices fixed, while the former includes any indirect effect of taxes on producer prices that would arise under incomplete pass-through. For completeness, we also define $\epsilon_S \equiv \frac{S'p}{q}$ as the price elasticity of supply. From these definitions and Lemma 1, we can derive the following:

Proposition 1. *The incidence on consumers, producers, government, the pass-through rate and the marginal excess burden in* ***perfect competition*** *may be expressed as:*

$$\frac{dCS}{dt} = -\rho q-(1-\theta)t\frac{dq}{dt}, \quad \frac{dPS}{dt} = -(1-\rho)q, \quad \frac{dR}{dt} = q+t\frac{dq}{dt} \tag{1}$$

$$\rho = 1-\frac{\theta\epsilon_D}{\epsilon_S+\epsilon_D} \tag{2}$$

$$\begin{aligned} I &= \frac{\rho}{1-\rho}+\frac{1-\theta}{1-\rho}\epsilon_{Dt} \\ &= \frac{1-\theta}{\theta}+\frac{\epsilon_S}{\theta\epsilon_D}-(1-\theta)\frac{t}{p}\epsilon_S \end{aligned} \tag{3}$$

$$\frac{dW}{dt} = \theta t\frac{dq}{dt} \tag{4}$$

Proof. See Appendix. □

We highlight several features of of Proposition 1. First, when $t = 0$, the formulas for consumer surplus and producer surplus, and hence incidence, are identical to Weyl and Fabinger (2013), except that pass-through is indirectly affected by salience. Intuitively, on the consumer side, when there are no taxes in the baseline equilibrium, consumers optimize and so the envelope theorem applies. Salience only affects consumers at the market level through changes in prices. Second, when $t > 0$, the pass-through rate is no longer sufficient for incidence; one also requires an independent estimate of tax salience (θ) along with the tax elasticity of demand (ϵ_{Dt}).[4] Intuitively, one has to account for behavioral responses since the envelope theorem does not apply when consumers misoptimize in the baseline equilibrium, and in our case the behavioral response is scaled by the degree of inattention. The new term $-(1-\theta)t\frac{dq}{dt}$ enters dCS/dt positively and we see that more inattention to taxes reduces the incidence on consumers, conditional on the pass-through rate and the behavioral response to the tax. Intuitively, if consumers are over-spending on taxable goods at baseline (because $\theta < 1$), then a tax increase that causes them to reduce their demand and brings them closer to their optimal choice. Finally, we see that when supply is perfectly elastic ($\epsilon_S = \infty$), the full burden of the tax is on consumers and is independent of θ.

3 Imperfect Competition

3.1 Monopoly

In this section, we depart from the benchmark case of perfect competition and consider a general model of imperfect competition. In order to develop intuition, we begin with the special case of monopoly. We assume that the monopolist's cost of production is given by $c(q)$, with marginal cost $mc(q) \equiv c'(q)$, and we continue to assume that $u'(q) = wtp(q)$ and $u''(q) = mwtp(q)$. Under the assumption that $\theta(p,t) = \theta t$, then $D(p+\theta t, 0) = D(p,t)$ and we may express the inverse demand function facing the firm as $P(q,t) = wtp(q) - \theta t$. The monopolist's problem can be stated as:

$$\max_q P(q,t)q - c(q)$$

The first-order condition for the monopoly problem is $mwtp(q)q + wtp(q) - \theta t = mc(q)$. We now introduce several new definitions which are relevant for characterizing incidence and efficiency under imperfect competition. First, we define the marginal surplus as $ms(q) = -mwtp(q)q$. Next, we define the elasticity of marginal surplus as $\epsilon_{ms} = \frac{ms(q)}{ms'(q)q}$. Finally, we define $\epsilon_S = \frac{c'(q)}{c''(q)q}$. Given

[4] Chetty, Looney and Kroft (2009) fully characterized incidence in terms of ρ; however, with the definition of incidence as $I = \frac{dCS/dt}{dPS/dt}$, ρ does not fully characterize incidence in the case where $t > 0$.

this, we can characterize the incidence and marginal excess burden of taxes for monopoly.

Proposition 2. *The incidence on consumers, producers, government, the pass-through rate and the marginal excess burden in* ***monopoly*** *may be expressed as:*

$$\frac{dCS}{dt} = -\rho q - (1-\theta)t\frac{dq}{dt}, \quad \frac{dPS}{dt} = -\theta q, \quad \frac{dR}{dt} = q + t\frac{dq}{dt} \tag{5}$$

$$\rho = 1-\theta+\frac{\theta}{1+\frac{\epsilon_D-1}{\epsilon_S}+\frac{1}{\epsilon_{ms}}} \tag{6}$$

$$\begin{aligned} I &= \frac{\rho}{\theta}+\frac{1-\theta}{\theta}\epsilon_{Dt} \\ &= \frac{1-\theta}{\theta}+\left(1-(1-\theta)\frac{t}{p}\epsilon_D\right)\frac{1}{1+\frac{\epsilon_D-1}{\epsilon_S}+\frac{1}{\epsilon_{ms}}} \end{aligned} \tag{7}$$

$$\frac{dW}{dt} = (p-mc(q)+\theta t)\frac{dq}{dt} \tag{8}$$

Proof. See Appendix. □

Several interesting insights emerge from the analysis of salience and taxation under monopoly. First, when the initial tax rate $t = 0$ and $mc(q)$ is constant, the effect of the tax on consumer surplus, $\frac{dCS}{dt} = -\rho q$, is the same under perfect competition and monopoly (for a given level of ρ). However, consumer misoptimization has a first-order effect on producer surplus ($\frac{dPS}{dt} = -\theta q$), since it attenuates the reduction in demand due to the tax. This contrasts with perfect competition where $\frac{dPS}{dt} = 0$ when $t = 0$ and $\epsilon_S = \infty$.

Second, there are interesting effects of salience on pass-through, ρ, which operate through the elasticity of marginal surplus, which is positive (negative) if demand is log convex (log concave). To see this, consider the case of constant marginal cost and suppose demand has constant pass-through form so that $\epsilon_{ms} = -\epsilon$ (Bulow and Pfleiderer 1983). Under these assumptions, $\rho = 1-\frac{\theta}{1-\epsilon}$ so that $\frac{d\rho}{d\theta} = \frac{1}{\epsilon-1}$, and so if demand is sufficiently elastic, then $\frac{d\rho}{d\theta} > 0$ and increased attention to the tax makes consumers *worse off,* in contrast to the logic in Chetty, Looney and Kroft (2009) under perfect competition.[5]

[5] See Bradley and Feldman (2019), who also demonstrated this possibility previously, but did not derive the general incidence formula in Proposition 2.

Third, we see that while θ enters directly in the numerator of I in Proposition 1, in the case of monopoly, it enters both the numerator and denominator which are both increasing in θ (conditional on ρ and ϵ_{Dt}). Thus, greater attention to the tax (conditional on ρ and ϵ_{Dt}) can lead to larger incidence on consumers when demand is sufficiently elastic to the tax.

Finally, the effects of salience on the marginal excess burden of the tax operate in similar ways under perfect competition and monopoly through the term θt; however, under monopoly the marginal excess burden depends additionally on the markup, $p - mc(q)$. In the simple case where $mc(q)$ is constant, a smaller value of θ leads to a higher equilibrium price and so all else equal, this will additionally affect the marginal excess burden.

To summarize, the analysis of the incidence and welfare consequences of a tax for the special case of monopoly suggests that the standard intuition for the case of perfect competition does not always apply when firms have market power. Instead, there are interesting interactions between tax salience and market structure. This motivates our analysis of tax salience in a general model of imperfect competition.

3.2 Symmetric Imperfect Competition

We consider a differentiated product market (the "inside market") which is subject to a unit tax t on each product in the market. Following Auerbach and Hines (2001) and Weyl and Fabinger (2013), we assume that markets for other goods are perfectly competitive and are not subject to taxation. There is a single representative individual with exogenous income Z. Preferences are given by the quasi-linear utility function $u(q_1, \ldots, q_J) + y$, where q_j is the quantity consumed of product $j = 1, \ldots, J$ and $y \in \mathbb{R}$ is the numeraire (representing consumption in all the outside markets). We assume that the subutility function, u, which represents preferences for the differentiated products, is strictly quasi-concave, twice differentiable, and symmetric in all of its arguments. The pre-tax (or producer) price for product j is given by p_j and the after-tax (or consumer) price is given by $p_j + t$ for all $j = 1, ..., J$. We define $u(Q) \equiv u(Q/J, \ldots, Q/J)$ to be the compact notation of utility for the symmetric case where the individual consumes $q = \frac{Q}{J}$ units of each product $j = 1, \ldots, J$, where

Q is the aggregate quantity in the market. Furthermore, we define $wtp(Q) = u'(Q)$, $mwtp(Q) = u''(Q)$, and $ms(Q) = -mwtp(Q)Q$.

Following Chetty, Looney and Kroft (2009), consumer demand for product j is given by $q_j = q_j(p_1, \ldots, p_J, t)$ which is a function of both prices and the tax. In order to connect our tax formulas to empirical objects, it is necessary to relate observed demand $q_j(p_1, \ldots, p_J, t)$ to consumer willingness to pay. We thus make the following assumptions which mirror assumptions $A1$ and $A2$ in Chetty, Looney and Kroft (2009).

Assumption 1. *Taxes affect utility only through their effects on the chosen consumption bundle. Indirect utility is given by:*

$$V(p, t, Z) = u(q_1(p, t), \ldots, q_J(p, t)) + Z - (p+t)Q(p, t)$$

Assumption 1 requires that taxes or salience have no impact on utility beyond their effects on consumption.

Assumption 2. *When tax-inclusive prices are fully salient, the agent chooses the same allocation as a fully-optimizing agent.*

$$(q_1, \ldots, q_J)(p_1, \ldots, p_J, 0) = \arg \max_{(q_1, \ldots, q_J)} u(q_1, \ldots, q_J) + Z - p_1 q_1 - \cdots - p_J q_J$$

Assumption 2 implies that when tax-inclusive prices are fully salient, agents maximize utility. As in section 2 we allow for salience effects by considering the possibility that $q_j(p_1, ..., p_J, 0) < q_j(p_1, ..., p_J, t) < q_j(p_1 + t, ..., p_J + t, 0)$. In what follows, we assume that the demand function $q_j(\cdot)$ is symmetric in all other prices which we denote by $(p_k)_{-j}$ and twice differentiable and denote by $q(p, t)$ demand corresponding to symmetric prices and J firms: $q(p, t) \equiv q_j(p, ..., p, t)$. Without loss of generality in the functional form of $q(\cdot, 0) = \frac{(u')^{-1}(\cdot)}{J}$, we assume $q(p, t) = q(p + \theta t, 0)$ for some $\theta \in (0, 1)$; therefore, the salience parameter satisfies $\theta = \frac{\frac{\partial q_j}{\partial t}}{\frac{\partial q_j}{\partial p}}$. We define market demand as $Q(p, t) = Jq(p, t)$.

On the supply side, we allow for different forms of competition by introducing the market conduct parameter $\nu_p = \frac{\partial p_k}{\partial p_j}$ $(k \neq j)$ following Weyl and Fabinger (2013). Each firm has cost function

$c_j(q_j) = c(q_j)$, where $c(\cdot)$ is increasing and twice differentiable with $c(0) = 0$ and $mc(q_j) \equiv c'(q_j)$. Firm j chooses p_j to maximize profits π_j:

$$\max_{p_j} \pi_j = p_j q_j(p_1 \ldots, p_J, t) - c(q_j(p_1 \ldots, p_J, t))$$
$$\text{s.t. } \frac{\partial p_k}{\partial p_j} = \nu_p \text{ for } k \neq j$$

The first-order condition for p_j is given by:

$$q_j + (p_j - mc(q_j)) \left(\frac{\partial q_j}{\partial p_j} + \nu_p \sum_{k \neq j} \frac{\partial q_j}{\partial p_k} \right) = 0.$$

In a symmetric equilibrium, $p_j = p$ solves:

$$q_j(p_j, p, \ldots, p, t) + (p_j - mc(q_j)) \left(\frac{\partial q_j(p_j, p, \ldots, p, t)}{\partial p_j} + (J-1)\nu_p \frac{\partial q_j(p_j, p, \ldots, p, t)}{\partial p_k} \right) = 0, k \neq j$$

We assume that $\frac{\partial \pi_j}{\partial p_j}(p_j, p)$ is strict single crossing (from above) in p_j and decreasing in p so that a unique symmetric equilibrium $p(t)$ exists.[6] By letting $\nu_q = \frac{1}{mwtp(Q)} \times \frac{1}{\frac{dq_j}{dp_j}} = \frac{1}{mwtp(Q)} \times \frac{1}{\frac{\partial q_j}{\partial p_j} + \nu_p \sum_{k \neq j} \frac{\partial q_j}{\partial p_k}}$ we can rewrite the first-order condition as a generalized Lerner index:

$$\frac{p - mc(q)}{p} = \frac{\nu_q}{J \epsilon_D} \tag{9}$$

where $\epsilon_D \equiv -\frac{wtp(Q) - \theta t}{mwtp(Q)Q} = -\frac{p}{mwtp(Q)Q}$. Setting $\nu_q = J$ yields the monopoly (perfect collusion) outcome and setting $\nu_q = 0$ gives the perfect competition (marginal cost pricing) solution. Setting $\nu_q = 1$ corresponds to Cournot competition when goods are homogeneous and setting $\nu_p = 0$ yields the Bertrand-Nash equilibrium. The model thus captures a wide range of market conduct.

We assume throughout that tax revenue $R = tQ$ and profits $J\pi$ are redistributed to the the representative consumer as a lump-sum transfer. The consumer treats profits and tax revenue as fixed when choosing consumption, failing to consider the external effects on the lump-sum transfer. Given the assumption of quasi-linear utility, the consumer will choose to allocate the lump-sum transfer to the outside market y. Thus, total welfare, W, is given by the sum of consumer surplus

[6] The case of strategic complementarities, where $\frac{\partial \pi_j}{\partial p_j}(p_j, p)$ is increasing in p allows for the existence of multiple symmetric equilibria. However, in that case if we assume there is a continuous and symmetric equilibrium selection $p(t)$ the same results follow.

(CS), producer surplus (PS) and government revenue (R).

$$W(p,t) = \underbrace{u(Q) - (p+t)Q}_{CS} + \underbrace{pQ - Jc(q)}_{PS} + \underbrace{tQ}_{R} \tag{10}$$

We can now state our main result. Consider a small increase in the tax t which applies to all goods in the inside market.

Proposition 3. *The incidence on consumers, producers, government, the pass-through rate and the marginal excess burden under* ***symmetric imperfect competition*** *may be expressed as:*

$$\frac{dCS}{dt} = -\rho Q - (1-\theta)t\frac{dQ}{dt}, \quad \frac{dPS}{dt} = -Q\left(\theta\frac{\nu_q}{J} + (1-\rho)\left(1 - \frac{\nu_q}{J}\right)\right), \quad \frac{dR}{dt} = Q + t\frac{dQ}{dt} \tag{11}$$

$$\rho = 1 - \theta + \frac{\theta}{1 + \frac{\epsilon_D - \frac{\nu_q}{J}}{\epsilon_S} + \frac{\frac{\nu_q}{J}}{\epsilon_{ms}}} \tag{12}$$

$$\begin{aligned} I &= \frac{1}{\theta\frac{\nu_q}{J} + (1-\rho)(1-\frac{\nu_q}{J})}\left(\rho + (1-\theta)\epsilon_{Dt}\right) \\ &= \frac{1-\theta}{\theta} + \frac{1 + \left(1 - \frac{\nu_q}{J}\right)\left(\frac{1-\theta}{\theta}\right) - (1-\theta)\frac{t}{p}\epsilon_D}{\frac{\nu_q}{J} + \frac{\epsilon_D - \frac{\nu_q}{J}}{\epsilon_S} + \frac{\frac{\nu_q}{J}}{\epsilon_{ms}}} \end{aligned} \tag{13}$$

$$\frac{dW}{dt} = \left(p - mc(q) + \theta t\right)\frac{dQ}{dt} \tag{14}$$

Proof. See Appendix. □

Proposition 3 leads to several additional insights. First, note that under monopoly ($\nu_q = J$) we obtain the formulas in Proposition 2 and we can retrieve Proposition 1 by setting $\nu_q = 0$.

Second, $\frac{dCS}{dt}$ has the same expression as perfect competition and monopoly, while $\frac{dPS}{dt}$ is a convex combination (with weights ν_q and $1-\nu_q$) of the monopoly and perfect competition cases. To understand this expression, note that when $\theta = 1$, $\frac{dPS}{dt} = -Q\left((1-\rho) + \rho\frac{\nu_q}{J}\right)$, similar to Weyl and Fabinger (2013). When firms have market power, they internalize the change in their own output (given by $\frac{\nu_q}{J}$), and so we need to adjust the price effect by $\rho\frac{\nu_q}{J}$. Under monopoly, this effect becomes ρ and $\frac{dPS}{dt} = -Q$.

Third, whether greater attention to the tax increases or decreases the tax burden on consumers relative to producers depends on the level of competition. When $\frac{\nu_q}{J}$ is sufficiently high (i.e., close to 1), then a higher level of θ can increase the incidence on consumers if demand is very elastic to taxes, conditional on ρ. The effect of θ on incidence scales with the conduct parameter $\frac{\nu_q}{J}$ in the general model. Thus, salience and the degree of competition *interact* in determining the relative incidence of taxes on consumers and producers.

Finally, we see that the marginal excess burden formula depends on the same set of sufficient statistics as in the monopoly case. In particular, the conduct parameter does not appear in the formula, and thus the intuition for welfare in the monopoly case carries over to the general model.

4 Data and Empirical Results

4.1 Data description

To measure p and Q, we use Nielsen Retail Scanner data, which records weekly prices and sales by product (Universal Product Code, or UPC) for stores across the US from 2006-2014. We limit our sample to grocery stores for two reasons: the distribution of store types varies substantially across locations, and we use retail chains in our instrumental variables analysis and there are too few retail chains for the other store types. Each UPC in the data set belongs to a "product module".[7] We aggregate the data to the store-module-year-quarter level. We measure average pre-tax (or producer) prices p using a store-module-year-quarter price index, and we measure quantity Q using a price-weighted quantity index. Both index measures adjust for differences in the composition of UPCs sold across stores and over time. Additional details on the data construction are provided in the Appendix.

To measure the sales tax rate, t, we collect data on local sales tax rates and tax exemptions. These rates and exemptions vary by county, year, quarter, and module. Grocery stores sell products that are often subject to sales taxes (e.g., toothpaste) and products that are often tax-exempt (e.g.,

[7] Table OA.1 gives examples of UPCs and the organizational hierarchy of the Nielsen data. For computational reasons we focus on the largest 198 modules based on average store-level expenditures.

food). Table OA.2 and Figures OA.1 and OA.2 describe the variation in tax rates. Finally, we combine the ad valorem sales tax rate with the pre-tax price to obtain the post-tax (or consumer) price. We define this price as $p(1+t)$ to distinguish it from the pre-tax price, p.

4.2 The effects of sales taxes on prices and quantity

We estimate the effects of sales taxes on consumer prices and output using two regression models. The first model uses the full sample of counties from the Neilsen Retail Scanner data:

$$\log y_{mr\tau} = \beta^y \log(1+t_{mcs\tau}) + \delta_{m,s,\tau} + \delta_{m,r} + \varepsilon_{mr\tau} \tag{15}$$

where the outcome $y_{mr\tau}$ is either consumer prices or quantity in year-quarter τ for module m and store r located in county c and state s. The terms $\delta_{m,r}$ and $\delta_{m,s,\tau}$ are module-by-store and module-by-state-by-year-quarter fixed effects, respectively. The identifying assumption is that changes in sales taxes do not change within counties in ways that are correlated with changes in consumer demand (conditional on the fixed effects). This model allows for arbitrary trends across states and modules and thereby relies on within-county-over-time variation in tax rates. The estimate β^y can be interpreted as the elasticity of prices or quantity with respect to taxes ($\beta^{p(1+t)}$ and β^Q, respectively).

The second regression model uses a subsample of counties and a "county border pair" research design, following Holmes (1998) and Dube, Lester and Reich (2010). For this analysis, we restrict the sample to stores located in contiguous counties on opposite sides of a state border. Two contiguous counties located in different states form a county-pair d, and counties are paired with as many cross-state counties they are contiguous with. The estimating equation is the following:

$$\log y_{mr\tau} = \beta^y \log(1+t_{mcs\tau}) + \delta'_{m,d,\tau} + \delta'_{m,r} + \varepsilon'_{mr\tau}. \tag{16}$$

where $\delta'_{m,d,\tau}$ are module-by-border-pair-by-year-quarter fixed effects. This specification includes flexible trends for each module in each county border pair. To estimate equation (16), the original dataset is rearranged by stacking all county pairs and weighting each county by the inverse of the number of times it is included in a border pair. In this regression model, the identifying assumption is that within a border pair, variation in tax rates for a given module over time is not correlated with other unobserved determinants that differentially affect one of the two counties in the border pair. One way this assumption could fail is if counties adjust their tax rates based on economic conditions within the border pair. To address this concern, we also report results in Table OA.6 which instrument the county tax rate with the state sales tax rate (and find similar results).

The main results from estimating equations (15) and (16) are reported in Panel A of Table 1. The first column uses the full sample, and the second column uses the "border pair" subsample. The first row reports results for log average prices. The coefficient estimate $\beta^{p(1+t)} = 0.961$ (s.e. 0.045) indicates a large amount of pass-through of taxes onto consumer prices. The next row reports the estimate $\beta^{Q} = -0.668$ (s.e. 0.185), indicating a meaningful quantity response to tax changes. The results in column (2) show similar results using the county border pair approach.

4.3 Tax salience parameter (θ)

In order to estimate tax salience parameter, the effects of sales taxes on quantity need to be scaled by the effect of salient price changes on quantity demanded. To estimate the price elasticity of demand, we follow the recent literature on uniform pricing by retail chains and construct a store-level instrument that is based on the pricing of products of other stores in a given retail chain (DellaVigna and Gentzkow 2019). This instrumental variables strategy relates to earlier work by Hausman (1996) and Nevo (2001), and has been employed in several recent papers (e.g., Atkin, Faber and Gonzalez-Navarro 2018 and Allcott et al. 2019).

Specifically, we construct an instrument $z_{mr\tau}$ that is equal to the average log pre-tax price across all other stores in the same chain. This is a valid instrument under the assumption that chain-level prices predict "own" store prices, but are not correlated with unobserved store-level demand determinants. We use this chain-level instrument to estimate the price elasticity of demand using the following Two Stage Least Squares (2SLS) regression model:

$$\begin{aligned}\log(p_{mr\tau}) &= \lambda z_{mr\tau} + \pi'_{m,s,\tau} + \pi'_{m,r} + \eta_{mr\tau} \\ \log Q_{mr\tau} &= \alpha \log(p_{mr\tau}) + \pi_{m,s,\tau} + \pi_{m,r} + \upsilon_{mr\tau}\end{aligned}$$

where the store-module log average prices at time τ is instrumented with the uniform pricing instrument ($z_{mr\tau}$). The 2SLS estimates of are reported in Panel B of Table 1. The price elasticity estimate in the full sample is $\alpha = -1.202$ (s.e. 0.027), and for the border pair subsample the estimate is $\alpha = -1.223$ (s.e. 0.027).

We estimate the tax salience parameter θ using the version of Lemma 1 for ad valorem taxes derived in the Appendix:

$$\theta = \frac{(1-\tilde{\rho})\,\tilde{\epsilon}_D + \tilde{\epsilon}_{Dt}}{(1+t\tilde{\rho})\,\tilde{\epsilon}_D - t\tilde{\epsilon}_{Dt}} \tag{17}$$

where $\tilde{\rho} \equiv d\log(p(1+t))/d\log(1+t)$ and corresponds to the parameter estimate $\beta^{p(1+t)}$, $\tilde{\epsilon}_D \equiv \frac{dlog(Q)}{dlog(p)}$ and corresponds to the parameter estimate α, and $\tilde{\epsilon}_{Dt} \equiv \frac{dlog(Q)}{dlog(1+t)}$, which corresponds to the parameter estimate β^Q. If there is complete pass-through ($\tilde{\rho} = 1$), then the "plug-in" estimate of θ reduces to the ratio of the tax elasticity ($\tilde{\epsilon}_{Dt}$) to the price elasticity ($\tilde{\epsilon}_D$) when $t = 0$. The formula adjusts for incomplete pass-through and also accounts for the fact that salience effects mean that $\tilde{\epsilon}_D$ does not exactly correspond to ϵ_D, which requires manipulating the perceived price, not the actual (pre-tax or after-tax) price.

Panel C of Table 1 reports results from implementing the formula in equation (17) using our reduced-form results and using $t = 0.036$ which is the sample average sales tax rate. We estimate $\theta = 0.586$ (s.e., 0.147) using the full sample and $\theta = 0.537$ (s.e., 0.130) using the border-pair subsample. Chetty, Looney and Kroft (2009) find that $\theta = 0.35$ in an analysis of grocery store purchases, while Taubinsky and Rees-Jones (2018) report a range of experimental estimates of θ between 0.263 and 0.535. If consumers become more attentive to taxes over time (following a tax change), then the fact that we use data several quarters after a tax change may be one reason for our slightly higher estimated values of the salience parameter.

5 Calibrations

Since our empirical analysis is based on ad valorem taxes, we provide derivations in the Appendix for pass-through, incidence, and marginal excess burden formulas that are analogous to Proposition 3, and we calibrate these formulas in this section. To do this, we first recover the markup and the conduct parameter in several intermediate steps shown in the bottom of Table 2. Our approach broadly follows Bergquist and Dinerstein (2020). We assume constant marginal costs and constant price elasticity of demand throughout this calibration exercise.

First, using our estimates of $\tilde{\rho}$ and θ, along with the pass-through expression, we recover an estimate of $v_q/(J\epsilon_{ms}) = 0.040$ by exploiting the fact that the elasticity of marginal surplus is equal to the inverse of the price elasticity of demand under constant elasticity of demand; i.e., $\epsilon_{ms} = 1/\epsilon_D$.[8] Next, in order to estimate the markup $(p-mc)/p$, we translate $v_q/(J\epsilon_{ms})$ into $v_q/(J\epsilon_D)$, and since the latter determines the markup, we estimate $(p-mc)/p = 0.028$.[9] Our last intermediate step estimates $v_q/J = 0.033$.

With the estimated markup and conduct parameters in hand, we calibrate the incidence and marginal excess burden formulas for ad valorem taxes. In the Appendix, we derive the following incidence formula which is valid with ad valorem taxes:

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

In column (1), we calculate $I = 17.051$, which suggests that much of the incidence of sales taxes falls on consumers. Ignoring salience ($\theta = 1$) and holding fixed the estimated markup at 0.028, we find $I = 13.829$ (column (2)). Lastly, column (3) continues to assume full optimization, but recalibrates the markup (assuming $\theta = 1$). This is important to consider since different assumptions on the value of θ affect the incidence formula directly, but also indirectly since it affects the

[8] This is a strong functional form assumption, so in Table OA.4 we show sensitivity to alternative values of the elasticity of marginal surplus. We also show analogous results for all of the results in Table 2 for the county border pair subsample.

[9] The estimated markup matches the widespread perception in the industry that grocery stores typically operate on relatively thin profit margins. For example, industry analyst Jeff Cohen recently said that "It's a very competitive industry ... grocery stores can only slightly mark up the prices for their products." https://www.marketplace.org/2013/09/12/groceries-low-margin-business-still-highly-desirable/.

estimated markup. In this case, we find $I = 17.124$, showing that the incidence on consumers is *greater* when consumers are more attentive to the tax, and contrasts with the intuition from Chetty, Looney and Kroft (2009). In the case of perfect competition, the incidence of the tax is fully born by consumers regardless of the magnitude of θ under our assumption of constant marginal costs. These results demonstrate how salience and imperfect competition interact to determine tax incidence.

Turning to marginal excess burden, we scale the ad valorem marginal excess burden formula presented in the Appendix so that it represents the change in welfare as a percentage of total revenue, which results in:

$$\frac{d\widetilde{W}}{dt} \equiv \frac{(1+t)}{pQ}\frac{dW}{dt} = \left(\frac{p-mc}{p} + \theta t\right)\tilde{\epsilon}_{Dt} \tag{18}$$

Using the sample average tax rate of 3.6 percent for t, we find $d\widetilde{W}/dt = -0.033$ (column (1)). This implies that the marginal excess burden is about 3.3 percent of total revenue. The formula in Chetty, Looney and Kroft (2009) gives an estimate of $d\widetilde{W}/dt = -0.014$ (column (1)), while the standard Harberger formula gives an estimate of $d\widetilde{W}/dt = -0.024$ (column (2)). Interestingly, both estimates are smaller than the main estimate in column (1), suggesting that accounting for both salience and imperfect competition leads to a change in welfare that is larger than the estimates implied by a standard analysis. Ignoring salience ($\theta = 1$) while holding fixed the markup increases the welfare cost of taxation (in magnitude) by 1 percentage point to -0.042, which is the exact same change as we move from the Chetty, Looney and Kroft (2009) formula to the standard Harberger formula. This illustrates the similar way that tax salience affects welfare under different market structures. Lastly, column (3) continues to assume full optimization, but recalibrates the markup (assuming $\theta = 1$). In this case, the markup falls to 1.6 percent, and the implied $d\widetilde{W}/dt = -0.035$, which is smaller than the estimate in column (2), but still larger in magnitude than the standard Harberger formula. This shows the subtle impact of salience on the welfare consequences of sales taxes, since salience both directly impacts the welfare formula through θt, but also affects it indirectly through our inference on the markup.

6 Conclusion

This paper develops new formulas for the welfare effects of commodity taxation in a general model featuring imperfect competition and tax salience. We show that there are important interactions between salience and the degree of competition for tax incidence, but no direct interactions for efficiency analysis.

We estimate the inputs into the formulas by combining Nielsen Retail Scanner data covering grocery stores in the US with detailed sales tax data. We find nearly-complete pass-through of sales taxes onto prices and meaningful effects of taxes on quantity. We also find that consumers "underreact" to taxes, which is consistent with taxes being less salient to consumers than prices, and we find a markup around 3 percent, which is a quantitatively meaningful departure from the benchmark of perfect competition.

We use these estimates to calibrate our new incidence and efficiency formulas. We find lower incidence on consumers (as compared to perfect competition) and that greater attention to the tax can lead to consumers bearing a higher share of the burden of the tax. Turning to welfare, we find the standard marginal excess burden formula substantially understates the welfare costs of commodity taxation, even after accounting for consumers' underreaction due to salience effects. As a result, we conclude that both imperfect competition and tax salience are important factors to consider together when analyzing the incidence and efficiency consequences of commodity taxation. Focusing on either one in isolation will, in some circumstances, lead to misleading estimates.

References

1. Adachi, Takanori and Michal Fabinger (2019). "Multi-Dimensional Pass-Through and Welfare Measures under Imperfect Competition," Working paper.
2. Allcott, Hunt and Dmitry Taubinsky (2015). "Evaluating Behaviorally Motivated Policy: Experimental Evidence from the Lightbulb Market," *American Economic Review*, 105(8): 2501-2538.
3. Allcott, Hunt, Benjamin B. Lockwood and Dmitry Taubinsky (2018). "Ramsey Strikes Back: Optimal Commodity Taxes and Redistribution in the Presence of Salience Effects," *American Economic Review, Papers and Proceedings*, 108(5): 88-92.
4. Allcott, Hunt, Rebecca Diamond, Jean-Pierre Dubé, Jessie Handbury, Ilya Rahkovsky, Molly Schnell (2019). "Food Deserts and the Causes of Nutritional Inequality," *The Quarterly Journal of Economics*, 134(4): 1793–1844, https://doi.org/10.1093/qje/qjz015.
5. Anderson, Simon P., Andre De Palma and Brent Kreider (2001a). "The Efficiency of Indirect Taxes under Imperfect Competition," *Journal of Public Economics*, 81(2): 231-251.
6. Anderson, Simon P., Andre De Palma and Brent Kreider (2001b). "Tax Incidence in Differentiated Product Oligopoly," *Journal of Public Economics*, 81(2): 173-192.
7. Atkin, David, Benjamin Faber and Marco Gonzalez-Navarro (2018). "Retail Globalization and Household Welfare: Evidence from Mexico," *Journal of Political Economy*, 126(1): 1-73.
8. Auerbach, Alan J. and James R. Hines Jr. (2001). "Perfect Taxation with Imperfect Competition," NBER Working Paper #8138.
9. Auerbach, Alan J. and James R. Hines Jr. (2002). "Taxation and Economic Efficiency," *Handbook of Public Economics*, Volume 3 (Chapter 21).
10. Baker, Scott R., Stephanie Johnson, and Lorenz Kueng (2018). "Shopping for Lower Sales Tax Rates," Working Paper.
11. Bergquist, Lauren Falcao and Michael Dinerstein (2020). "Competition and Entry in Agricultural Markets: Experimental Evidence from Kenya," Working Paper.
12. Besley, Timothy J. and Harvey S. Rosen (1999). "Sales taxes and prices: an empirical analysis,"*National Tax Journal*, 52(2): 157-158.
13. Bradley, Sebastien and Naomi E. Feldman (2019). "Hidden Baggage: Behavioral Responses to Changes in Airline Ticket Tax Disclosure," forthcoming *American Economic Journal: Economic Policy*.
14. Bulow, Jeremy and Paul Pfleiderer (1983). "A Note on the Effect of Cost Changes on Prices," *Journal of Political Economy*, 91(1): 182-185.
15. Chetty, Raj, Adam Looney and Kory Kroft (2009). "Salience and Taxation: Theory and Evidence," *American Economic Review*, 99 (4): 1145-77.
16. DellaVigna, Stefano and Matthew Gentzkow (2019). "Uniform Pricing in US Retail Chains," *The Quarterly Journal of Economics*, 134(4): 2011-2084.

17. Delipalla, Sophia and Michael Keen (1992). "The Comparison between Ad Valorem and Specific Taxation under Imperfect Competition," *Journal of Public Economics*, 49(3): 351-361.

18. Dube, Arindrajit, T. William Lester, and Michael Reich (2010). "Minimum Wage Effects Across State Borders: Estimates Using Contiguous Counties," *The Review of Economics and Statistics*, 92(4): 945–964.

19. Einav, Liran, Jonathan D. Levin, Neel Sundaresan (2012). "Sales Taxes and Internet Commerce," *American Economic Review*, 104(1): 1-26.

20. Fabinger, Michal and Glen Weyl, (2016). "The Average-Marginal Relationship and Tractable Equilibrium Forms". Working Paper.

21. Farhi, Emmanuel and Xavier Gabaix (2017). "Optimal Taxation with Behavioral Agents," forthcoming *American Economic Review*.

22. Goldin, Jacob and Tatiana Homonoff (2013). "Smoke Gets in Your Eyes: Cigarette Tax Salience and Regressivity," *American Economic Journal: Economic Policy*, 5(1): 302-36.

23. Hackner, Jonas and Mathias Herzing (2016). "Welfare Effects of Taxation in Oligopolistic Markets," *Journal of Economic Theory*, 163(C): 141-166.

24. Harberger, Arthur (1964). "The Measurement of Waste," *American Economic Review* 54(3): 58-76.

25. Hart, Oliver (1982). "Reasonable Conjectures". Discussion Paper. London School of Economics.

26. Hausman Jerry A. (1996). "Valuation of new goods under perfect and imperfect competition," *The Economics of New Goods*, eds. TF Bresnahan, RJ Gordon, chap. 5. Chicago: University of Chicago Press, 209–248.

27. Holmes, Thomas J. (1998). "The Effects of State Policies on the Location of Industry: Evidence from State Borders," *Journal of Political Economy*, 106(4): 667-705.

28. Miravete, Eugenio J., Katja Seim and Jeff Thurk (2018). "Market Power and the Laffer Curve," *Econometrica*, 86(5): 1651-1687.

29. Morrison, William and Dmitry Taubinsky (2020). "Rules of Thumb and Attention Elasticities," Working Paper.

30. Nevo, Aviv (2001). "Measuring market power in the ready-to-eat cereal industry," *Econometrica*, 69: 307–42.

31. Rees-Jones, Alex and Dmitry Taubinsky (2018). "Attention Variation and Welfare: Theory and Evidence from a Tax Salience Experiment," *Review of Economic Studies*, 85: 2462-2496.

32. Riordan, Michael (1985). "Imperfect Information and Dynamic Conjectural Variations". *Rand Journal of Economics* 16: 41-50.

33. Seade, Jesus (1987). "Profitable Cost Increases and the Shifting of Taxation: Equilibrium Responses of Markets in Oligopoly," Working Paper.

34. Stern, Nicholas (1987). "The Effects of Taxation, Price Control, and Government Contracts in Oligopoly and Monopolistic Competition," *Journal of Public Economics*, 32: 133-158.

35. Taubinsky, Dmitry and Alex Rees-Jones (2018). “Attention Variation and Welfare: Theory and Evidence from a Tax Salience Experiment,” *The Review of Economic Studies*, 85(4): 2462–2496.

36. Vives, Xavier (2001), “Oligopoly Pricing: Old Ideas and New Tools”. MIT Press.

37. Weyl, Glen and Michal Fabinger (2013). “Pass-Through as an Economic Tool: Principle of Incidence under Imperfect Competition,” *Journal of Political Economy*, 121(3): 528-583.

Table 1

Estimates of Tax Elasticities, Price Elasticity of Demand, and Tax Salience Parameter

Sample:	Full Sample	County Border Pair Subsample
	(1)	(2)
Panel A: Reduced-form OLS Estimates of the Effects of Sales Taxes on Consumer Prices and Quantity		
$d\log(p(1+t))/d\log(1+t)$	0.961	0.986
	(0.045)	(0.016)
$d\log(Q)/d\log(1+t)$	-0.668	-0.650
	(0.185)	(0.084)
Panel B: 2SLS Estimates of the Price Elasticity of Demand		
$d\log(Q)/d\log(p)$	-1.202	-1.223
	(0.027)	(0.027)
Panel C: "Plug-in" Estimate of the Tax Salience Parameter		
θ	0.586	0.537
	(0.147)	(0.130)
Specification:		
Store × Module fixed effects	y	y
Module × Year-Quarter fixed effects	y	y
Module × State × Year-Quarter fixed effects	y	
Module × Border Pair × Year-Quarter fixed effects		y
N	53,895,446	33,749,157

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+t) 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. For this parameter, standard errors are based on 100 bootstrap replications. 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 is restricted to stores in border counties and the regression model includes module-by-store and module-by-border-pair-by-year-quarter fixed effects, where border pairs denote pairs of contiguous counties on opposite sides of a state border. In column (2), observations are weighted by the inverse of the number of times a store appears in the data.

Table 2

Calibration of Incidence and Marginal Excess Burden Formulas

	Using plug-in estimate of tax salience parameter	Assuming full salience (θ=1), but using same markup from (1)	Assuming full salience (θ=1), but re-calibrating markup
	(1)	(2)	(3)
Panel A: Incidence and Marginal Excess Burden Formulas			
Incidence (I)			
General formula (imperfect salience, imperfect competition):			
$(\rho(1+t) + (1-\theta)t\epsilon_{D,t+1}) / (\theta(v/J)(1+t\rho) + (1-\rho)(1-v/J))$	17.051	13.829	17.124
Incidence under perfect competition (for $0 < \theta \leq 1$)	∞	∞	∞
Marginal Excess Burden ($d\tilde{W}/dt$)			
General formula (salience, imperfect competition):			
$d\tilde{W}/dt$ = [$(p\text{-}mc)/p + \theta(t)$] * $d\log(Q)/d\log(1+t)$	-0.033	-0.042	-0.035
Harberger/Chetty-Looney-Kroft formulas (perfect competition):			
$d\tilde{W}/dt = \theta * t * d\log(Q)/d\log(1+t)$	-0.014	-0.024	
Panel B: Inputs and Intermediate Estimates Needed to Calibrate Formulas			
<u>Inputs:</u>			
Average tax rate, t	0.036	0.036	0.036
Price Elasticity, $d\log(Q)/d\log(p)$	-1.202	-1.202	-1.202
Tax Pass-Through, $d\log(p(1+t))/d\log(1+t)$	0.961	0.961	0.961
Tax Elasticity, $d\log(Q)/d\log(1+t)$	-0.668	-0.668	-0.668
Tax Salience Parameter, θ			
Implied "Plug-In" Estimate of θ	0.586		
Assuming full salience ($\theta = 1$)		1.000	1.000
<u>Intermediate estimates:</u>			
Implied estimate of $v/(J * \epsilon_{ms})$	0.040		0.023
Implied markup $(p\text{-}mc)/p$, which equals $v/(J * \epsilon_D)$	0.028		0.016
Implied estimate of v/J	0.033		0.019
($v/J = 0$ is perfect competition, $v/J = 1$ is perfect collusion)			

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

Online Appendix for "Salience and Taxation with Imperfect Competition"

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1 Proofs

Proof of Lemma 1

Proof. Note that

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

□

Proof of Proposition 1

Proof. Consumer surplus can be expressed as

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

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

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

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

Next, producer surplus can be expressed as

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

Differentiating this expression with respect to t:

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

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

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

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

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

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

Therefore,

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

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

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

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

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

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

Finally, marginal excess burden is:

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

□

Proof of Proposition 2

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

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

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

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

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

Substituting into the expression of ρ, we have

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

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

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

The marginal excess burden of the tax is:

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

□

Proof of Proposition 3

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

Analogous to the perfect competition, we have

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

We also have

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

The producer surplus can be expressed as

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

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

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

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

We also have

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

Therefore,

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

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

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

The marginal excess burden of the tax is

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

$\square$

2 Ad valorem taxes

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

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

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

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

and

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

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

Proof. Observe

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

Solving for θ we obtain:

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

□

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

imperfect competition *may be expressed as:*

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

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

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

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

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

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

Finally note:

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

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

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

Proof. Consumer surplus can be expressed as

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

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

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

We also have

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

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

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

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

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

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

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

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

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

so from lemma A1 we obatin:

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

and therefore:

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

Next, incidence follows directly from $I = \frac{\frac{dCS}{dt}}{\frac{dPS}{dt}}$.

Finally, the marginal excess burden of the tax is

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

□

3 Data Appendix

3.1 Nielsen Retail Scanner Data

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

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

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

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

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

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

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

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

3.2 US Sales Tax Exemptions and Rates

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

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

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

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

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

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

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

3.3 Descriptive Statistics

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

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

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

3.4 Instrumental variable construction

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

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

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

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

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

3.5 Robustness of Calibration of Incidence and Welfare Formulas

Table OA.3 reports all of the results in Table 2 using the county border pair subsample instead of the full sample of counties. Since the reduced-form effects are fairly similar, it is not surprising that the incidence and welfare results are broadly similar, although the difference between the Harberger formula and the full welfare formula allowing for imperfect competition and tax salience is reduced somewhat. This is because using the county border pair results we find that the attenuating effect of the tax salience parameter largely offsets the increase in magnitude of welfare change due to imperfect competition. In Table OA.4, we show senstivity to alternative values of the elasticity of marginal surplus. In the main results in Table 2, we assume that this elasticity if equal to the inverse of the price elasticity of demand. Alternative functional form assumptions would lead to different relationships between these parameters. Since we do not have sufficient data to estimate this elasticity directly, we instead show sensitivty across different values of this parameter. Varying this parameter by roughly 50 percent in either direction does not change the main qualitative conclusions from our main results – that the incidence largely falls on consumers, the incidence is actually increasing in the tax salience parameter, and Harberger formula understates the welfare change.and OA.4.

References

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

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

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

Source: Nielsen's Retail Scanner Data.

Online Appendix Table OA.2: Sales Tax Exemptions

Panel A: Food Modules

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

Panel B: Non-Food Modules

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

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

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

[County Border Pair Sample Estimates]

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

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

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

[Sensitivity to Alternative Values of Elasticity of Marginal Surplus]

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

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

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

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

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

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

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

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

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

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

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

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

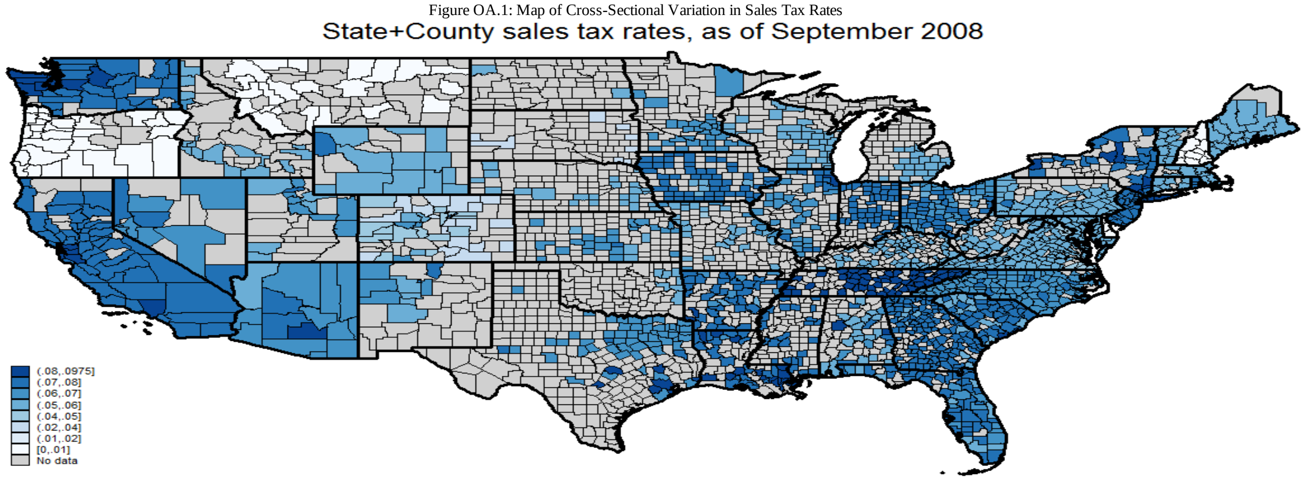
State	URLs	Type of Document
AL	http://revenue.alabama.gov/salestax/rules/810-6-5-.02.pdf	Laws and Regulations
AL	http://www.alabamaadministrativecode.state.al.us/docs/rev/810-6-3.pdf	Laws and Regulations
AL	http://revenue.alabama.gov/publications/business-taxes/sales/Sales_Tax--Sales_Tax_Brochure.pdf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

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

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

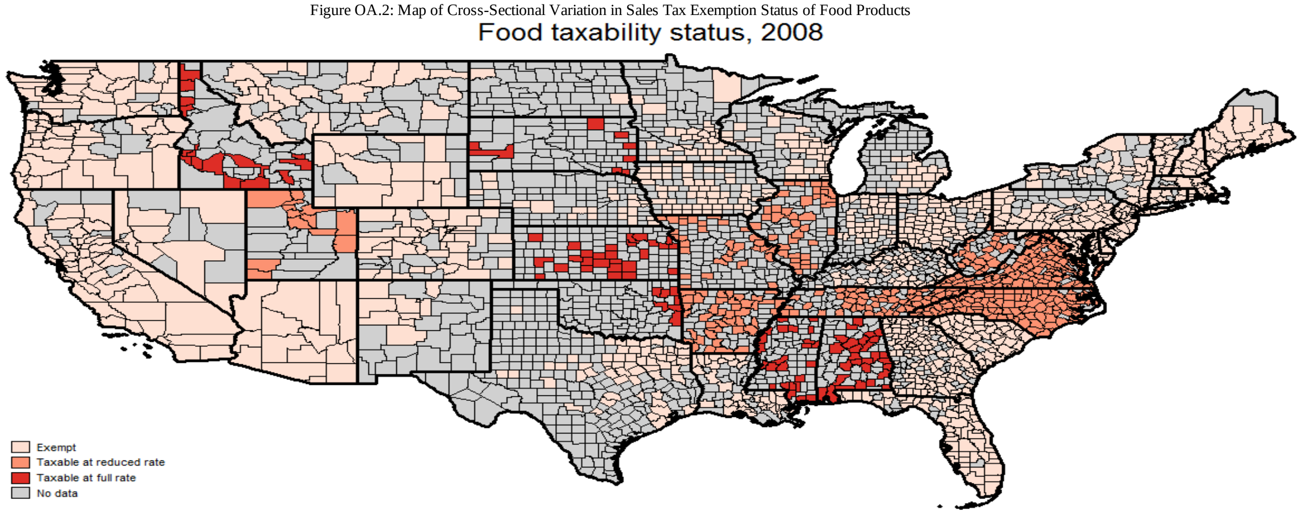
* States indexed participate in the Streamlined Sales Tax Project (SSTP): http://www.streamlinedsalestax.org/

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



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

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



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