Salience and Taxation with Imperfect Competition

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Abstract

This paper studies commodity taxation in a general model featuring imperfect competition and tax salience. We derive new formulas for the incidence and marginal excess burden of commodity taxation, and 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:

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

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):			
$d\tilde{W}/dt = [\ (p-mc)/p + \theta(t)\ ] * d\log(Q)/d\log(1+t)$	-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			
Inputs:			
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
Intermediate estimates:			
Implied estimate of $v/(J * \epsilon_{ms})$	0.040		0.023
Implied markup $(p-mc)/p$, 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)			

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.