WORKING PAPER #561
PRINCETON UNIVERSITY
INDUSTRIAL RELATIONS SECTION
December, 2010

Smoke Gets in Your Eyes: Cigarette Tax Salience and Regressivity

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December 16, 2010

Abstract

Recent work suggests that consumers respond differently to taxes that are included in a good's posted price and taxes that are added upon checking out at the register. This paper investigates how the government's choice between these "posted" and "register" taxes affects the distribution of a tax's burden. We show that when high- and low-income consumers differ in their attentiveness to register taxes, policymakers can lessen a tax's regressivity by manipulating the fraction of a tax that is added at the register. We then turn to the case of cigarettes, and investigate whether high- and low-income consumers do in fact differ in their attentiveness to register taxes on that good. To answer that question, we link state and time variation in cigarette excise and sales tax rates to survey data about cigarette consumption from the Behavioral Risk Factor Surveillance System. Whereas both high- and low-income consumers respond to cigarette excise taxes (which appear in the posted price), we find that only low-income consumers respond to sales taxes on cigarettes (which are added at the register). Our results suggest that policymakers can ease the financial burden of cigarette taxes on the poor by levying such taxes at the register instead of including them in the cigarette's posted price.

Should governments levy commodity taxes at the register or include them in a good's posted price? The economics literature offers little guidance to policymakers grappling with this question. Neoclassical theory suggests that this aspect of tax design – the choice between "posted" and "register" taxes – does not affect consumer welfare because consumers correctly compute and account for all taxes that will be assessed on a given transaction. However, a series of recent findings call that prediction into doubt. In particular, Raj Chetty, Adam Looney, and Kory Kroft (2009) present compelling evidence that consumers pay more attention to goods' posted prices than to register taxes because the former are more salient – consumers see the posted tax-inclusive price when making their purchasing decisions. Related work by Amy N. Finkelstein (2009) and Marika I. Cabral and Caroline M. Hoxby (2010) also concludes that the salience of a tax affects how it is perceived by consumers. These results suggest that the policy choice between posted and register taxes may not be as irrelevant as neoclassical theory predicts.

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This paper investigates the distributional effects of the government's choice between posted and register taxes. Part I considers the case in which consumers differ in their attentiveness to register taxes – that is, when only some consumers take register taxes into account when making their purchasing decisions. Drawing on a stylized model of consumer behavior, we show how a revenue-neutral shift from posted to register taxes reduces the tax burden on attentive consumers, unambiguously improving the welfare of that group.

Part II turns to a practical implication of this insight. A concern with many commodity taxes is that they are regressive – they constitute a proportionately greater burden for low-income taxpayers. However, if low-income consumers pay more attention to register taxes, policymakers can reduce a tax's regressivity by adding it at the register instead of including it in the commodity's posted price. Conversely, when low-income consumers are relatively less attentive to register taxes, reducing a tax's salience will exacerbate its regressivity. Hence, knowing how consumers' attentiveness to register taxes varies by income is essential for understanding the distribution of a tax's burden.

We investigate that question empirically in the context of cigarette taxes. Cigarette purchases are typically subject to two types of taxes in the United States: an excise tax, which is included in the cigarette's posted price, and a sales tax, which is added at the register. Drawing on individual survey data about cigarette consumption, we exploit state and time variation in cigarette sales and excise tax rates to estimate the relation between the two tax types and cigarette demand. We find that both high- and low-income consumers respond to changes in the cigarette excise tax, but that only low-income consumers respond to changes in the sales tax rate on cigarettes. These results suggest that in the case of cigarettes, attentiveness to register taxes declines by income. Consequently, a revenue-neutral shift from posted to register taxes would likely reduce the burden of the cigarette tax on low-income consumers.

Because the choice between register and posted taxes is a practical question that policymakers must confront, the lack of economic literature on the topic is surprising. A notable exception is the recent paper by Chetty, Looney, and Kroft (CLK), referenced above. In addition to presenting the results from a field-experiment, that paper finds that changes in state excise taxes on beer are associated with a greater decline in state-wide beer sales than are changes in the state sales tax rate. CLK's results suggest that the salience of a tax shapes the extent to which consumers take the tax into account. However, the aggregate nature of their data precludes CLK from investigating heterogeneity in attentiveness between consumers – our focus here. Moreover, the welfare analytic tools developed in that paper are geared toward assessing the efficiency of a tax in the context of a representative-agent, rather than the distribution of a tax's burden across consumers. To our knowledge, our paper is the first in the literature to investigate the link between the salience of a tax and the distribution of its burden across consumers.

Our paper also fits into a nascent behavioral literature investigating heterogeneity in the extent to which individuals depart from neoclassical decision-making. For example, Crystal C. Hall (2010) documents differences by income in the mental accounting approaches that individuals employ for making financial decisions. Similarly, Sendhil Mullainathan and Eldar Shafir (2009) argue that a number of behavioral phenomena affect the poor in distinctive ways because that group lacks many of the resources used by higher-income consumers to improve the quality of their decision-making (such as access to financial advising). Our paper contributes to this growing literature by exploring a particular context in which limitations faced by all decision-makers (e.g. bounded attention and computational abilities) affect high- and low-income consumers in distinctive ways.

The remainder of the paper is organized as follows. Part I constructs a stylized model of consumer behavior and uses it to analyze the welfare effects of a policy shift from posted to register taxes. The model takes as its starting point the assumption that consumers differ in their attentiveness to register taxes. Part II constitutes the core of the paper, an empirical investigation of that assumption in the context of cigarette taxes. In particular, we investigate whether high- and low-income consumers respond differently to cigarette register taxes, using those groups' responsiveness to posted taxes on cigarettes as a baseline. Part III concludes.

I. Tax Salience and Distribution

Part I demonstrates that when consumers differ in their attentiveness to register taxes, the government's choice between posted and register taxes affects the distribution of a tax's burden. In particular, replacing a posted tax with a register tax increases total tax revenue because only attentive agents consider the full after-tax price when determining their demand for x. That extra revenue accommodates a reduction in the combined tax rate on x, generating a positive income effect for attentive consumers. Inattentive consumers also benefit from the reduction in the combined tax on x, but their welfare gains are offset by optimization error induced by the register tax.

Our modeling approach is similar to that employed in Chetty, Looney, and Kroft (2007), except that we allow for heterogeneity in agents' attentiveness to register taxes. Suppose that society is composed of two agents (A and B) who make consumption decisions between some good x, and a composite of all other goods, y. Good x is subject to both a register tax and a posted tax, whereas good y is left untaxed. Both agents pay attention to posted taxes when making their consumption decisions, but only A takes register taxes into account. B ignores the register tax when choosing how much x to consume, treating it as if it were zero. The agents share a utility function $U(x,y)$,

and both have budget constraints of the form

$$BC_i : (p + t_p + t_r)\, x_i + y_i \leq M_i \tag{1}$$

where the agent's type is denoted by $i \in \{A, B\}$, p is the pre-tax price of x, t_p is the posted tax rate, t_r is the register tax rate, M is income, and the pre-tax price of y is normalized to one.

Consumption is determined in two steps. First, agents choose their intended consumption bundle according to their perceived budget constraint $\left(\widehat{BC}_i\right)$. A is attentive to the register tax, so her perceived budget constraint matches her true budget constraint, $BC_A = \widehat{BC_A}$. In contrast, B misperceives the register tax to be zero: $\widehat{BC_B}$: $(p + t_p)\, x_i + y_i \leq M_i$. The (x, y) pair that maximizes utility subject to the agent's perceived budget constraint is the *intended consumption bundle* $(\widehat{x_i}, \widehat{y_i})$.[1] Note that B's intended consumption bundle will be infeasible when it fails to satisfy her true budget constraint.

Because the bundle that agents consume must ultimately be feasible, closing the model requires specifying the final consumption bundle for agents whose intended consumption bundle is infeasible. Because A chooses a feasible bundle to begin with, her final bundle always equals her intended bundle, $(x_A, y_A) \equiv (\widehat{x_A}, \widehat{y_A})$. To pin down consumption for B, we assume that agents who over-spend on x reduce their expenditures on y by the amount that they overspent on x. In our notation: $x_B = \widehat{x_B}$ and $y_B = M_B - (p + t_p + t_r)\widehat{x_B}$.[2] This assumption is natural for the case in which y represents all goods other than x and agents make at least some of their consumption decisions after purchasing x because consumers who accidently overspend on x will have less income available to spend on their remaining purchases (which are all part of y).[3]

We are now in a position to link consumer demand to the tax rates. Holding the posted price and agents' income fixed, we can express demand as a function of the tax rates, $x_i = x_i(t_p, t_r)$ and $y_i = y_i(t_p, t_r)$. For A, final consumption always equals intended consumption, so demand corresponds to the solution of the standard utility maximization problem:

$$(x_A, y_A) = \arg\max_{x,y} U(x, y) \text{ s.t. } BC_A. \tag{2}$$

Because the tax rates do not enter the utility function directly and because they appear symmetrically in the budget

[1] That is, $(\widehat{x_i}, \widehat{y_i})$ satisfies argmax $U(x, y)$ s.t. $\widehat{BC}$.

[2] Note that we are implicitly assuming x to be a small enough portion of total consumption so that an agent's intended consumption of x is never infeasible, even after taking the register tax into account.

[3] In principle, one could choose a different rule for mapping consumers' sub-optimal decision-making into feasible consumption bundles. Chetty, Looney, and Kroft (2007) identify three intuitive "budget adjustment rules": the one that we employ, as well as two others. Appendix A demonstrates that the results in this section are robust to all three of those rules. More generally, the Appendix demonstrates that our main result holds as long as individuals who misperceive the price of x to be lower than it really is end up allocating more of their income to x and less of their income to y relative to the case where they take the true after-tax price of x into account.

constraint, A's demand will depend only on the combined tax rate – whether it takes the form of a register or posted tax does not matter. Hence we can write $x_A(t_p,t_r) = x_A(t_p+t_r,0)$, or $x_A(t_p+t_r)$ for short. And similarly for y: $y_A(t_p,t_r) = y_A(t_p+t_r) = M_A - (p+t_p+t_r)x_A(t_p+t_r)$, where the last equality follows from A's budget constraint. Note that in accordance with the neoclassical model's prediction, we have $\frac{\partial x_A}{\partial t_r} = \frac{\partial x_A}{\partial t_p} = \frac{\partial x_A}{\partial p}$.

In contrast, B's intended consumption bundle will not match B's final consumption bundle whenever the register tax rate is positive. Because all of the income overspent on x comes out of expenditures intended for y, we have $x_B(t_p,t_r) = \widehat{x_B}(t_p,t_r)$ for all values of t_p and t_r. Since B's *intended* consumption of x is insensitive to register taxes, $\widehat{x_B}(t_p,t_r) = \widehat{x_B}(t_p,t_r')$ for all t_r and t_r', it must also be the case that B's *final* consumption of x is insensitive to register taxes, $x_B(t_p,t_r) = x_B(t_p,t_r')$ for all t_r and t_r'. In particular, this result holds for $t_r' = 0$. Hence, we can write $x_B(t_p,t_r) = x_B(t_p,0) \equiv x_B(t_p)$. In words, B's demand for x under any non-zero register tax corresponds to B's optimal demand for x in the special case where the register tax is zero.

Using B's true budget constraint, we can derive B's final consumption of y:

$$y_B(t_p,t_r) = M_B - (p+t_p+t_r)x_B(t_p). \tag{3}$$

Note that in contrast to the neoclassical model, B responds differently to the two types of taxes: $\frac{\partial x_B}{\partial t_p} = \frac{\partial x_B}{\partial p} \neq \frac{\partial x_B}{\partial t_r} = 0$.

To incorporate tax policy into the model, consider a government that must raise a fixed amount of revenue, $\overline{R}$, from register and posted taxes on x. How does the government's choice between register and posted taxes affect the well-being of the agents? In particular, we focus on the effects of a revenue-neutral increase in the register tax – that is, an increase in the register tax coupled with a reduction in the posted tax by an amount that keeps total revenue constant (at $\overline{R}$). Let R denote total revenue collected by the two tax types:

$$R(t_p,t_r) = (t_p+t_r)(x_A+x_B). \tag{4}$$

If both agents were fully attentive to both types of tax, a revenue-neutral one dollar increase in the register tax would require a one dollar decrease in the posted tax; changing the balance between register and posted taxes would not affect the combined tax rate necessary to raise a given amount of revenue. When some agents are inattentive, however, the demand reduction that typically accompanies a tax increase will be muted. As a result, an incremental

increase in the posted tax will, all else equal, raise less revenue than an incremental increase in the register tax:[4]

$$\begin{aligned}\frac{\partial R}{\partial t_p} &= (x_A + x_B) + (t_p + t_r)\left(\frac{\partial x_A}{\partial p} + \frac{\partial x_B}{\partial p}\right) \\ &< (x_A + x_B) + (t_p + t_r)\left(\frac{\partial x_A}{\partial p}\right) = \frac{\partial R}{\partial t_r}\end{aligned}$$

The reduction in the posted tax associated with a *revenue-neutral* increase in the register tax can be found by totally differentiating the government's budget constraint and solving for $\left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}}$:

$$\left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}} = -\frac{x_A + x_B + (t_p + t_r)\frac{\partial x_A}{\partial p}}{x_A + x_B + (t_p + t_r)\frac{\partial x_A}{\partial p} + (t_p + t_r)\frac{\partial x_B}{\partial p}}. \tag{5}$$

Note that the denominator is positive as long as $\frac{\partial R(t_p,t_r)}{\partial t_p} > 0$, i.e., that demand is not so sensitive that raising the tax rate would actually decrease revenue.

How does a revenue-neutral increase in the register tax affect the combined tax rate, $t_p + t_r$? The effect of the shift is given by $\left.\frac{d(t_p+t_r)}{dt_r}\right|_{\overline{R}} = \left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}} + 1$. Because demand is downward-sloping ($\frac{\partial x_B}{\partial p} < 0$), (5) implies that $\left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}} < -1$. Consequently, a revenue-neutral increase in the register tax is associated with an overall reduction in the combined tax rate, $\left.\frac{d(t_p+t_r)}{dt_r}\right|_{\overline{R}} < 0$.

What are the welfare effects of a revenue-neutral shift towards register taxes? Indirect utility is given by $V_i(t_p,t_r) = U(x_i(t_p,t_r), y_i(t_p,t_r))$. The welfare effect of the shift is thus:

$$\left.\frac{dV_i}{dt_r}\right|_{\overline{R}} = U_x(x_i,y_i)\left(\frac{\partial x_i}{\partial t_r} + \frac{\partial x_i}{\partial t_p}\left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}}\right) + U_y(x_i,y_i)\left(\frac{\partial y_i}{\partial t_r} + \frac{\partial y_i}{\partial t_p}\left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}}\right)$$

First, consider the effect of the shift on A's welfare. Recall that $\frac{\partial x_A}{\partial t_r} = \frac{\partial x_A}{\partial t_p} = \frac{\partial x_A}{\partial p}$ so that

$$\left.\frac{dV_A}{dt_r}\right|_{\overline{R}} = U_x(x_A,y_A)\left(1 + \left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}}\right)\frac{\partial x_A}{\partial p} + U_y(x_A,y_A)\left(1 + \left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}}\right)\frac{\partial y_A}{\partial p}$$

Differentiating A's budget constraint with respect to p yields $\frac{\partial y_A}{\partial p} = -x - (p + t_p + t_r)\frac{\partial x_A}{\partial p}$. Additionally, assuming that (x_A, y_A) constitutes an interior solution in A's budget set, we have

$$U_x(x_A,y_A) = (p + t_p + t_r)U_y(x_A,y_A).$$

Substituting both of these pieces into the above expression and cancelling terms yields the effect of the shift on A's

[4]The 2-good nature of the model guarantees $\frac{\partial x_B}{\partial p} < 0$.

welfare:

$$\left.\frac{dV_A}{dt_r}\right|_{\overline{R}} = -U_y(x_A, y_A)\, x_A \left(1 + \left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}}\right). \tag{6}$$

Because we know that a revenue-neutral shift towards register taxes reduces the combined tax rate, $1 + \left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}} < 0$, we can conclude that the shift unambiguously increases the welfare of the attentive agent. This is the main result of the section, and the intuition is straightforward. Replacing a posted tax with a register tax raises total revenue because only attentive agents reduce their demand for x in response to the higher after-tax price. The extra revenue accommodates a reduction in the combined tax rate on x, generating a positive income effect for attentive consumers.[5]

What about the inattentive agent? The change in utility for B from a revenue-neutral shift towards register taxes is given by

$$\left.\frac{dV_B}{dt_r}\right|_{\overline{R}} = U_x(x_B, y_B)\, \frac{\partial x_B}{\partial p}\, \left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}} + U_y(x_B, y_B) \left(\frac{\partial y_B}{\partial p}\, \left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}} + \frac{\partial y_B}{\partial t_r}\right)$$

Differentiating B's budget constraint with respect to the price and the register tax yields:

$$\frac{\partial y_B}{\partial p} = -x - (p + t_p + t_r)\, \frac{\partial x_B}{\partial p} \quad \text{and}$$

$$\frac{\partial y_B}{\partial t_r} = -x.$$

Substituting those conditions into the above expression gives the effect of the shift on B's welfare:

$$\left.\frac{dV_B}{dt_r}\right|_{\overline{R}} = -U_y(x_B, y_B)\, x_B \left(1 + \left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}}\right) + \left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}} \frac{\partial x_B}{\partial p}\, \varepsilon \tag{7}$$

where $\varepsilon \equiv U_x(x_B, y_B) - (p + t_r + t_p)\, U_y(x_B, y_B)$ represents optimization error from B's inattention to the register tax. Because B consumes too much x and too little y relative to her optimal quantity, declining marginal utility in x and y implies that $\varepsilon < 0$.

From (7), we can see that the net welfare effect on inattentive consumers is ambiguous. Like the attentive consumer, B benefits because the shift lowers the combined tax rate. On the other hand, by raising the register tax, the shift pushes B further from her optimal consumption bundle. In general, either of these effects may dominate.

[5] This result can be weakened by endogenizing agents' decisions about whether to pay attention to register taxes. If a small increase in the register tax causes a large number of formerly inattentive agents to start taking register taxes into account, the shift might necessitate an *increase* in the combined tax rate. In such cases, the shift to register taxes would actually generate a negative income effect, reducing the welfare of all agents. Consequently, the results presented here are most applicable to situations in which small changes in the tax rate do not induce dramatic shifts in which agents are attentive.

That even inattentive consumers can be made better off by a shift towards register taxes is somewhat surprising. The explanation is that for low register tax rates, the welfare loss caused by optimization error is small (the marginal utilities of expenditures on x and y are similar), but the income effect from the lower tax rate may still be substantial. To develop this intuition, let (x_B^*, y_B^*) represent the (interior) optimal bundle in B's true budget set, that is, the consumption bundle that B would choose were she to take the register tax into account. Assume that utility is additively separable in x and y so that $\varepsilon = U_x(x_B) - (p + t_p + t_r) U_y(y_B)$. Taking first-order Taylor approximations around (x_B^*, y_B^*) and using the fact that the pair (x_B^*, y_B^*) satisfies the first order condition $U_x(x_B^*) = (p + t_r + t_p) U_y(y_B^*)$, we can write

$$\varepsilon \approx \gamma (x_B - x_B^*)$$

where $\gamma \equiv U_{xx}(x_B^*) + (p + t_r + t_p)^2 U_{yy}(y_B^*)$. Additionally, taking the Taylor approximation of $x_B^*(t_p, t_r)$ around $t_r = 0$, and using the fact that $x_B^*(t_p, 0) = x_B(t_p, 0)$ implies

$$(x_B - x_B^*) \approx -t_r \frac{\partial x_B}{\partial p}.$$

Substituting these conditions into (7) gives

$$\left. \frac{dV_B}{dt_r} \right|_{\overline{R}} > 0 \text{ iff } U_y(x_B, y_B) x_B - \frac{t_r}{t_r + t_p} \frac{\partial x_B}{\partial p} \gamma \frac{\partial R}{\partial t_r} > 0.$$

When register taxes are zero, the distortion caused by the optimization error will also be zero and hence the effect on B's welfare will be positive.[6] When register taxes represent a large fraction of the total tax on x, a further shift in that direction can reduce B's welfare by exacerbating her optimization error. So although shifting towards a register tax always benefits attentive consumers, the welfare effect for inattentive consumers depends on the fraction of the combined tax currently imposed at the register.[7]

For simplicity, we have assumed that the pre-tax price of x is fixed at p. In reality, firms may adjust the price they charge for x in response to changes in the type of tax imposed. If a shift from posted to register taxes induced firms to raise p by a sufficient quantity, the policy could end up *increasing* the after-tax price of x, generating a negative income effect for all consumers. Appendix B expands the model to account for this possibility and identifies conditions under which the welfare results derived above are valid. We show that a shift from register to

[6] An immediate implication of this result is that the optimal register tax rate is always non-zero.

[7] As noted above, the qualitative results in this section are robust to a range of rules for mapping infeasible intended consumption bundles into feasible consumption bundles. However, such rules yield different implications for when a shift will benefit inattentive consumers. Under a budget adjustment rule in which over-spending on x translates into reduced expenditures on *both* x and y, the income effect term will be lower for both agents (register taxes will not reduce the total tax rate by as much) and the optimization error term for B will be smaller as well (over-spending on x does not move B as far from her optimal feasible consumption bundle).

posted taxes is most likely to result in a net increase in the after-tax price when supply is quite inelastic and demand is quite elastic.[8] As a result, the welfare results presented here are most applicable to goods for which demand is relatively inelastic and for which supply is relatively elastic – that is, goods for which posted taxes are most likely to be passed on to consumers.

II. Attentiveness to Cigarette Taxes by Income

In Part I, we showed that policymakers can manipulate the salience of a tax to redistribute the tax's burden between attentive and inattentive agents. In practice, policymakers are often concerned with how the burden of a tax is distributed by income. In particular, a concern with many commodity taxes is that they are regressive – that is, they constitute a disproportionately greater burden for low-income consumers. An implication of the results in Part I is that if the poor tend to pay less attention to register taxes than the rich, a shift towards register taxes will make a commodity tax more progressive. On the other hand, if low-income consumers are less attentive to register taxes, such a shift would exacerbate the tax's regressivity. It is therefore important to determine whether attention to register taxes varies by income, and if so, whether high- or low-income consumers are the more attentive.

In Part II, we undertake that task in the context of cigarette taxes. There are good reasons to expect that low-income consumers will be more attentive to register taxes on cigarettes. In particular, the utility cost of optimization errors will tend to be greater for those with less income to spend on other goods. As a result, low-income consumers should be particularly motivated to spend the effort required to take register taxes into account. On the other hand, other factors could push high-income consumers to pay more attention to register taxes. For example, because the rich tend to consume more of each good, the magnitude of their optimization errors will tend be greater as well. Appendix C utilizes a cognitive cost model to explore these tensions more formally. For the case of cigarettes, the analysis suggests that attentiveness to cigarette register taxes is likely to decline by income.[9] However, because it is difficult to predict which group will be more attentive on the basis of theory alone, the remainder of Part II is primarily empirical.

Our goal is to investigate whether low-income cigarette consumers are more attentive to register taxes than

[8] One way to understand the intuition behind these conditions is as follows. The incidence of a posted tax is shifted to producers when demand is elastic and supply is inelastic. Replacing a posted tax with a register tax effectively reduces the elasticity of consumer demand (because some consumers are less sensitive to taxes imposed at the register). Consequently, when supply and demand for a good are such that much of the burden of the posted tax falls on producers, the shift to a register tax will cause a large change in the distribution of the tax's incidence.

[9] The framework we develop does not make a uniform prediction for all goods, but rather highlights the factors that determine which income group will be more attentive to register taxes on a particular good. In general, high-income consumers tend to be less attentive to register taxes on goods for which demand is relatively insensitive to income.

high-income consumers are. Cigarette purchases are subjected to two types of tax in the United States, an excise tax that consumers see reflected in the posted price and a sales tax that is typically added at the register. We use state and time variation in these tax rates to estimate how consumers respond to each type of tax. We assume that consumers fully account for posted taxes, so that inattention to register taxes can be measured by the gap between consumers' responsiveness to register taxes and their responsiveness to posted taxes.

Part II is structured as follows. We begin by investigating whether the general population appears to pay more attention to register taxes than to posted taxes on cigarettes. The analysis applies the basic empirical strategy of CLK to a new product (cigarettes instead of beer) and at a different unit of observation (individual instead of aggregate consumption data). We then turn to our central question, whether attentiveness to cigarette register taxes differs by income, which we assess empirically by interacting the excise and sales tax variables with respondents' income. Finally, we undertake a number of robustness tests to investigate whether our results actually reflect heterogeneous attentiveness to register taxes as opposed to various alternative explanations.

A. Data

We obtain cross-sectional micro data on cigarette consumption from the Behavioral Risk Factor Surveillance System (BRFSS), supported by the National Center for Chronic Disease Prevention and Health Promotion and the Centers for Disease Control and Prevention. The BRFSS is a state-based telephone survey system that tracks health conditions and risk behaviors of individuals 18 years and older. The number of states participating in the survey has grown over time, from 15 in 1984 to 50 in 1994 (as well as the District of Columbia). The survey disproportionately samples certain groups, so we use sample weights to obtain nationally representative estimates.

The BRFSS data contains two measures of smoking demand: whether the respondent is a smoker (smokes at least one cigarette every day) and how many cigarettes the respondent typically consumes each day. Although the BRFSS questionnaire asked respondents about smoking participation in each year of the survey, data on the number of cigarettes consumed are only available through 2000. Consequently, our analysis restricts the sample to those interviewed between 1984 and 2000. The BRFSS also collects information on a number of demographic variables, including income. [10]

Data on state-level cigarette excise tax rates, sales tax rates, and average cigarette prices were obtained from

[10] We make use of information concerning the respondent's age, race, sex, educational attainment, marital status, employment status, and income. Household income is measured in terms of income-categories. Two problems arise when using this variable. First, the income measure is top-coded at a relatively low value ($75,000 for much of our sample period). Second, the income categories are not adjusted for inflation, making it difficult to compare respondents in the same category over time. Rather than attempt to convert the BRFSS income category data into a measure of real income, we measure income in percentile terms, assigning respondents the midpoint of the percentiles of their income category boundaries. For example, if 10 percent of the sample in one year reports an income between zero and $10,000, all individuals in that income category in that year are assigned a value of 0.05.

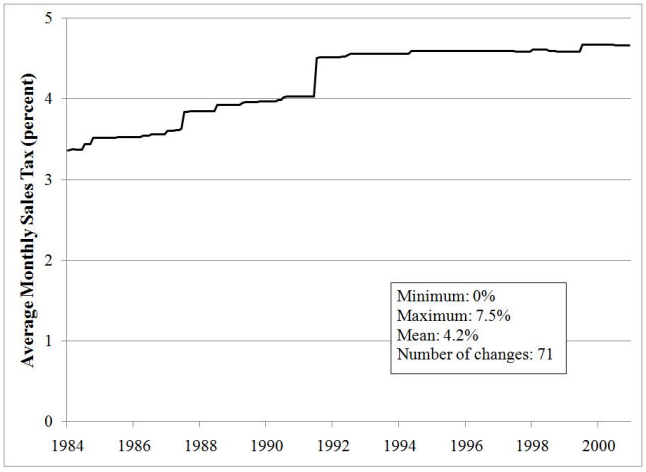
the *Tax Burden on Tobacco* 2008 report, published by Orzechowski and Walker (and previously by the Tobacco Institute). We gathered information on the exact date of enactment of sales tax changes from a number of sources including the World Tax Database (University of Michigan), state government websites, and archives of local newspaper accounts. Following convention, our measure of state tax rates includes local taxes to the extent that they are uniform across the state.

Whereas the sales tax is an ad valorem tax (consumers are charged a fixed fraction of a good's price), the excise tax is a unit tax (consumers pay a set dollar amount per pack, regardless of the pre-tax price). In order to make the two types of taxes comparable for the empirical analysis, we convert the excise tax to an ad valorem tax using the method described in CLK. [11] We also follow CLK by dropping two states from the analysis: Hawaii, because sales taxes in that state are included in the posted price, and West Virginia, because of frequent changes to that state's sales tax base over the sample period. After dropping observations that are missing demographic variables, our final dataset contains approximately 1.3 million observations.

Both sales and excise taxes increased between 1984 and 2000 (Figures 1a and 1b). In 1984, 38 states imposed sales taxes on cigarettes, and the median sales tax rate was 4 percent. By 2000, 45 states imposed sales taxes on cigarettes, and the median sales tax rate had climbed to 5 percent. Similarly, median state excise taxes on cigarettes increased from 14 cents in 1984 to 34 cents in 2000. In addition, the federal excise tax on cigarettes increased three times over the same period, climbing from 16 to 34 cents per pack.

Figure 1: Average Monthly Taxes, 1984-2000

(a) Sales Tax



(b) Excise Tax

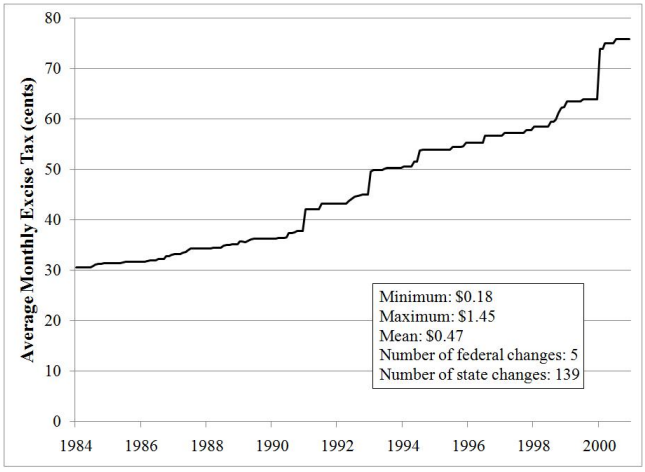


Figure 2 shows that aggregate cigarette consumption in the United States declined between 1984 and 2000.

[11] We divide the excise tax by the average national price of a pack of cigarettes in 2000, adjusted for inflation. The rationale for using the inflation-adjusted national price in 2000 as a proxy for the true price is to avoid endogeneity problems arising from the fact that changes in cigarette prices are likely correlated with unobserved shocks to smoking demand.

That decline, however, was not uniform across the population. Figure 3 separately plots smoking participation rates over time for the highest and lowest income quartiles. Low-income individuals were more likely to smoke than high-income ones in 1984, and that gap widened over time.

Figure 2: Aggregate Cigarette Consumption

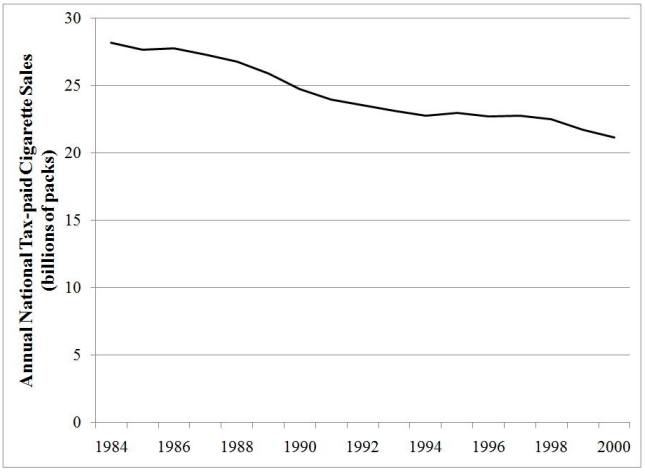
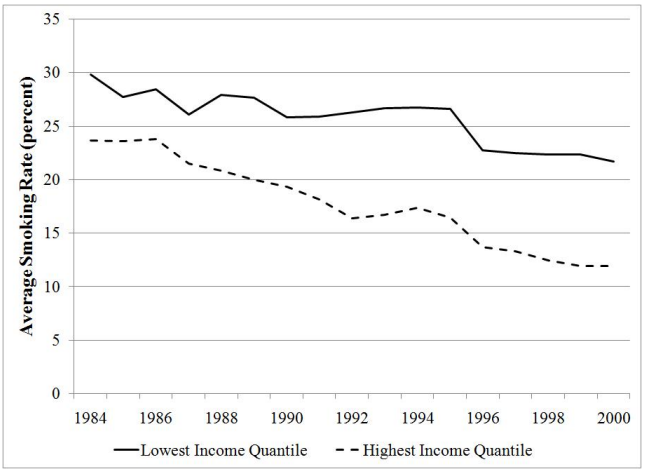


Figure 3: Smoking Rates by Income



B. Attentiveness to Cigarette Taxes in the General Population

We begin our empirical analysis by investigating whether consumers in the general population respond differently to register and posted taxes on cigarettes. The neoclassical model predicts that the salience of a tax (e.g., whether it is included in the posted price or added at the register) should not affect how consumers respond to it. To see this formally, suppose that demand for a good x depends on a consumer's income I and the price of x, p_x:

$$x = x(p_x, I).$$

Purchases of x are subject to both a sales tax and an excise tax, so that the final price of x is given by $p_x = p(1+t)(1+s)$, in which p is the pre-tax price of x, t is the excise tax rate, and s is the sales tax rate. [12]

Because the excise and sales tax affect the price of x symmetrically, we have that

$$\frac{\partial x}{\partial \log(1+t)} = \frac{\partial x}{\partial \log p_x}\frac{\partial \log p_x}{\partial \log(1+t)} = \frac{\partial x}{\partial \log p_x}\frac{\partial \log p_x}{\partial \log(1+s)} = \frac{\partial x}{\partial \log(1+s)}$$

In words, how consumers adjust their demand for x in response to a tax change should not depend on whether the change occurred in the excise tax rate or the sales tax rate.[13]

CLK assess this prediction for the case of beer by linking changes in aggregate beer consumption by state to changes in the state's sales tax rate and excise tax on beer. They find that changes in the beer excise tax are negatively and significantly correlated with changes in beer consumption, whereas sales tax changes appear to have little effect. As a result, CLK conclude that the neoclassical model is mistaken and that the salience of a tax affects how consumers respond. Because they lack disaggregated consumption data, CLK are unable to assess whether the salience of a tax affects different parts of the population differently, our goal in Section II.C.

Our analysis in this section differs from CLK by focusing on cigarettes instead of beer and by using individual survey data rather than aggregate state consumption data. Our baseline empirical model takes the form:

$$y_{ismt} = \alpha + \beta_1 \tau^e_{smt} + \beta_2 \tau^s_{smt} + \gamma x_{smt} + \delta z_{ismt} + \mu_s + \lambda_t + \pi_m + \varepsilon_{ismt} \tag{8}$$

where the unit of observation is an individual i in state s, calendar month m, and year t. The dependent variable (y) represents cigarette demand, τ^e is the log excise tax rate, τ^s is the log sales tax rate, z are individual-level covariates, and x are covariates that do not vary between individuals interviewed in the same state, month, and year. We include state fixed effects μ_s to capture unobserved factors that are correlated with both state tax rates and the level of smoking demand. Year fixed effects λ_t capture time trends in smoking demand as well as yearly shocks to national cigarette consumption, such as a national anti-smoking campaign. Finally, π_m is a calendar month effect, which accounts for seasonal or monthly patterns in cigarette demand.

As is standard in the cigarette literature,[14] we model the decision of whether an individual smokes (the extensive margin) separately from the decision of how much to smoke, conditional on being a smoker (the intensive margin).

[12] Some states do not include the excise tax in the price used to calculate the sales tax, so that final prices are given by $p_x = p(1+t+s)$. Because the excise and sales tax still affect the price of x symmetrically in such states, the neoclassical model predicts that demand should respond identically to sales and excise tax changes of the same proportion.

[13] Two assumptions are important for this result: first, that tax rates only enter consumer utility through their effect on product prices, and second, that p_x is the only price that affects demand for x. We maintain the first assumption throughout but consider the implications of relaxing the second in Section II.E.

[14] See Frank J. Chaloupka and Kenneth E. Warner (2000) for a helpful review of the extensive literature on estimating cigarette demand.

Consequently, in some specifications y is a binary choice variable indicating whether the individual reports being a smoker, and in other specifications y is the non-zero count of the number of cigarettes consumed in the last month, where the sample is restricted to self-reported smokers. This "double-hurdle" model is common in the cigarette literature because the decision of whether to smoke may be fundamentally different than the decision of how much to smoke, and is informative as to whether taxes affect consumption by turning smokers into non-smokers or by inducing current smokers to reduce the number of cigarettes they smoke.[15]

Table 1 presents the results of this analysis.[16] The specifications in Columns 1 and 4 regress smoking demand on the two tax rates, individual demographic variables, and state, year, and calendar month fixed-effects. Since state taxes are often increased to meet budgetary shortfalls in bad economic times, it is likely that tax rate changes are correlated with state-level economic variables that are not captured by state fixed effects. If cigarette consumption is also correlated with the business cycle, this omitted variable could bias our results. To account for this possibility, Columns 2 and 5 include state-level measures of real income and unemployment rate.[17]

To motivate Columns 3 and 6, recall that smoking participation rates fell more steeply over the sample period for higher income consumers (Figure 3). Although this change could stem from increasing tax rates over this period, it may also reflect a secular trend in smoking consumption among higher income consumers, such as changing social acceptance of smoking among high SES individuals. Because tax rates trend upwards over the sample period, a secular trend in smoking demand among high-income consumers could be conflated with the two tax-income interaction terms in the regression. To account for the possibility that the relationship between income and smoking demand changes over the sample period, Columns 3 and 6 add an interaction between income and a linear time trend.

The regressions in Table 1 show the effect of taxes on the intensive and extensive margins separately. In order to provide a better picture of the overall effect of a tax change on cigarette demand, Table 2 uses a back of the envelope technique to combine the intensive and extensive margin estimates. In particular, one can decompose the conditional expectation of cigarette demand into its intensive and extensive components:

$$E[y|x] = E[y|x, y > 0] * P(y > 0|x),$$

[15] A drawback of the two-part approach is that estimation results for the intensive margin may be biased by changes to the composition of the smoking population. We investigate the robustness of this specification in Section II.E.2.

[16] We estimate demand on the extensive margin with a linear probability model. A Probit model yields similar results. Because unobserved shocks to smoking demand may be correlated across time for consumers living in the same state, all tables report standard errors that are clustered at the state level.

[17] Real state income data comes from the Bureau of Economic Analysis and the state unemployment rate data comes from the Bureau of Labor Statistics. Both variables are measured quarterly.

Table 1: Attentiveness to Cigarette Taxes - Intensive and Extensive Margins

	Intensive Margin			Extensive Margin		
	(1)	(2)	(3)	(4)	(5)	(6)
Excise Tax	-6.649***	-6.496***	-6.669***	-0.126***	-0.115***	-0.116***
	(1.197)	(1.199)	(1.226)	(0.031)	(0.026)	(0.026)
Sales Tax	-0.193	0.954	0.846	-0.262*	-0.132	-0.132
	(5.317)	(5.628)	(5.735)	(0.141)	(0.100)	(0.101)
Income	-0.004	-0.004	1.753***	-0.099***	-0.099***	-0.075***
	(0.163)	(0.163)	(0.258)	(0.005)	(0.005)	(0.008)
Female	-3.486***	-3.486***	-3.487***	-0.039***	-0.039***	-0.039***
	(0.119)	(0.119)	(0.119)	(0.003)	(0.003)	(0.003)
White	6.147***	6.146***	6.147***	0.082***	0.082***	0.082***
	(0.203)	(0.203)	(0.201)	(0.006)	(0.006)	(0.006)
H.S. Grad	-1.278***	-1.278***	-1.283***	-0.062***	-0.062***	-0.062***
	(0.211)	(0.211)	(0.213)	(0.009)	(0.009)	(0.009)
College Grad	-1.826***	-1.826***	-1.826***	-0.123***	-0.123***	-0.123***
	(0.141)	(0.141)	(0.142)	(0.005)	(0.005)	(0.005)
Married	-0.369***	-0.369***	-0.360***	-0.067***	-0.067***	-0.067***
	(0.071)	(0.071)	(0.072)	(0.002)	(0.002)	(0.002)
Unemployed	1.007***	1.009***	1.041***	0.086***	0.087***	0.087***
	(0.123)	(0.122)	(0.125)	(0.004)	(0.004)	(0.005)
Age	-0.351*	-0.351*	-0.360*	0.034***	0.035***	0.034***
	(0.204)	(0.204)	(0.204)	(0.005)	(0.005)	(0.005)
Age^2	0.032***	0.032***	0.032***	-0.001***	-0.001***	-0.001***
	(0.007)	(0.007)	(0.007)	(0.000)	(0.000)	(0.000)
Age^3	-0.001***	-0.001***	-0.001***	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age^4	0.000***	0.000***	0.000***	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log Unemp. Rate		-0.227	-0.253		-0.028***	-0.029***
		(0.274)	(0.278)		(0.008)	(0.008)
Log State Income		0.208	0.257		-0.013	-0.013
		(0.681)	(0.681)		(0.028)	(0.028)
Income Trend			-0.208***			-0.003**
			(0.024)			(0.001)
Economic Conditions		x	x		x	x
Income Trend			x			x
F-stat	1.32	1.55	1.53	0.99	0.03	0.02
prob>F	0.26	0.22	0.22	0.32	0.87	0.89
N	274,138	274,138	274,138	1,288,031	1,288,031	1,288,031

Clustered standard errors in parentheses.

All specifications include state, year, and calendar month fixed effects.

The F-stat is for the test of equality between the excise tax and the sales tax.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

where y represents cigarette demand and x represents the covariates. Using the product rule, the total effect of a change in one of the covariates on cigarette demand is given by:

$$\frac{\partial E[y|x]}{\partial x} = \frac{\partial E[y|x, y>0]}{\partial x} * P(y>0|x) + \frac{\partial P(y>0|x)}{\partial x} * E[y|x, y>0].$$

By utilizing sample estimates of $P(y>0|x)$ and $E[y|x, y>0]$, evaluated at the sample mean of each covariate, we can combine the estimated coefficients from the intensive and extensive margin regressions into a rough estimate of the overall effect of the taxes on cigarette demand.[18]

Table 2: Attentiveness to Cigarette Taxes - Overall Effect

	(1)	(2)	(3)
Excise Tax	-3.846***	-3.606***	-3.676***
	(0.500)	(0.499)	(0.498)
Sales Tax	-4.939**	-2.253	-2.269
	(2.168)	(2.212)	(2.210)
Economic Conditions		x	x
Income Trend			x
F-stat	0.22	0.33	0.35
prob>F	0.64	0.57	0.55

Clustered standard errors in parentheses.
All specifications include individual demographic characteristics and state, year, and calendar month fixed effects.
The F-stat is for the test of equality between the excise tax and the sales tax.
* $p<0.10$, ** $p<0.05$, *** $p<0.01$

The results in Tables 1 and 2 are consistent with a salience effect on the intensive margin: a one-percent increase in the cigarette excise tax is associated with an average reduction of 6.5 cigarettes per month, whereas the point estimate on the sales tax term is near zero and is not statistically significant. However, the coefficient on the sales tax is measured imprecisely, and consequently, we cannot reject the hypothesis that the two coefficients are actually equal to one another. On the extensive margin, the point estimates for the coefficients on the two types of taxes are similar in magnitude. Overall, the evidence is qualitatively consistent with smokers paying more attention to posted taxes than to register taxes when deciding how many cigarettes to consume, although the low value of the F-statistic indicates that this result is far from conclusive.

[18]This method for combining the intensive and extensive margin estimates is only meant to provide a rough guide for the aggregate effect of tax rate changes on smoking demand. When calculating standard errors for the aggregate effect, we ignore uncertainty in the sample averages of $P(y>0|x)$ and $E[y|x, y>0]$. This approximation is reasonable because the size of our sample guarantees those quantities are estimated precisely.

C. Heterogeneous Attentiveness by Income

The inconclusive results for the general population in Section II.B might mask heterogeneous effects across income groups. We now turn to our primary question of interest, whether high- and low-income consumers differ in their attentiveness to cigarette register taxes. The baseline empirical model for this section is given by:

$$\begin{aligned} y_{ismt} &= \alpha + \beta_1 \tau^e_{smt} + \beta_2 \tau^s_{smt} + \rho_1 \tau^e_{smt} I_{ismt} + \rho_2 \tau^s_{smt} I_{ismt} + \eta I_{ismt} + \\ &\quad \gamma x_{smt} + \delta z_{ismt} + \mu_s + \lambda_t + \pi_m + \varepsilon_{ismt} \end{aligned} \tag{9}$$

Compared to the model in II.2, this specification adds interaction terms between the respondent's income and the two tax rates.

The coefficients on the two tax types, β_1 and β_2, describe how the lowest-income consumers modify their demand in response to changes in the excise and sales taxes, respectively. In turn, the coefficients on the income-interaction terms, ρ_1 and ρ_2, measure whether consumers become more or less sensitive to the taxes as their income changes. For example, the effect of an excise tax change on cigarette demand by a consumer with income I is given by$\beta_1 + \rho_1 I$.

Our primary question is whether attentiveness to the sales tax varies by income. In answering this question, one must distinguish between attentiveness – the extent to which consumers account for a tax when making their consumption decisions – and price-sensitivity – which describes how a tax that consumers account for affects their optimal purchase. The sales-income interaction term (ρ_2) may reflect differences in attentiveness between high- and low-income consumers, but it may also reflect differences in price-sensitivity by income. That is, a positive coefficient on ρ_2 could stem from high-income smokers being less sensitive to cigarette prices *in any form*, even if high- and low-income smokers were equally attentive to the sales tax.

To deal with this possibility, it is useful to introduce the notion of the "attention gap," the amount by which a consumer's responsiveness to the excise tax exceeds her responsiveness to the sales tax. For a consumer with income I, the attention gap is therefore given by $(\beta_2 + \rho_2 I) - (\beta_1 + \rho_1 I)$. Recall that the neoclassical model described above predicts that consumers should respond identically to excise and sales taxes that they take into account. Consequently, we interpret a non-zero value of the attention gap to be evidence that consumers account for one type of tax more than the other. In particular, a positive attention gap at some income level I indicates that consumers with income I pay more attention to excise taxes than to sales taxes.

Although the sign and magnitude of the attention gap at a particular income level are interesting in their own right, more relevant to our analysis are *changes* in the attention gap by income. That is, we are less concerned with

whether a particular group of consumers pays more attention to the excise tax relative to the sales tax, and more concerned with whether low-income consumers pay more attention to the sales tax (relative to the excise tax) than high-income consumers do.[19] The difference between the attention gap for the richest and poorest consumers is given by:

$$\begin{aligned} \Delta AttentionGap &= [(\beta_2 + \rho_2 * 1) - (\beta_1 + \rho_1 * 1)] - [(\beta_2 + \rho_2 * 0) - (\beta_1 + \rho_1 * 0)] \\ &= \rho_2 - \rho_1 \end{aligned} \tag{10}$$

Intuitively, the sales-interaction coefficient (ρ_2) reflects changing responsiveness to the sales tax by income, and the excise-interaction coefficient (ρ_1) removes the portion of that change due to changes in consumers' price sensitivity. Hence, the gap between the coefficients on the two interaction terms rates, $\rho_2 - \rho_1$, measures the extent to which attentiveness to the register tax changes as income rises. When $\rho_2 - \rho_1 > 0$, high-income consumers pay less attention to the sales tax (relative to the excise tax) than low-income consumers do.

Table 3 presents our results. Columns 1 and 4 include the two tax rates, on their own and interacted with income. In addition, the regressions include demographic variables as well as state, year, and month fixed-effects. As before, Columns 2 and 5 add real state income and the state unemployment rate, and Columns 3 and 6 include an interaction between income and a linear time trend to capture the changing relationship between income and smoking behavior over time. The estimated coefficients on the demographic and macroeconomic variables are qualitatively similar to those reported in Table 1, and are omitted. Table 4 combines the intensive and extensive margin estimates into an overall effect, using the method described in Section II.B.[20]

The results in Tables 3 and 4 support the view that attentiveness to register taxes declines with income. As before, Column 3 is our preferred specification. On the intensive margin, the point estimates on the excise and sales tax coefficients are negative and similar in magnitude, suggesting that low-income consumers respond similarly to changes in excise and sales tax rates. The coefficient on the sales-income interaction is positive and significant, which implies that sales tax increases prompt high-income consumers to reduce their demand by a smaller magnitude than low-income consumers. The only qualitative difference between the specifications is the coefficient on the excise-income interaction, which declines sharply in magnitude once the income-year interaction term is added

[19] After all, it is the *differences* in behavior between high- and low-income consumers that shapes the distribution of a tax's burden.

[20] The robustness checks that follow use the specification in Columns 3 and 6 as their baseline.

Table 3: Attentiveness to Cigarette Taxes by Income - Intensive and Extensive Margins

	Intensive Margin			Extensive Margin		
	(1)	(2)	(3)	(4)	(5)	(6)
Excise Tax	-2.476**	-2.301**	-5.601***	-0.090	-0.079	-0.134**
	(1.086)	(1.066)	(1.350)	(0.066)	(0.055)	(0.061)
Sales Tax	-9.212	-8.041	-8.314	-0.716***	-0.587***	-0.591***
	(7.144)	(7.066)	(7.021)	(0.252)	(0.187)	(0.174)
Excise*Income	-9.328***	-9.356***	-2.311	-0.070	-0.071	0.034
	(2.388)	(2.379)	(2.436)	(0.091)	(0.091)	(0.098)
Sales*Income	18.933*	19.014*	19.267**	0.878***	0.880***	0.885***
	(9.513)	(9.483)	(8.487)	(0.305)	(0.305)	(0.276)
Income	0.718	0.719	1.174*	-0.130***	-0.130***	-0.121***
	(0.521)	(0.520)	(0.585)	(0.023)	(0.023)	(0.027)
Income Trend			-0.204***			-0.003***
			(0.026)			(0.001)
Economic Conditions		x	x		x	x
Income Trend			x			x
F-stat	7.90	8.03	7.17	9.54	9.56	8.51
prob>F	0.01	0.01	0.01	0.00	0.00	0.01
N	274,138	274,138	274,138	1,288,031	1,288,031	1,288,031

Clustered standard errors in parentheses.

All specifications include individual demographic characteristics and state, year, and calendar month fixed effects.

The F-stat is associated with the test for equality between the excise-income and sales-income interaction terms.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

to the model.[21] Columns 4 - 6 show that the extensive margin results are qualitatively similar.[22]

Figures 4a, 4b, and 4c graph the estimated relationship between attentiveness to register taxes and income. The positive slope indicates that the attention gap is increasing in income; that is, the difference between excise and sales taxes is greater for high-income consumers than for low-income consumers. To verify this graphical evidence, recall from (10) that the attention gap increases by income when $\rho_2 - \rho_1 > 0$. The associated F-test is reported in Tables 3 and 4. Under each specification, we can strongly reject the null hypothesis that the two tax-income interaction terms are equal to one another. Hence it appears that low-income consumers pay more attention to cigarette register taxes than high-income consumers do.[23]

[21] Because the sign on the excise income interaction is negative in the first two columns, excluding the income-year interaction term strengthens the result that attentiveness to the register tax declines by income.

[22] One difference is that on the extensive margin, the point estimate on the sales tax coefficient is more negative than the point estimate on the excise tax coefficient, implying that the lowest income consumers respond more to the sales tax than to the excise tax. This result might stem from the fact that we are imposing a linear relationship between an individual's tax responsiveness and their income. It could also reflect differences in the goods included in the excise and sales tax bases, a possibility explored in Section II.D.

[23] An implicit assumption in our analysis (and throughout the smoking literature) is that changes in cigarette taxes are uncorrelated with unobserved shocks to individuals' cigarette consumption. However, cigarette taxes are not set randomly; a positive shock to cigarette demand might prompt state legislators to raise excise taxes to capture additional revenue. Although such correlations could provide an alternative explanation for the discrepancy between the excise and sales tax coefficients in Section II.B, it is more difficult to imagine them driving the heterogeneous attentiveness results in Section II.C. That is, although there are many possible reasons for cigarette taxes to be correlated with unobserved shocks to smoking demand, there are fewer plausible reasons why adoption of such laws would be differently correlated with shocks to cigarette demand for high and low-income consumers. Moreover, to the extent that policymakers do consider

Table 4: Attentiveness to Cigarette Taxes by Income - Overall Effect

	(1)	(2)	(3)
Excise Tax	-2.245***	-1.992***	-3.757***
	(0.659)	(0.658)	(0.665)
Sales Tax	-15.471***	-12.788***	-12.919***
	(2.629)	(2.657)	(2.658)
Excise*Income	-3.411***	-3.430***	0.115
	(0.831)	(0.831)	(0.841)
Sales*Income	20.680***	20.733***	20.888***
	(2.866)	(2.867)	(2.864)
Income	-2.263***	-2.262***	-2.000***
	(0.176)	(0.176)	(0.187)
Income Trend			-0.103***
			(0.012)
Economic Conditions		x	x
Income Trend			x
F-stat	55.67	55.97	42.03
prob>F	0.00	0.00	0.00

Clustered standard errors in parentheses.

All specifications include individual demographic characteristics and state, year, and calendar month fixed effects.

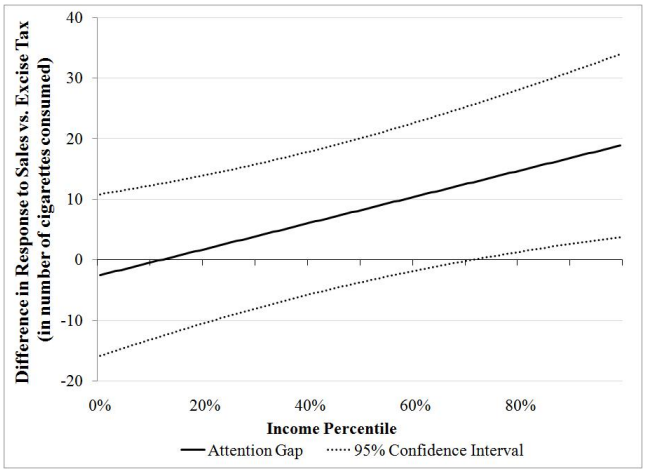
The F-stat is associated with the test for equality between the excise-income and sales-income interaction terms.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

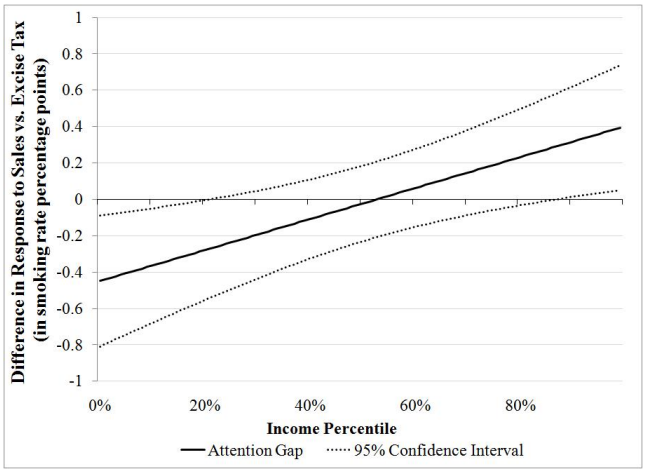
cigarette demand by high- and low-income consumers differently when setting tax rates, it would be surprising if they took such behavior into account when setting the *sales tax* (for which cigarette sales constitute only a small fraction of total revenue). So although it appears unlikely that the endogenous adoption of tax laws is driving our main results, we cannot rule that possibility out definitively.

Figure 4: Attention Gap by Income Percentile

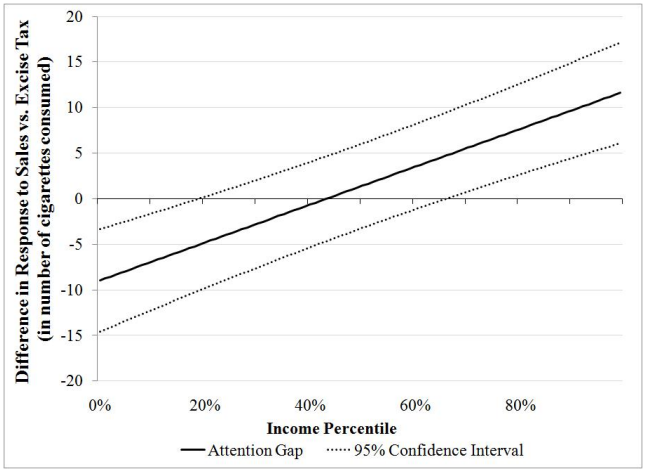
(a) Intensive Margin



(b) Extensive Margin



(c) Overall Effect



So far, we have assumed linearity in the relationship between a consumer's income and her responsiveness to changes in the tax rates. The regressions presented in Table 5 relax that assumption by allowing consumers in each income quartile to react to the taxes in different ways. The econometric model in Table 5 is given by:

$$\begin{aligned} y_{ismt} &= \alpha + \beta_1 \tau^e_{smt} + \beta_2 \tau^s_{smt} + \sum_{j \in \{II,III,IV\}} \left\{ \eta^j I^j_{ismt} + \rho^j_1 \tau^e_{smt} I^j_{ismt} + \rho^j_2 \tau^s_{smt} I^j_{ismt} \right\} + \\ &\quad \gamma x_{smt} + \delta z_{ismt} + \mu_s + \lambda_t + \pi_m + \varepsilon_{ismt} \end{aligned} \tag{11}$$

As before, income differences in how consumers respond to the excise tax tend to be small and statistically insignificant. In contrast, responsiveness to the sales tax declines monotonically with income. F-tests for the equality of the attention gap between consumers in different income quartiles are presented as well. Here too, the

results suggest that attentiveness to cigarette register taxes declines by income.

Table 5: Income Quartile Interactions

	Intensive Margin (1)	Extensive Margin (2)
Excise Tax	-6.714***	-0.077
	(1.830)	(0.057)
Excise*Income Q2	2.047	-0.106**
	(2.527)	(0.046)
Excise*Income Q3	-1.348	-0.040
	(1.801)	(0.073)
Excise*Income Q4	-0.371	0.000
	(2.324)	(0.071)
Sales Tax	-7.532	-0.516***
	(7.153)	(0.166)
Sales*Income Q2	8.073	0.271*
	(7.655)	(0.155)
Sales*Income Q3	12.775*	0.562**
	(7.326)	(0.222)
Sales*Income Q4	13.257**	0.634***
	(6.544)	(0.193)
F-stat: Q2	0.59	5.23
prob>F	0.45	0.03
F-stat: Q3	4.56	6.00
prob>F	0.04	0.02
F-stat: Q4	4.37	9.51
prob>F	0.04	0.00
N	274,138	1,288,031

Clustered standard errors in parentheses.

F-stats are associated with testing $\rho_{2,j} - \rho_{1,j} = 0$ for j in $\{2,3,4\}$

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

D. Tax Base Differences Between the Excise and Sales Tax

Our strategy for measuring attentiveness has been to compare consumer responsiveness to excise and sales tax rates. When demand for cigarettes depends only on the price of cigarettes and income, any gap between how consumers respond to the sales tax and how they respond to the excise tax implies a departure from the neoclassical model (as explained in Section II.B). In reality, the price of goods other than cigarettes may enter the cigarette demand function as well; if some of those other goods are also covered by the sales tax, the effect of a sales tax increase on cigarette demand will differ from the effect of an excise tax increase. This observation complicates our analysis because income differences in the attention gap may be due to differences in the excise and sales tax bases, rather than differences in attentiveness.

To clarify the nature of the problem, it will be helpful to discuss this tax-base effect in some detail. Under the neoclassical model, a tax can affect cigarette demand in two ways: by raising the price of cigarettes (a direct effect), and by raising the price of other goods (an indirect effect). Because the excise tax applies only to cigarettes, it generates only a direct effect. In contrast, the sales tax applies to many goods,[24] and consequently, it generates both a direct effect and an indirect effect on cigarette consumption. As a result, income differences in the attention gap could reflect both income differences in attentiveness as well as income differences in the nature of the sales tax's indirect effect. In particular, if the indirect effect of the sales tax on cigarette demand were more negative for low-income consumers than for high-income ones, it could be that a tax base effect rather than changing attentiveness is driving our results. That is, low-income consumers' greater responsiveness to the sales tax could stem from income differences in how consumers adjust cigarette demand in response to price changes on other sales-taxed good.

Might income differences in the indirect effect of the sales tax be driving our results? It is difficult to dismiss this possibility out of hand. The indirect effect of the sales tax can be decomposed into an income effect and a substitution effect. By raising the price of many goods at once, the sales tax diminishes consumers' purchasing power, causing them to reduce their consumption of cigarettes (the income effect). In addition, raising the price of other goods might cause consumers to substitute toward or away from cigarettes, depending on whether the other goods covered by the sales tax are primarily substitutes or complements to cigarettes (the substitution effect). In theory, either of these effects could be more negative for low-income consumers. For example, the other sales-taxed goods could be important substitutes with cigarettes for well-off consumers, but not for low-income consumers. Similarly, the loss in real income associated with a sales tax increase could induce a bigger reduction in cigarette demand for low-income consumers.

We present two pieces of evidence that tax base effects are not responsible for all of the observed differences in consumer behavior by income. Our first check is motivated by the fact that some states impose a general sales tax, but exempt cigarettes from it.[25] In states that exempt cigarettes from the sales tax, changes in the sales tax rate would not directly affect the price of cigarettes; the sales tax would not have a direct effect on cigarette consumption. However, sales tax changes would still affect the price of other sales tax-eligible goods. Hence, the indirect effect of the sales tax would still occur. Consequently, analyzing the effect of the sales tax in cigarette-exempting states allows us to measure income differences in the indirect effect of the sales tax.

If indirect effects were responsible for the observed differences in responsiveness to the sales tax by income, responsive to the sales tax should decline by income, even in states that exempted cigarettes. Table 6 compares the effect of the sales tax in states that exempt cigarettes from the sales tax ("exempting states") with the effect of

[24] Approximately 40 percent of retail sales, according to CLK.

[25] In our sample, seven states exempt cigarettes from the sales tax base for at least one year.

the sales tax in states that include cigarettes in the sales tax base ("including states"). To do so, we modify our econometric model to allow heterogeneity in the effect of the sales tax between exempting and including states:

$$\begin{aligned} y_{ismt} &= \alpha + \beta_1 \tau^e_{smt} + \beta_2 \tau^s_{smt} * E_s + \beta_3 \tau^s_{smt} * (1 - E_s) + \\ & \rho_1 \tau^e_{smt} I_{ismt} + \rho_2 \tau^s_{smt} I_{ismt} * E_s + \rho_3 \tau^s_{smt} I_{ismt} * (1 - E_s) + \\ & E_s * t + E_s * t^2 + \eta I_{ismt} + \gamma x_{smt} + \delta z_{ismt} + \mu_s + \lambda_t + \pi_m + \varepsilon_{ismt} \end{aligned} \tag{12}$$

where E_s indicates whether state s exempts cigarettes from the sales tax base.

Table 6 shows that the effect of the sales tax on cigarette demand appears to vary substantially more in including states than in exempting states. The estimated coefficient of the sales-income interaction term in exempting states, ρ_2, is close to zero and is statistically insignificant on both the intensive and extensive margins. In contrast, the coefficient on the sales-income interaction term in the including states, ρ_3, remains large and significant. Moreover, on the extensive margin, we are able to reject the hypothesis that the sales-income interaction coefficient in the exempt states is as large as in the non-exempt states. These findings suggest that income differences in indirect effects are not driving the results in Section II.C.

Table 6: States that Exempt Cigarettes from Sales Tax

	Intensive Margin	Extensive Margin
	(1)	(2)
Excise Tax	-5.725***	-0.128*
	(1.317)	(0.064)
Excise*Income	-2.392	0.033
	(2.439)	(0.099)
Sales Tax*Non-exempt	-5.487	-1.010***
	(13.767)	(0.334)
Sales*Income*Non-exempt	20.424**	0.917**
	(9.846)	(0.374)
Sales Tax*Exempt	-38.707	-0.681*
	(29.219)	(0.374)
Sales*Income*Exempt	3.903	0.149
	(16.826)	(0.503)
F-stat	1.34	11.68
prob>F	0.25	0.00
N	274,138	1,288,031

Clustered standard errors in parentheses.

The F-stat is for the test of equality between the sales-income interaction terms in the two types of states.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We also present a second check that tax base effects are not driving our results. Tax base effects are most likely to dampen the impact of the sales tax relative to the excise tax when the excise tax exempts important substitutes for cigarettes.[26] Because other tobacco products constitute likely substitutes for cigarettes, there is less potential for tax base differences to play a role in states where the excise tax also applies to other tobacco products. Consequently, we restrict the analysis in Section II.C to states that apply the excise tax to cigars and smokeless tobacco. Table 7 shows that our results are largely unchanged by this restriction.

Table 7: States that Tax All Other Types of Tobacco

	Intensive Margin	Extensive Margin
	(1)	(2)
Excise Tax	-5.034**	-0.071
	(2.271)	(0.075)
Sales Tax	-6.842	-0.481***
	(9.153)	(0.167)
Excise*Income	-2.263	0.015
	(2.791)	(0.109)
Sales*Income	20.625**	1.270***
	(9.449)	(0.284)
F-stat	6.40	16.87
prob>F	0.02	0.00
N	185,741	904,206

Clustered standard errors in parentheses.
The F-stat is for the test of equality between the excise-income and sales-income interaction terms.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In summary, there are plausible reasons to believe that differences in the excise and sales tax bases could generate results similar to those presented in Section II.C. However, the evidence in Tables 6 and 7 suggests that tax base effects cannot fully supplant attentiveness as an explanation for the large differences in behavior that we find between high- and low-income consumers.

E. Robustness Checks

1. Including Pre-Tax Prices in the Regression

One variable not included in our basic econometric model is the pre-tax price of cigarettes. On the one hand, the pre-tax price depends on both supply and demand; including it as a regressor could bias our results if it were correlated with unobserved shocks to consumer demand (the classic simultaneous systems problem). On the other

[26]For example, raising the excise tax might reduce cigarette demand substantially by inducing cigarette smokers to switch to cigars. In contrast, raising the sales tax would raise the price of both cigarettes and cigars, dampening the effect on cigarette consumption.

hand, the pre-tax price enters the consumer's demand function symmetrically with the excise and sales tax rates; excluding it from the regression may create an omitted variable bias if pre-tax price fluctuations were not equally correlated with the two tax types.

In this section, we modify our empirical strategy to account for the pre-tax price of cigarettes. Whereas previously we compared sales tax changes to excise tax changes, we now compare sales tax changes to changes in the posted price of cigarettes (the pre-tax price plus the excise tax). As before, this approach isolates income differences in attentiveness rather than changing price-sensitivity. The econometric takes the following form:

$$y_{ismt} = \alpha + \beta_1 pp_{smt} + \beta_2 \tau^s_{smt} + \rho_1 pp_{smt} I_{ismt} + \rho_2 \tau^s_{smt} I_{ismt} + \gamma x_{smt} + \delta z_{ismt} + \mu_s + \lambda_t + \pi_m + \varepsilon_{ismt} \tag{13}$$

where pp represents the (excise tax inclusive) posted price of cigarettes. To address the possible correlation between pre-tax prices and unobserved demand shocks, we utilize the excise tax as a supply shifter. In particular, we employ the excise tax (τ^e) and the excise-income interaction ($\tau^e * I$) as instruments for the posted price (pp) and the posted price-income interaction ($pp * I$). This identification strategy is valid under the same assumptions as the main specification, namely that excise tax changes are uncorrelated with unobserved shocks to cigarette demand. Table 9 shows that the results from the IV specification are similar to the specification that omits pre-tax prices.

Table 8: Instrumenting for Price with Excise Tax - First Stage

	Intensive Margin		Extensive Margin	
	(1)	(2)	(3)	(4)
Excise Tax	1.097***	-0.450***	0.995***	-0.537***
	(0.177)	(0.097)	(0.188)	(0.107)
Sales Tax	0.773	0.271	0.818	0.320
	(0.462)	(0.228)	(0.498)	(0.256)
Excise*Income	0.051**	2.105***	0.035***	2.066***
	(0.024)	(0.116)	(0.010)	(0.103)
Sales*Income	0.013	0.233	-0.011	0.173
	(0.028)	(0.306)	(0.013)	(0.262)
F-stat	68,090	48,192	290,334	252,529
R^2	0.96	0.98	0.95	0.98
N	274,138	274,138	1,288,031	1,288,031

Clustered standard errors in parentheses.

(1) and (3): Dependent variable = post-tax price

(2) and (4): Dependent variable = post-tax price*income

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Instrumenting for Cigarette Prices with the Excise Tax

	Intensive Margin		Extensive Margin	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
Posted Price	-1.054	-5.468***	-0.053**	-0.121**
	(0.637)	(1.717)	(0.022)	(0.050)
Sales Tax	-10.907	-3.730	-0.604***	-0.491***
	(6.593)	(7.041)	(0.173)	(0.155)
Posted Price*Income	-1.040	-0.999	0.015	0.013
	(0.922)	(1.150)	(0.031)	(0.048)
Sales Tax*Income	19.824**	19.280**	0.886***	0.871***
	(8.653)	(8.486)	(0.275)	(0.269)
F-test	6.39	6.14	10.16	9.99
prob>F	0.01	0.01	0.00	0.00
N	274,138	274,138	1,288,031	1,288,031

Clustered standard errors in parentheses.

Price includes the excise tax.

The F-stat is for the test of equality between the price-income and sales-income interaction terms.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

2. Alternative Demand Models

So far, we have followed the approach taken by much of the smoking literature by separately modeling the extensive and intensive margins of cigarette consumption. This approach has the advantage of providing information about the mechanism by which tax changes reduce cigarette demand, in particular whether higher prices reduce demand by motivating smokers to quit or cut back. However, a drawback of this approach is that the intensive margin results may be biased by changes to the composition of the smoking population.[27]

As a robustness check, we estimate smoking demand using a linear regression and a Tobit model censored at zero. The dependent variable in these regressions is the number of cigarettes smoked per day, with the variable assigned a value of zero when the individual in question is not a smoker. Because the entire population of respondents is used, these approaches avoid the problem that tax rate changes affect selection into the smoking population. The flip side of the coin is that these models do not allow variables to differ in how they affect smoking demand on the intensive and extensive margins. Moreover, the Tobit specification relies on the normality of the unobservables and the linear functional form is probably unrealistic for an application in which so many of the observations have a dependent variable equal to zero. The results of the linear and Tobit specifications are presented in Table 10 and are consistent with the results from the two-part model used in the rest of the paper.

[27]For example, suppose that smokers' demand for cigarettes were completely insensitive to price changes, but that light smokers quit when the price became too high. In such a world, a tax increase would appear to raise the intensity of smoking demand on the intensive margin merely by raising the fraction of heavy smokers in the smoking population.

Table 10: Alternative Demand Models

	Linear Demand	Tobit Demand
	(1)	(2)
Excise Tax	-3.478***	-13.917***
	(1.208)	(5.368)
Sales Tax	-12.202***	-44.365***
	(3.858)	(13.454)
Excise*Income	1.620	-4.498
	(2.147)	(8.565)
Sales*Income	18.016***	71.288***
	(6.597)	(22.483)
F-stat	5.78	9.15
prob>F	0.02	0.00
N	1,281,525	1,281,525

Clustered standard errors in parentheses.
The F-stat is for the test of equality between the excise-income and sales-income interaction terms.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3. Delayed Responses to Tax Changes

So far we have assumed that smoking demand depends only upon current cigarette taxes, but it could be that tax changes affect consumer behavior with a lag. For example, higher prices might motivate smokers to quit, but the quitting process itself could take several months. Alternatively, it could be that consumers take some time to learn about sales tax changes, only gradually incorporating them into their behavior. If these lags were different for high and low-income consumers, it could provide an alternative explanation for our results.[28] To investigate this issue, we examine the sensitivity of our results to using various lags of the tax rates instead of the current rate.

$$\begin{aligned} y_{ismt} &= \alpha + \beta_1 \tau^e_{sm,t-k} + \beta_2 \tau^s_{sm,t-k} + \rho_1 \tau^e_{sm,t-k} I_{ismt} + \rho_2 \tau^s_{sm,t-k} I_{ismt} + \eta I_{ismt} + \\ &\quad \gamma x_{smt} + \delta z_{ismt} + \mu_s + \lambda_t + \pi_m + \varepsilon_{ismt} \end{aligned} \tag{14}$$

where k, is three, six, or twelve months. The results are reported in Table 11 and suggest that our results are not being driven by differences in the time it takes high- and low-income consumers to respond to cigarette tax changes.

[28] For example, high-income consumers may be better able to afford top of the line smoking-cessation products.

Table 11: Timing

	Intensive Margin			Extensive Margin		
	3 Month	6 Month	12 month	3 Month	6 Month	12 month
	(1)	(2)	(3)	(4)	(5)	(6)
Excise Tax	-4.841***	-4.694***	-3.857**	-0.130**	-0.136**	-0.156**
	(1.449)	(1.518)	(1.689)	(0.062)	(0.062)	(0.067)
Sales Tax	-6.917	-7.631	-3.547	-0.595***	-0.684***	-0.635***
	(7.669)	(8.044)	(8.421)	(0.190)	(0.173)	(0.155)
Excise*Income	-2.437	-1.562	-0.656	0.051	0.070	0.080
	(2.529)	(2.656)	(2.838)	(0.100)	(0.108)	(0.116)
Sales*Income	19.181**	18.599**	15.673*	0.855***	0.838***	0.800***
	(8.810)	(8.490)	(8.673)	(0.270)	(0.253)	(0.237)
F-stat	6.50	6.58	3.69	8.20	8.60	8.68
prob>F	0.01	0.01	0.06	0.01	0.01	0.00
N	273,407	272,637	271,089	1,285,448	1,282,765	1,277,073

Clustered standard errors in parentheses.

The F-stat is for the test of equality between the excise-income and sales-income interaction terms.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4. State Specific Trends

Although including state fixed-effects accounts for unobserved factors that affect the levels of smoking demand by state, it could be that changes in a state's tax rates are correlated with trends in that state's cigarette demand, such as anti-smoking sentiment. To reduce the influence of any such omitted third factors, we add state-specific year trends to the econometric model.[29]

$$\begin{aligned} y_{ismt} &= \alpha + \beta_1 \tau^e_{smt} + \beta_2 \tau^s_{smt} + \rho_1 \tau^e_{smt} I_{ismt} + \rho_2 \tau^s_{smt} I_{ismt} + \eta I_{ismt} + \\ &\quad \gamma x_{smt} + \delta z_{ismt} + \mu_s + \lambda_t + \xi_s * t + \pi_m + \varepsilon_{ismt} \end{aligned} \tag{15}$$

Table 12 shows that the estimated coefficients are largely unchanged by this addition.

[29] Although our tax rate data is probably largely free of measurement error, including state trends could still cause substantial attenuation bias in the current context. Suppose that smoking demand depends upon a function of current and past tax rates, $x_t = x(a(L)x_t)$, where $a(L)$ is some lag polynomial. The situation here is analagous to the standard measurement error problem: although the original tax variable x_t may be highly correlated with the "true" tax variable $a(L)x_t$, the new tax measure after including state trends may only be weakly correlated with the "true" tax rate, causing an attenuation bias.

Table 12: State Trends

	Intensive Margin	Extensive Margin
	(1)	(2)
Excise Tax	-4.595**	-0.009
	(1.909)	(0.057)
Sales Tax	-5.061	-0.443***
	(6.784)	(0.136)
Excise*Income	-2.193	0.036
	(2.440)	(0.099)
Sales*Income	18.347**	0.875***
	(8.580)	(0.274)
F-stat	6.33	8.36
prob>F	0.02	0.01
N	274,138	1,288,031

Clustered standard errors in parentheses.
The F-stat is for the test of equality between the excise-income and sales-income interaction terms.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

III. Conclusion

Policymakers at all levels of government depend on commodity taxes to raise revenue, but such taxes are typically regressive, constituting a greater burden for low-income consumers. This paper has suggested a novel way for policymakers to lessen that regressivity: by manipulating the fraction of the tax levied at the register rather than being included in a good's posted price. In particular, we showed that levying a greater proportion of a commodity tax at the register shifts the tax's burden away from attentive consumers. When low-income consumers pay more attention to register taxes than high-income consumers do, designing a tax in this way can lessen its regressivity. Conversely, when high-income consumers are more attentive, imposing a commodity tax at the register will exacerbate its regressivity.

With this motivation in mind, we investigated whether high- and low-income consumers respond differently to register taxes on cigarettes. Exploiting state and time variation in tax rates, we found that low-income consumers respond to both excise and sales taxes on cigarettes, whereas high-income consumers only respond to excise taxes. This finding suggests that attentiveness to cigarette register taxes declines by income. Hence, policymakers may be able to ease the financial burden of cigarette taxes on the poor by levying such taxes at the register instead of including them in cigarettes' posted price.

Two qualifications are important when interpreting this result. First, we have treated cigarettes as a standard consumption good, abstracting away from their addictive nature. However, the fact that cigarettes are addictive could alter the welfare implications of our results. For example, models along the lines suggested by Jonathan

Gruber and Botond Koszegi (2004) or Jonathan Gruber and Sendhil Mullainathan (2002) suggest that cigarette taxes can benefit consumer welfare when voters adopt such taxes as a method of exercising self-control; consequently, shifting a cigarette tax to the register could deprive some consumers of a valuable tool for self-discipline. At the other extreme, a rational-addiction model such as that presented in Gary S. Becker, Michael Grossman, and Kevin M. Murphy (1994) would imply that cigarette consumption decisions are informed by consumers' expectations concerning future prices; if such expectations are important, the demand equations employed here are misspecified.

Second, readers should be cautious about extrapolating our results to goods other than cigarettes. Although we believe that there are strong theoretical and empirical reasons to think that attentiveness to cigarette register taxes declines by income, the cognitive cost model presented in Appendix C highlights the fact that this result can vary between goods. In particular, low-income consumers may well be less attentive to register taxes on goods that are relatively sensitive to income and that constitute a larger share of expenditures for high-income consumers. Moreover, Appendix B shows that shifting to a register tax has the potential to make consumers worse off by inducing producers to raise the good's pre-tax price. In particular, for goods whose markets are characterized by elastic demand and inelastic supply, shifting to a register tax could actually worsen the burden of those taxes on the poor.

Although our discussion has focused on taxes designed to raise revenue, the empirical findings presented here also speak to broader questions of tax design. For example, a number of public health advocates have suggested raising taxes on soft drinks as a way to combat population obesity, with some proponents calling for an expanded tax of any form on those products (Carolyn L. Engelhard, Arthur Garson Jr., and Stan Dorn (2009)) and others arguing that including the tax in the posted product price would be most effective (Kelly D. Brownell et al. (2009)). Our results suggest an important consideration is missing from this discussion, namely that taxes imposed at the register may affect the eating habits of high- and low-income consumers in different ways. Such issues deserve further investigation.

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Appendix A: Welfare Analysis Under Alternate Budget Adjustment Rules

Part I assumed that inattentive consumers who misperceive the price of x satisfy their budget constraints by reducing expenditures on y. This Appendix considers the robustness of our results to alternate rules for mapping infeasible intended consumption bundles into feasible final consumption bundles.

In addition to the rule that we employ, Chetty, Looney, and Kroft (2007) identify two other "intuitive" budget adjustment rules. First, consumers who misperceive the price of x may satisfy their budget constraints by reducing expenditures on x rather than y. This rule represents the other end of the spectrum from the one that we employ, and would be appropriate if consumers purchased x after completing their purchases of all other goods. Under this rule, it is easy to show that:

$$\frac{\partial x_B}{\partial t_r} = \frac{-x_B}{p+t_r+t_p} \tag{16}$$

$$\frac{\partial x_B}{\partial t_p} = \frac{-\left(\frac{\partial y_B}{\partial p}+x_B\right)}{p+t_r+t_p} \tag{17}$$

The second alternate budget adjustment considered by Chetty, Looney, and Kroft (2007) is for inattentive agents to reduce consumption of both x and y to make up the income lost to the register tax. Inattentive consumers ignore the register tax when making their consumption decisions, but recognize that their net-of-tax income is lower because of the tax. For example, consumers who purchase x and y repeatedly will eventually realize that they consistently have less money in their bank account than they had anticipated. Inattentive consumers whose behavior is described by this rule will fully account for the tax's income effect but fail to account for the tax's substitution effect. As a result, we have:

$$\frac{\partial x_B}{\partial t_r} = -x_B \frac{\partial x_B}{\partial I} \tag{18}$$

$$\frac{\partial x_B}{\partial t_p} = \frac{\partial x_B}{\partial t_r} + \frac{\partial \tilde{x}_B}{\partial p} \tag{19}$$

where $\frac{\partial \tilde{x_B}}{\partial p}$ represents Hicksian (compensated) demand.

As before, we consider the welfare effects of a revenue-neutral shift from posted to register taxes. Because the attentive agent optimizes correctly, the welfare effect for that agent is the same as before:

$$\left.\frac{dV_A}{dt_r}\right|_{\overline{R}} = -U_y(x_A, y_A)\, x_A \left(1 + \left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}}\right)$$

Totally differentiating the government's budget constraint yields an expression for the posted tax reduction associated with a revenue-neutral increase in the register tax:

$$\left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}} = -\frac{x_A + x_B + (t_p + t_r)\left(\frac{\partial x_A}{\partial t_r} + \frac{\partial x_B}{\partial t_r}\right)}{x_A + x_B + (t_p + t_r)\left(\frac{\partial x_A}{\partial t_p} + \frac{\partial x_B}{\partial t_p}\right)}$$

A little algebra reveals that the welfare effect of the shift is positive for attentive consumers if and only if $\frac{\partial x_B}{\partial t_r} > \frac{\partial x_B}{\partial t_p}$, that is, when inattentive consumers reduce their demand for the taxed good by a larger amount in response to a posted tax increase than in response to a register tax increase. Intuitively, this condition ensures that the new register tax will be more effective at raising revenue than the old posted tax was. Consequently, the shift accomodates a reduction in the combined tax rate, thus generating a positive income effect. Using (16) - (19), it is easy to see that this condition is satisfied under the two alternate budget adjustment rules.[30]

The welfare analysis for inattentive consumers proceeds as in Part I. Under the first alternate rule,

$$\left.\frac{dV_B}{dt_r}\right|_{\overline{R}} = -\left(1 + \left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}}\right) U_x(x_B, y_B)\left(\frac{x_\mathbf{B}}{p + t_r + t_p}\right) + \frac{\left(\frac{\partial y_B}{\partial p}\right)\left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}}}{(p + t_r + t_p)}\left(U_y(x_A, y_A)(p + t_r + t_p) - U_x(x_A, y_A)\right)$$

Like the result in Part I, the welfare effect for inattentive consumers is ambiguous under this rule. Shifting to a register tax accomodates a reduction in the combined tax rate, generating a positive welfare effect (captured by the first term). Unlike before, however, the magnitude of this effect depends on the marginal utility of x rather than y because providing the consumer with additional income reduces the amount that the consumer must reduce her consumption of x to satisfy the budget constraint. The second term represents the cost of optimization error. Like before, this cost is zero when there are no register taxes and grows in size as register taxes push inattentive consumers further from their optimal bundle.

Under the second alternate rule, the welfare effect of the shift for inattentive consumers is also similar to that found in Part I. Here the welfare effect is given by

$$\left.\frac{dV_B}{dt_r}\right|_{\overline{R}} = -\left(1 + \left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}}\right) U_y(x_B, y_B) x_B + \left(\frac{\partial x_B}{\partial p}\left.\frac{\partial t_p}{\partial t_r}\right|_{\overline{R}} - x_B \frac{\partial x_B}{\partial I}\right)\left(U_x(x_B, y_B) - (p + t_r + t_p) U_y(x_B, y_B)\right)$$

Again, the first term represents a positive income effect and the second term represents a negative welfare effect stemming from optimization error, which grows in size as register taxes increase.

[30] Because y represents all goods other than x, we assume that $\frac{\partial y_B}{\partial p} > 0$.

Appendix B: Welfare Analysis under Endogenous Producer Prices

This Appendix expands the model developed in Part I to the setting in which firms adjust their prices in response to changes in the type of tax imposed. Like before, the policy change we consider is an increase in the register tax accompanied by a reduction in the posted tax designed to keep government revenue unchanged.

For the attentive consumer (A), the welfare effect of the shift may be found by differentiating the indirect utility function:

$$\begin{aligned}\left.\frac{dV_a}{dt_r}\right|_R &= -U_y(x_A,y_A)\,(x_A)\left(\left.\frac{\partial p_x}{\partial t_r}\right|_R\right)\\ &= -U_y(x_A,y_A)\,(x_A)\left(1+\left.\frac{\partial t_p}{\partial t_r}\right|_R+\frac{\partial p}{\partial t_r}\right)\end{aligned}$$

This equation differs from (6) in that it reflects changes in the pre-tax price of x in addition to changes in the combined tax on x. In words, the welfare effect of the shift for A stems entirely from the change in the after-tax price of x, $p_x = p+t_p+t_r$. When the net effect is negative, $\left.\frac{dp_x}{dt_r}\right|_R < 0$, the resulting income effect makes A better off ($\left.\frac{dV_a}{dt_r}\right|_R > 0$). In turn, when the net effect of the shift is to raise the after-tax price of x, the associated income effect reduces A's welfare.

To solve for $\left.\frac{\partial t_p}{\partial t_r}\right|_R$ and $\left.\frac{\partial p}{\partial t_r}\right|_R$, consider the market clearing condition $x(p,t_p,t_r) = s(p)$, in which aggregate demand is the sum of demand by attentive and inattentive consumers, $x(p,t_p,t_r) \equiv x_a(p+t_p+t_r)+x_b(p+t_p)$, and $s(p)$ represents producer supply. Totally differentiating this condition as well as the government's budget constraint yields:

$$\begin{aligned}\left.\frac{\partial p}{\partial t_r}\right|_R &= \frac{\frac{\partial x_b}{\partial p}}{\frac{\partial x}{\partial p}-\frac{\partial s}{\partial p}-\frac{t_r+t_p}{x}\left(\frac{\partial x}{\partial p}\right)\left(\frac{\partial s}{\partial p}\right)}\\ \left.\frac{\partial t_p}{\partial t_r}\right|_R &= \frac{\frac{\partial s}{\partial p}-\frac{\partial x}{\partial p}+\frac{t_r+t_p}{x}\left(\frac{\partial s}{\partial p}\right)\left(\frac{\partial x_A}{\partial p}\right)}{\frac{\partial x}{\partial p}-\frac{\partial s}{\partial p}-\frac{t_r+t_p}{x}\left(\frac{\partial X}{\partial p}\right)\left(\frac{\partial s}{\partial p}\right)}\end{aligned}$$

Hence, the net effect of a revenue-neutral shift on the after-tax price of x is given by:

$$\begin{aligned}
\left.\frac{\mathrm{d}p_x}{\mathrm{d}t_r}\right|_R &= \left.\frac{\partial p}{\partial t_r}\right|_R + \left.\frac{\partial t_p}{\partial t_r}\right|_R + 1 \\
&= \frac{\frac{\partial x_b}{\partial p}\left(1-\frac{t_r+t_p}{x}\left(\frac{\partial s}{\partial p}\right)\right)}{\frac{\partial x}{\partial p}-\frac{\partial s}{\partial p}-\frac{t_r+t_p}{x}\left(\frac{\partial x}{\partial p}\right)\left(\frac{\partial s}{\partial p}\right)} \\
&= \frac{\frac{\partial x_b}{\partial p}\left(1-\frac{t_r+t_p}{x}\left(\frac{\partial s}{\partial p}\right)\right)}{\frac{\partial x}{\partial p}-\left(1-\frac{t_r+t_p}{x}\left(\frac{\partial s}{\partial p}\right)\right)-\left(\frac{\partial s}{\partial p}\right)}
\end{aligned}$$

The shift positively affects A's welfare if and only if

$$\frac{\frac{\partial x_b}{\partial p}\left(1-\frac{t_r+t_p}{x}\left(\frac{\partial s}{\partial p}\right)\right)}{\frac{\partial x}{\partial p}\left(1-\frac{t_r+t_p}{x}\left(\frac{\partial s}{\partial p}\right)-\frac{\partial s}{\partial p}\right)} > 0 \tag{20}$$

When will (20) hold? Some algebra yields the following sufficient conditions:

$$\varepsilon^s > \frac{p}{t_r+t_p} \tag{21}$$

$$\varepsilon < \frac{p}{t_r+t_p} \tag{22}$$

where ε^s and ε^d are the elasticities of supply and demand, both defined to be positive.[31]

When demand is too elastic, or supply is too inelastic, the shift from posted to register taxes causes a net increase in the after-tax price of x.[32] Intuitively, this result emerges because the shift to register taxes is equivalent to a reduction in the elasticity of aggregate consumer demand. When demand is relatively elastic and supply is relatively inelastic, much of the posted tax will have been shifted onto producers. Hence the change in incidence due to the shift will be large. In contrast, when supply is relatively elastic and demand is relatively inelastic, the change in incidence will be small, and as a result, the revenue mechanism described in Part I will dominate.

[31] These conditions are sufficient but not necessary for (20) to hold. In particular, as supply becomes more elastic, the elasticity of demand may be greater than $p/(t_r+t_p)$ without (20) being violated.

[32] Of course, consumers may ultimately benefit from the higher after-tax price when firms' income is distributed to its owners and employees. The final distributive effects of the shift will thus depend on how producer income is divided between attentive and inattentive agents. Incorporating such elements into the analysis is outside the scope of this paper.

Appendix C: A Cognitive Cost Model of Heterogeneous Attentiveness

How does attentiveness to register taxes vary by income? The model we develop in this Appendix does not make a uniform prediction for all goods, but rather highlights the factors that determine which income group will be more attentive for a particular good. We then consider those factors in the context of cigarettes to predict whether high- or low-income consumers are likely to be more attentive to cigarette register taxes.

Suppose all agents have the option of paying attention to register taxes, but that doing so carries with it some positive utility cost.[33] This "cognitive cost" could stem from the mental effort needed to remember and calculate a good's tax-inclusive price or might simply represent the opportunity cost of time spent on that task.

Assume that agents' final utility is additively separable between the cognitive cost and consumption so that we can write $W_i = U(x_i, y_i) - b_i c_i$ in which b_i is a binary choice variable indicating whether agent i pays the congitive cost and c_i is the magnitude of the cost for agent i. We assume that the cognitive cost is fixed for a given individual and does not depend on the register tax rate (it requires just as much effort to take a 6 cent register tax into account as a 7 cent one).

The timing of the model with cognitive costs proceeds as in Part I, except here we add an initial step in which agents choose whether or not they will take register taxes into account when deciding on their consumption of x. As before, all agents choose an intended consumption bundle $(\hat{x}, \hat{y})$ subject to their perceived budget constraint, which we can now express as $\widehat{BC}: x_i(p + b_i t_r + t_p) + y_i \leq M_i$.

A few final pieces of notation will be helpful. Let (x_i^*, y_i^*) denote the (optimal) bundle that i would consume if she were to pay attention to the register tax and let $(\tilde{x}, \tilde{y})$ denote the (sub-optimal) bundle she would consume were she to ignore the register tax. Agents who fail to pay the cognitive cost misperceive the after-tax price of x as being lower than it actually is; as a result, they over-spend on x and under-spend on y. The net change in i's utility from taking the tax into account is therefore given by

$$W(x_i^*, y_i^*, 1) - W(\tilde{x}_i, \tilde{y}_i, 0) = G_i - c_i$$

where $G_i \equiv U(x_i^*, y_i^*) - U(\tilde{x}, \tilde{y})$ represents the agent's utility gain from consuming the optimal feasible bundle.

We assume that agents opt to pay the cognitive cost when doing so affords them greater utility: $b_i = 1\{G_i - c_i \geq 0\}$. Although a full-fledged comparison between the utility that would be achieved in the two scenarios would likely require more cognitive effort than simply taking the tax into account in the first place, it seems reasonable that the agents who decide to pay the cognitive cost tend to be the ones for whom doing so has the most benefit.[34]

[33] The cognitive cost model we use as our starting point follows the basic approach laid out in Chetty, Looney, Kroft (2007).

[34] Another justification for this approach is that agents might make a one-time comparison between G_i and c_i to decide whether to pay the

Under the assumption that utility is additively separable in x and y, Chetty, Looney, and Kroft (2007) showed that one can express G_i (the gain in consumption utility from taking the tax into account) as

$$G_i = \frac{1}{2} t^2 \varepsilon_{x,p} x_i^* v'(y_i^*) \left(\frac{1}{p+t} + \mu_i \gamma_i \right)$$

where $U(x,y) = u(x) + v(y)$, $\varepsilon_{x,p}$ is the elasticity (defined to be positive) of x_i^* with respect to its price, $\mu_i \equiv \frac{x_i^*}{y_i^*}$represents the optimal ratio of x to y, and γ_i measures the curvature of $v()$ at y_i: $\gamma_i \equiv \frac{-v''(y_i^*)}{v'(y_i^*)} y_i^*$.

CLK allow differences in the extent to which individuals take taxes into account by assuming heterogeneity in the cognitive costs that agents face (c_i), although they do not model the sources of that heterogeneity. Because our goal is to link differences in attentiveness to agents' income, we allow G_i to vary over individuals while abstracting from individual heterogeneity in cognitive costs: $c_i = \overline{c}$.[35] In particular, we focus on individual heterogeneity that arises from differences in agents' income. For a fixed tax rate and price, we can write G_i as a function of the agent's income(M_i)

$$G(M_i) = \frac{1}{2} t^2 \varepsilon_{x,p}(M_i) \left\{ \frac{x_i^*(M_i)}{p+t} + \mu_i(M_i) \gamma_i(M_i) \right\} v'(y_i^*(M_i))$$

The question we are interested in is whether low- or high-income individuals are more likely to take register taxes into account. Because agents are alike apart from their incomes, the question at hand is whether $G(.)$ is increasing or decreasing in M_i. Differentiating the above expression with respect to income yields:

$$\frac{\partial G_i}{\partial M_i} = \frac{1}{2} t^2 \left\{ \frac{\partial \varepsilon_{x,p}}{\partial M_i} x_i^* A v'(y_i^*) + \frac{\partial A}{\partial M_i} \varepsilon_{x,p} x_i^* v'(y_i^*) + \frac{\partial v'(y_i^*)}{\partial M_i} \varepsilon_{x,p} x_i^* A \right\} + \frac{\partial x_i^*}{\partial M_i} \varepsilon_{x,p} A v'(y_i^*)$$

where $A = \frac{1}{p+t} + \mu_i(M_i) \gamma_i(M_i)$. Since A, x_i^*, $\varepsilon_{x,p}$ and $v'(y_i^*)$ are all positive, the key terms to sign are $\frac{\partial \varepsilon_{x,p}}{\partial M_i}$, $\frac{\partial A}{\partial M_i}$, $\frac{\partial x_i^*}{\partial M_i}$, and $\frac{\partial v'(y_i^*)}{\partial M_i}$.

First, consider $\frac{\partial v'(y_i^*)}{\partial M_i}$. We know that $\frac{\partial v'(y_i^*)}{\partial M_i} = v''(y_i^*) \frac{\partial y_i^*}{\partial M_i} < 0$ assuming concave utility and that y is a normal good. Intuitively, when the marginal utility of income declines rapidly with wealth, consumers who have little income to begin with are made much worse off by accidently over-spending on x.

Second, consider $\frac{\partial x_i^*}{\partial M_i}$. This term will be positive as long as x is a normal good, but will be smaller in magnitude for goods for which consumption does not much change as income rises. In words, consumers who consume more will gain more from optimizing correctly simply because the consumption difference caused by the optimization error will be larger in magnitude. When demand for x is relatively insensitive to income, contribution of this term

cognitive cost in future circumstance.

[35] In reality, cognitive costs may also be correlated with income. The correlation may be positive, if high earners are better at cognitive tasks of this sort, or negative, if high earners have a greater opportunity cost of time. The extension to either of these cases is straightforward.

will be small.

Next consider $\frac{\partial \varepsilon_{x,p}}{\partial M_i}$. Are high- or low-income consumers more price sensitive in their demand for x? In general, theory is ambiguous as to whether elasticities rise or fall with income (the sign depends upon the magnitude of the third derivative of the utility function with respect to x).

Finally, consider $\frac{\partial A}{\partial M_i} = \frac{\partial \mu_i}{\partial M_i}\gamma_i + \frac{\partial \gamma_i}{\partial M_i}\mu_i$. Let's take the two pieces in turn. $\frac{\partial x_i^*}{\partial M_i}$ is clearly positive as long as x is a normal good. $\frac{\partial \mu_i}{\partial M_i}$ refers to how the optimal ratio of x to y changes with income. This term is zero when preferences are homothetic and negative for consumption goods that constitute a larger share of expenditures for poor consumers than for rich consumers. The second term, $\frac{\partial \gamma_i}{\partial M_i}$, captures change in the curvature of utility from wealth as income rises; it will be weakly negative when consumers exhibit constant or decreasing relative risk aversion.

We have highlighted the factors that determine whether attentiveness to a register tax is increasing or decreasing by income. What does the analysis imply for the case of cigarettes? Regardless of the good in question, low-income consumers suffer more from lost consumption of other goods when they accidently overspend on the taxed good. The key determinants that vary between goods are $\frac{\partial x}{\partial M_i}$, $\frac{\partial \varepsilon_{x,p}}{\partial M_i}$, and $\frac{\partial \mu}{\partial M_i}$.

For the case of cigarettes, all three of these factors suggest that attentiveness to register taxes should decrease by income. The income elasticity of cigarettes is generally found to be quite small (or even negative), implying a low value for $\frac{\partial x}{\partial M_i}$. Similarly, on average, poor households spend a substantially larger fraction of their income on cigarettes compared to rich households (Chaloupka and Warner 2000), which implies that $\frac{\partial \mu}{\partial M_i} < 0$. Finally, the sign of $\frac{\partial \varepsilon_{x,p}}{\partial M_i}$ hinges on whether low- or high-income consumers are more sensitive to cigarette prices. The empirical literature on this question is mixed, with most studies concluding that low-income smokers are slightly more price sensitive and other studies finding the opposite. In our data, we find the differences in price-sensitivity between rich and poor smokers to be negligible, implying that $\frac{\partial \varepsilon_{x,p}}{\partial M_i}$ is small in magnitude.

As a whole, our model suggests that attentiveness to cigarette register taxes should decline by income. Low-income consumers suffer more when they over-spend on y because their marginal utility of wealth is greater than that of high-income consumers. Although the magnitude of the optimization error will in general be larger for high-income consumers (the difference between their intended and realized bundles is bigger), this factor is mitigated in the case of cigarettes by the fact that smoking demand is relatively insensitive to income and by the fact that low-income consumers spend a substantially higher fraction of their income on cigarettes compared to high-income consumers.