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AN ASSESSMENT OF THE FORWARD-LOOKING HYPOTHESIS OF THE DEMAND FOR CIGARETTES

Robert Kaestner
Kevin Callison

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Among economists, Michael Grossman was one of the first to conduct research on smoking and he has made many, important contributions that have advanced both theory and policy. Grossman's research on the economics of smoking spans his long and distinguished career and continues to this day (Grossman et al. 1981; Becker et al. 1994; Grossman and Chaloupka 1997; Grossman et al. 1998; Grossman et al. 2003; Saffer et al. 2018). In this article, we build on some of Grossman's research and we hope that our contribution honors his legacy.

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ABSTRACT

In this article we develop a model of the demand for cigarettes that incorporates forward-looking behavior related to the adverse health consequences of smoking and the addictive nature of cigarettes. The model results in several testable hypotheses that we use to examine the extent to which smokers exhibit forward-looking behavior. Results of our study are generally supportive of the notion that smokers behave in a forward-looking manner.

Robert Kaestner
Department of Economics
University of Illinois at Chicago
601 S. Morgan Street
Chicago, IL 60607
and Institute of Government and Public Affairs
and also NBER
kaestner.robert@gmail.com

Kevin Callison
Department of Global Health Management and Policy
School of Public Health and Tropical Medicine
Tulane University
1440 Canal Street
New Orleans, LA 70112
kcallison@tulane.edu

1. Introduction

Since the 1964 Surgeon General's report on smoking, cigarette consumption and the control of that consumption has been an important concern for policymakers. As indicated by the role of the Surgeon General, the policy interest in cigarettes stems, in part, from the harmful health consequences of smoking. Cigarettes, and taxes on their purchase, are also an important source of government revenue. These two features of cigarette consumption make cigarettes a particularly salient commodity to study and there is a large literature studying the health effects of smoking, the effects of regulatory policy on tobacco consumption, and the fiscal implications of tobacco taxation.

Cigarette consumption has also been a source of particular interest to economists and other social scientists (Chaloupka and Warner 2000; Cawley and Ruhm 2011). Part of the interest in cigarettes by social scientists is due to aspects of cigarette consumption that differentiate it from many other commodities. In particular, the potential external costs of smoking (e.g., second hand smoke), the addictive nature of cigarettes, and the future health consequences of smoking make cigarette consumption "different" from most other goods.

However, the feature of cigarette consumption that has garnered arguably the most theoretical attention from social scientists is the addictive nature of smoking (Becker et al. 1994; Grossman and Chaloupka 1997). Addiction implies that current cigarette consumption depends in some way on past consumption and many theories have been developed to explain how the physiological (e.g., tolerance) and psychological (e.g., regret) aspects of addiction affect the consumption of cigarettes (Becker and Murphy 1988; Jones 1989; Akerlof 1991; Orphanides and Zervos 1995; Gruber and Kozegi 2001; Bernheim and Rangel 2004).

A prominent theory of cigarette consumption in economics is the rational addiction model of Becker and Murphy (1988) and its variants (Barthold and Hochman 1988; Michaels 1988; Suranovic et al. 1999). The key prediction of this model is that current consumption is influenced not only by past consumption, as in myopic models of consumer behavior and in models of habit persistence, but also by future consumption because consumers are rational and understand that their actions today affect their actions tomorrow. A key prediction of the rational addiction model is that addictive goods exhibit a larger long-run price elasticity of demand than short-run elasticity because contemporaneous changes in price affect future demand. Several papers have tested this prediction and found evidence to support the rational addiction model (e.g., Chaloupka 1991; Becker et al. 1994; Keeler et al. 1993; Fenn et al. 2001). However, there have also been studies that have pointed out the fragility of these estimates, and, in general, that empirical assessment of the rational addiction model is difficult given current data and methods (Baltagi and Griffin 2001; Gruber and Koszegi 2001; Auld and Grootendorst 2004; Laporte et al. 2017).

While most, if not all, empirical studies in economics have focused on testing the prediction of the rational addiction model that past and future consumption of cigarettes influence current consumption, the forward looking aspect of the model implies several other predictions that are arguably easier to assess empirically.[1] In particular, the future consequences of current cigarette consumption in terms of effects on health and effects on the value (utility) of future consumption generate predictions about the heterogeneity of the price responsiveness of cigarette consumption. For example, as the price of cigarettes increases, consumers will adjust cigarette consumption in response to the new price and decrease use. However, in a forward-looking model, as cigarette use declines in response to a price increase, the non-monetary costs of smoking fall because of the reduced future adverse health effects of cigarette consumption. This decrease in the non-monetary costs of smoking offsets some of the increased monetary cost and mutes the consumption response to a price increase. Therefore, those who experience particularly

[1] We do not know of any studies that assess the rational addiction model other than by assessing whether past and future consumption affect current consumption.

large adverse health effects of smoking will be less likely to quit smoking after a price increase (all else equal). In other words, such persons will have a smaller price elasticity of demand.[2]

In this article, we formalize the intuition just described about the relationship between the price elasticity of demand for cigarettes and the observable characteristics of smokers. We develop a simple theory of the demand for cigarettes that incorporates forward-looking behavior related to the adverse health consequences of smoking and the addictive nature of cigarettes. We then use the model to generate several hypotheses about the heterogeneity of the relationship between cigarette price/tax changes and changes in cigarette consumption. To our knowledge, our predictions and tests of those predictions are novel.

To test these hypotheses, we use data from the Behavioral Risk Factor Surveillance System (BRFSS) and the Current Population Survey Tobacco Use Supplements (CPS-TUS). We focus on 38 recent, large (>$0.50) increases in state excise taxes to make the comparisons of interest. Notably, we use a paired difference-in-differences (paired-DiD) model to obtain estimates of associations between tax changes and smoking participation and then test whether these associations differ by individual characteristics that are indicative of the forward-looking behavior of smokers. The paired-DiD model treats each state tax change as a separate (quasi) experiment and relies on a paired grouping of comparison states that are matched on pre-period smoking rates (Callison and Kaestner, 2014). We provide further explanation of the method below.

Results of our study are generally supportive of the forward-looking model of smokers. Specifically, we find that smokers appear to be less addicted after a tax increase and that the price responsiveness of smoking is larger for those with stronger preferences for the present. Both of these results are consistent with forward-looking behavior. We find no evidence to support the prediction that price responsiveness differs by self-rated health, although self-rated health may

[2] They will also be less likely to smoke all else equal.

not measure accurately the health consequences of smoking. Finally, we find that high-income persons are more price elastic than low-income smokers, which is inconsistent with predictions of our model of forward-looking behavior, but this prediction is not definitive because of it is also consistent with an income effect in the traditional model of the consumer.

2. A Simple Model of Forward Looking Behavior of Cigarette Consumption

We use a two-period model of consumer choice to model the demand for cigarettes and generate testable hypotheses of forward-looking behavior (Becker 2007). In our model, consumers value consumption other than cigarettes, which is denoted by *X*, and cigarettes, which is denoted by *C.* It is a two period model where everyone lives through the first period, but survival in the second period is uncertain. The survival probability is denoted by *S*, and survival depends on cigarette consumption in the first period. This feature of the model incorporates the adverse health consequences of smoking that make the forward-looking behavior of the consumer relevant.[3] Biological considerations related to addiction suggest another type of potential inter-temporal dynamic of the demand for smoking. Addiction implies that the value of current cigarette consumption depends on past consumption because of the tolerance and reinforcement effects of nicotine. We use δ to represent the influence of past consumption on the utility gained from current consumption and incorporate this feature into the model using a simple multiplicative specification [see below, $\delta(C_1)U(C_2)$].[4] We assume that utility is separable in

[3] In this model, a "harmful addiction" is one in which there are negative health (social) consequences. Becker and Murphy (1988) define a harmful addiction as one in which past consumption lowers future utility, although they do not specify that it is due to health. They refer to tolerance as a possible reason for lower utility, but this conflates health consequences with the characteristics of consumption of the good (i.e., tolerance and reinforcement).

[4] Typically, economic models of rational addiction (e.g., Becker and Murphy 1988) separate the effects of past consumption on current consumption into tolerance, which lowers utility of current consumption, and reinforcement, which raises the value of current consumption. As noted, the tolerance mechanism of these models can be viewed, although not in a very intuitive way, as analogous to the adverse health consequence in our model. Addiction in these models is defined as the condition that past consumption raises future consumption, which essentially assumes that on average there is reinforcement.

consumption (X) and cigarettes (C) and separable over time. Consumers discount the future and the discount rate (one over one plus the rate of time preference) is denoted by B. Algebraically, consumer lifetime utility is:

$$(1)\quad U = U(X_1) + U(C_1) + BS(C_1)[U(X_2) + \delta(C_1)U(C_2)]$$

In equation (1), the forward-looking behavior of consumers is captured by the dependence of the survival function on past cigarette consumption and the dependence of utility of cigarettes in period two on cigarette consumption in period one [$\delta(C_1)U(C_2)$].[5]

Turning to the budget constraint, consumers have exogenous income W in each period and pay a price p for cigarettes. The price of consumption is normalized to one. We assume there is a fair annuity market that equates expected income to expected lifetime expenditures. Consumers face an interest rate of r to lend or borrow. The consumer's budget constraint is thus:

$$(2)\quad X_1 + pC_1 + \frac{S(C_1)}{(1+r)}(X_2 + pC_2) = W_1 + W_2\frac{S(C_1)}{(1+r)}$$

Given this setup, the consumer makes choices about the optimal amount of consumption and cigarette use in each period. The first order conditions for cigarette consumption in periods one and two are:

$$(3)\quad U_{c1} + B\frac{\partial S}{\partial C_1}[U(X_2) + \delta(C_1)U(C_2)] + BS(C_1)\frac{\partial \delta}{\partial C_1}U(C_2) - \lambda_p - \lambda\frac{\partial S}{\partial C_1}\frac{1}{1+r}(pC_2 + X_2 - W_2) = 0 \rightarrow$$

$$U_{c1} = \lambda\left[p + \frac{\partial S}{\partial C_1}\frac{1}{1+r}(pC_2 + X_2 - W_2)\right] - B\frac{\partial S}{\partial C_1}[U(X_2) + \delta(C_1)U(C_2)] - BS(C_1)\frac{\partial \delta}{\partial C_1}U(C_2)$$

and,

$$(4)\quad U_{c2}BS(C_1)\delta(C_1) - \lambda\frac{S(C_1)}{1+r}p = 0 \rightarrow$$

[5] We assume that δ=1 in period one.

$$U_{c2} B\delta(C_1) = \lambda \frac{p}{1+r}$$

If we assume that the rate of interest equals the rate of time preference, then the consumer will choose a constant rate of consumption (*X*) in each period and the marginal utility of consumption (U_x) is equal to the Lagrange multiplier (λ). Using this result and rewriting equations (3) and (4) yield:

(5) $$U_{c1} = U_x \left[p + \frac{\partial S}{\partial C_1} \frac{1}{1+r} (pC_2 + X_2 - W_2)\right] - B \frac{\partial S}{\partial C_1} [U(X_2) + \delta(C_1) U(C_2)] - BS(C_1) \frac{\partial \delta}{\partial C_1} U(C_2)$$

(6) $$U_{c2} \delta(C_1) = U_x p$$

Equations (5) and (6) are the standard results indicating that, in each period, the consumer equates the marginal benefit and marginal cost of cigarette consumption. The marginal benefit of cigarette consumption is the marginal utility of smoking. The marginal cost of first period cigarette consumption is the utility from foregone consumption of other goods ($U_x p$), the change in utility associated with the change in savings necessary to fund second period spending because of the lower survival probability [$\frac{\partial S}{\partial C_1} \frac{1}{1+r} (pC_2 + X_2 - W_2)$], the decreased utility in period two because of a lower probability of survival {$B \frac{\partial S}{\partial C_1} [U(X_2) + \delta(C_1) U(C_2)]$}, and the change in utility of second period cigarette consumption due to the additive nature of cigarettes, for example, because of greater tolerance and/or reinforcement of cigarette consumption [$BS(C_1) \frac{\partial \delta}{\partial C_1} U(C_2)$]. Note that the sign of the last term can be negative (benefit) or positive (cost) because tolerance and reinforcement have opposite effects on the utility of cigarette consumption. If the last term is positive, then as shown in equation (6), past consumption raises the benefits of future consumption. This is what Becker and Murphy (1988) define as addiction.[6] The marginal cost of second period consumption is just the utility from foregone consumption of other goods.[7]

Importantly, in the absence of forward-looking behavior by consumers about the health and addictive consequences of smoking, equation (5) would effectively become:

(7) $U_{c1} = U_X p$,

which is the standard result from the generic model of consumer choice. For this to be the case, the consumer would in effect assume that there were no future consequences of smoking (i.e., $\frac{\partial S}{\partial C_1} = 0$ and $\frac{\partial \delta}{\partial C_1} = 0$).

2.1. Heterogeneity of the Price Elasticity of Demand

In this section, we examine how the responsiveness of smoking to changes in prices differs by the exogenous factors in equation (5), which we express in slightly different form:

(8) $U_{C1} - U_X p = U_X \frac{\partial S}{\partial C_1} \frac{1}{1+r} (pC_2 + X_2 - W_2) - B \frac{\partial S}{\partial C_1} [U(X_2) +$

$\delta(C_1)U(C_2)] - BS(C_1) \frac{\partial \delta}{\partial C_1} U(C_2)$

The interesting aspect of equation (8) is that the left-hand side is not equal to zero, as in the traditional model of the consumer. The reason for this is that there are non-monetary costs of smoking that are given by the right-hand side of equation (8). These include the adverse health effects of smoking and the future costs of smoking resulting from the addictive nature of cigarettes. Equation (8) shows that for a given price of cigarettes, all else equal (e.g., income) there can be consumers with different preferences for other consumption (*X*) and cigarettes (*C*) because of differences in the other determinants of the cost of smoking. A person with relatively weak preferences for smoking [relatively low value of left hand side of equation (8)] may still

[6] We assume that the equilibrium is stable and ignore the dynamics that are part of some rational addiction models.
[7] We can make δ(0)=0 so that if you do not smoke in first period you do not smoke in second.

smoke if they face lower non-monetary costs of smoking, for example, because the health consequences of smoking are relatively small. Moreover, a price change will change the composition of consumers not just with respect to preferences, but also with respect to the non-price costs of smoking.

Equation (8) indicates that an increase in price (tax) of cigarettes raises the monetary marginal cost of smoking causing some, but not all, people to quit smoking. The response to the price increase is not random, however, and is systematically related to preferences and the non-monetary costs of smoking. Before describing how the price response differs by factors determining the non-monetary cost of smoking, it is important to note that the only choice variables in equation (8) are cigarette use and other consumption. So, a consumer can respond to a price increase *only* by altering these consumption choices, but not other parameters in equation (8) (e.g., time preference). However, these other parameters will interact with changes in cigarette use and will affect the change in the total cost of smoking that go beyond the price change.

Based on equation (8), the model predicts that a price increase will have a larger effect among those with the following characteristics:

1. Relatively weak preferences for cigarettes. This is the case in the traditional model (equation 7) and the forward-looking model (equation 8). However, in the forward-looking model, preferences will have a less dominant effect because there are other pathways that will influence the change in consumption necessary to maintain the equilibrium.
2. A higher degree of addiction, perhaps because of biological factors. For those who are more addicted, (i.e. when reinforcement dominates tolerance, $\frac{\partial \delta}{\partial C_1} > 0$) reductions in smoking in response to a price increase also erode the "addictive" benefits of prior smoking. This addictive channel increases the non-monetary cost of smoking and

raises the total cost of smoking above the increase due solely to price. Thus, these persons will exhibit a larger response to a price change.

3. Lower incomes. This result is because the reduction in smoking from a price increase also reduces the adverse health effects of smoking and raises second period utility, which offsets some of the price increase and moderates the total change in marginal cost. Those with lower incomes will have a smaller offset because they are less wealthy and utility is relatively lower. Thus, the increase in utility from a higher price and less current consumption is less for those with lower incomes than it is for those with higher. Therefore, the total change in the marginal cost associated with a price increase is greater for those with lower incomes and so their response is predicted to be larger.[8]
4. Small adverse effects of smoking on health ($\frac{\partial S}{\partial C_1}$). This prediction stems from the fact that reductions in smoking because of a price increase raises future utility because it reduces the future, adverse health impacts of smoking and lowers non-monetary costs. For those who do not have large impacts on health (survival) the decrease in the non-monetary costs of smoking is smaller and offsets less of increase in monetary costs. Thus, those for whom smoking has few adverse health impacts will have a larger consumption response to a change in price.
5. Stronger preferences for the present. This result is because the improvement in survival (and greater future utility) that accompany smoking reductions due to price increases provide relatively little value to those who heavily discount the future. So those who are more present-oriented experience larger changes in the marginal cost of smoking following a price increase and will respond more strongly.

2.2. Summary

[8] We have ignored income effects at this point, but discuss them later in the article.

The economics of the demand for cigarettes is different than many other commodities because of the inter-temporal linkages associated with cigarette consumption that arise due to the future health consequences of smoking and the addictive nature of smoking. For the most part, empirical analyses have assessed the importance of these linkages primarily by evaluating whether past and future prices (consumption) of cigarettes are associated with current consumption. However, this empirical strategy is most germane to the addictive nature of smoking, and largely ignores the health consequences. It is also difficult to test this hypothesis empirically (Baltagi and Griffin 2001).

Here, we take a different approach. The simple theoretical model presented here demonstrates that the importance of the "dynamic" aspects of the demand for cigarettes may also be assessed by examining heterogeneity in the price responsiveness of smoking participation. If smokers exhibit forward-looking behavior, a price increase will have a larger effect on smoking participation for those who are more present oriented, who are more addicted to cigarettes, whose health is relatively unaffected by smoking, and who have a lower income. In addition, and like the traditional model, the responsiveness of smoking to price will be larger for those with relatively weaker preferences and lower income.

3. Empirical Strategy

Our theoretical model of smokers' forward-looking behavior presented in the previous section predicted that an increase in the price of cigarettes would have heterogeneous effects on smoking participation by individual characteristics. Accordingly, we estimate a series of empirical models that identify changes in smoking participation associated with a state cigarette tax increase to test the hypotheses generated by the model.

Following our earlier work on cigarette tax increases and smoking, we specify a "paired difference-in-differences" (paired-DiD) model that pairs a state experiencing a cigarette tax increase (i.e. treatment state) with a control group of states that have similar smoking rates, but no tax change (Callison and Kaestner, 2014). There are two advantages of this approach over the more commonly used two-way fixed effects model (difference-in-differences) that include state- and year-fixed effects. The first is that we match treated and control states using baseline smoking rates, which has intuitive appeal and plausibly improves the likelihood that the parallel trends assumption holds. Second, it facilitates a falsification exercise because we can re-estimate the models using the same matched treated and control states, but in periods when there was no tax change. We discuss the construction of the state groupings and the falsification tests in more detail below, but first we discuss the paired-DiD regression specification, which takes the following form:

$$(9)\ Y_{ijkt} = \alpha_0 + \alpha_1 Tax_{jt} + \alpha_2 X_{ijkt} + \alpha_3 Z_{jkt} + \sum_{jk} \pi_{jk} State_{jk} + \sum_{kt} \rho_{kt} Post_{kt} + \sum_{kt} \sigma_{kt} Group_{kt} + \varepsilon_{ijkt}$$

In most analyses, the dependent variable in equation (9) is a dichotomous variable indicating whether person *i* in state *j*, state grouping *k*, and month-year *t* smokes every day or some days. For our analysis of heterogeneity in response to a tax increase by degree of addiction, we condition on current smokers and use minutes from waking to smoking the first cigarette of the day as the dependent variable. The choice to condition on smokers for this outcome is necessitated by the data as time to first cigarette is only applicable to current smokers. Time from waking to first cigarette is a commonly used measure of strength of addiction, as those who are less addicted tend to wait longer to smoke their first cigarette of the day, and allows us to test our hypothesis that those who are more addicted will be more responsive to a change in price (tax) (Baker et al., 2007; Branstetter et al., 2015; Heatherton et al., 1989). This information is only collected form smokers. The remaining variables are as follows: *Tax* is the nominal state cigarette tax in dollars; *Z* is a vector of clean-air ordinances including bans on cigarette smoking in workplaces, restaurants, or bars; *State* is an indicator for state *j*; *Post* is an indicator the for the post-tax increase period; *Group* is an indicator for each grouping of treatment and control states;

and X is a vector of individual demographic and socioeconomic characteristics. In practice, we use a less restrictive specification for individual controls by creating dichotomous indicators of demographic groups defined by the interaction of age groups (age 20 to age 79 in five-year intervals), sex, race/ethnicity (white or non-white), education (less than high school, high school, some college, or college), and marital status (married or not married). This process results in 384 demographic indicators that enter the model separately.

The inclusion of the state and group fixed effects in equation (9) ensures that our identification relies on within-state changes in cigarette taxes over time between treatment and control states in the same grouping. By definition these changes are equal to zero for the control states in each group, so that the variable *Tax* in equation (9) is similar to the variable of interest in a standard difference-in-differences regression model.

To test the predictions of our theoretical model, we interact the *Tax* variable in equation (9) with family income, self-rated health (which is a proxy for the adverse health consequences of smoking), and proxy measures of time preference: health insurance coverage, flu shot receipt, doctor and dentist visits, and seat belt use. Estimates associated with these interactions provide evidence as to whether smokers are forward-looking in their behavioral responses to a price increase. We also estimate a specification using time from waking to first cigarette as the dependent variable to measure changes in strength of addiction between smokers before and after a tax increase. Note that we do not test whether those with relatively weak preferences for cigarettes will be more responsive to a price increase. There are two reasons for this: there is not good information available to characterize peoples preferences, and the prediction is the same for both the traditional and forward-looking models and, therefore, does not aid us in distinguishing between the two.

4. Data

The primary data for our analysis comes from the 2001-2010 waves of the Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is a large-scale national survey administered by the Centers for Disease Control and Prevention that focuses on risky behaviors related to health. Along with demographic and socioeconomic characteristics the survey contains information on smoking participation (whether a respondent smokes every day, some days, or not at all) and the proxies for individual discount rate and degree of addiction listed above.

We limit the sample to the years 2001-2010 to coincide with several large state cigarette tax increases and because the BRFSS survey design changed significantly beginning in 2011. Furthermore, we restrict the sample to adults between the ages of 20 and 79 with non-missing information on current smoking behavior, race/ethnicity, education, marital status, family income, health insurance coverage, flu shot receipt, and self-reported health.[9]

To construct our paired-DiD sample, we began by identifying state cigarette tax increases of $0.50 or greater that occurred during our study period. Focusing on relatively large tax increases allows us to identify changes in the composition of smokers before and after the tax change that would be difficult to identify using more modest increases. We obtained data on cigarette tax changes from *The Tax Burden on Tobacco*, an annual compilation of tobacco taxes and tobacco revenue published by the consulting firm Orzechowski and Walker and data on state-level smoking restrictions from the American Nonsmokers' Rights Foundation (ANRF, 2017; Orzechowski and Walker 2012). This resulted in 38 “treatment states" (i.e. states imposing a tax increase) to which we assigned specific control states based on smoking rates in the pre-tax increase period. Specifically, we matched states with statistically similar pre-treatment smoking rates and no tax change over the treatment period with each of our 38 treatment states. The treatment period for each matched grouping consisted of a pre- and post-period of at least six months and often more than one year that preceded or followed the tax increase in the treatment

[9] The requirement that those in our sample have non-missing information for health insurance coverage, flu shot receipt, and self-reported health reduces our full sample by approximately 1.3%.

state where no other tax changes occurred for any state in the grouping. We then combined each of these 38 treatment and control groups into a single dataset for the analyses that follow.[10] We list each of these tax increases in Appendix Table 1.

One shortcoming of the BRFSS is that the survey lacks a proxy for degree of addiction, making it difficult to test that aspect of the forward-looking behavior. To address this issue, we supplement our analysis with data from the Current Population Survey Tobacco Use Supplement (CPS-TUS) from 1999 to 2011, which asks current smokers how long they wait from waking until smoking their first cigarette of the day.[11] The CPS-TUS also contains information about smoking participation and relevant demographic characteristics including age, sex, race, education, marital status, employment status, family income, and state of residence so that we can estimate certain models using samples from both the BRFSS and CPS-TUS data.

Descriptive statistics for our sample are shown in Table 1. There are very few differences in smoking outcomes between our treatment and control states. For example, 14.6% of individuals in both the treatment and control states report that they smoke every day. Demographic and socioeconomic characteristics of those living in treatment and control states are largely similar with a few exceptions: those living in treatment states are less likely to be married, more likely to be non-white, and slightly more likely to have a college degree and report family income greater than $75,000 per year. Lastly we note that, as expected, cigarette taxes are substantially higher in treatment states and smoke-free air ordinances (i.e. smoking bans) are more common.

[10] Because some control states are assigned to different treatment states, and because some treatment states act as controls in certain periods, individual observations often appear multiple times in our constructed dataset.
[11] CPS-TUS data used in the analyses are from the following waves of the CPS: June and November 2001, February 2002, February, June, and November 2003, May and August 2006, and January 2007, May and August 2010, and January 2011. January and May 2000 are omitted because they lack data on smoking intensity.

5. Results

5.1. Validity of the Paired-DiD Research Design

As with any difference-in-differences analysis, the validity of our research design depends on the parallel trends assumption. In other words, smoking participation rates should trend similarly for treatment and control states in the absence of a tax change. By definition, our paired-DiD approach is likely to satisfy this assumption because we selected treatment and control states based on pre-tax increase smoking rates. However, before discussing implications for the forward-looking behavior of smokers, we provide evidence that smoking participation rates were trending similarly for treatment and control states in the months before a tax increase.

To do so, we estimated an event-study model to test for statistical differences in pre-period smoking rates between the treatment and control states using our BRFSS sample.[12] The specification for our event-study is similar to equation (9), but replaces the *Tax* variable with interactions between an indicator for treatment status and indicators for years before and after a tax increase takes effect for each treatment state in the 38 separate groupings.[13]

Regression estimates from our event-study model for every day smoking participation are plotted in Figure 1 and can be interpreted as differential changes in smoking participation for treatment states relative to 3 or more years prior to the tax increase. Results indicate no statistically significant differences in smoking trends between treatment and control states in the two years before a tax increase. The pattern of coefficient estimates suggests that smoking rates for treatment states noticeably diverge from control states in the period before and after the tax increase (i.e., a break in trend). In addition, we conducted separate partial F-tests on the pre- and post-period interaction terms in the model and found no joint significance for pre-period terms, while the post-period interaction terms were jointly significant at the 5% level.

[12] Note that it is not possible to test for parallel trends in the pre-tax increase period using the CPS-TUS sample as many state groupings have only one wave of pre-period data.
[13] We do not have a balanced panel due to the construction of our state groupings. We have fewer observations in the sample the further we move in time from the date of the tax increase.

In addition to the standard parallel trends analysis, the nature of the paired-DiD design allows us to conduct a series of falsification or "placebo" tests where we restrict the same state groupings to periods where no tax increase occurred. We then randomly assign a $0.50 tax increase to one state in each grouping and re-estimate our empirical model. Since no actual tax increase occurred for any state in the placebo analysis, we expect the coefficients on our tax variable and interactions of our tax variable with individual characteristics to be zero. Results for our placebo analyses are presented in Appendix Table 2. While we do find some marginally statistically significant estimates in our placebo test using the BRFSS data (p-value <0.10), we find no such statistical significance in the CPS. Furthermore, estimates in Appendix Table 2 using both the BRFSS sample and the CPS sample are close to zero, and, even when marginally significant, only a fraction of the magnitude of esitmates in Table 2 (see next). Together, the event study analysis and the placebo assessment provide evidence that the paired, DiD approach is valid.

5.2. Cigarette Tax Increases and Smoking Participation

We begin by presenting paired-DiD results for the effect of state cigarette tax increases on smoking participation. Table 2 presents estimates of equation (9) and establishes a baseline relationship between tax increases and smoking participation. Columns 1 and 2 contain estimates on a sample of those who report smoking every day in both the BRFSS and CPS data, while columns 3 and 4 include both every day and some day smokers. Estimates in all four columns indicate that increases in state cigarette taxes are associated with small reductions in smoking participation. For example, using the BRFSS data we find that a $1.00 tax increase results in a 1 percentage point reduction in the probability of being an everyday smoker, a relative reduction of 6.8%. Estimates for everyday smokers using the CPS are also negative, but smaller than the BRFSS estimates. Using the CPS sample, a $1.00 tax increase leads to a 0.6 percentage point (4%) reduction in everyday smoking. Estimates from models that include every day and some day smoking are similar in magnitude to those reported for everyday smokers only. And, as noted, the placebo estimates analogous to these estimates were small and only marginally statistically significant for the BRFSS sample. Our estimates of the effect of a tax increase on smoking participation using the paired-DiD technique are smaller than those commonly found in the literature, but are nearly identical in magnitude to a previous analysis using a paired-DiD specification and a different dataset (Callison and Kaestner, 2014).

5.3. Do Tax Induced Changes in Smoking Participation Differ by Strength of Addiction?

According to our model of forward-looking behavior, those who are more addicted to cigarettes should experience a larger response to a price increase. We test this prediction by using time from waking to first cigarette as a proxy measure for addiction strength and consider more time passing before the first daily cigarette is smoked as an indication that addiction strength has weakened. In addition, since this measure is only available among those who smoke, the sample is limited to smokers and the dependent variable time to first cigarette. In this case, the prediction is that smokers who are more (less) addicted to cigarettes should exhibit a larger (smaller) response to a tax increase. This prediction is because, for this group, the non-monetary cost of smoking increase as cigarette consumption decreases and raises the total cost of smoking above the increase due solely to price.

Columns 1 through 4 of Table 3 include estimates of the effect of a cigarette tax increase on the average time from waking to the first cigarette smoked. We include four measures of time to first cigarette in Table 5: less than 15 minutes after waking, less than 30 minutes after waking, more than 60 minutes after waking, or more than 120 minutes after waking. Estimates suggest that those who continue to smoke following a tax increase are less likely to smoke their first cigarette of the day within 15 minutes of waking and more likely to wait more than 2 hours. The probability of smoking the first daily cigarette within 15 minutes of waking falls by 1.9 percentage points, or 5.7%, while the probability of waiting at least two hours to smoke the first cigarette increases by 1.8 percentage points, or 7.3%. The coefficients on less than 30 minutes and more than 60 minutes are consistent with a pattern of delayed time to first daily cigarette, though not statistically significant. These results suggest that smokers who are more addicted to cigarettes are more responsive to a tax increase than those who are less addicted, a finding that supports the forward-looking behavior of smokers.

5.4. Do Tax Induced Changes in Smoking Participation Differ by Income?

Our theoretical model predicts that those with lower incomes are more likely to quit smoking in response to a tax increase. This prediction is again based on the forward-looking behavior of smokers and ignores the potential income effects associated with an increase in the price of cigarettes. Income effects of the traditional model also suggest that low-income smokers will be more likely to respond to a tax increase, particularly because lower income smokers devote a greater proportion of their income to cigarette consumption.[14]

We examine this prediction empirically by allowing the effect of state cigarette tax to differ by categories of family income. Results for every day and some day smokers using both the BRFSS and CPS data are presented in Table 4. Estimates of the interaction terms in the BRFSS sample reported in columns 1 and 3 are negative, which suggests that higher income respondents are more responsive to a tax increase compared to those with lower incomes. Similar estimates using the CPS sample are reported in columns 2 and 4 and show no differential effect of a cigarette tax increase by family income. Neither of these findings are consistent with either the traditional or forward-looking models of smokers. We return to the relationship between income and smoking participation in subsequent analyses.

5.5. Do Tax Induced Changes in Smoking Participation Differ by Health Status?

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[14] The empirical evidence on whether low-income or high-income have larger response to a price increase is mixed (Farrelly et al. 2001; Remler 2004; Vijayaraghavan et al. 2013).

The forward-looking model predicts that those for whom the adverse health effects of smoking are small will be more responsive to a price increase. We test this hypothesis by including measures of individual health and interactions of health with state tax. Our measure for health status is an indicator for whether the respondent reports being in excellent or very good health. Health status is only included in the BRFSS data, so the analysis in this section is limited to that dataset.[15]

Table 5 presents our estimates for health. Whether focusing on every day smokers in column 1 or every day and some day smokers in column 2, we find that those in better health are less likely to smoke. However, the coefficient on the interaction term between excellent/very good health and state tax is statistically insignificant and near zero suggesting that there is no differential response to a tax change by health status. This finding does not support a model of smokers' forward-looking behavior where those in better health are expected to be less responsive to a price increase.

Additionally, Table 5 retains estimates of the effect of a state tax increase by family income. The differential effect of a tax increase on smoking participation by income level becomes more apparent with the inclusion of self-rated health and proxies for risk-preference. We now find stronger evidence that those with higher incomes are more responsive to a tax increase, which is inconsistent with both the traditional and forward-looking models.

5.5. Do Tax Induced Changes in Smoking Participation Differ by Time Preference?

We use several proxy measures for time preference including: whether the respondent has health insurance coverage, received a flu shot in the past 12 months, reported a doctor or dentist visit in the past 12 months, or reports always or nearly always wearing a seat belt when driving.

[15] We acknowledge that the correlation between self-rated health and whether cigarettes adversely affect health is not perfect, but we expect it to be positive.

Questions on doctor/dentist visits and seatbelt use are only included intermittently in the BRFSS and, therefore, we present results with and without these characteristics for consistency.

We begin with Table 6, which includes the two of our four measures of time preference that are available for the full sample, health insurance coverage and flu shot receipt. Having health insurance coverage and receiving a flu shot in the past 12 months are negatively associated with current smoking participation. Estimates in column 1 for the interaction terms between health insurance and flu shot and tax are positive and statistically significant for every day smokers, which is consistent with the predictions of the forward-looking model. Column 2 reports results for every day or some day smokers. Estimates are somewhat smaller in magnitude compared to every day smokers, but follow a similar pattern. These findings coincide with our model of forward-looking behavior, which predicted that smokers with stronger preferences for the present, which we proxy by the absence of health insurance and absence of a flu shot, would be more likely to quit after a tax increase. Furthermore, the differential response to a tax increase by income is more firmly established with the addition of the time preference proxies.

Table 7 extends the analysis of time preference and smokers' response to a tax increase by adding an indicator for a doctor or dentist visit in the past year to the regression specification used to generate the results in Table 6. We present results for this model separately because information on doctor or dentist visits is missing for a large share of our BRFSS sample. To differentiate between any effects of using the reduced sample and the effects of including the doctor/dentist visit indicator, columns 1 and 3 of Table 7 re-estimate the specification used in Table 6 on the reduced sample, while columns 2 and 4 add the new proxy measure for time preference.

As expected, those who were more likely to visit a doctor or dentist in the past 12 months, (i.e. have a stronger preference for the future), are also less likely to smoke. In accordance with our findings in Table 6, we find evidence that the price responsiveness of smoking is larger for those with stronger preferences for the present. The interaction term between doctor/dentist visit and state tax is positive and statistically significant indicating that price responsiveness is smaller for those who are future oriented.

Table 8 adds our last proxy measure for time preference, an indicator for always or nearly always wearing a seat belt while driving. Because our sample is further reduced with the inclusion of seat belt use, we once again repeat the pattern in Table 7 and present estimates of the previous specification on the reduced sample in columns 1 and 3 and add the new measure in columns 2 and 4. Unlike our previous results on the relationship between time preference and smoking participation after a tax increase, it appears that those who always or nearly always wear a seat belt are *more* responsive to a tax increase, although the coefficient estimates are small and only marginally statistically significant.

In sum, our analysis of the differential response to a cigarette tax increase by time preference provides evidence that supports a model of the forward-looking behavior of smokers. Proxies for time preference that include health insurance coverage, flu shot receipt, and doctor or dentist visits all indicate that those who are more present-oriented are more responsive to a tax increase. Only our results for seatbelt use fail to show this pattern, although estimates for this outcome are less precise due to a significant reduction in sample size. These findings support the prediction from our model of the forward-looking behavior of smokers that suggests those who are more present-oriented will be more likely to quit following a price increase.

6. Conclusion

While the inter-temporal aspect of cigarette consumption has received significant theoretical consideration in the economics literature, empirical evidence on the forward-looking behavior of smokers has concentrated primarily on the relationship between past and future prices and current cigarette consumption that stem from the rational addiction model (Becker and Murphy 1988). However, a number of studies have raised concerns about the validity and feasibility of empirical analyses of the rational addiction model (Balatagi and Griffin 2001; Gruber and Koszegi 2001; Auld and Grootendorst 2004; Gruber and Koszegi 2004).

In this article, we develop a simple model of the demand for cigarettes that incorporates the forward-looking behavior of smokers and both the adverse health consequences of smoking and the addictive aspects of nicotine. Unlike previous efforts to identify smokers' forward-looking behavior, our model does not focus on the role of past or future cigarette consumption in determining current consumption levels. Instead, we use the model to derive a number of testable predictions concerning heterogeneity in the price responsiveness of smoking to taxes. The advantages of our approach are that we have a richer set of predictions to test and we are able to sidestep the empirical challenges associated with earlier research in this area (Baltagi and Griffin 2001; Gruber and Koszegi 2001; Auld and Grootendorst 2004).

Our forward-looking model predicts that the price responsiveness of smoking should be larger for those who are more present-oriented, who are more addicted to cigarettes, whose health is relatively unaffected by smoking, and who have a lower income. In addition, and like the traditional model, the responsiveness of smoking to price will be larger for those with relatively weaker preferences and lower income. We tested these predictions using data from the BRFSS and the CPS-TUS along with a paired-DiD methodology that targeted 38 large state cigarette tax increases.

Overall, we generally found evidence consistent with predictions of forward-looking behavior, particularly when we had relative good measures of these characteristics. Specifically, we find that smokers appear to be less addicted after a tax increase. We also find that those with stronger preferences for the present, as measured by health insurance coverage, whether a person obtained a flu shot, and whether the person reported a doctor or dentist visit in the past 12 months, are more responsive to a tax increase. Contrary to the predictions of our model, we found no evidence that smokers' self-rated health was substantially impacted by a tax increase, but self-rated health is an imperfect measure of the adverse health effects of smoking, which is the attribute of interest. In terms of income, we find that those with higher incomes are more responsive to a price increase. This is inconsistent with the forward-looking model, but this prediction is confounded by potential income effects.

We acknowledge that the data used to test the predictions of the forward-looking model were less than ideal in some cases. However, we believe one of the most important contributions of our study is the novel formulation of the problem and novel predictions generated from the theory, which provide a fruitful way to proceed for future research in this area. While we believe our findings to be credible and plausible, combining our conceptual approach with better data that more closely aligns with the theoretical factors that affect cigratette consumption is a goal that future research should pursue.

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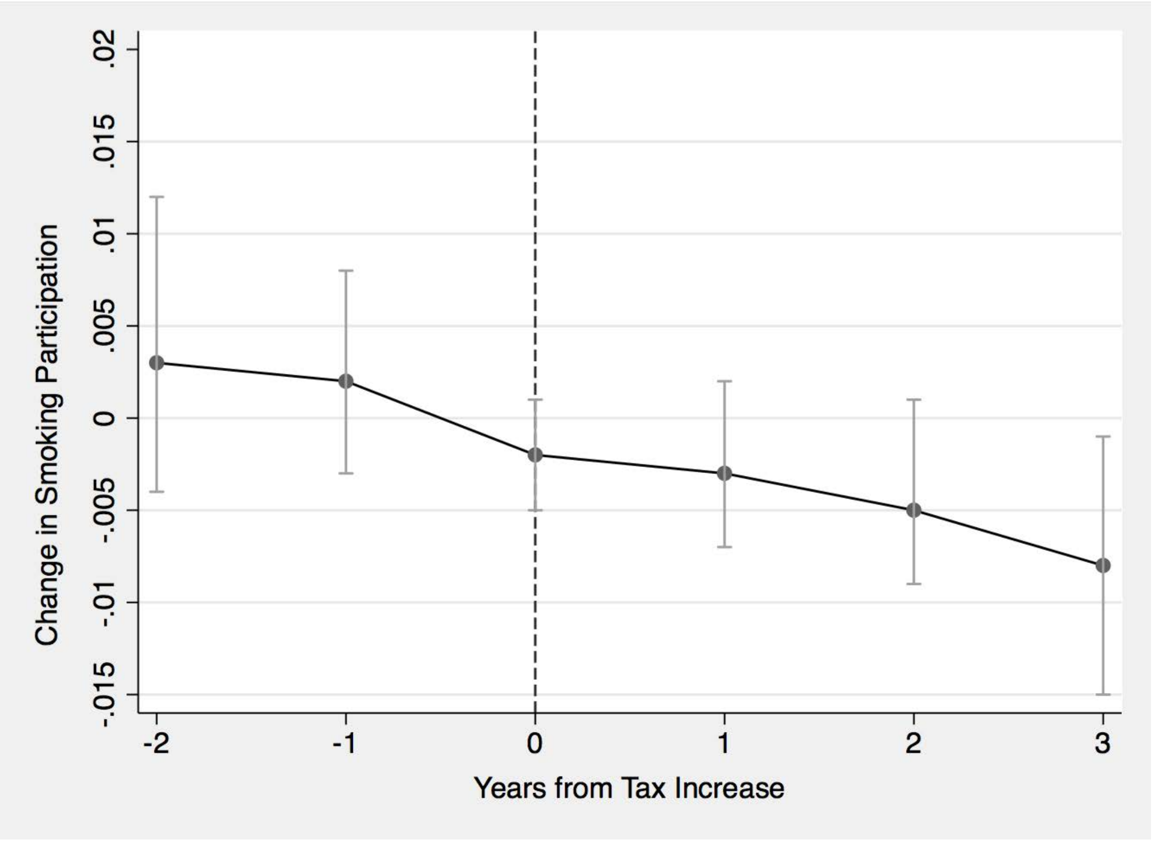
Figure 1: Estimates of the Change in Smoking Rates by Year From Tax Increase



Notes: Plot of coefficients from an event study model of changes in smoking participation rates by year from a tax increase for treatment states compared to control states using data on everyday smokers from the BRFSS.

Table 1: Descriptive Statistics – BRFSS Sample

	Treatment States		Control States	
	Mean	Standard Deviation	Mean	Standard Deviation
Smoke Every Day	0.146	0.353	0.146	0.353
Smoke Some Days	0.196	0.397	0.194	0.395
Individual Characteristics				
Age	50.780	14.685	51.047	14.663
Female	0.601	0.490	0.597	0.490
Married	0.603	0.489	0.628	0.483
Non-White Race/Ethnicity	0.208	0.406	0.182	0.386
Health Insurance Coverage	0.885	0.319	0.877	0.329
Excellent or Very Good Health	0.548	0.498	0.541	0.498
Doctor or Dentist Visit in Past Year	0.715	0.451	0.680	0.466
Always or Nearly Always Wear Seat Belt	0.927	0.261	0.922	0.269
Flu Shot	0.391	0.488	0.401	0.490
Education				
Less Than High School	0.078	0.268	0.078	0.268
High School	0.278	0.448	0.288	0.453
Some College	0.267	0.442	0.284	0.451
College	0.377	0.485	0.351	0.477
Family Income				
< $10,000	0.048	0.215	0.048	0.213
$10k - $24,999	0.212	0.409	0.218	0.413
$25k - $49,999	0.287	0.453	0.301	0.459
$50k - $74,999	0.176	0.380	0.180	0.384
>= $75,000	0.276	0.447	0.253	0.435
Smoking Bans				
Workplace Ban	0.489	0.500	0.261	0.439
Restaurant Ban	0.539	0.498	0.398	0.490
Bar Ban	0.414	0.493	0.268	0.443
State Cigarette Tax	1.350	0.691	0.813	0.533
Full Sample Observations	1,219,074		4,854,346	

Notes: Descriptive statistics for the paired-DiD BRFSS. Treatment states are those that experienced a tax increase of $0.50 or greater during the study period. Control states are matched to the treatment states based on pre-tax smoking rates and experienced no tax change during the study period. See Appendix Table 1 for a list of treatment states and periods.

Table 2: Effect of State Tax Increases on Smoking Participation

	Every Day Smoker		Every Day or Some Day Smoker	
	BRFSS	CPS	BRFSS	CPS
State Tax	-0.010***	-0.006***	-0.010***	-0.008***
	(0.001)	(0.002)	(0.001)	(0.003)
Mean Smoking Rate	0.146	0.151	0.194	0.188
Mean State Tax	0.921	0.902	0.921	0.902
Observations	6,073,420	1,338,023	6,073,420	1,338,023

Notes: Estimates are from a paired-DiD regression grouping treatment states experiencing a tax increase and control states with no tax change. All regressions include a fully saturated set of individual controls including age, sex, race/ethnicity, education, and marital status; state and group fixed effects, and an indicator for the post-tax increase period. Standard errors are clustered at the state level. **p<0.10, **p<0.05, ***p<0.01*.

Table 3: Effect of State Tax Increases on Extent of Addiction

	Time from Waking to First Cigarette			
	< 15 Minutes	< 30 Minutes	> 60 minutes	> 120 minutes
State Tax	-0.019**	-0.016	0.017	0.018**
	(0.009)	(0.012)	(0.011)	(0.008)
Share of Smokers	0.336	0.528	0.452	0.247
Mean State Tax	0.928	0.928	0.928	0.928
Observations	164,345	164,345	164,345	164,345

Notes: Estimates are from a paired-DiD regression grouping treatment states experiencing a tax increase and control states with no tax change. All regressions include a fully saturated set of individual controls including age, sex, race/ethnicity, education, and marital status; state and group fixed effects, and an indicator for the post-tax increase period. Standard errors are clustered at the state level. *p<0.10, **p<0.05, ***p<0.01.

Table 4: Effect of State Cigarette Tax Increases on Smoking Participation by Family Income

	Every Day Smoker		Every Day or Some Day Smoker	
	BRFSS	CPS	BRFSS	CPS
State Tax	-0.001	-0.007	0.003	-0.008
	(0.005)	(0.006)	(0.006)	(0.007)
Family Income <$10k	Omitted	Omitted	Omitted	Omitted
Family Income $10k - $24,999	-0.021***	-0.026***	-0.032***	-0.034***
	(0.004)	(0.005)	(0.005)	(0.006)
Family Income $10k - $24,999 × State Tax	-0.004	0.004	-0.005	0.003
	(0.003)	(0.005)	(0.004)	(0.006)
Family Income $25k - $49,999	-0.061***	-0.056***	-0.082***	-0.073***
	(0.006)	(0.007)	(0.007)	(0.008)
Family Income $25k - $49,999 × State Tax	-0.009*	0.001	-0.012*	0.003
	(0.005)	(0.007)	(0.007)	(0.008)
Family Income $50k - $74,999	-0.087***	-0.081***	-0.111***	-0.100***
	(0.006)	(0.008)	(0.008)	(0.008)
Family Income $50k - $74,999 × State Tax	-0.011*	-0.002	-0.016**	-0.002
	(0.006)	(0.008)	(0.007)	(0.008)
Family Income ≥ $75,000	-0.107***	-0.111***	-0.132***	-0.131***
	(0.006)	(0.008)	(0.007)	(0.008)
Family Income ≥ $75,000 × State Tax	-0.011**	0.003	-0.017**	0.004
	(0.005)	(0.007)	(0.007)	(0.008)
F-Test of Income Interactions	1.46	1.80	2.18*	1.92
Mean Smoking Rate	0.146	0.151	0.194	0.188
Mean State Tax	0.921	0.902	0.921	0.902
Observations	6,073,420	1,338,023	6,073,420	1,338,023

Notes: Estimates are from a paired-DiD regression grouping treatment states experiencing a tax increase and control states with no tax change. All regressions include a fully saturated set of individual controls including age, sex, race/ethnicity, education, and marital status; state and group fixed effects, and an indicator for the post-tax increase period. Standard errors are clustered at the state level. *$p<0.10$, **$p<0.05$, ***$p<0.01$.

Table 5: Effect of State Cigarette Tax Increases on Smoking Participation by Health Status

	Every Day Smoker	Every Day or Some Day Smoker
State Tax	-0.002	0.002
	(0.005)	(0.006)
Excellent or Very Good Health	-0.049***	-0.056***
	(0.003)	(0.002)
Excellent or Very Good Health × State Tax	0.000	-0.001
	(0.002)	(0.002)
Family Income <$10k	Omitted	Omitted
Family Income $10k - $24,999	-0.017***	-0.027***
	(0.004)	(0.005)
Family Income $10k - $24,999 × State Tax	-0.003	-0.005
	(0.003)	(0.003)
Family Income $25k - $49,999	-0.050***	-0.069***
	(0.006)	(0.006)
Family Income $25k - $49,999 × State Tax	-0.008*	-0.012*
	(0.005)	(0.006)
Family Income $50k - $74,999	-0.072***	-0.095***
	(0.006)	(0.007)
Family Income $50k - $74,999 × State Tax	-0.011**	-0.016**
	(0.005)	(0.007)
Family Income ≥ $75,000	-0.089***	-0.112***
	(0.005)	(0.006)
Family Income ≥ $75,000 × State Tax	-0.011*	-0.016**
	(0.005)	(0.006)
F-Test of Income Interactions	1.92	2.52*
Mean Smoking Rate	0.146	0.194
Mean State Tax	0.921	0.921
Observations	6,073,420	6,073,420

Notes: Estimates are from a paired-DiD regression grouping treatment states experiencing a tax increase and control states with no tax change. All regressions include a fully saturated set of individual controls including age, sex, race/ethnicity, education, and marital status; state and group fixed effects, and an indicator for the post-tax increase period. Standard errors are clustered at the state level. *$p<0.10$, **$p<0.05$, ***$p<0.01$.

Table 6: Effect of State Cigarette Tax Increases on Smoking Participation by Health Insurance Coverage and Flu Shot Receipt

	Every Day Smoker	Every Day or Some Day Smoker
State Tax	-0.009	-0.002
	(0.006)	(0.008)
Insured	-0.061***	-0.067***
	(0.004)	(0.005)
Insured × State Tax	0.012***	0.011**
	(0.004)	(0.004)
Flu Shot	-0.039***	-0.041***
	(0.002)	(0.002)
Flu Shot × State Tax	0.004**	0.002
	(0.002)	(0.002)
Excellent or Very Good Health	-0.051***	-0.058***
	(0.003)	(0.002)
Excellent or Very Good Health × State Tax	0.000	-0.001
	(0.002)	(0.002)
Family Income <$10k	Omitted	Omitted
Family Income $10k - $24,999	-0.014***	-0.024***
	(0.004)	(0.005)
Family Income $10k - $24,999 × State Tax	-0.006*	-0.007**
	(0.003)	(0.004)
Family Income $25k - $49,999	-0.037***	-0.055***
	(0.006)	(0.006)
Family Income $25k - $49,999 × State Tax	-0.014***	-0.017***
	(0.005)	(0.006)
Family Income $50k - $74,999	-0.054***	-0.075***
	(0.006)	(0.007)
Family Income $50k - $74,999 × State Tax	-0.016***	-0.022***
	(0.005)	(0.006)
Family Income ≥ $75,000	-0.069***	-0.090***
	(0.006)	(0.006)
Family Income ≥ $75,000 × State Tax	-0.017***	-0.022***
	(0.005)	(0.006)
F-Test of Income Interactions	4.92***	5.09***
Mean Smoking Rate	0.146	0.194
Mean State Tax	0.921	0.921
Observations	6,073,420	6,073,420

Notes: Estimates are from a paired-DiD regression grouping treatment states experiencing a tax increase and control states with no tax change. All regressions include a fully saturated set of individual controls including age, sex, race/ethnicity, education, and marital status; state and group fixed effects, and an indicator for the post-tax increase period. Standard errors are clustered at the state level. *$p<0.10$, **$p<0.05$, ***$p<0.01$.

Table 7: Effect of State Cigarette Tax Increases on Smoking Participation by Doctor or Dentist Visits

	Every Day Smoker		Every Day or Some Day Smoker	
State Tax	-0.010	-0.013*	-0.003	-0.006
	(0.007)	(0.007)	(0.009)	(0.008)
Doctor or Dentist Visit	-	-0.041***	-	-0.042***
		(0.003)		(0.004)
Doctor or Dentist Visit × State Tax	-	0.006**	-	0.006*
		(0.003)		(0.003)
Insured	-0.060***	-0.051***	-0.067***	-0.057***
	(0.005)	(0.005)	(0.005)	(0.006)
Insured × State Tax	0.011**	0.010**	0.010**	0.009*
	(0.005)	(0.005)	(0.005)	(0.005)
Excellent or Very Good Health	-0.050***	-0.051***	-0.056***	-0.058***
	(0.003)	(0.003)	(0.003)	(0.003)
Excellent or Very Good Health × State Tax	-0.000	0.000	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Flu Shot	-0.040***	-0.035***	-0.041***	-0.036***
	(0.002)	(0.002)	(0.003)	(0.003)
Flu Shot × State Tax	0.004*	0.003*	0.002	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Family Income <$10k	Omitted	Omitted	Omitted	Omitted
Family Income $10k - $24,999	-0.017***	-0.018***	-0.028***	-0.029***
	(0.005)	(0.005)	(0.006)	(0.006)
Family Income $10k - $24,999 × State Tax	-0.003	-0.003	-0.005	-0.005
	(0.003)	(0.003)	(0.004)	(0.004)
Family Income $25k - $49,999	-0.043***	-0.043***	-0.063***	-0.062***
	(0.007)	(0.007)	(0.007)	(0.007)
Family Income $25k - $49,999 × State Tax	-0.010**	-0.010**	-0.013**	-0.013**
	(0.005)	(0.005)	(0.006)	(0.006)
Family Income $50k - $74,999	-0.060***	-0.059***	-0.082***	-0.081***
	(0.006)	(0.006)	(0.007)	(0.007)
Family Income $50k - $74,999 × State Tax	-0.013**	-0.013**	-0.018***	-0.018***
	(0.005)	(0.005)	(0.006)	(0.006)
Family Income ≥ $75,000	-0.075***	-0.073***	-0.097***	-0.096***
	(0.006)	(0.006)	(0.007)	(0.007)
Family Income ≥ $75,000 × State Tax	-0.013***	-0.013***	-0.018***	-0.018***
	(0.005)	(0.005)	(0.006)	(0.006)
F-Test of Income Interactions	3.74**	4.13***	3.85***	4.20***
Mean Smoking Rate	0.141	0.141	0.189	0.189
Mean State Tax	0.963	0.963	0.963	0.963
Observations	4,997,134	4,997,134	4,997,134	4,997,134

Notes: Estimates are from a paired-DiD regression grouping treatment states experiencing a tax increase and control states with no tax change. All regressions include a fully saturated set of individual controls including age, sex, race/ethnicity, education, and marital status; state and group fixed effects, and an indicator for the post-tax increase period. Standard errors are clustered at the state level. **p<0.10, **p<0.05, ***p<0.01*.

Table 8: Effect of State Cigarette Tax Increases on Smoking Participation by Seat Belt Use

	Every Day Smoker		Every Day or Some Day Smoker	
State Tax	-0.011	-0.002	0.000	0.009
	(0.007)	(0.008)	(0.008)	(0.009)
Always or Nearly Always Wear Seat Belt	-	-0.053***	-	-0.050***
		(0.005)		(0.006)
Always or Nearly Always Wear Seat Belt × State Tax	-	-0.008*	-	-0.010*
		(0.005)		(0.005)
Doctor or Dentist Visit	-0.039***	-0.037***	-0.042***	-0.040***
	(0.003)	(0.003)	(0.004)	(0.004)
Doctor or Dentist Visit × State Tax	0.004*	0.004	0.005*	0.005
	(0.002)	(0.002)	(0.003)	(0.003)
Insured	-0.052***	-0.051***	-0.055***	-0.054***
	(0.005)	(0.005)	(0.005)	(0.005)
Insured × State Tax	0.012***	0.012***	0.009**	0.009**
	(0.004)	(0.004)	(0.004)	(0.004)
Excellent or Very Good Health	-0.051***	-0.050***	-0.058***	-0.057***
	(0.003)	(0.003)	(0.003)	(0.003)
Excellent or Very Good Health × State Tax	0.001	0.001	-0.000	0.000
	(0.002)	(0.002)	(0.002)	(0.002)
Flu Shot	-0.037***	-0.035***	-0.037***	-0.035***
	(0.002)	(0.002)	(0.003)	(0.003)
Flu Shot × State Tax	0.004**	0.004**	0.002	0.002
	(0.002)	(0.002)	(0.002)	(0.002)
Family Income <$10k	Omitted	Omitted	Omitted	Omitted
Family Income $10k - $24,999	-0.017**	-0.017**	-0.024***	-0.024***
	(0.007)	(0.007)	(0.008)	(0.008)
Family Income $10k - $24,999 × State Tax	-0.006	-0.006	-0.011**	-0.011**
	(0.005)	(0.005)	(0.005)	(0.005)
Family Income $25k - $49,999	-0.041***	-0.041***	-0.057***	-0.057***
	(0.008)	(0.008)	(0.008)	(0.008)
Family Income $25k - $49,999 × State Tax	-0.013**	-0.012**	-0.019***	-0.019***
	(0.005)	(0.005)	(0.007)	(0.007)
Family Income $50k - $74,999	-0.059***	-0.059***	-0.081***	-0.081***
	(0.008)	(0.008)	(0.009)	(0.009)
Family Income $50k - $74,999 × State Tax	-0.014**	-0.014**	-0.021***	-0.020***
	(0.006)	(0.006)	(0.007)	(0.007)
Family Income ≥ $75,000	-0.073***	-0.072***	-0.093***	-0.092***
	(0.008)	(0.008)	(0.009)	(0.009)
Family Income ≥ $75,000 × State Tax	-0.015**	-0.014**	-0.022***	-0.022***
	(0.006)	(0.006)	(0.007)	(0.007)
F-Test of Income Interactions	2.70**	2.58**	2.83**	2.73**
Mean Smoking Rate	0.139	0.139	0.185	0.185
Mean State Tax	1.001	1.001	1.001	1.001
Observations	2,463,022	2,463,022	2,463,022	2,463,022

Notes: Estimates are from a paired-DiD regression grouping treatment states experiencing a tax increase and control states with no tax change. All regressions include a fully saturated set of individual controls including age, sex, race/ethnicity, education, and marital status; state and group fixed effects, and an indicator for the post-tax increase period. Standard errors are clustered at the state level. **p<0.10, **p<0.05, ***p<0.01*.

Appendix Table 1: List of State Tax Changes

State	Date of Increase	Pre-Increase Tax	Post-Increase Tax	Tax Increase
New York	7/1/10	$2.75	$4.35	$1.60
New York	6/3/08	$1.50	$2.75	$1.25
Rhode Island	7/1/04	$1.32	$2.46	$1.14
Minnesota	8/1/05	$0.48	$1.485	$1.005
Utah	7/1/10	$0.695	$1.70	$1.005
Connecticut	10/1/09	$2.00	$3.00	$1.00
District of Columbia	10/1/08	$1.00	$2.00	$1.00
Florida	7/1/09	$0.339	$1.339	$1.00
Iowa	4/1/07	$0.36	$1.36	$1.00
Maine	9/19/05	$1.00	$2.00	$1.00
Maryland	1/1/08	$1.00	$2.00	$1.00
Massachusetts	7/1/08	$1.51	$2.51	$1.00
Montana	1/1/05	$0.70	$1.70	$1.00
Rhode Island	4/10/09	$2.46	$3.46	$1.00
South Dakota	1/1/07	$0.53	$1.53	$1.00
Texas	1/1/07	$0.41	$1.41	$1.00
Washington	5/1/10	$2.025	$3.025	$1.00
Wisconsin	1/1/08	$0.77	$1.77	$1.00
Arizona	12/4/06	$1.18	$2.00	$0.82
Oklahoma	1/1/05	$0.23	$1.03	$0.80
Massachusetts	7/25/02	$0.76	$1.51	$0.75
Michigan	7/1/04	$1.25	$2.00	$0.75
New Mexico	7/1/10	$0.91	$1.66	$0.75
Wisconsin	9/1/09	$1.77	$2.52	$0.75
New Jersey	7/1/02	$0.80	$1.50	$0.70
New Mexico	7/1/03	$0.21	$0.91	$0.70
Ohio	7/1/05	$0.55	$1.25	$0.70
Pennsylvania	7/15/02	$0.31	$1.00	$0.69
Colorado	1/1/05	$0.20	$0.84	$0.64
Connecticut	4/3/02	$0.50	$1.11	$0.61
Arizona	11/26/02	$0.58	$1.18	$0.60
Delaware	8/1/07	$0.55	$1.15	$0.60
Hawaii	7/1/09	$2.00	$2.60	$0.60
Oregon	11/1/02	$0.68	$1.28	$0.60
Vermont	7/1/06	$1.19	$1.79	$0.60
Washington	1/1/02	$0.825	$1.425	$0.60
Washington	7/1/05	$1.425	$2.025	$0.60
Arkansas	3/1/09	$0.59	$1.15	$0.56
New Jersey	7/1/03	$1.50	$2.05	$0.55
District of Columbia	10/1/09	$2.00	$2.50	$0.50
Michigan	8/1/02	$0.75	$1.25	$0.50

Notes: Data on tax increases are collected from Orzechowski and Walker (2012). Taxes are imposed per package of 20 cigarettes.

Appendix Table 2: Placebo Estimates of the Effect of State Tax Increases on Smoking Participation

	Every Day Smoker		Every Day or Some Day Smoker	
	BRFSS	CPS	BRFSS	CPS
Pseudo Tax	-0.002*	0.001	-0.003*	-0.000
	(0.001)	(0.003)	(0.002)	(0.002)
Mean Smoking Rate	0.144	0.155	0.193	0.193
Mean State Tax	0.964	0.793	0.964	0.793
Observations	4,845,932	965,426	4,845,932	965,426

Notes: Estimates are from a paired-DiD regression grouping treatment states and control states over periods where no state experiences a tax change. A pseudo-tax increase of $0.50 is randomly assigned to one state in the grouping. All regressions include a fully saturated set of individual controls including age, sex, race/ethnicity, education, and marital status; state and group fixed effects, and an indicator for the post-tax increase period. Standard errors are clustered at the state level. **p<0.10, **p<0.05, ***p<0.01*.