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Three Essays on the Effects of Tobacco Control Policies on Smoking Outcomes

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Master of Arts, Emory University, 2011
BBA/BS, University of Wisconsin – Madison, 2004

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An abstract of
A dissertation submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
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Doctor of Philosophy
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Abstract

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By Erik T. Nesson

This study explores the effects of tobacco control policies on smoking outcomes and the differences between self-reported measures of smoking outcomes and serum cotinine levels, a biomarker of recent nicotine exposure. The first paper uses quantile regression to estimate whether adult smokers' responses to tobacco control policies change across the distribution of smoking levels. I find that reductions in cigarette smoking from increases in cigarette excise taxes and cigarette prices are concentrated among the heaviest smokers. However, using serum cotinine levels, I find little evidence that cigarette excise taxes or prices affect smokers' intake of nicotine at any smoking level. I directly test whether the amount of nicotine smokers ingest from each cigarette is affected by tobacco control policies, and in fact I find evidence that the heaviest smokers consume more nicotine from each cigarette in response to higher cigarette prices. The second paper estimates the effects of tobacco control policies on non-smoking workers' exposure to secondhand smoke at their jobs. I find that smoke-free air laws reduce secondhand smoke exposure at work and these reductions translate into reduced overall nicotine exposure. I find some evidence that this reduction in nicotine exposure comes from reductions in secondhand exposure at work and evidence that smoke-free air laws reduce secondhand smoke exposure through other pathways as well. The third paper examines how adolescent smokers change their smoking behavior in response to tobacco control policies. I find that higher cigarette excise taxes are associated with reduced nicotine intake among adolescent smokers and these reductions are robust to controls for antismoking sentiment and other youth tobacco laws. In fact, I find some evidence that more stringent tobacco control policies actually lead to reductions in the amount of nicotine that adolescent smokers ingest from each cigarette. Lastly, I check whether misreports of smoking status are related to tobacco control policies, which could bias the coefficients in models where the dependent variable is self-reported smoking status. I find some evidence that measures of youth access laws are related to misreports.

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Preface

Every year, smoking kills more people than HIV, illegal drug use, alcohol use, motor vehicle crashes, suicides, and murders combined, and the total annual economic burden of smoking diseases is estimated at $160 billion. This economic burden stems from both individuals' own smoking behavior and also individuals' exposure to secondhand smoke. Given the large economic burdens associated with smoking, policy makers have long sought to influence smoking behaviors through tobacco control policies. For almost as long, economists have sought to understand the effectiveness of tobacco control policies. However, studying the effects of tobacco control policies on smoking outcomes is complicated by the difficulties in measuring smoking outcomes. The harms from tobacco smoke, whether through own smoking behavior or secondhand smoke exposure, stem from the intensity and duration of smoke exposure. However, measuring smoke exposure, especially in a context of studying how tobacco control policies change exposure, is very difficult.

Papers studying the effects of tobacco control policies on adult and adolescent smoking behaviors have mostly used the number of cigarettes smoked per day as the smoking outcome and proxy for smoke inhalation. However, this variable presents problems. Most importantly, the number of cigarettes smoked per day is not equal to the amount of smoke ingested. Many laboratory experiments document that smokers change their inhalation patterns to compensate for changes in their preferred number or type of cigarettes. Additionally, the number of cigarettes smoked per day is a self-reported variable, and individuals may inaccurately report the number of cigarettes smoked per day. This is especially relevant for adolescents, who may fear reprisals from reporting illegal smoking behavior. In examining secondhand smoke exposure, studies have mostly used self-reported measures of secondhand smoke exposure, which may face the same problems of inaccurate reporting found in the number of cigarettes smoked per day.

In this study, I contribute to the economic literature examining the effects of tobacco control policies on smoking outcomes for adult smokers, adolescent smokers, and non-smokers. Throughout the study, I examine smoking outcomes using both self-reported measures and serum cotinine levels, a biomarker of recent nicotine exposure. My data come from six waves of the National Health and Nutritional Examination Surveys (NHANES) covering the years 1988 to 1994 and 1999 to 2008. NHANES is a cross-sectional survey of health and nutritional information conducted by the CDC which combines surveys, physical examinations, and laboratory measurements. NHANES III, conducted between 1988 and 1994, consists of about 33,000 respondents. Starting in 1999, NHANES switched to releasing waves every two years. Each wave is nationally representative and contains about 10,000 individuals.

In my first paper, I use quantile regression to estimate whether adult smokers' responses to tobacco control policies change across the distribution of smoking levels, measuring smoking behavior with the number of cigarettes smoked per day and serum cotinine levels. I find that higher cigarette excise taxes reduce smoking prevalence, and both higher cigarette prices and excise taxes reduce the number of cigarettes smoked per day among smokers. Using quantile regression, I find that the reductions in cigarette smoking are concentrated among the heaviest smokers. However, using serum cotinine levels, I find little evidence that cigarette excise taxes or prices affect smokers' intake of nicotine at any smoking level. I directly test whether the amount of nicotine smokers ingest from each cigarette is affected by tobacco control policies, and in fact I find evidence that the heaviest smokers consume more nicotine from each cigarette in response to higher cigarette prices.

In my second paper, I estimate the effects of tobacco control policies on non-smoking workers' exposure to secondhand smoke at their jobs. I measure secondhand smoke exposure using a novel measure of workers' self-reported exposure to secondhand smoke at their jobs as well as serum cotinine levels. While I find little evidence that cigarette excise taxes or prices reduce workers' exposure to secondhand smoke, I find evidence that workplace and restaurant or bar smoke-free air laws reduce secondhand smoke exposure and these reductions translate into reduced overall nicotine exposure. I find that this reduction in nicotine exposure comes from reductions in secondhand smoke exposure at work and through other pathways as well.

In my third paper, I examine how adolescent smokers change their smoking behavior in response to tobacco control policies using the number of cigarettes smoked per day and serum cotinine concentrations to measure smoking behavior. I find that higher cigarette excise taxes are associated with reduced nicotine intake among adolescent smokers and these reductions are robust to controls for antismoking sentiment and other youth tobacco laws. In fact, I find some evidence that more stringent tobacco control policies actually lead to reductions in the amount of nicotine that adolescent smokers ingest from each cigarette. Lastly, I use the serum cotinine levels to check whether misreports of smoking status are related to tobacco control policies, which could bias the coefficients in models where the dependent variable is self-reported smoking status. I find some evidence that measures of youth access laws are related to misreports.

Chapter 1

Heterogeneity in Adult Smokers' Responses to Tobacco Control Policies: A Quantile Regression Approach

Erik Nesson *

Abstract

This paper uses quantile regression to estimate whether adult smokers' responses to tobacco control policies change across the distribution of smoking levels. I measure smoking behavior with the number of cigarettes smoked per day and also with serum cotinine levels, a continuous biomarker of nicotine exposure, using individual level repeated cross-section data from the National Health and Nutritional Examination Surveys. I find that higher cigarette excise taxes reduce smoking prevalence, and both higher cigarette prices and excise taxes reduce the number of cigarettes smoked per day among smokers. Using quantile regression, I find that the reductions in cigarette smoking are concentrated among the heaviest smokers. However, using serum cotinine levels, I find little evidence that cigarette excise taxes or prices affect smokers' intake of nicotine at any smoking level. I directly test whether the amount of nicotine smokers ingest from each cigarette is affected by tobacco control policies, and in fact I find evidence that the heaviest smokers consume more nicotine from each cigarette in response to higher cigarette prices. Additionally, I find evidence that smoke-free air laws in private workplaces and restaurants or bars are associated with reduced smoking prevalence, but not reductions in cigarette smoking or serum cotinine levels among smokers.

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1.1. Introduction

A large body of economic research finds that tobacco control policies decrease the number of cigarettes that smokers consume. However, although heavy smokers are almost four times more likely than light smokers to develop lung cancer and twice as likely to develop coronary heart disease, little research addresses whether light and heavy smokers respond differently to tobacco control policies (Hammond et al. 1976). Additionally, while a large body of medical literature suggests that smokers are adept at changing smoking habits to inhale a preferred amount of nicotine when faced with reductions in the available number of cigarettes, few economic studies account for this compensating behavior.

This paper aims to fill these two gaps in the economic literature. I use quantile regression to provide new evidence on how tobacco control policies, in particular cigarette prices, cigarette excise taxes, and smoke-free air laws, affect smokers' cigarette demand and intake of nicotine, and how the effects of tobacco control policies vary across the distribution of smoking levels. My data come from six waves of the National Health and Nutritional Examination Surveys (NHANES) covering the years 1988 to 1994 and 1999 to 2008. In addition to measuring smoking behavior through the number of cigarettes smoked per day, NHANES contains individuals' serum cotinine levels. Cotinine is a direct and continuous biomarker of smokers' intake of nicotine with a relatively long half-life in the body, and cotinine is a well-established bio-marker of smoking exposure in the medical literature.

I find that cigarette excise taxes are associated with reduced smoking prevalence, and both cigarette prices and excise taxes are associated with reductions in the quantity of cigarettes demanded by smokers. Moreover, using quantile regression, I find that the reductions in the number of cigarettes smoked per day are concentrated among heavier smokers. However, I find little evidence that cigarette prices or excise taxes affect smokers' intake of nicotine at any smoking level, indicating that smokers compensate for reduced cigarette consumption by inhaling more nicotine from each cigarette by either switching to cigarette brands with higher nicotine contents or smoking each cigarette more intensely. In specifications that directly test whether smokers change the amount of nicotine they ingest from each cigarette in response to tobacco control policies, I find evidence that the heaviest smokers indeed ingest more nicotine from each cigarette in response to higher cigarette prices. I find that smoke-free air laws in private workplaces and restaurants or bars are associated with reductions in smoking prevalence, but I find little evidence that smoke-free air laws affect cigarette smoking or cotinine levels among smokers.

This study provides three main contributions to the literature. First, I extend the literature estimating smokers' compensating behavior. Smokers have a lot of control over how much nicotine they consume from each cigarette (Benowitz et al. 1983a; Benowitz and Jacob 1984; Benowitz et al. 1986b; Zacny and Stitzer 1988). However, only a few economic studies examine whether smokers compensate for tobacco control policies by ingesting more nicotine from each cigarette, and whether this compensating behavior decreases the effectiveness of tobacco control policies in reducing smoking behavior (Harris 1980; Evans and Farrelly 1998; Farrelly et al. 2004; Adda and Cornaglia 2006). These studies mostly use data series ending before the 1998 Master Settlement Agreement between the large tobacco companies and state attorneys general, and as I document below, cigarette excise taxes and prices rose rapidly after the Master Settlement Agreement. I also extend the analysis of smokers' compensating behavior to smoke-free air laws. As smoke-free air laws raise the time cost of smoking, smokers may also compensate for the presence of smoke-free air laws. Lastly, Adda and Cornaglia (2006) is the only study to not use the self-reported numbers of cigarettes smoked and cigarette characteristics to indirectly measure compensating behavior. Like Adda and Cornaglia (2006), my results utilize serum cotinine concentrations, which are a continuous measurement without the problems of a self-reported variable like the number of cigarettes smoked per day.

The second contribution is that I use quantile regression to examine how the responses of smokers to tobacco control policies differ across the distribution of smokers. It is important for policy makers to understand how light and heavy smokers respond to tobacco control policies, because heavy smokers are much more likely to suffer adverse effects from smoking than light smokers. While heavy smokers are more likely to develop lung cancer and coronary heart disease, heavy smokers may also be more addicted to nicotine and thus have lower cigarette price elasticities. On the other hand, all else equal, cigarettes comprise a larger share of heavy smokers' budgets, so heavy smokers may have higher price elasticities. As noted above, smokers can compensate for reduced cigarette consumption, so it is important to not only examine cigarette demand but also the demand for nicotine. The continuous nature of serum cotinine levels provides a natural variable for quantile regression estimation.

The third contribution is that I provide direct estimates of how much smokers change the amount of nicotine they ingest from each cigarette in response to tobacco control policies. A few previous papers provide indirect estimates of smokers' compensating behavior through examining changes in the tar or nicotine contents of cigarettes (Evans and Farrelly 1998; Farrelly et al. 2004). Additionally, Adda and Cornaglia (2006) estimate smokers' compensating behavior by regressing the log of the ratio of smokers' cotinine levels and the number of cigarettes smoked per day on cigarette taxes. Both methods find that smokers compensate for higher cigarette taxes. However, indirectly measuring compensating behavior cannot account for changes in smokers' inhalation patterns. Moreover, neither method allows for an examination of whether compensating behavior differs between light and heavy smokers. I circumvent these problems by estimating specifications using serum cotinine concentration as the dependent variable and including the number of cigarettes smoked per day and interaction terms between the number of cigarettes smoked per day and the tobacco control policies as independent variables. In these specifications, the coefficients on the interaction terms show the effects of tobacco control policies on the amount of nicotine extracted from each cigarette. Also, as the dependent variable in these specifications is the serum cotinine concentration, these specifications naturally allow an examination of compensating behavior across the distribution of smoking levels.

The rest of this paper is organized as follows. Section 1.2 provides an overview of the relevant medical and economics research examining the effects of tobacco control policies on smoking outcomes, smoker compensation, cotinine, and the link between smoking intensity and mortality. Section 1.3 explains the identification strategy, Section 1.4 describes the data sources used and summarizes the data set, Sections 1.5, 1.6 and 1.7 review the results, and Section 1.8 concludes.

1.2. Background

Understanding whether heavy and light smokers respond differently to tobacco control policies is important because heavy smokers are more likely than light smokers to suffer adverse effects from smoking. The earliest medical studies linking smoking to lung cancer generally find a linear relationship between the number of cigarettes smoked per day and the relative risk of lung cancer for consumption levels below about 30 cigarettes per day, tapering off at higher consumption levels, and later studies confirm these results (Hammond and Horn 1958b, a; Hammond et al. 1976; Law et al. 1997; Godtfredsen, Prescott and Osler 2005; Pope et al. 2009). In one of the landmark studies linking smoking to lung cancer, Hammond et al. (1976) find that while male smokers of less than 20 cigarettes a day are about four times as likely to die from lung cancer as non-smokers, male smokers of between 20 and 39 cigarettes a day are almost 15 times more likely to die from lung cancer as non-smokers. Smoking is also related to other diseases, including many other cancers and coronary heart disease. Compared to non-smokers, smokers of less than one half of a pack of cigarettes per day are 1.8 times more likely to develop coronary heart disease, smokers of one pack of cigarettes a day are two times more likely to develop coronary heart disease, and smokers of more than one pack a day are 3.2 times more likely to develop coronary heart disease (Pooling Project Research Group 1978).

Although the observed relationship between the number of cigarettes smoked and lung cancer is linear or concave, medical theory suggests a quadratic relationship between smoke inhalation and lung cancer risk (Doll and Peto 1978). Recent medical literature suggests the apparent discrepancy is due to differences in how smokers smoke cigarettes (Law et al. 1997). Law et al. find that heavy smokers ingest much less nicotine from every cigarette smoked. Law et al. then account for heavier smokers inhaling less nicotine and harmful chemicals to create an "adjusted number of cigarettes smoked per day," which shows the expected quadratic relationship with lung cancer prevalence. In fact, recent medical research suggests that biomarkers of smoking exposure are better predictors of adverse effects from smoking that self-reported smoking levels (Perez-Stable, Benowitz and Marin 1995; Boffetta et al. 2006). The amount of nicotine and harmful chemicals that may be ingested from a single cigarette varies widely, and it is smokers' intake of harmful chemicals, and not the number of cigarettes consumed, per se, that leads to adverse outcomes.

Medical and epidemiologic studies have long suggested that smokers may vary their smoking habits to extract a preferred amount of nicotine from each cigarette. For example, laboratory experiments document that when smokers are switched to cigarettes with lower nicotine and tar contents, the smokers compensate by inhaling more deeply or smoking more of each cigarette (Benowitz et al. 1983a; Benowitz and Jacob 1984; Benowitz et al. 1986b; Zacny and Stitzer 1988). Often this compensation results in smokers extracting the same amount of tar and nicotine from the lower nicotine and tar cigarettes (Benowitz et al. 1983a). Furthermore, laboratory experiments show that smokers also compensate for reduced quantities of cigarettes by smoking more intensely. Benowitz et al. (1986a) find when smokers who smoked on average 37 cigarettes per day were permitted to smoke only five cigarettes per day, a decrease of over 85 percent, they consumed three times as much nicotine per cigarette compared with their normal smoking exposure, and their nicotine intake only decreased by 50 percent.

In the economics literature, research on smoking focuses mainly on the effects of tobacco control policies on smoking behavior. With respect to taxes and prices, the literature has established a negative price elasticity of adult cigarette demand of around -0.4 at the mean number of cigarettes (Chaloupka and Warner 2000). Only a few studies examine heterogeneity in price elasticities, and these are discussed below. With respect to the effects of smoke-free air laws, the economics literature is more mixed. For example, Chaloupka and Saffer (1992) use aggregate cigarette demand and smoke-free air law information from a 1986 Surgeon General's Report and find that public place laws decrease smoking but workplace laws do not. Chaloupka (1992) use individual-level data and the smoke-free air law information from the 1986 Surgeon General's Report and find that the existence of public place smoke-free air laws reduces smoking but more stringent smoke-free air laws do not reduce smoking. Evans, Farrelly, and Montgomery (1999) and Farrelly, Evans, and Sfekas (1999) find that voluntary workplace smoke-free air laws reduce smoking. Tauras (2006) uses smoke-free air law information from Project ImpacTeen and finds that an index of smoke-free air laws is negatively associated with both smoking prevalence and conditional cigarette demand. However, Bitler, Carpenter, and Zavodny (2010) find little evidence of compliance with state smoke-free air laws and changes in employee smoking behavior, although they find smoke-free air laws in bars do reduce the smoking behavior of bartenders. Adda and Cornaglia (2010) use smoke-free air laws from the American Non-Smokers' Rights Foundation (ANSRF) and find no effect of smoke-free air laws on smoking behavior. Lastly, using Canadian data, Carpenter (2009) and Carpenter, Postolek, and Warman (2011) confirm these results and find that smoke-free air laws generally do not affect smoking behavior.

Despite the breadth of previous research, a few important areas remain largely unexplored. First, the economics literature largely ignores the potential heterogeneity in smokers' responses to tobacco control policies. A few papers in the economics literature do examine heterogeneous responses to tobacco control policies, but these papers largely focus on adolescent smokers and delineate smokers into categorical smoking levels. Ross, Chaloupka, and Wakefield (2006), Liang and Chaloupka (2002) and Tauras (2005) categorize young adult smokers into groups based on the number of cigarettes smoked per day and find that prices and taxes have larger effects at higher levels of smoking. Their results are confirmed by Emery, White, and Pierce (2001), who find that price only affects older, established smokers. Katzman, Markowitz, and McGeary (2007) and Emery et al. (1999) suggest that the reason for the heterogeneity in price elasticities among adolescents is due to a social market for cigarettes among adolescents, where many adolescents borrow cigarettes from their friends. Emery et al. (1999) find that adolescent smokers loan at most 10 cigarettes a month, and at roughly $0.13 a cigarette, the price of loaning cigarettes is likely not high. Consistent with the finding that heavier smokers are more price sensitive, Katzman, Markowitz, and McGeary (2007) find that cigarette borrowers are lighter smokers than cigarette buyers. In contrast to the above studies, Fletcher, Deb, and Sindelar (2009) find that finite mixture models delineate adolescents into two groups. One group is responsive to cigarette prices and another group is not. The responsive group smokes less than one cigarette per day while the unresponsive group smokes almost eight cigarettes a day.

A few papers also examine heterogeneity in adult smoking in the framework of consumer search for lower cigarette prices. Chiou and Muehlegger (2008) use data from the 2003 wave of the Current Population Survey Tobacco Use Supplement and find that heavy smokers are more likely to cross state borders to buy cigarettes in lower tax venues. DeCicca et al. (2010b) confirm these results using data from the 2003 and 2006-2007 waves of the Current Population Survey Tobacco Use Supplement. DeCicca et al. find suggestive evidence that excise taxes are passed on to consumers that engage in less searching, such as non-daily smokers.

Laporte, Karimova, and Ferguson (2010) use quantile regression to estimate a rational addiction model of smoking. Using panel data from Canada, they find that forward looking behavior declines as smoking increases, indicating that heavier smokers are less forward looking than light smokers. Additionally, the authors find that price has an insignificant effect on cigarette consumption, although the study time period is limited, and the price may not have sufficient variation for identification. Lastly, Laporte, Karimova, and Ferguson find that smoking restrictions at work reduce cigarette consumption, and the effect is most pronounced at the upper quantiles.[1]

In addition to heterogeneity in the responses to tobacco control policies, the economics literature only recently started examining the robustness of using the number of cigarettes smoked per day to measure smoking behavior. Evans and Farrelly (1998) find that although smokers living in states with higher cigarette excise taxes smoke fewer cigarettes, they tend to smoke cigarettes with higher tar and nicotine contents. The increase in tar and nicotine intake per cigarette completely offsets the reduction in tar and nicotine intake from smoking fewer cigarettes. Farrelly et al. (2004) use longitudinal data

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[1] There is one additional paper that uses quantile regression to estimate the effects of cigarette prices on smoking outcomes. Goel and Ram (2004) use aggregate state per-capita cigarette sales and state average prices from 1993 to 1999 and find price elasticities ranging from -1.3 at the 25th quantile to -1.0 at the 75th quantile. However, the use of both state-level per-capita sales and state-level prices raises concerns about endogeneity.

from the COMMIT project and also find that smokers facing higher cigarette prices decrease the number of cigarettes smoked but increase the tar and nicotine content of the cigarettes to keep daily estimated nicotine intake unchanged.

However, using cigarette characteristics cannot take into account changes in how smokers smoke each cigarette and may provide an incomplete picture of smokers' responses to cigarette excise taxes. Another way to measure smoking behavior is through biomarkers of nicotine intake. The most popular biomarker of nicotine exposure is the level of cotinine in an individual's system, and cotinine levels have been used in the medical and epidemiology literature since the 1970s to measure smoking behavior (Williams et al. 1979; Benowitz et al. 1983a; Benowitz et al. 1983b; Benowitz and Jacob 1984; McNeill et al. 1987; Blackford et al. 2006; Benowitz et al. 2009).

Cotinine is the major metabolite of nicotine, and approximately 70 percent of ingested nicotine is converted into cotinine (Benowitz and Jacob 1994; Benowitz et al. 1994). Although nicotine is rapidly metabolized by the body, with a half-life of about two hours, cotinine has a much longer half-life of about 16 to 20 hours. Smokers often have a fairly stable level of cotinine in their systems which does not vary much during the day or even across days (Kemmeren et al. 1994). Measuring smoking levels through cotinine offers several advantages over measuring smoking through the self-reported number of cigarettes smoked. As noted above, smokers can vary the amount of nicotine and harmful chemicals they ingest from each cigarette. Since cotinine measures the amount of nicotine metabolized, it is a direct measure of nicotine intake. Moreover, cotinine is not a self-reported measure and is robust to underreporting, misremembering, or rounding of the self-reported number of cigarettes smoked.

Despite its popularity in the medical and epidemiology literature, Adda and Cornaglia (2006) is the only paper in the economics literature to use cotinine as a measure of smoking behavior. Adda and Cornaglia (2006) use NHANES data from 1988 to 1994 and 1999 to 2000 and serum cotinine as a measure of nicotine intake.[2] They find that while increased cigarette excise taxes decrease the number of cigarettes smoked, cigarette excise taxes do not change the average level of serum cotinine found in smokers. Adda and Cornaglia (2006) also construct a ratio of the serum cotinine level and the number of cigarettes smoked to measure smoking "intensity," and they find that increased cigarette excise taxes increase this measure of smoking intensity.

Many aspects of the economics literature examining smoker compensation warrant reexamination. First, these studies generally use data ending in 2000. As I document below, cigarette excise taxes and prices have changed dramatically in the past decade, providing more variation to identify effects. Second, the few economics papers examining smokers' compensation do not examine the effects of smoke-free air laws. Conceptually, smoke-free air laws could be thought of as an increase in the full price of smoking a cigarette. Instead of an increase in the monetary price of a cigarette, smoke-free air laws increase the opportunity cost, as smokers must go outside to smoke during work or while at a restaurant or bar. If smokers reduce the number of cigarettes they consume because of smoke-free air laws, they may offset that reduction by smoking more intensely.[3] Third, these studies measure the effects of tobacco control policies at the

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[2] Adda and Cornaglia use a subsample of publicly-available NHANES data covering 1988 to 1994 from respondents living in counties with more than 500,000 residents. A recent working paper by Abrevaya and Puzzello (2010) finds that Adda and Cornaglia's results are unstable when the sample is increased to all respondents in the applicable NHANES waves.

[3] Farrelly et al. (2004) provide some empirical evidence that smoke-free air laws could affect smokers' compensating behavior. They find that an index of community-level clean air regulations decreases the tar and nicotine contents of smokers' cigarettes.

mean. If smokers respond differently to tobacco control policies based on their smoking level, estimating effects at the mean could provide an incomplete picture of how smokers respond to tobacco control policies.

1.3. Identification Strategy

To identify the effects of changes in tobacco control policies on smoking behavior, I use a two-part model. I split smoking behavior into an individual's decision to smoke, and given that an individual smokes, that individual's smoking level. I model the decision to smoke separately from the decision of how much to smoke because a large percent of my sample does not smoke. Not accounting for the large number of non-smokers in the sample could lead to biased coefficients. Moreover, the two-part model allows me to examine whether tobacco control policies affect smoking behavior through the extensive margin or the intensive margin.

The first part of the model estimates a linear probability model of the decision to smoke:

$$E(Smk|x) = \alpha_0 + \alpha_1 P + \alpha_2 SFA + \alpha_3 X + \mu_s + \delta_t + \gamma_q \, , \quad (1)$$

where Smk is an indicator variable for whether an individual is a current smoker, P is a measure of the monetary price of smoking, SFA measures smoke-free air laws, X is a matrix of individual and geographic characteristics, and μ_s, δ_t, and γ_q are state, year and quarter fixed effects. Next, I model the decision of how much to smoke given smoking participation. I first estimate an ordinary least squares regression model conditional on smoking participation,

$$E(Y|Smk = 1; x) = \beta_0 + \beta_1 P + \beta_2 SFA + \beta_3 X + \sigma_s + \phi_t + \eta_q \, , \quad (2)$$

where Y is the smoking behavior of interest for an individual conditional on that individual smoking, and the other variables are as defined above. I cluster the standard errors at the state level in all linear probability and ordinary least squares specifications (Bertrand, Duflo and Mullainathan 2004).

Equation (2) will estimate changes in the conditional mean of the smoking outcome of interest, but it is possible that smokers of different smoking levels may respond differently to tobacco control policies. Since equation (2) does not allow the coefficients to vary across the distribution of the smoking dependent variables, I use quantile regression to estimate the impacts of tobacco control policies over the distribution of smoking behaviors. First developed by Koenker and Bassett (1978), quantile regression predicts the quantiles of a conditional distribution as a function of explanatory variables instead of predicting the conditional mean as a function of the explanatory variables. For quantile τ of the conditional distribution of a smoking outcome, Y, the quantile regression model can be written as,

$$Q_{(Y|Smk=1)}(\tau|x) = \beta_{0\tau} + \beta_{1\tau}P + \beta_{2\tau}SFA + \beta_{3\tau}X + \sigma_{s\tau} + \phi_{t\tau} + \eta_{q\tau}. \quad (3)$$

In Equation (3), the marginal effect of a change in cigarette monetary cost on the conditional quantile function is $\frac{\partial Q_{(Y|Smk=1)}(\tau|x)}{\partial P} = \beta_{1\tau}$, so in Equation (3) the marginal effects of the explanatory variables may change for each conditional quantile, τ, of the smoking outcome. I estimate quantile regressions at every 5th quantile between the 5th and 95th quantiles and calculate standard errors using 299 bootstrap replications.[4]

Aside from allowing the marginal effects to change across the distribution of the dependent variable, quantile regression offers other advantages. First, quantile regression

[4] The number of bootstrap replications should be chosen so that $\alpha(N+1)$ is an integer, where α is the level of the test and N is the number of bootstrap replications (Davidson and MacKinnon 2000).

is more robust to outliers than ordinary least squares. Second, quantile regression uses the entire distribution of the outcome variable to calculate the coefficients at each quantile. Other avenues to calculating heterogeneous marginal effects, such as running separate OLS regressions over different parts of the distribution of the dependent variable, exclude information by segmenting the dependent variable. Along the same lines, quantile regression does not split the dependent variable into categories as in a generalized ordered logit model. Thus, quantile regression preserves all the within-category information lost through categorization. Lastly, while quantile regression estimates coefficients across the distribution of the dependent variable, quantile regression also preserves a parametric framework. Unlike non-parametric estimation, the parametric framework of quantile regression makes estimation feasible in a situation with many thousands of observations and many independent variables.

1.4. Data

1.4.1. Tobacco Control Policies

The tobacco control policies I focus on are the monetary cost of cigarettes and smoke-free air laws. To measure the monetary cost of cigarettes, I run separate models using cigarette prices and cigarette excise taxes. Cigarette prices are the most direct measure of cigarette cost and include more information than cigarette excise taxes (Chou, Grossman and Saffer 2004, 2006). However, prices may be related to aggregate state characteristics that determine cigarette demand and thus endogenous (Gruber and Frakes 2006). Cigarette excise taxes, while potentially politically endogenous, likely suffer from less bias than cigarette prices. Moreover, the effects of cigarette excise taxes on smoking behaviors measure what policy makers control.

I use state-level cigarette price and excise tax data compiled by the Tax Burden on Tobacco (TBOT) output by Orzechowski and Walker (2009).[5] I transform the cigarette prices into the real (2009 dollars) average annual price paid for a pack of cigarettes. I transform the taxes into the real quarterly state cigarette excise taxes paid on a pack of cigarettes and add imputed taxes from the 1998 Master Settlement Agreement between state attorneys general and tobacco manufacturers (Lillard and Sfekas 2010).[6] I measure smoke-free air laws in three common venues: private workplaces, restaurants and bars using data from Project ImpacTeen. ImpacTeen records the presence of smoke-free area laws in different venues for each state, and I construct indicator variables denoting whether a state has smoking restrictions in private workplaces and restaurants or bars in each year.[7]

Figure 1.1 shows a time series of changes in tobacco control policies from 1988 to 2008. Both prices and taxes rose through the sample period, but prices and taxes both rose rapidly after the Master Settlement Agreement in 1998. The average cigarette excise tax rose from $0.83 in 1998 to $1.92 in 2008, and the average price rose from $2.85 in 1998 to $4.50 in 2008. As with cigarette excise taxes, the prevalence of smoke-free air laws increased after the 1998 Master Settlement Agreement. The prevalence of smoke-free area laws in private workplaces, and restaurants or bars increased from 51 percent and 59 percent, respectively, in 1998 to 75 percent and 81 percent, respectively, in 2008.

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[5] I add city taxes for municipalities and counties which make up large proportions of their respective state populations. I add excise taxes for the five counties which comprise New York City, NY; Cook County, IL; Anchorage and Juneau, AK; Arlington and Fairfax Counties, VA; and Cuyahoga County, OH.

[6] The Master Settlement Agreement required cigarette manufacturers to pay into an escrow account an amount proportional to the number of cigarettes they sell. As Lillard and Sfekas point out, including the implicit taxes from the MSA will not change the tax coefficients if year fixed effects are included in the model, but they will affect calculated elasticities.

[7] The ImpacTeen data is available at http://www.impacteen.org/tobaccodata.htm. I aggregate the restaurant and bar SFA laws because all states with bar SFA laws also have restaurant SFA laws.

1.4.2. NHANES Data

I use six waves of the NHANES data sets covering 1988 to 1994 and 1999 to 2008. NHANES is a cross-sectional survey of health and nutritional information conducted by the CDC which combines surveys, physical examinations, and laboratory measurements. NHANES III, conducted between 1988 and 1994, consists of about 33,000 respondents. Starting in 1999, NHANES switched to releasing waves every two years. Each wave is nationally representative and contains about 10,000 individuals.

I define a respondent as a current smoker if the respondent reports they have smoked cigarettes in the past 30 days.[8] I construct two main variables to measure smoking behavior among current smokers. First, I measure the average number of cigarettes smoked per day by multiplying the reported number of cigarettes smoked per day on the days respondents smoked in the past 30 days by the percent of days the respondent smoked in the past 30 days. Second, I use the level of serum cotinine, collected by NHANES, measured in nanograms per milliliter. NHANES collects blood samples from individuals age three and older as part of its examinations, and the samples are sent to the CDC for analysis. Serum cotinine levels as low as 0.035 ng/ml can be detected in the NHANES data.

1.4.3. Demographics

State and county of residence information for the NHANES data is available through the NCHS Restricted Data Center which allows me to merge the tobacco control policy information and geographic characteristics with the individual level data. NHANES

[8] I remove individuals who self-report as non-smokers but have serum cotinine levels above 10 ng/ml, a common cutoff in the medical literature to distinguish between smokers and non-smokers. I retain individuals who self-report as smokers but have serum cotinine levels below 10 ng/ml as to not remove light smokers from the analysis.

provides detailed demographic characteristics, and using these I include variables for gender, age, race, ethnicity, height, marital status, family income, and education.[9]

Additionally, previous research suggests that omitting state anti-smoking sentiment may bias the coefficients of tobacco control policies, as anti-smoking sentiment may both drive the adoption of tobacco control policies and reductions in smoking outcomes (DeCicca et al. 2008). I follow the methodology of DeCicca et al. (2008) to construct a measure of state anti-smoking sentiment, and I include this measure in all models. I use questions about attitudes towards smoking in various places to measure anti-smoking sentiment from the 1992-1993, 1995-1996, 1998-1999, 2000-2001, 2002-2003, and 2006-2007 waves of the Current Population Survey Tobacco Use Supplement (TUS-CPS). The TUS-CPS is a nationally representative sample of tobacco use covering about 240,000 individuals in each survey period. For restaurants, bars and cocktail lounges, work places, and sporting events, respondents answer whether they think smoking should be allowed in all areas, allowed in some areas, or not allowed at all. Lastly, respondents answer whether smoking is allowed anywhere inside their home, in certain areas inside their home, or not allowed at all inside their home. I combine the answers to these questions into one latent variable using factor analysis, and I find that one latent factor best explains the variation of the five smoking attitude questions. I compute this latent variable for

[9] One drawback of the NHANES data is that the 2005-2006 and 2007-2008 survey waves do not contain information on an individual's occupation. Omitting occupation variables should not bias the coefficients on tobacco control policies as long as an individual's occupation is not related to aggregate-level tobacco control policies. However, omitting occupation information could increase the standard errors of the coefficients. Additionally, the other demographic variables included in the regression models should proxy for much of the variation contained in an individual's occupation category. To check this, I ran simple regressions using as outcome variables an indicator variable for whether an individual was employed, and given employment, that individual's employment category and using as explanatory variables the other demographic controls. These regressions yielded adjusted r-squared statistics of around 0.35. Nonetheless, I tested the robustness of my results to excluding the 2005-2006 and 2007-2008 survey waves and including occupation information and found similar results both in magnitude and statistical significance.

each respondent, take the average of the latent variable for each state and year, and linearly impute missing year and state observations.[10]

Previous research also suggests that cigarette smuggling may bias the coefficients of cigarette prices and taxes (Baltagi and Levin 1986; Baltagi and Goel 1987; Chiou and Muehlegger 2008; Colman and Remler 2008; Chiou and Muehlegger 2010; DeCicca, Kenkel and Liu 2010a). To account for cigarette smuggling, I use each individual's county of residence and calculate the difference between the cigarette price or excise tax and the price or excise tax in the nearest state with a lower cigarette price or excise tax. I include this tax or price difference in all models.

1.4.4. Summary Statistics

Table 1 shows summary statistics for the sample. The total number of individuals interviewed in the NHANES surveys is 85,617. However, NHANES does not interview individuals in all 50 states in each survey cycle. There are ten states that contain interviews in only one year and two years containing interviews from only one state. I drop these 4,334 observations, as including state and year fixed effects necessitates that each state span at least two years and each year span at least two states. Of the 81,283 remaining observations, 36,489 are over age 20 and contain information on smoking and geographic residence.[11] After removing all individuals with missing values on demographic controls and all individuals indicating the use of other tobacco products,

[10] DeCicca et al. (2008) also include questions pertaining to smoking in hospitals and shopping malls, as well as whether cigarette companies should be allowed to give away free samples or advertise. However, more recent versions of the TUS-CPS do not consistently ask these questions. To check whether using five variables rather than nine materially changed results, I ran a regression of the anti-smoking index using the nine variables on the anti-smoking index using the five variables. The t-statistic on the five variable index is 73.46 and the r-squared is 0.97.

[11] I examine adults age 20 and over because the NHANES adult surveys are administered to adults age 20 and over.

33,201 individuals remain, 7,874 of which are current smokers.[12] Table 1 shows that smokers are generally younger, less likely to be married, and less educated. While men and African Americans are more likely to smoke, Hispanics are less likely to smoke. Current self-reported smokers smoke about 16 cigarettes per day and have an average cotinine concentration of about 217 ng/ml compared with an average concentration of 0.26 ng/ml for self-reported non-smokers. Cotinine works well in distinguishing smokers from non-smokers. Figure 1.2 shows the kernel density functions for the log of the cotinine concentration for current smokers and current non-smokers. The density function for cotinine is clearly bi-modal with a mass at low cotinine concentrations for self-reported non-smokers and a mass at higher cotinine levels for self-reported smokers. Cotinine also matches well to the number of cigarettes individuals smoke. Figure 1.3 shows a scatter plot of the total number of cigarettes self-reported smokers consumed over the past 30 days compared with the individuals' log cotinine levels.

1.5. OLS Results

Table 2 shows baseline results from the regressions described in Equations (1) and (2) to test the impact of tobacco control policies on smoking outcomes. Table 2 has nine columns. The first three columns show regressions including smoke-free air law variables in both private workplaces and restaurants or bars. The first column reports coefficients from a linear probability model on whether an individual is a current smoker, and the second and third columns report coefficients from OLS regressions using as dependent variables the average number of cigarettes smoked per day and the serum cotinine level, conditional on current smoking participation, respectively. In the top panel, the

[12] Just over 2,500 individuals in the sample report using other tobacco products which include cigars, pipes, chewing tobacco, snuff and nicotine gum.

independent variables of interest are the real average cigarette price and indicator variables for the presence of smoke-free air laws in private workplaces and restaurants or bars. The bottom panel shows results analogous to the top panel, but replaces the average real cigarette price with the average real cigarette excise tax in each state. All regressions also control for gender, age, age squared (divided by 100), race, ethnicity, education, income-to-poverty ratio, whether the serum cotinine sample was drawn on a weekday or weekend, the time of day the serum cotinine sample was drawn (morning, afternoon, or evening), marital status, state unemployment rate, state anti-smoking sentiment, the difference between the state's cigarette price or cigarette excise tax and the nearest lower price or tax in surrounding states, and state, year and quarter fixed effects. The standard errors are clustered at the state level (Bertrand, Duflo and Mullainathan 2004), and t-statistics are shown in parentheses.

The results in column one show that cigarette excise taxes are negatively and statistically significantly related to smoking prevalence, and although cigarette prices are negatively related, the coefficients are not statistically significant. A $1.00 increase in cigarette excise taxes is related to a 2.4 percentage point decrease in smoking prevalence. In column two, both cigarette prices and cigarette excise taxes are negatively related to conditional cigarette demand. For smokers, a $1.00 increase in cigarette prices is associated with a 1.7 cigarette decrease in the average number of cigarettes smoked per day, and a $1.00 increase in cigarette excise taxes is associated with a 1.1 cigarette per day decrease. Since the smoking prevalence is 25 percent, the tax coefficient from the linear probability model translates to a semi-elasticity of roughly -0.10. For the conditional demand models, the conditional price semi-elasticity for the number of cigarettes smoked per day is -0.12, and the tax semi-elasticity is roughly -0.08. These conditional price and tax semi-elasticities are consistent with previous estimates from the literature, for example tax elasticities of -0.15 and -0.14 from Evans and Farrelly (1998) and -0.15 from Adda and Cornaglia (2006).

While cigarette prices and excise taxes are negatively related to the average number of cigarettes smoked per day for smokers, there is no evidence that prices or excise taxes affect cotinine levels. A $1.00 increase in cigarette prices leads to a decrease in cotinine concentration of 8.1 ng/ml, and a $1.00 increase in cigarette excise taxes leads to a decrease of 8.5 ng/ml. However, the coefficients are not significant at conventional levels. The insignificant coefficients support previous research that argues that smokers' compensation undercuts the effects of cigarette excise taxes and prices (Evans and Farrelly 1998; Farrelly et al. 2004; Adda and Cornaglia 2006).

In columns one and two, smoke-free air laws are not related with either smoking participation or conditional cigarette demand. Column three suggests that smoke-free air laws affect cotinine concentrations in divergent ways. In column three, smoke-free air laws in private workplaces increase cotinine concentrations while smoke-free air laws in restaurants or bars decrease cotinine concentrations. To test whether these results could be due to multicollinearity among the smoke-free air laws in the sample, I calculated variance inflation factors and correlation coefficients for the smoke-free air law variables. In the linear probability model, the variance inflation factors for the private workplace and restaurant or bar smoke-free air laws are 45 and 46, respectively, and in the OLS specifications the variance inflation factors are both 39. The high variance inflation factors are supported by correlation coefficients of approximately 0.75 between the two smoke-free air law variables.

Thus, I re-estimate the models from columns one through three using each smoke-free air law variable separately. Columns four through nine in Table 2 show results from these regressions. The effects of cigarette prices and excise taxes are very similar to the first three columns. The tax semi-elasticity for participation is -0.10, and the price and tax semi-elasticities for conditional cigarette demand are -0.12 and -0.07 (The semi-elasticities for the coefficients in Tables 1.2 through 1.6 are displayed in Table 7). However, now both private workplace and restaurant or bar smoke-free air laws are negatively associated with smoking prevalence. The presence of either category of smoke-free air law is associated with a 2.2 to 2.6 percentage point reduction in smoking prevalence, depending on the specification. Neither category of smoke-free air law affects conditional cigarette demand or cotinine concentration.

In models not shown but available upon request, I re-estimate Table 2 using different specifications to check the robustness of the findings. First, I re-estimate the linear probability models using logistic models. The marginal effects of cigarette excise taxes are similar to the coefficients in the linear probability model and statistically significant at the five percent level. As in Table 2, cigarette prices are not statistically related to smoking prevalence. In the logit regressions, private workplace smoke-free air laws are negatively related to smoking prevalence both with and without including restaurant or bar smoke-free air laws, while restaurant or bar smoke-free air laws are negatively related with smoking prevalence in specifications without private workplace smoke-free air laws.

Next, I re-estimate Table 2 using NHANES survey weights. Cigarette prices are not associated with a decrease in smoking prevalence, but a $1.00 increase in cigarette prices leads to a 2.2 cigarette decrease in the conditional demand for cigarettes in all specifications, and the effects are significant at the ten percent level. A $1.00 increase in cigarette excise taxes is associated with a 3.0 to 3.3 percentage point decrease in smoking prevalence and a 1.5 to 1.6 cigarette decrease in the conditional demand for cigarettes, depending on which smoke-free air laws are included, although the conditional cigarette demand coefficients are not statistically significant. Private workplace smoke-free air laws are negatively related to smoking prevalence both with and without including restaurant or bar smoke-free air laws, while restaurant or bar smoke-free air laws are negatively related with smoking prevalence in specifications without private workplace smoke-free air laws.

Lastly, I re-estimate the OLS models from Table 2 using the log of the average number of cigarettes smoked per day and the log of the serum cotinine levels. A $1.00 increase in the cigarette price (excise tax) leads to a 7 (9) percent decrease in the average number of cigarettes smoked per day by smokers, but the effects are not statistically significant at conventional levels. However, workplace smoke-free air laws are associated with reductions in the log of the average number of cigarettes smoked per day. The presence of a workplace smoke-free air law is associated with a 10 to 12 percent decrease in conditional cigarette demand, depending on the specification. Additionally, restaurant or bar smoke-free air laws reduce conditional cigarette demand by 12 percent in the cigarette excise tax specifications. As in Table 2, I find little evidence that any tobacco control policies affect the log of serum cotinine concentrations.

The results from the OLS regressions confirm previous economic studies which find that cigarette excise taxes and prices reduce the number of cigarettes consumed. I also find that smoke-free air laws reduce smoking prevalence but not conditional cigarette demand. However, using serum cotinine levels I find no evidence that tobacco control policies are related to smokers' intake of nicotine.

1.6. Quantile Regression Results

1.6.1. Baseline Results

Next I turn to estimating how the effects in Table 2 vary across the distribution of the two main dependent variables of interest, the average number of cigarettes smoked per day and individuals' serum cotinine levels, conditional on smoking participation. Figures 1.4 through 1.7 and Tables 1.3 through 1.6 show results from quantile regressions estimating how the effects of tobacco control policies change across the distributions of the two dependent variables. As collinearity between the smoke-free air law variables led to divergent coefficients in Table 1.2, I focus on estimating quantile regression models including the smoke-free air laws separately.

In each figure, the solid line represents the quantile regression coefficients for cigarette excise taxes or cigarette prices at every 5^{th} quantile between the 5^{th} and 95^{th} quantiles, and the shaded area represents the 95 percent confidence interval for the quantile regression coefficients, calculated from bootstrapped standard errors using 299 replications. The dashed lines represent the corresponding OLS coefficients and 95 percent confidence intervals, calculated from standard errors clustered at the state level. For brevity, I show figures for quantile regressions using cigarette prices, although the corresponding tables outline both the cigarette price and cigarette tax models. Tables 1.3

through 1.6 each have eight columns. Column one repeats the relevant OLS results from Table 1.2, and columns two through eight show results for quantile regressions at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th quantiles. All regressions control for the same demographic variables in Table 1.2. Tables 1.3 and 1.5 show results from quantile regressions using private workplace smoke-free air laws, and Tables 1.4 and 1.6 show results using restaurant or bar smoke-free air laws.

Figure 1.4 and Tables 1.3 and 1.4 show that the decreases in the average number of cigarettes smoked per day associated with higher cigarette monetary costs are concentrated among heavier smokers. In Figure 1.4, the strength of the association between the cigarette price and the average number of cigarettes smoked per day grows steadily across the quantiles of cigarette consumption. The coefficients are insignificant in the lower part of the distribution but significant at the 75th through 95th quantiles. A $1.00 increase in cigarette prices decreases conditional cigarette demand by 1.7 cigarettes per day at the 75th quantile, 3.7 to 3.8 cigarettes at the 90th quantile, and 3.9 to 4.3 cigarettes at the 95th quantile. The coefficients for cigarette excise taxes follow a similar pattern, decreasing steadily across the distribution of smoking level. The coefficients on cigarette excise taxes increase from a 1.7 cigarette per day decrease in conditional demand for every $1.00 increase in taxes at the 75th quantile to more than a 2.3 cigarette per day decrease in conditional demand for every $1.00 increase in taxes at the 90th quantile. A Wald test confirms that the cigarette price coefficients are statistically different at the 10th and 90th quantiles at the five percent level, although the cigarette excise tax coefficients are not statistically different.[13] Figure 1.5 and Tables 1.3 and 1.4

[13] As with Table 1.2, I also estimate Tables 3 and 4 using the log of the number of cigarettes smoked. I find similar results both in terms of magnitude and statistical significance. The coefficients on cigarette excise

indicate that neither smoke-free air law has an effect on the average number of cigarettes smoked per day.[14] In terms of semi-elasticities, a $1.00 increase in cigarette prices (cigarette excise taxes) is associated with a 6 percent (7 percent) decrease in the number of cigarettes smoked per day at the median, a 9 percent (10 percent) decrease at the 75th quantile, and a 12 percent (9 percent) decrease at the 90th quantile.

Figure 1.6 and Tables 1.5 and 1.6 show the effects of tobacco control policies on smokers' serum cotinine levels across the cotinine distribution. Neither cigarette prices nor excise taxes are associated with cotinine concentrations at any part of the cotinine distribution. The effects for both prices and excise taxes are constant around the OLS estimates and insignificant for almost all the quantiles. Figure 1.7 and Tables 1.5 and 1.6 illustrate that neither smoke-free air law is associated with serum cotinine levels. [15]

1.6.2. Demographic Characteristics

Figures 1.8 and 1.9 plot the quantile regression and OLS coefficients for the individual demographic characteristics included in Tables 1.3 and 1.5.[16] Conditional on smoking, OLS results indicate that females smoke fewer cigarettes than men and have lower cotinine concentrations. Quantile coefficients indicate that the differences between

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taxes and cigarette prices are not significant at lower quantiles, but significant for most upper quantiles. A $1.00 increase in cigarette excise taxes (prices) leads to a 10 percent (5 percent) decrease in the average number of cigarettes smoked at the median, a 15 percent (12 percent) decrease at the 75th quantile, and a 9 percent (14 percent) decrease at the 90th quantile.

[14] The coefficients for cigarette prices and excise taxes are similar when both smoke-free air laws are included in the quantile regressions. A $1.00 increase in prices decreases conditional cigarette demand by 1.75 cigarettes per day at the 75th quantile, 3.47 cigarettes at the 90th quantile, and 4.18 cigarettes at the 95th quantile. A $1.00 increase in cigarette excise taxes decreases conditional demand by 2 cigarettes at the 75th quantile and more than 2.5 cigarettes at the 90th quantile. A Wald test confirms that the coefficients at the 10th and 90th quantiles are statistically different at the 10 percent level for cigarette excise taxes and at the 5 percent level for prices.

[15] I also estimate Tables 3 and 4 using the log of the number the serum cotinine level. I find similar results both in terms of magnitude and statistical significance. Neither cigarette excise taxes nor cigarette prices have an effect on log cotinine levels.

[16] Appendix Tables 1 and 2 show full results from the linear probability, OLS, and quantile regressions in Tables 3 and 5.

men and women increase for heavier smokers, although the coefficients are not statistically significant. Older people smoke more cigarettes and have higher serum cotinine concentrations, and both relationships are concave. Taller people smoke more cigarettes at all levels, but height does not affect cotinine concentrations. This is perhaps because taller people, with more body mass, need more cigarettes to achieve the same amount of nicotine stimulation as shorter people. African Americans and Hispanics smoke fewer cigarettes at all quantiles, and the effects grow at higher levels of smoking. But while Hispanics also have lower cotinine concentrations at all levels, African Americans' serum cotinine concentrations are higher at most parts of the distribution. This discrepancy between self-reported smoking status and cotinine concentration could be due to the popularity of menthol cigarettes in the African American community or differences in smoking habits (Caraballo et al. 1998). Marital status has little effect on either conditional cigarette demand or cotinine concentration. Income, like marital status, has little effect on conditional cigarette demand or cotinine concentration.[17]

1.6.3. Changes in Smoking Behavior

The results from the previous section show that although smokers reduce their cigarette consumption in response to higher cigarette prices and excise taxes, they do not inhale less nicotine. These results indicate that smokers change their smoking behavior in response to higher prices and taxes to inhale more smoke from each cigarette. In this section, I directly test whether smokers inhale more nicotine from each cigarette in response to increased cigarette excise taxes and prices, either through switching to

[17] Neither the time of day when the serum cotinine sample is drawn nor the weekday on which the sample is drawn have large effects on cotinine concentrations (results not shown in graphs). However, an evening examination increases cotinine levels by 15 to 17 ng/ml for individuals in the 50th and 75th quantiles.

cigarette brands with higher nicotine contents or smoking each cigarette more intensely, and test how these changes vary across the smoking distribution.

I modify Equation (3), using serum cotinine concentrations as the dependent variable, and I include the average number of cigarettes smoked per day and interaction terms between the tobacco control policies and the average number of cigarettes smoked per day as additional independent variables. I estimate the following equation:

$$Q_{(Cot|Smk=1)}(\tau|x) = \beta_{0\tau} + \beta_{1\tau}Cigs + \beta_{2\tau}P + \beta_{3\tau}SFA + \beta_{4\tau}Cigs \times P + \beta_{5\tau}Cigs \times SFA + \beta_{6\tau}X + \sigma_{s\tau} + \phi_{t\tau} + \eta_{q\tau} \quad (4)$$

In Equation (4), the derivative of cotinine levels with respect to the average number of cigarettes smoked per day is $\frac{\partial Q_{(Cot|Smk=1)}(\tau|x)}{\partial Cigs} = \beta_{1\tau} + \beta_{4\tau} \times P + \beta_{5\tau} \times SFA$. Thus, Equation (4) estimates whether the impact of the number of cigarettes smoked per day on cotinine levels changes based on the level of tobacco control policies. Put another way, the cross-partial derivative of cotinine levels with respect to the average number of cigarettes smoked per day and cigarette price is $\frac{\partial^2 Q_{(Cot|Smk=1)}(\tau|x)}{\partial Cigs\, \partial P} = \beta_{4\tau}$, and the cross-partial derivative of cotinine levels with respect to the average number of cigarettes smoked per day and smoke-free air laws is $\frac{\partial^2 Q_{(Cot|Smk=1)}(\tau|x)}{\partial Cigs\, \partial SFA} = \beta_{5\tau}$. Thus, if $\beta_{4\tau}$ is positive, an increase in cigarette price increases the amount of nicotine a smoker draws from each cigarette, and if $\beta_{5\tau}$ is positive, an increase in smoke-free air laws increases the amount of nicotine a smoker draws from each cigarette.

An alternative to estimating Equation (4) could be to estimate Equation (3) using the log ratio of cotinine to cigarettes smoked per day ("smoking intensity") as the dependent variable. This is the strategy undertaken by Adda and Cornaglia (2006). However, Equation (4) offers three main advantages. First, using Equation (4) allows me to examine the effects of tobacco control policies across the distribution of cotinine concentrations rather than distribution of smoking intensities. This is advantageous since the quantiles of smoking intensity do not necessarily correspond to the quantiles of smoking amounts. Figure 1.10 plots the relationship between the number of cigarettes smoked per day and smoking intensity. There is not much of a relationship between the number of cigarettes smoked and smoking intensity, and if anything, as the number of cigarettes increases, the average smoking intensity slightly decreases.

Second, using cotinine as a dependent variable allows a test of whether cigarette policies directly affect cotinine levels or only affect cotinine through changes in smoking behaviors. In Equation (4), the derivative of cotinine with respect to cigarette price is $\frac{\partial Q_{(Cot|Smk=1)}(\tau|x)}{\partial P} = \beta_{2\tau} + \beta_{4\tau} \times Cigs$. Thus, if $\beta_{2\tau}$ is statistically significantly different from zero, tobacco control policies affect smokers intake of cotinine directly and not only through $\beta_{4\tau}$ or $\beta_{5\tau}$, which measure changes in cigarette smoking behaviors.

Third, Equation (4) allows a direct examination of how much nicotine smokers inhale from each cigarette across the distribution of smoking levels. As noted in Section 1.2, the medical literature suggests that heavier smokers ingest less nicotine from each cigarette in order to smooth their nicotine consumption. If this hypothesis is correct, the coefficient for cigarettes smoked per day in Equation (4), $\beta_{1\tau}$, should follow a decreasing or concave pattern across the distribution of cotinine levels.

Figures 1.11 through 1.13 and Tables 1.8 and 1.9 show results from quantile regressions estimating Equation (4) and the corresponding OLS regressions. As with the quantile regressions in the previous section, I estimate Equation (4) including the smoke-free air law coefficients separately. Figure 1.11 plots the quantile regression coefficients for the direct price effect coefficient, $\beta_{2\tau}$, and the price-cigarette interaction coefficient, $\beta_{4\tau}$. Figure 1.11 plots the quantile regression coefficients for the direct smoke-free air law coefficient, $\beta_{3\tau}$, and the smoke-free air law-cigarette interaction coefficient, $\beta_{5\tau}$. Table 8 shows quantile regression and OLS results using private workplace smoke-free air laws, and Table 9 shows results using restaurant or bar smoke-free air laws.

The coefficients on cigarette prices and excise taxes are insignificant, indicating that cigarette prices and excise taxes are not directly related to cotinine concentrations, but rather are indirectly related through changes in cigarette smoking behavior. The coefficients for the interaction between the cigarettes smoked per day and cigarette prices are significant at the upper quantiles, indicating that heavier smokers adjust their smoking behavior in response to higher cigarette prices. At the median, every \$1.00 increase in cigarette prices increases the cotinine extracted from each cigarette by 0.45 to 0.49 ng/ml, and at the 95th quantile, every \$1.00 increase in cigarette prices increases the cotinine extracted from each cigarette by 1.18 to 1.24 ng/ml. Table 8 shows that every cigarette smoked per day adds about 5.6 ng/ml of cotinine at the 95th quantile in the corresponding regression, so an increase of 1.24 ng/ml corresponds to a change of 20 percent off the value of cotinine per cigarette. The coefficients for cigarette excise taxes follow a similar pattern, but are generally not significant at conventional levels. Lastly, similar to the previous quantile regression results, smoke-free air laws do not have an effect on smoking behavior. The coefficients are all small and statistically insignificant.[18]

[18] The coefficients for cigarette prices and excise taxes are similar when both smoke-free air laws are included in the quantile regressions. The coefficients on cigarette prices and taxes are insignificant, indicating the cigarette excise taxes and prices only affect cotinine levels through changes in cigarette smoking. The coefficients for the interaction between cigarettes smoked per day and prices are significant

Figure 1.13 shows results estimating the amount of cotinine that smokers ingest from each additional cigarette along the conditional cotinine distribution. The amount of cotinine from each cigarette smoked first increases as the total amount of cotinine increases, but decreases at the very upper quantiles. At the 5th quantile every additional cigarette per day adds 3.4 to 3.5 ng/ml of cotinine, at the median every additional cigarette per day adds 5.9 to 6.0 ng/ml of cotinine, and at the 90th quantile every additional cigarette per day adds between 5.7 to 5.9 ng/ml of cotinine. A Wald Test confirms that the coefficients for the cigarettes smoked per day at the 10th and 90th quantiles are statistically different at the one percent level. These results confirm previous medical research suggesting that heavier smokers ingest less nicotine from each cigarette, preferring to smooth their consumption of nicotine (Law et al. 1997).

1.7. Robustness Checks

1.7.1. Generalized Ordered Logit

One potential problem with the quantile regression estimates of the number of cigarettes smoked per day is bunching of the dependent variable around round numbers such as 10 cigarettes per day or 20 cigarettes per day. As a robustness check, I re-estimate the effects of tobacco control policies on the number of cigarettes smoked per day using a generalized ordered logit model. Generalized ordered logit models estimate the effects of independent variables on an ordered dependent variable, but unlike traditional ordered logit models, the coefficients can vary across the different categories of the dependent variable. The generalized ordered logit model is written as

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at the upper quantiles. At the median, every \$1.00 increase in cigarette prices increases the cotinine extracted from each cigarette by 0.48 ng/ml, and at the 95th quantile, every \$1.00 increase in cigarette prices increases the cotinine extracted from each cigarette by 1.24 ng/ml.

$$P(Y_i > j) = \frac{\exp\left(\alpha_0 + \beta_{1j}P_{stq} + \beta_{2j}SFA_{stq} + \beta_{3j}X_{istq} + \mu_{sj} + \delta_{tj} + \gamma_{qj}\right)}{1 + \exp\left(\beta_{1j}P_{stq} + \beta_{2j}SFA_{stq} + \beta_{3j}X_{istq} + \mu_{sj} + \delta_{tj} + \gamma_{qj}\right)}, \quad (5)$$

where the explanatory variables are as defined in Section 1.3.

I split the dependent variable of individuals' average number of cigarettes smoked per day into four categories: (a) 0 cigarettes smoked per day; (b) greater than 0 but less than or equal to 10 cigarettes smoked per day; (c) greater than 10 but less than or equal to 20 cigarettes smoked per day; and (d) greater than 20 cigarettes smoked per day. I estimate the model using the user-written Stata command gologit2 (Williams 2006), and I adjust the standard errors for clustering at the state level. As with the previous models, I estimate the generalized ordered logit models separately for each smoke-free air law. Table 10 shows results from generalized ordered logit regressions estimating the effects of tobacco control policies on the number of cigarettes smoked per day. Each column shows the marginal effects for the relevant category of cigarette smoking. The top panel shows results using cigarette prices, and the bottom panel shows results using cigarette excise taxes.

Like Tables 1.3 and 1.4, the coefficients show that cigarette prices and excise taxes have larger effects for heavier smokers. The coefficients for cigarette prices (excise taxes) show that a $1.00 increase in cigarette excise taxes (prices) increases the probability of being a non-smoker by 0.8 to 0.9 percentage points (2.6 to 2.7 percentage points) and decreases the probability of smoking more than 20 cigarettes per day by 0.6 percentage points (0.5 to 0.6 percentage points). Chi-squared tests for the equality of the coefficients confirm that the coefficients for cigarette prices are statistically different at the 5 percent level while the coefficients for cigarette excise taxes are statistically different at just above the 10 percent level.

Private workplace and restaurant or bar smoke-free air laws reduce smoking prevalence by 2.4 to 2.8 percentage points. Additionally, Table 10 provides some evidence that smoke-free air laws are associated with reductions in the average number of cigarettes smoked per day by smokers, and the reductions are largest in the 10 to 20 cigarettes per day category. Private workplace or restaurant smoke-free air laws are associated with a 1.0 to 1.4 percentage point decrease in the probability of smoking 10 to 20 cigarettes per day.[19]

1.7.2. Other Potential Issues

My results could suffer from a few additional potential issues. First, as the NHANES data are a repeated cross section, I cannot observe individuals over time. The ideal statistical design for examining individuals' responses to tobacco control policies would be a panel of individuals, allowing direct examination of how an individual behaves before and after changes in tobacco control policies. This is a problem in most papers estimating the effects of tobacco control policies, but it may be an additional problem as my paper uses a biomarker of nicotine consumption. Unobservable individual differences in nicotine metabolism may add measurement error to the observed cotinine concentrations. However, the medical literature suggests cotinine levels in smokers are fairly consistent across time (Kemmeren et al. 1994). Moreover, the individual

[19] The coefficients for cigarette prices and excise taxes are similar when including both smoke-free air laws in the models. The coefficients for cigarette prices (excise taxes) show that a $1.00 increase in cigarette prices (excise taxes) increases the probability of being a non-smoker by 0.8 percentage points (2.6 percentage points) and decreases the probability of smoking more than 20 cigarettes per day by 0.6 percentage points (0.6 percentage points). Chi-squared tests for the equality of the coefficients confirm that the coefficients for prices are statistically different at the 5 percent level while the coefficients for taxes are nearly statistically different at the 10 percent level. Private workplace smoke-free air laws decrease smoking prevalence and also reduce conditional cigarette demand. However, restaurant or bar smoke-free air laws do not affect cigarette smoking.

differences in cotinine metabolism will not bias my coefficients as long as these differences in nicotine metabolism are unrelated to tobacco control policies.

Another potential issue arising from the use of repeated cross section data is selection. If tobacco control policies induce more light smokers than heavy smokers to quit, changes in smokers' outcomes may be due to changes in the pool of smokers and not actual behavioral changes. However, if selection was an issue and either light or heavy smokers were quitting, that should manifest itself in the OLS and quantile regressions for cotinine concentrations. Additionally, I would expect to see changes in the conditional distribution of cotinine concentrations for smokers over time, as cigarette excise taxes and prices have generally increased. Figure 1.11 plots the log of smokers' serum cotinine concentrations for each NHANES survey wave. There is not a clear pattern of a change in the distributions over the survey waves.

Lastly, policy endogeneity may affect my results. If cigarette excise taxes, prices or smoke-free air laws are related to state anti-smoking sentiment, then anti-smoking sentiment could drive both reductions in smoking outcomes and the enactment of tobacco control policies. I account for anti-smoking sentiment by including state and year fixed effects, which will control for any time-invariant, state-specific, characteristics and aggregate trends, and by including a time-varying measure of state-level anti-smoking sentiment following the methodology of DeCicca et al. (2008). This measure of anti-smoking sentiment is generally insignificant, indicating that additional, unobservable anti-smoking sentiment is not an issue.

1.8. Conclusion

This paper uses quantile regression to examine how tobacco control policies affect smoking behavior across the distribution of smoking levels. I use individual level repeated cross-section data from NHANES, and I measure smoking behavior both using the traditional metric of cigarettes smoked per day and also using levels of serum cotinine, a direct and continuous biomarker of nicotine intake.

On the surface, my results suggest that cigarette excise taxes are an effective policy instrument for reducing smoking behavior, as higher cigarette prices and excise taxes reduce the number of cigarettes smokers consume per day. Using quantile regression, I find that the reductions in cigarette consumption are concentrated among heavier smokers. I generally find similar results when examining cigarette excise taxes and cigarette prices, although heavy smokers are generally more responsive to cigarette prices. These results agree with the results of Ross, Chaloupka, and Wakefield (2006), Liang and Chaloupka (2002) and Tauras (2005), who find that cigarette prices have larger effects for heavier youth smokers.

However, in stark contrast to the results using the number of cigarettes smoked per day as the dependent variable, I find that tobacco control policies are not associated with the nicotine intake of smokers at any level. Although smokers consume fewer cigarettes, I find that for every $1.00 increase in cigarette prices, the heaviest smokers may inhale as much as 20 percent more nicotine from each cigarette through switching brands or smoking more intensely. Thus, my results indicate that cigarette excise taxes and smoke-free air laws are not an effective means to reduce the nicotine consumption of smokers.

My results do indicate that cigarette excise taxes are effective at reducing smoking prevalence. I also find that smoke-free air laws in private workplaces and restaurants or bars reduce smoking prevalence when examining the laws separately in regressions. However, collinearity between the smoke-free air laws inflates the standard errors when the variables are both included in regression models.

My results add to the growing literature estimating the distributional effects of public policies and illustrate that only examining effects at the mean may provide an incomplete picture of the effects of public policies. For example, as heavy smokers are the most likely to develop cancer or other adverse effects from smoking, policy makers may be most interested in curbing the smoking behavior of heavy smokers. The well-established finding in the economics literature that tobacco control policies reduce cigarette consumption at the mean does not reveal whether heavy smokers, light smokers, or both are driving the reductions. However, my results also illustrate the importance of considering substitution effects. As cigarette excise taxes and smoke-free air laws do not directly raise the price of consuming nicotine, but rather raise the fixed cost of smoking a cigarette, smokers can compensate for increased tobacco control policies by inhaling more deeply or switching cigarette brands.

Policy makers should take note that cigarette excise taxes and smoke-free air laws reduce nicotine exposure at the extensive margin but not through the intensive margin. That is, my results suggest that although cigarette excise taxes and smoke-free air laws are not effective methods for reducing nicotine consumption among smokers, these policies can reduce smoking prevalence. Although raising the cost of cigarettes is not effective at reducing smokers' intake of nicotine, policies that affect the demand for nicotine more directly may be effective at both reducing smoking prevalence and conditional cigarette demand. For example, a tax that is based on the nicotine content of cigarettes, rather than levied equally on each cigarette, may be more effective at reducing nicotine exposure.

Moreover, policy makers should consider that changing inhalation patterns by smokers could affect the development of adverse effects from smoking. While the medical literature has established that it is the amount of smoke and harmful chemicals inhaled, not the number of cigarettes smoked, that leads to the development of cancers and chronic obstructive pulmonary disease, the medical literature also suggests that different inhalation patterns of tobacco smoke lead to different types of lung cancers. Epidemiologists have connected the surge in adenocarcinomas of the lung, a lung cancer that typically develops in the peripheries of the lung, to changes in how smokers inhale cigarette smoke (Wald et al. 1983; Wynder and Muscat 1995; Burns, Anderson and Gray 2011). Adenocarcinoma of lung are harder to detect at earlier stages, since the common symptoms of lung cancer such as a chronic cough or coughing up blood, may not arise until the tumor has progressed to a later stage. My results suggest that cigarette excise taxes could increase the prevalence of these cancers that are harder to detect.

This paper calls for more research into the compensating behavior of smokers and the distributional effects of tobacco control policies. Future research could make use of data sources allowing for an examination of a panel of individuals' serum cotinine levels over time. More broadly, my results suggest that studies of the effects of other public policies may miss important heterogeneity if they only measure the effects at the mean or do not consider compensating behavior.

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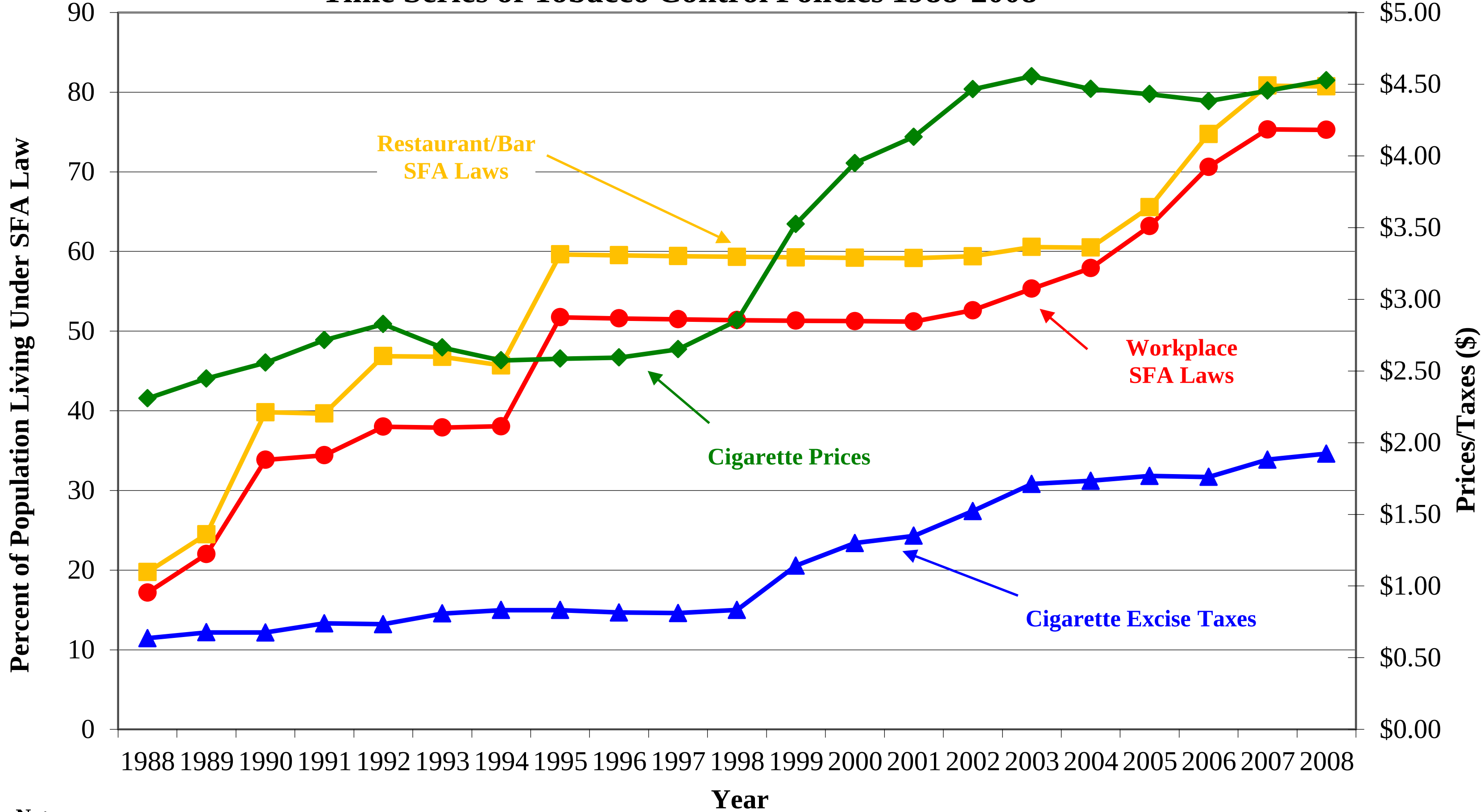
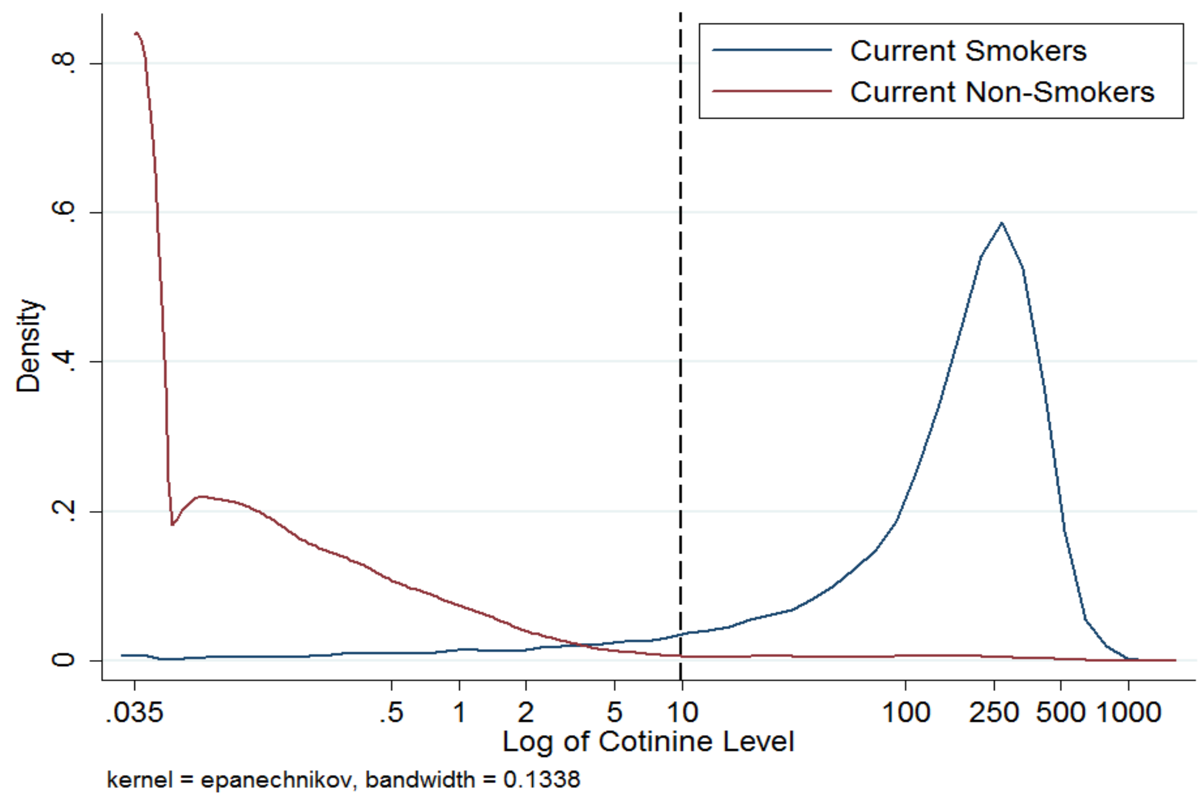
Figure 1.1
Time Series of Tobacco Control Policies 1988-2008



Notes:
Data from the Tax Burden on Tobacco output by Orzechowski and Walker, Project ImpacTeen, and Lillard and Sfekas (2010). All taxes and prices are in 2009 dollars. Cigarette taxes are the state excise tax paid on one pack of cigarettes, and cigarette prices are the weighted average price of one pack of cigarettes, excluding generic brands. All taxes, prices and SFA laws are aggregated across states using population weights.

Figure 1.2

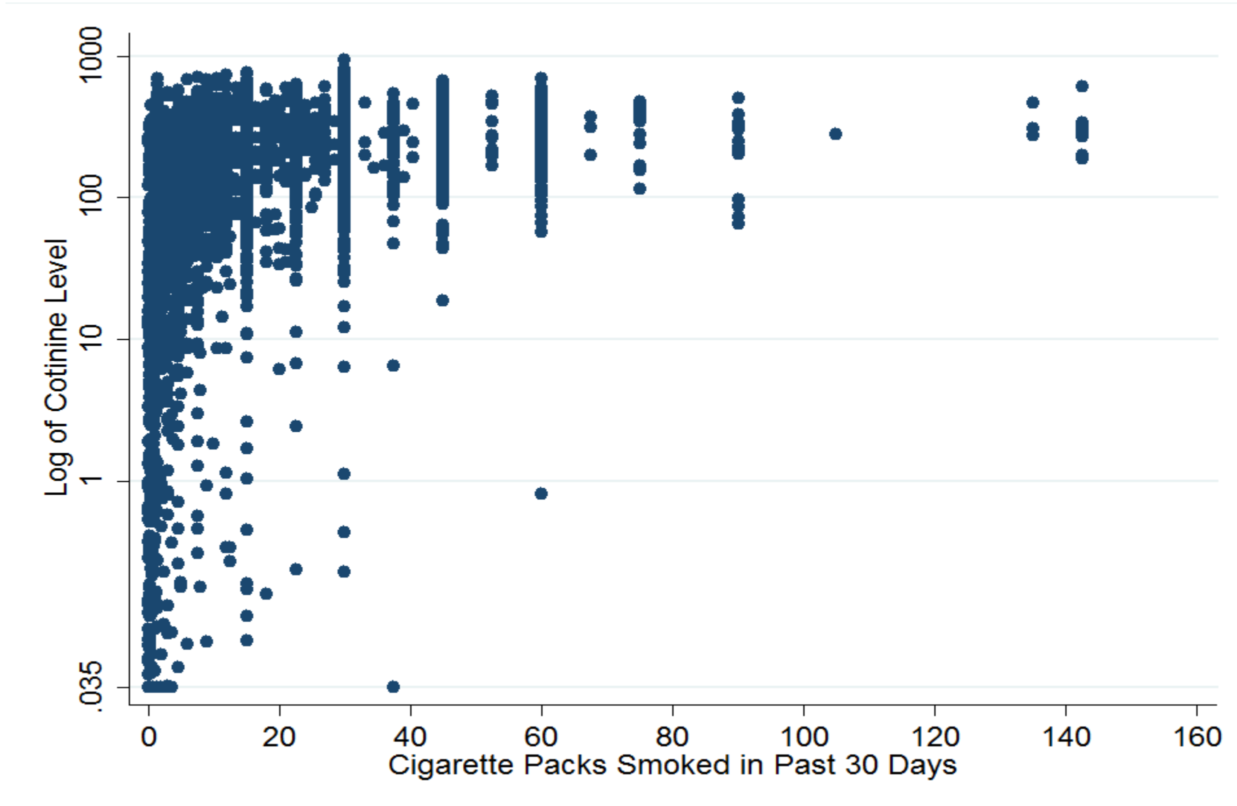
Kernel Density Plot of Log Cotinine Levels by Smoking Status



Notes:
Data from NHANES III and NHANES 1999/2000 - NHANES 2007/2008. The black dashed line indicates a serum cotinine concentration of 10 mg/nl, the common cutoff for distinguishing smokers from non-smokers.

Figure 1.3

Scatter Plot of Cigarettes Smoked per Day and Log Cotinine Levels

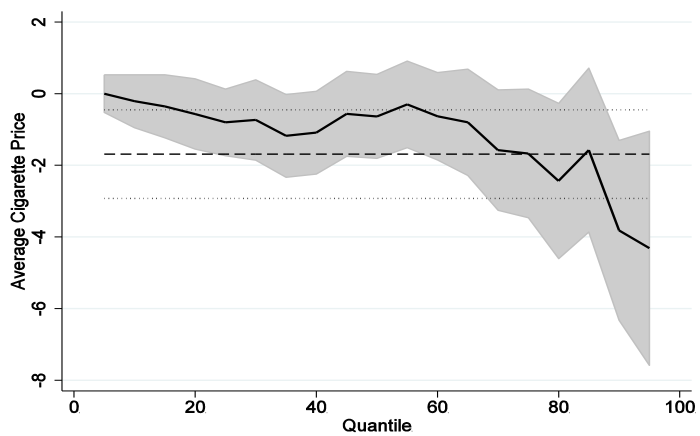


Notes:

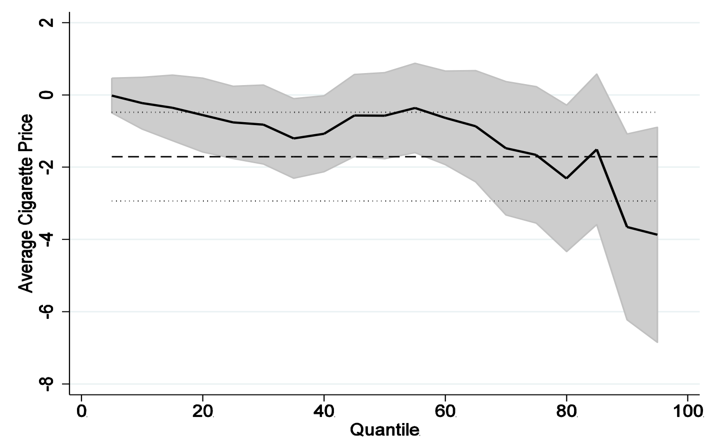
Data from NHANES III and NHANES 1999/2000 - NHANES 2007/2008.

Figure 1.4
Quantile Regression Results of the Impact of Cigarette Prices on The Average Number of Cigarettes Smoked per Day

Panel A. Cigarette Prices in Work SFA Laws Model



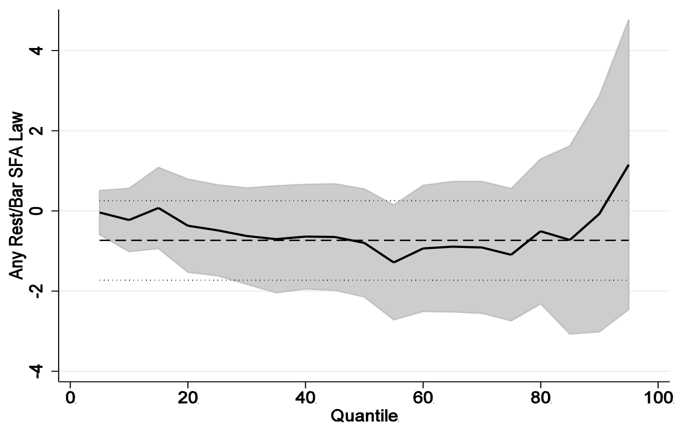
Panel B. Cigarette Prices in Rest/Bar SFA Laws Model



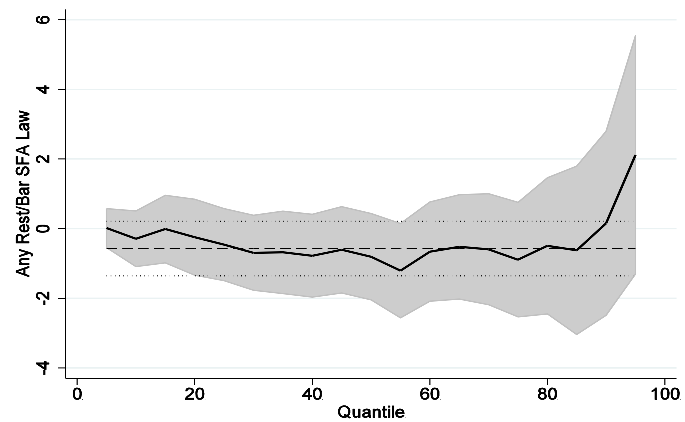
Notes:
The plots display quantile regression coefficients for every 5th quantile between the 5th through 95th quantiles and corresponding OLS coefficients. The dependent variable in both plots is the average number of cigarettes smoked per day, conditional on smoking participation. The solid line represents the quantile regression coefficients and the shaded area represents the 95 percent confidence interval for the quantile regression coefficients, calculated from bootstrapped standard errors using 299 replications. The dashed lines represent the corresponding OLS coefficients and 95 percent confidence interval, calculated from standard errors clustered at the state level. All regressions also control for the presence of smoke-free air laws, gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the price and the nearest lower price in another state, and state, year and quarter fixed effects.

Figure 1.5
Quantile Regression Results of the Impact of Smoke-Free Air Laws on The Average Number of Cigarettes Smoked per Day

Panel A. Work SFA Laws in Cigarette Prices Model



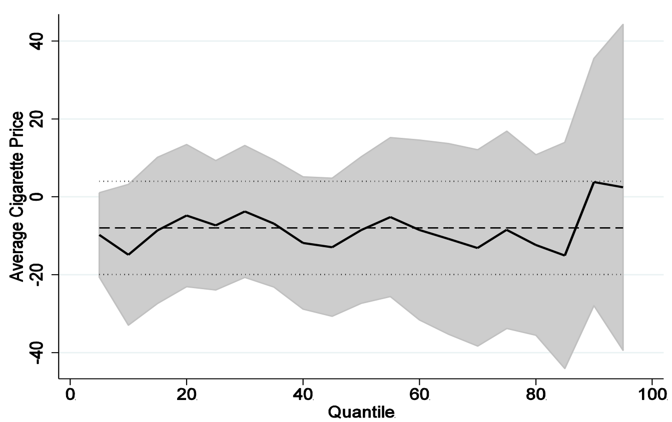
Panel B. Rest/Bar SFA Laws in Cigarette Prices Model



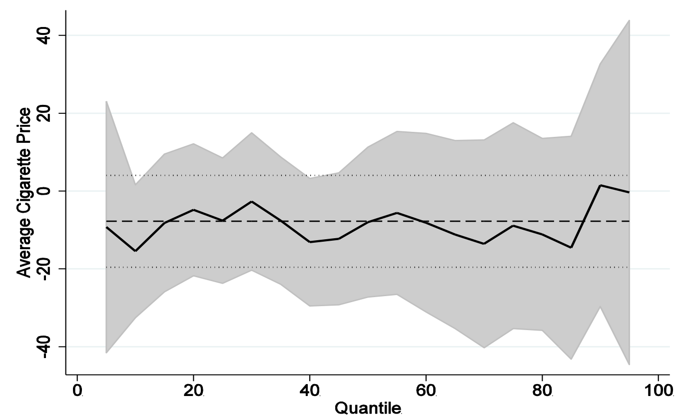
Notes:
The plots display quantile regression coefficients for every 5th quantile between the 5th through 95th quantiles and corresponding OLS coefficients. The dependent variable in both plots is the average number of cigarettes smoked per day, conditional on smoking participation. The solid line represents the quantile regression coefficients and the shaded area represents the 95 percent confidence interval for the quantile regression coefficients, calculated from bootstrapped standard errors using 299 replications. The dashed lines represent the corresponding OLS coefficients and 95 percent confidence interval, calculated from standard errors clustered at the state level. All regressions also control for cigarette price, gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the price and the nearest lower price in another state, and state, year and quarter fixed effects.

Figure 1.6
Quantile Regression Results of the Impact of Cigarette Prices on Serum Cotinine Levels

Panel A. Cigarette Prices in Work SFA Laws Model



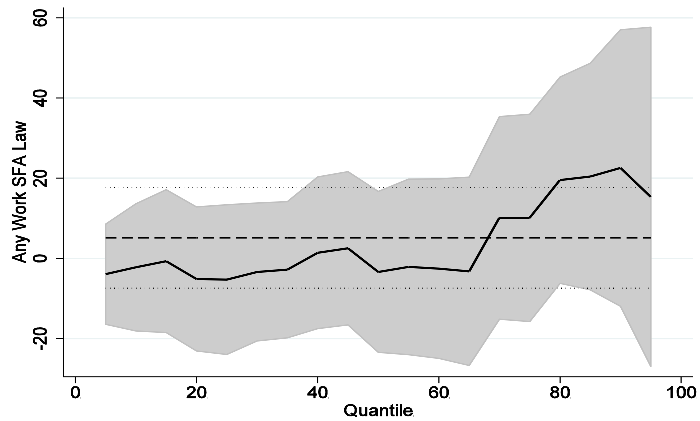
Panel B. Cigarette Prices in Rest/Bar SFA Laws Model



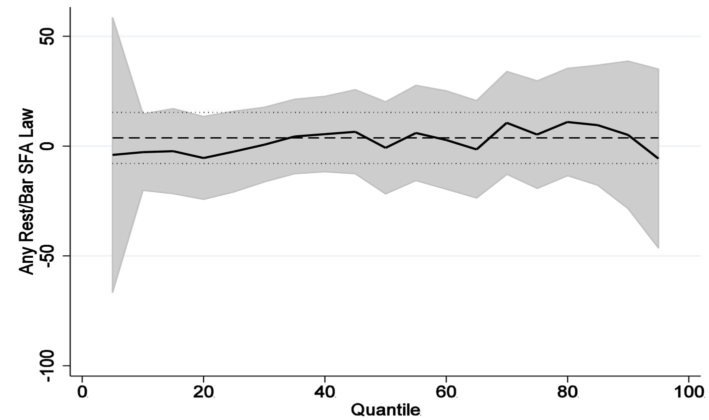
Notes:
The plots display quantile regression coefficients for every 5th quantile between the 5th through 95th quantiles and corresponding OLS coefficients. The dependent variable in both plots is the serum cotinine concentration, measured in ng/ml, conditional on smoking participation. The solid line represents the quantile regression coefficients and the shaded area represents the 95 percent confidence interval for the quantile regression coefficients, calculated from bootstrapped standard errors using 299 replications. The dashed lines represent the corresponding OLS coefficients and 95 percent confidence interval, calculated from standard errors clustered at the state level. All regressions also control for the presence of smoke-free air laws, gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the price and the nearest lower price in another state, and state, year and quarter fixed effects.

Figure 1.7
Quantile Regression Results of the Impact of Smoke-Free Air Laws on Serum Cotinine Levels

Panel A. Work SFA Laws in Cigarette Prices Model

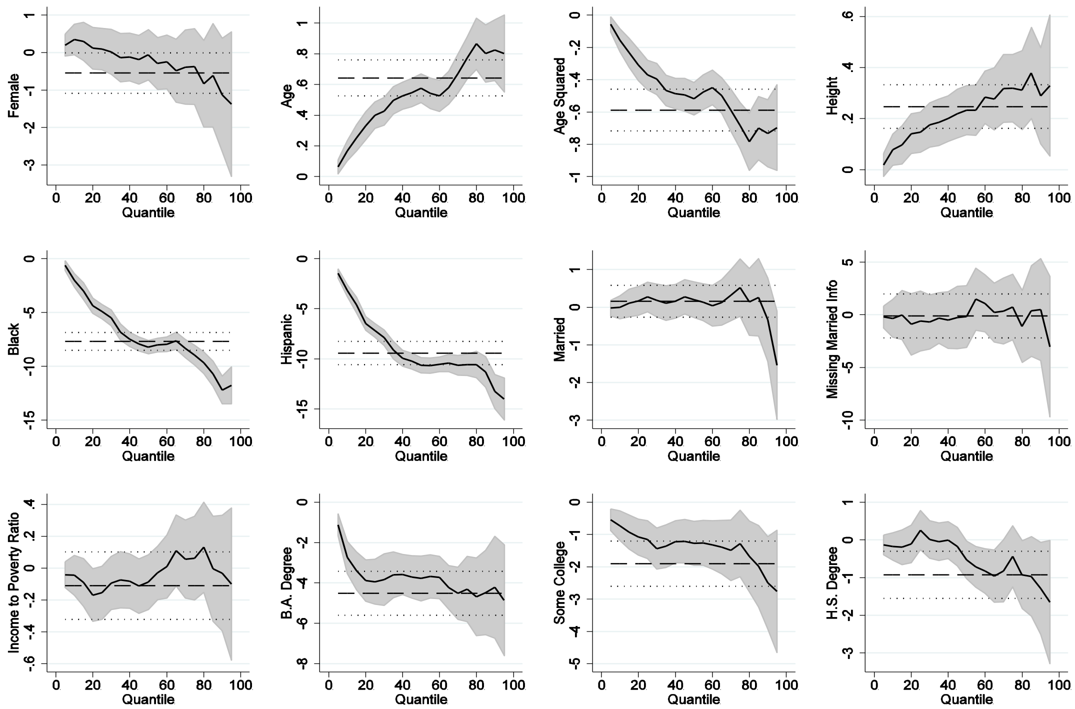


Panel B. Rest/Bar SFA Laws in Cigarette Prices Model



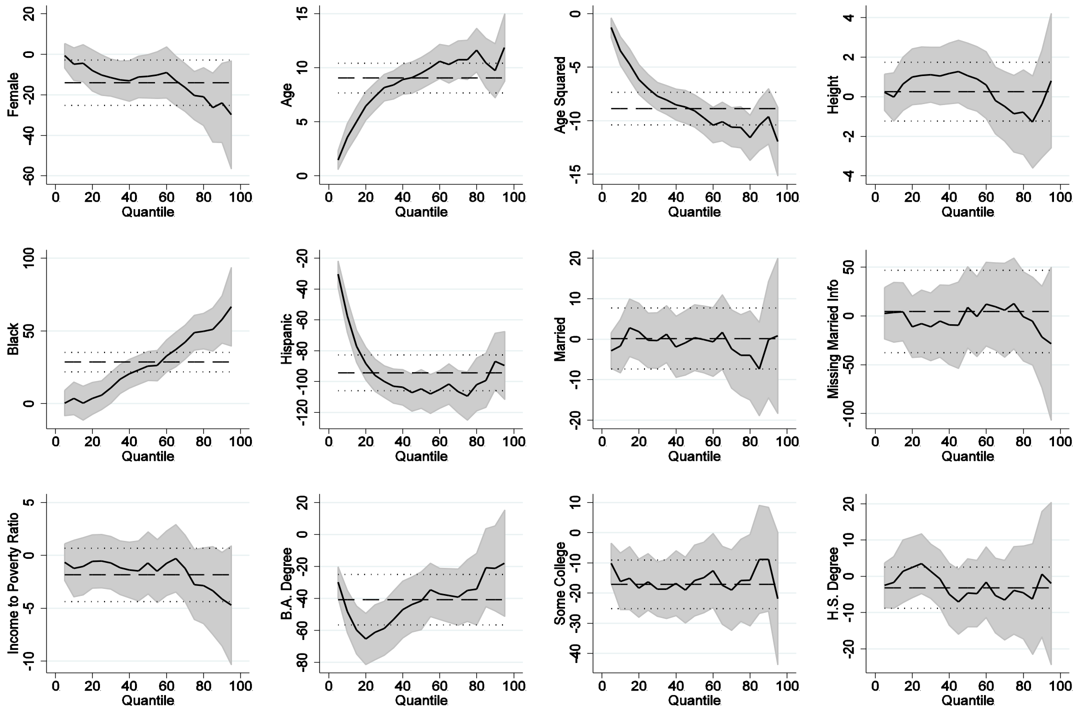
Notes:
The plots display quantile regression coefficients for every 5th quantile between the 5th through 95th quantiles and corresponding OLS coefficients. The dependent variable in both plots is the serum cotinine concentration, measured in ng/ml, conditional on smoking participation. The solid line represents the quantile regression coefficients and the shaded area represents the 95 percent confidence interval for the quantile regression coefficients, calculated from bootstrapped standard errors using 299 replications. The dashed lines represent the corresponding OLS coefficients and 95 percent confidence interval, calculated from standard errors clustered at the state level. All regressions also control for cigarette price, gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the cigarette price and the nearest lower price in another state, and state, year and quarter fixed effects.

Figure 1.8
Quantile Regression Results of the Impact of Demographic Variables on The Average Number of Cigarettes Smoked Per Day



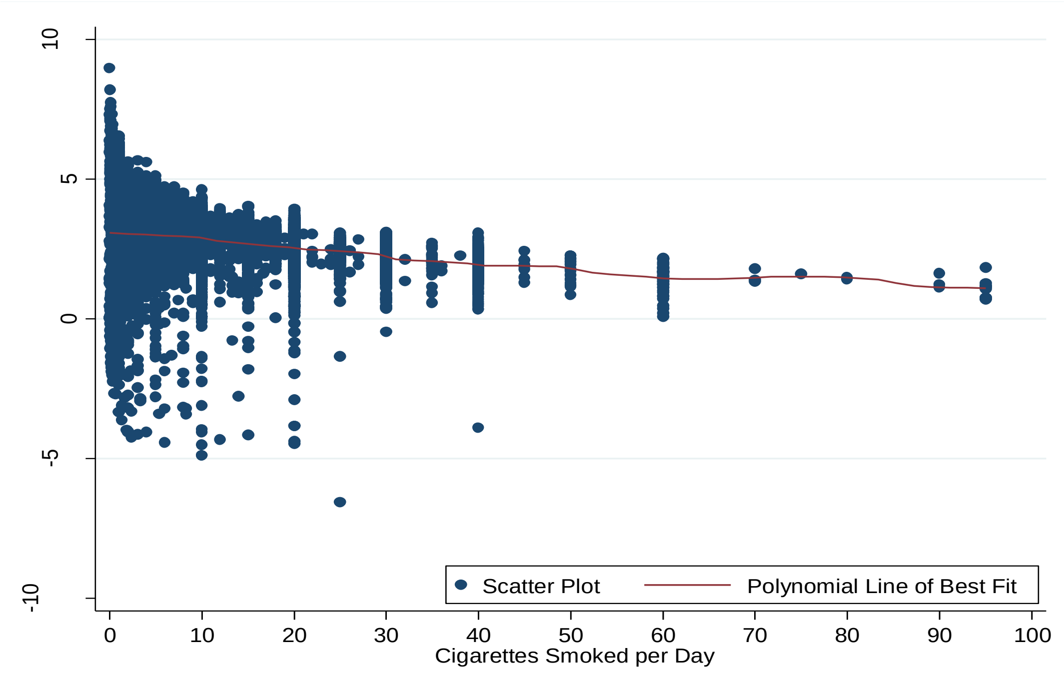
Notes:
The plots display quantile regression coefficients for every 5th quantile between the 5th through 95th quantiles and corresponding OLS coefficients. The dependent variable in all plots is the average number of cigarettes smoked per day, conditional on smoking participation. The solid line represents the quantile regression coefficients and the shaded area represents the 95 percent confidence interval for the quantile regression coefficients, calculated from bootstrapped standard errors using 299 replications. The dashed lines represent the corresponding OLS coefficients and 95 percent confidence interval, calculated from standard errors clustered at the state level. All regressions also control for cigarette prices, the presence of smoke-free air laws, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the cigarette price and the nearest lower price in another state, and state, year and quarter fixed effects.

Figure 1.9
Quantile Regression Results of the Impact of Demographic Variables on Serum Cotinine Levels



Notes:
The plots display quantile regression coefficients for every 5th quantile between the 5th through 95th quantiles and corresponding OLS coefficients. The dependent variable in all plots is the serum cotinine concentration, conditional on smoking participation. The solid line represents the quantile regression coefficients and the shaded area represents the 95 percent confidence interval for the quantile regression coefficients, calculated from bootstrapped standard errors using 299 replications. The dashed lines represent the corresponding OLS coefficients and 95 percent confidence interval, calculated from standard errors clustered at the state level. All regressions also control for cigarette prices, the presence of smoke-free air laws, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the price and the nearest lower price in another state, and state, year and quarter fixed effects.

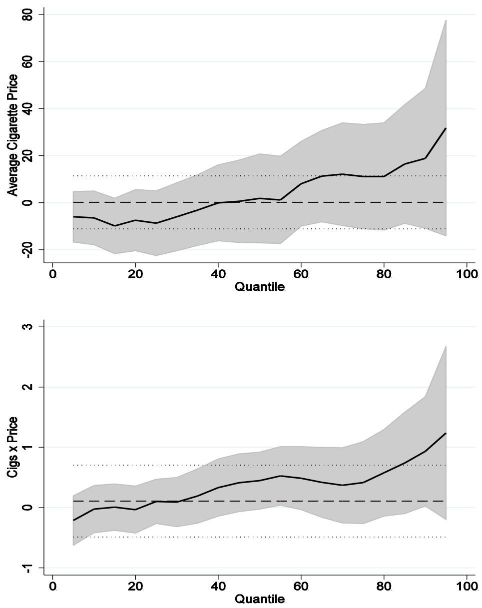
Figure 1.10
Smoking Intensity and Cigarettes Smoked Per Day



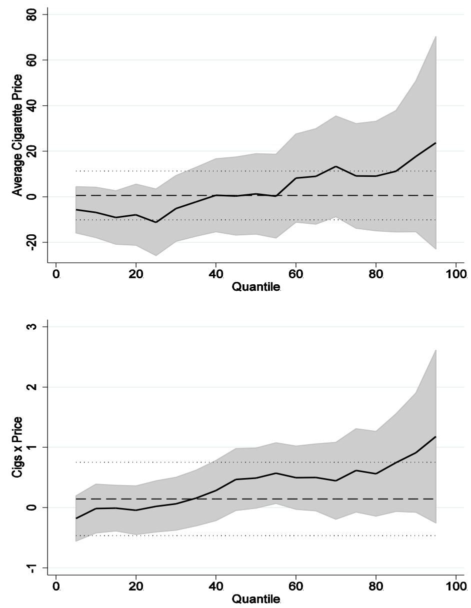
Notes:
Data from NHANES. Smoking intensity is defined as the log of the cotinine concentration minus the log of cigarettes smoked per day.

Figure 1.11
Quantile Regression Results of the Impact of Cigarette Prices on Changes in Smoking Behavior

Panel A. Cigarette Prices in Work SFA Laws Model

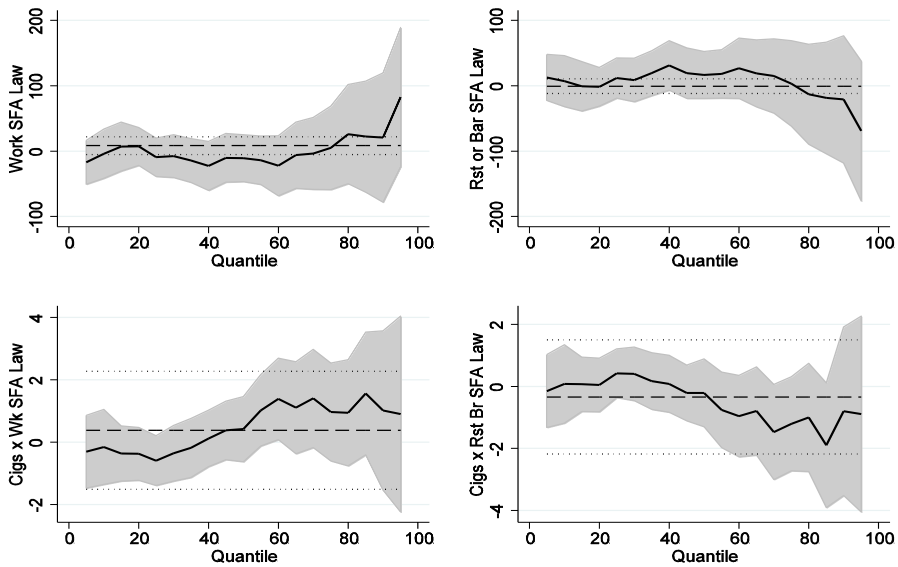


Panel B. Cigarette Prices in Rest/Bar SFA Laws Model



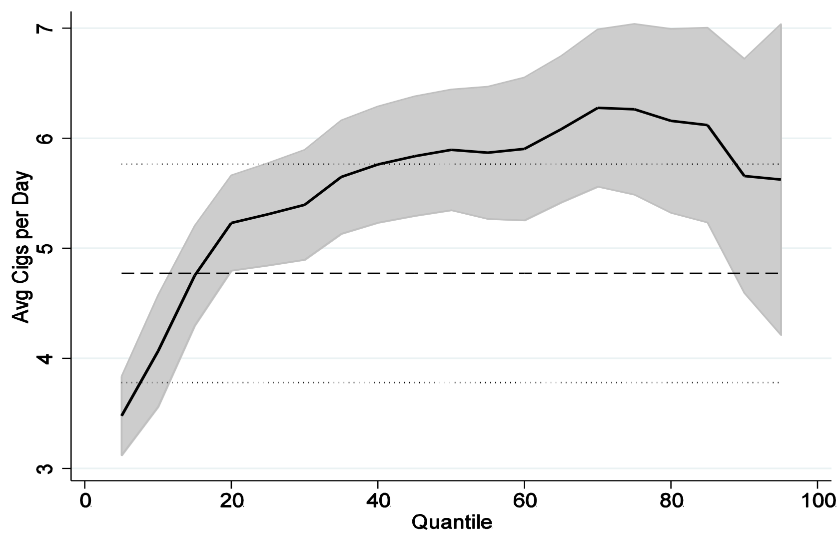
Notes:
The plots display quantile regression coefficients for every 5th quantile between the 5th through 95th quantiles and corresponding OLS coefficients. The dependent variable in all plots is the serum cotinine concentration, measured in ng/ml, conditional on smoking participation. The solid line represents the quantile regression coefficients and the shaded area represents the 95 percent conficence interval for the quantile regression coefficients, calculated from bootstrapped standard errors using 299 replications. The dashed lines represent the corresponding OLS coefficients and 95 percent confidence interval, calculated from standard errors clustered at the state level. All regressions also control for the average number of cigarettes smoked per day, smoke-free air laws, gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the tax/price and the nearest lower tax/price in another state, and state, year and quarter fixed effects.

Figure 1.12
Quantile Regression Results of the Impact of Smoke-Free Air Laws on Changes in Smoking Behavior



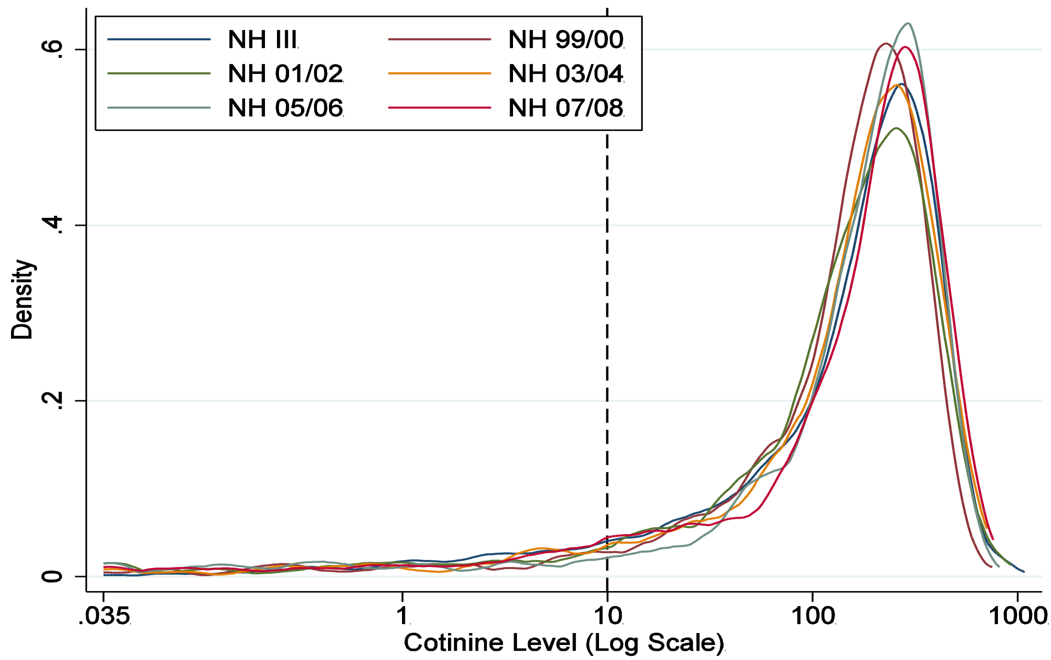
Notes:
The plots display quantile regression coefficients for every 5th quantile between the 5th through 95th quantiles and corresponding OLS coefficients. The dependent variable in all plots is the serum cotinine concentration, measured in ng/ml, conditional on smoking participation. The solid line represents the quantile regression coefficients and the shaded area represents the 95 percent conficence interval for the quantile regression coefficients, calculated from bootstrapped standard errors using 299 replications. The dashed lines represent the corresponding OLS coefficients and 95 percent confidence interval, calculated from standard errors clustered at the state level. All regressions also control for the average number of cigarettes smoked per day, cigarette prices, gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the tax/price and the nearest lower tax/price in another state, and state, year and quarter fixed effects.

Figure 1.13
Quantile Regression Results of the Impact of
The Average Number of Cigarettes Smoked per Day on Serum Cotinine Levels



Notes:
The plots display quantile regression coefficients for every 5th quantile between the 5th through 95th quantiles and corresponding OLS coefficients. The dependent variable is the serum cotinine concentration, measured in ng/ml, conditional on smoking participation. The solid line represents the quantile regression coefficients and the shaded area represents the 95 percent confidence interval for the quantile regression coefficients, calculated from bootstrapped standard errors using 299 replications. The dashed lines represent the corresponding OLS coefficients and 95 percent confidence interval, calculated from standard errors clustered at the state level. All regressions also control for cigarette prices, the presence of smoke-free air laws in private workplaces, interactions between the tobacco control policies and the average number of cigarettes smoked per day, gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the cigarette price and the nearest lower price in another state, and state, year and quarter fixed effects.

Figure 1.14
Cotinine Levels for Smokers by NHANES Survey Wave



Notes:
Data from NHANES. The black dashed line indicates a serum cotinine concentration of 10 mg/nl, the common cutoff for distinguishing smokers from non-smokers.

Table 1.1
Summary Statistics

Variable	Total Sample (N=33,201)		Smokers (N=7874)		Non-Smokers (N=25,327)		Diff in Means
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	P-Value
Currently Smoke	0.2506	0.4334	1.0000	n/a	0.0000	n/a	n/a
Avg Cigs per Day	3.9795	9.1093	15.8773	11.9237	0.0000	n/a	n/a
Cotinine Concentration	54.5905	116.4990	217.0177	137.6285	0.2631	0.7668	0.000
Average Cigarette Price	4.0162	0.9006	3.9563	0.9217	4.0363	0.8926	0.000
Cigarette Excise Tax	1.5070	0.7011	1.4640	0.7118	1.5214	0.6969	0.000
Any Work SFA Law	0.4654	0.4988	0.4500	0.4975	0.4706	0.4992	0.025
Any Rst or Bar SFA Law	0.5769	0.4941	0.5517	0.4974	0.5853	0.4927	0.000
Female	0.5454	0.4979	0.4738	0.4993	0.5694	0.4952	0.000
Age	46.2349	16.5508	41.2238	13.9077	47.9110	17.0193	0.000
Height	66.2900	3.9312	66.9130	3.7341	66.0817	3.9733	0.000
Black	0.1067	0.3088	0.1222	0.3276	0.1015	0.3020	0.000
Hispanic	0.1231	0.3286	0.1088	0.3114	0.1279	0.3340	0.000
Married	0.6396	0.4801	0.5582	0.4966	0.6668	0.4714	0.000
Missing Married Info	0.0200	0.1401	0.0181	0.1331	0.0207	0.1424	0.351
Income to Poverty Ratio	2.8175	1.7150	2.3798	1.6459	2.9639	1.7127	0.000
B.A. Degree	0.2503	0.4332	0.1137	0.3175	0.2960	0.4565	0.000
Some College	0.2828	0.4504	0.2655	0.4416	0.2886	0.4531	0.006
H.S. Degree	0.2634	0.4405	0.3370	0.4727	0.2388	0.4263	0.000
State Unemployment Rate	5.3216	1.2424	5.3013	1.2247	5.3284	1.2483	0.207

Notes:
Data from NHANES III and NHANES 1999/2000 through NHANES 2007/2008, the Tax Burden on Tobacco, Project ImpacTeen, Lillard and Sfekas (2010), U.S. Census, and the Bureau for Labor Statistics. Summary statistics are weighted by NHANES sample weights.

Table 1.2
The Impact of Tobacco Control Policies on Smoking Outcomes

	Both SFA Laws			Work SFA Law Only			Restaurant/Bar SFA Law Only		
	Prevalence	Avg. Cigarettes per Day	Serum Cotinine Level	Prevalence	Avg. Cigarettes per Day	Serum Cotinine Level	Prevalence	Avg. Cigarettes per Day	Serum Cotinine Level
Cigarette Prices									
Average Cigarette Price	-0.0069	-1.7184***	-8.1381	-0.0071	-1.6907***	-7.9701	-0.0078	-1.7099***	-7.7604
	(-0.628)	(-2.823)	(-1.393)	(-0.649)	(-2.804)	(-1.367)	(-0.703)	(-2.854)	(-1.349)
Any Work SFA Law	-0.0324	0.2108	9.391	-0.0255**	-0.4947	5.1106			
	(-1.572)	-0.179	-0.926	(-2.196)	(-1.149)	(0.836)			
Any Rest/Bar SFA Law	0.0073	-0.7587	-4.6033				-0.0223*	-0.5714	3.7387
	(0.281)	(-0.694)	(-0.555)				(-1.778)	(-1.503)	(0.658)
Adjusted R^2	0.118	0.22	0.176	0.118	0.220	0.176	0.118	0.220	0.176
Num. Obs	33201	7874	7874	33201	7874	7874	33201	7874	7874
Cigarette Excise Taxes									
Cigarette Excise Tax	-0.0243**	-1.1172*	-8.4390	-0.0242**	-1.0492	-7.4794	-0.0254**	-1.0908*	-7.3413
	(-2.693)	(-1.708)	(-1.457)	(-2.670)	(-1.610)	(-1.280)	(-2.627)	(-1.705)	(-1.266)
Any Work SFA Law	-0.0222	0.4309	17.9201*	-0.0247**	-0.6108	3.2220			
	(-1.176)	(0.397)	(1.848)	(-2.213)	(-1.124)	(0.519)			
Any Rest/Bar SFA Law	-0.0027	-1.1151	-15.7348*				-0.0229*	-0.7349	0.0759
	(-0.109)	(-1.149)	(-1.704)				(-1.837)	(-1.520)	(0.012)
Adjusted R^2	0.118	0.219	0.176	0.118	0.219	0.176	0.118	0.219	0.176
Num. Obs	33201	7874	7874	33201	7874	7874	33201	7874	7874

Notes:
The dependent variable in the 1st, 4th, and 7th columns is an indicator variable for whether an individual is a current smoker, the dependent variables in the 2nd, 5th, and 8th columns is the number of cigarettes smoked per day, conditional on smoking participation, and the dependent variable in the 3rd, 6th, and 9th columns is an individual's serum cotinine level, conditional on smoking participation. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the tax/price and the nearest lower tax/price in another state, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 1.3
Quantile Regression Results of the Impact of Tobacco Control Policies on The Average Number of Cigarettes Smoked Per Day

		Quantile Regressions						
	OLS Results	5th Quantile	10th Quantile	25th Quantile	50th Quantile	75th Quantile	90th Quantile	95th Quantile
Cigarette Prices								
Average Cigarette Price	-1.6907***	-0.0028	-0.2134	-0.8017*	-0.6352	-1.6704*	-3.8173***	-4.3146***
	(-2.804)	(-0.011)	(-0.564)	(-1.690)	(-1.061)	(-1.822)	(-2.979)	(-2.587)
Any Work SFA Law	-0.4947	-0.0298	-0.3209	-0.4458	-0.7257	-0.3580	0.8219	2.7677
	(-1.149)	(-0.105)	(-0.841)	(-0.787)	(-1.004)	(-0.475)	(0.552)	(1.442)
Adjusted/Pseudo R^2	0.220	0.035	0.066	0.121	0.167	0.098	0.168	0.159
Num. Obs	7874	7874	7874	7874	7874	7874	7874	7874
Cigarette Excise Taxes								
Cigarette Excise Tax	-1.0492	-0.0228	-0.0962	-0.3940	-0.5889	-1.7233**	-2.1930	-1.9646
	(-1.610)	(-0.104)	(-0.300)	(-0.867)	(-0.967)	(-2.109)	(-1.506)	(-1.152)
Any Work SFA Law	-0.6108	-0.0301	-0.1918	-0.4750	-0.7425	-0.6295	0.5476	1.7728
	(-1.124)	(-0.108)	(-0.505)	(-0.853)	(-1.054)	(-0.735)	(0.400)	(0.912)
Adjusted/Pseudo R^2	0.219	0.035	0.065	0.121	0.167	0.098	0.167	0.158
Num. Obs	7874	7874	7874	7874	7874	7874	7874	7874
Mean/Quantiles of Cigs per Day	14.37	1.00	1.33	5.00	10.00	20.00	30.00	40.00

Notes:
The dependent variable in all columns is the average number of cigarettes smoked per day, conditional on smoking participation. T-statistics are shown in parentheses, and are calculated from standard errors clustered at the state level for column 1 and from bootstrapped standard errors using 299 replications in columns 2-8. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the tax/price and the nearest lower tax/price in another state, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 1.4

Quantile Regression Results of the Impact of Tobacco Control Policies on The Average Number of Cigarettes Smoked Per Day

		Quantile Regressions						
	OLS Results	**5th Quantile**	**10th Quantile**	**25th Quantile**	**50th Quantile**	**75th Quantile**	**90th Quantile**	**95th Quantile**
Cigarette Prices								
Average Cigarette Price	-1.7099***	-0.0179	-0.2300	-0.7626	-0.5764	-1.6630*	-3.6551***	-3.8728**
	(-2.854)	(-0.073)	(-0.629)	(-1.494)	(-0.947)	(-1.727)	(-2.786)	(-2.550)
Any Rest/Bar SFA Law	-0.5714	0.0151	-0.2907	-0.4606	-0.8067	-0.8919	0.1523	2.1172
	(-1.503)	(0.053)	(-0.716)	(-0.874)	(-1.275)	(-1.063)	(0.113)	(1.213)
Adjusted/Pseudo R^2	0.220	0.035	0.066	0.121	0.167	0.098	0.168	0.159
Num. Obs	7874	7874	7874	7874	7874	7874	7874	7874
Cigarette Excise Taxes								
Cigarette Excise Tax	-1.0908*	-0.0187	-0.1236	-0.4104	-0.6556	-1.7052**	-2.3382*	-2.1784
	(-1.705)	(-0.094)	(-0.405)	(-0.953)	(-1.217)	(-2.033)	(-1.824)	(-1.322)
Any Rest/Bar SFA Law	-0.7349	-0.0415	-0.2284	-0.4829	-0.7989	-1.0924	-0.0750	1.1534
	(-1.520)	(-0.148)	(-0.568)	(-0.837)	(-1.163)	(-1.298)	(-0.050)	(0.626)
Adjusted/Pseudo R^2	0.219	0.035	0.065	0.121	0.167	0.098	0.167	0.158
Num. Obs	7874	7874	7874	7874	7874	7874	7874	7874
Mean/Quantiles of Cigs per Day	14.37	1.00	1.33	5.00	10.00	20.00	30.00	40.00

Notes:

The dependent variable in all columns is the average number of cigarettes smoked per day, conditional on smoking participation. T-statistics are shown in parentheses, and are calculated from standard errors clustered at the state level for column 1 and from bootstrapped standard errors using 299 replications in columns 2-8. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the tax/price and the nearest lower tax/price in another state, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 1.5
Quantile Regression Results of the Impact of Tobacco Control Policies on Serum Cotinine Concentrations

		Quantile Regressions						
	OLS Results	**5th Quantile**	**10th Quantile**	**25th Quantile**	**50th Quantile**	**75th Quantile**	**90th Quantile**	**95th Quantile**
Cigarette Prices								
Average Cigarette Price	-7.9701	-9.7633*	-14.8563	-7.3128	-8.5147	-8.4810	3.7974	2.4483
	(-1.367)	(-1.764)	(-1.611)	(-0.863)	(-0.887)	(-0.656)	(0.234)	(0.115)
Any Work SFA Law	5.1106	-3.9506	-2.2354	-5.3132	-3.3749	10.0985	22.5358	15.3473
	(0.836)	(-0.620)	(-0.276)	(-0.558)	(-0.330)	(0.765)	(1.282)	(0.712)
Adjusted/Pseudo R^2	0.176	0.047	0.082	0.125	0.118	0.104	0.105	0.107
Num. Obs	7874	7874	7874	7874	7874	7874	7874	7874
Cigarette Excise Taxes								
Cigarette Excise Tax	-7.4794	-6.4738	-8.5028	-6.9629	-7.9552	-10.4808	-0.9993	-18.8400
	(-1.280)	(-1.267)	(-1.044)	(-0.825)	(-0.900)	(-0.923)	(-0.070)	(-0.904)
Any Work SFA Law	3.2220	-0.0141	-4.0522	-7.1231	-6.3132	16.4749	24.8731	17.1810
	(0.519)	(-0.002)	(-0.466)	(-0.716)	(-0.590)	(1.174)	(1.351)	(0.749)
Adjusted/Pseudo R^2	0.176	0.045	0.081	0.125	0.118	0.104	0.104	0.107
Num. Obs	7874	7874	7874	7874	7874	7874	7874	7874
Mean/Quantiles of Serum Cotinine Concentration	215.09	6.11	25.90	104.50	204.00	307.00	406.00	467.00

Notes:
The dependent variable in all columns is the serum cotinine level, measured in ng/ml, conditional on smoking participation. T-statistics are shown in parentheses, and are calculated from standard errors clustered at the state level for column 1 and from bootstrapped standard errors using 299 replications in columns 2-8. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the tax/price and the nearest lower tax/price in another state, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 1.6
Quantile Regression Results of the Impact of Tobacco Control Policies on Serum Cotinine Concentrations

	OLS	Quantile Regressions						
	OLS Results	**5th Quantile**	**10th Quantile**	**25th Quantile**	**50th Quantile**	**75th Quantile**	**90th Quantile**	**95th Quantile**
Cigarette Prices								
Average Cigarette Price	-7.7604	-9.2483	-15.4672*	-7.6071	-7.9803	-8.8952	1.4999	-0.3593
	(-1.349)	(-0.561)	(-1.777)	(-0.926)	(-0.812)	(-0.659)	(0.094)	(-0.016)
Any Rest/Bar SFA Law	3.7387	-3.9843	-2.7597	-2.4588	-0.7796	5.2591	5.1399	-5.6476
	(0.658)	(-0.125)	(-0.311)	(-0.263)	(-0.073)	(0.421)	(0.300)	(-0.272)
Adjusted/Pseudo R^2	0.176	0.047	0.082	0.125	0.118	0.104	0.104	0.107
Num. Obs	7874	7874	7874	7874	7874	7874	7874	7874
Cigarette Excise Taxes								
Cigarette Excise Tax	-7.3413	-5.8996	-9.0635	-6.0834	-8.4968	-8.8762	-2.9740	-18.3129
	(-1.266)	(-1.168)	(-1.218)	(-0.739)	(-0.969)	(-0.720)	(-0.214)	(-0.924)
Any Rest/Bar SFA Law	0.0759	-1.9539	-5.6287	-2.7612	-2.3484	9.3149	5.4943	-11.3313
	(0.012)	(-0.322)	(-0.692)	(-0.314)	(-0.233)	(0.653)	(0.342)	(-0.544)
Adjusted/Pseudo R^2	0.176	0.045	0.081	0.125	0.118	0.103	0.104	0.107
Num. Obs	7874	7874	7874	7874	7874	7874	7874	7874
Mean/Quantiles of Serum Cotinine Concentration	215.09	6.11	25.90	104.50	204.00	307.00	406.00	467.00

Notes:
The dependent variable in all columns is the serum cotinine level, measured in ng/ml, conditional on smoking participation. T-statistics are shown in parentheses, and are calculated from standard errors clustered at the state level for column 1 and from bootstrapped standard errors using 299 replications in columns 2-8. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the tax/price and the nearest lower tax/price in another state, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 1.7

Semi-Elasticities for OLS and Quantile Regression Coefficients Estimating the Effects of Tobacco Control Policies on Serum Cotinine Levels and the Average Number of Cigarettes Smoked per Day

			Quantile Regressions						
	Prevalence	OLS Results	5th Quantile	10th Quantile	25th Quantile	50th Quantile	75th Quantile	90th Quantile	95th Quantile
Cigarettes Smoked per Day									
Table 2/Table 3									
Cigarette Price	-0.028	-0.118***	-0.003	-0.160	-0.160*	-0.064	-0.084*	-0.127***	-0.108***
Any Work SFA Law	-0.102**	-0.034	-0.030	-0.241	-0.089	-0.073	-0.018	0.027	0.069
Cigarette Tax	-0.097**	-0.073	-0.023	-0.072	-0.079	-0.059	-0.086**	-0.073	-0.049
Any Work SFA Law	-0.099**	-0.043	-0.030	-0.144	-0.095	-0.074	-0.031	0.018	0.044
Table 2/Table 4									
Cigarette Price	-0.031	-0.119***	-0.018	-0.173	-0.153	-0.058	-0.083*	-0.122***	-0.097**
Any Rest/Bar SFA Law	-0.089*	-0.040	0.015	-0.218	-0.092	-0.081	-0.045	0.005	0.053
Cigarette Tax	-0.101**	-0.076*	-0.019	-0.093	-0.082	-0.066	-0.085**	-0.078*	-0.054
Any Rest/Bar SFA Law	-0.091*	-0.051	-0.042	-0.171	-0.097	-0.080	-0.055	-0.003	0.029
Means/Quantiles of									
Participation/Cigs per Day	0.25	14.37	1.00	1.33	5.00	10.00	20.00	30.00	40.00
Serum Cotinine Levels									
Table 2/Table 5									
Cigarette Price	-0.028	-0.037	-1.598*	-0.574	-0.070	-0.042	-0.028	0.009	0.005
Any Work SFA Law	-0.102**	0.024	-0.647	-0.086	-0.051	-0.017	0.033	0.056	0.033
Cigarette Tax	-0.097**	-0.035	-1.060	-0.328	-0.067	-0.039	-0.034	-0.002	-0.040
Any Work SFA Law	-0.099**	0.015	-0.002	-0.156	-0.068	-0.031	0.054	0.061	0.037
Table 2/Table 6									
Cigarette Price	-0.031	-0.036	-1.514	-0.597*	-0.073	-0.039	-0.029	0.004	-0.001
Any Rest/Bar SFA Law	-0.089*	0.017	-0.652	-0.107	-0.024	-0.004	0.017	0.013	-0.012
Cigarette Tax	-0.101**	-0.034	-0.966	-0.350	-0.058	-0.042	-0.029	-0.007	-0.039
Any Rest/Bar SFA Law	-0.091*	0.000	-0.320	-0.217	-0.026	-0.012	0.030	0.014	-0.024
Means/Quantiles of									
Participation/Cotinine	0.25	215.09	6.11	25.90	104.50	204.00	307.00	406.00	467.00

Notes:
The table shows semi-elasticities for the coefficients in Tables 2-6. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the tax/price and the nearest lower tax/price in another state, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 1.8
Quantile Regression Results of the Impact of Tobacco Control Policies on Changes in Smoking Behavior

	OLS	Quantile Regressions						
	Results	5th Quantile	10th Quantile	25th Quantile	50th Quantile	75th Quantile	90th Quantile	95th Quantile
Cigarette Prices								
Average Cigarette Price	0.2234	-5.9738	-6.4132	-8.6572	1.8411	11.1088	18.8612	31.7555
	(0.041)	(-1.092)	(-1.106)	(-1.232)	(0.191)	(0.982)	(1.245)	(1.359)
Cigs x Price	0.1064	-0.2144	-0.0249	0.1018	0.4483*	0.4156	0.9334**	1.2385*
	(0.366)	(-1.024)	(-0.125)	(0.543)	(1.859)	(1.197)	(2.018)	(1.691)
Any Work SFA Law	7.8717	-3.6897	3.0143	0.1047	3.4045	8.8599	1.0800	26.1281
	(1.603)	(-0.657)	(0.516)	(0.013)	(0.389)	(0.775)	(0.063)	(0.993)
Cigs x Any Work SFA Law	0.1611	-0.3875	-0.1005	-0.4190	0.2630	0.1690	0.2065	0.1478
	(0.273)	(-1.122)	(-0.316)	(-1.297)	(0.654)	(0.298)	(0.274)	(0.139)
Avg Cigs per Day	4.6913***	3.4047***	4.1045***	5.4061***	5.8463***	5.9555***	5.6419***	5.5210***
	(10.013)	(20.282)	(16.652)	(24.600)	(20.566)	(16.068)	(11.918)	(8.642)
Adjusted/Pseudo R^2	0.286	0.140	0.190	0.224	0.202	0.169	0.154	0.144
Num. Obs	7874	7874	7874	7874	7874	7874	7874	7874
Cigarette Excise Taxes								
Cigarette Excise Tax	-1.7149	-2.7349	-4.5391	-8.5207	-2.3534	9.6551	-0.0859	19.7055
	(-0.324)	(-0.507)	(-0.778)	(-0.098)	(-0.231)	(0.899)	(-0.006)	(0.855)
Cigs x Tax	0.1268	-0.1870	-0.0435	0.2296	0.8199*	0.6393	1.1799	1.0975
	(0.289)	(-0.567)	(-0.158)	(0.112)	(1.684)	(0.942)	(1.121)	(0.841)
Any Work SFA Law	6.4582	-4.2152	2.5268	-0.5815	3.3769	8.0835	3.5623	19.9048
	(1.310)	(-0.679)	(0.402)	(-0.008)	(0.389)	(0.743)	(0.217)	(0.804)
Cigs x Any Work SFA Law	0.1058	-0.3534	-0.1021	-0.5001	-0.0032	0.2135	0.2008	-0.2669
	(0.176)	(-1.061)	(-0.339)	(-0.001)	(-0.008)	(0.376)	(0.252)	(-0.256)
Avg Cigs per Day	4.7156***	3.3874***	4.1088***	5.5050	5.9320***	6.0113***	5.5678***	5.7114***
	(10.275)	(17.686)	(16.389)	(0.146)	(18.880)	(16.857)	(11.645)	(8.551)
Adjusted/Pseudo R^2	0.286	0.139	0.189	0.224	0.202	0.169	0.153	0.142
Num. Obs	7874	7874	7874	7874	7874	7874	7874	7874
Mean/Quantiles of Serum Cotinine Concentration	215.090	6.110	25.900	104.500	204.000	307.000	406.000	467.000

Notes:
The dependent variable in all columns is the serum cotinine level, measured in ng/ml, conditional on smoking participation. T-statistics are shown in parentheses, and are calculated from standard errors clustered at the state level for column 1 and from bootstrapped standard errors using 299 replications in columns 2-8. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the tax/price and the nearest lower tax/price in another state, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 1.9
Quantile Regression Results of the Impact of Tobacco Control Policies on Changes in Smoking Behavior

		Quantile Regressions						
	OLS Results	5th Quantile	10th Quantile	25th Quantile	50th Quantile	75th Quantile	90th Quantile	95th Quantile
Cigarette Prices								
Average Cigarette Price	0.5914	-5.6944	-6.8671	-11.2194	1.2231	9.1282	17.7305	23.7135
	(0.113)	(-1.100)	(-1.217)	(-1.509)	(0.136)	(0.779)	(1.049)	(0.997)
Cigs x Price	0.1428	-0.1823	-0.0171	0.0188	0.4892*	0.6168*	0.9121*	1.1786
	(0.481)	(-0.952)	(-0.083)	(0.087)	(1.919)	(1.750)	(1.805)	(1.612)
Any Rest/Bar SFA Law	6.5198	-2.4159	4.5749	3.4187	6.1868	4.6657	-2.6056	4.0527
	(1.360)	(-0.402)	(0.735)	(0.468)	(0.731)	(0.407)	(-0.159)	(0.165)
Cigs x Any Rest/Bar SFA Law	-0.0885	-0.3584	-0.0406	0.0133	0.0028	-0.7211	0.0584	-0.3935
	(-0.156)	(-1.052)	(-0.102)	(0.038)	(0.007)	(-1.343)	(0.071)	(-0.391)
Avg Cigs per Day	4.7959***	3.4771***	4.0898***	5.2538***	5.9588***	6.3534***	5.7083***	5.6964***
	(9.906)	(17.700)	(14.591)	(21.304)	(18.505)	(16.743)	(11.487)	(8.106)
Adjusted/Pseudo R^2	0.286	0.140	0.190	0.224	0.202	0.169	0.154	0.144
Num. Obs	7874	7874	7874	7874	7874	7874	7874	7874
Cigarette Excise Taxes								
Cigarette Excise Tax	-1.3263	-3.2593	-4.9293	-10.1584	-2.9598	9.3874	3.6610	20.0059
	(-0.262)	(-0.572)	(-0.906)	(-1.413)	(-0.281)	(0.131)	(0.241)	(0.778)
Cigs x Tax	0.2373	-0.1754	-0.0603	0.0034	0.8856*	1.0964	1.5572	1.4548
	(0.502)	(-0.518)	(-0.197)	(0.009)	(1.784)	(0.008)	(1.583)	(1.149)
Any Rest/Bar SFA Law	3.6565	-1.3218	2.6805	3.8004	3.9904	1.5514	-3.2589	-11.2062
	(0.743)	(-0.215)	(0.447)	(0.544)	(0.449)	(0.010)	(-0.198)	(-0.479)
Cigs x Any Rest/Bar SFA Law	-0.1967	-0.2864	-0.0713	-0.0287	-0.1653	-0.6971	-0.5394	-1.0657
	(-0.340)	(-0.960)	(-0.220)	(-0.090)	(-0.394)	(-0.086)	(-0.595)	(-0.910)
Avg Cigs per Day	4.8523***	3.3976***	4.0855***	5.3108***	6.0408***	6.3961	5.7919***	6.2458***
	(9.999)	(17.751)	(15.209)	(23.325)	(18.702)	(0.141)	(11.224)	(8.828)
Adjusted/Pseudo R^2	0.286	0.139	0.189	0.224	0.202	0.169	0.153	0.142
Num. Obs	7874	7874	7874	7874	7874	7874	7874	7874
Mean/Quantiles of Serum Cotinine Concentration	215.090	6.110	25.900	104.500	204.000	307.000	406.000	467.000

Notes:
The dependent variable in all columns is the serum cotinine level, measured in ng/ml, conditional on smoking participation. T-statistics are shown in parentheses, and are calculated from standard errors clustered at the state level for column 1 and from bootstrapped standard errors using 299 replications in columns 2-8. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the tax/price and the nearest lower tax/price in another state, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 1.10
Generalized Ordered Logit Regression Results of the Impact of Tobacco Control Policies on The Average Number of Cigarettes Smoked Per Day

	Work SFA Laws				Restaurant/Bar SFA Laws			
Cigarette Prices	**Non-Smokers**	**0 to 10 Cigs/Day**	**10 to 20 Cigs/Day**	**>20 Cigs/Day**	**Non-Smokers**	**0 to 10 Cigs/Day**	**10 to 20 Cigs/Day**	**>20 Cigs/Day**
Average Cigarette Price	0.0082	0.0026	-0.0049	-0.0059***	0.0089	0.0025	-0.0055	-0.0059***
	(0.7211)	(0.3048)	(-0.8791)	(-2.7142)	(0.7697)	(0.2889)	(-0.9723)	(-2.7489)
Work SFA Law	0.0275**	-0.0101	-0.0142***	-0.0032				
	(2.5093)	(-1.3504)	(-3.3498)	(-1.5360)				
Rst or Bar SFA Law					0.0237**	-0.0076	-0.0125**	-0.0036
					(2.0310)	(-0.9490)	(-2.5392)	(-1.5689)
Adjusted R^2	0.124				0.124			
Num Obs.	33201				33201			
Brant Test Chi^2	1545.478				1545.346			
Brant Test P-Value	0.00000				0.00000			
Brant Test Chi^2 for Prices	9.173				9.576			
Brant Test P-Value for Prices	0.01019				0.00833			

	Work SFA Laws				Restaurant/Bar SFA Laws			
Cigarette Taxes	**Non-Smokers**	**0 to 10 Cigs/Day**	**10 to 20 Cigs/Day**	**>20 Cigs/Day**	**Non-Smokers**	**0 to 10 Cigs/Day**	**10 to 20 Cigs/Day**	**>20 Cigs/Day**
Cigarette Excise Tax	0.0259***	-0.0111	-0.0094*	-0.0054***	0.0272***	-0.0113	-0.0103*	-0.0056***
	(2.6608)	(-1.2690)	(-1.7287)	(-2.7859)	(2.5862)	(-1.2692)	(-1.8562)	(-2.8780)
Any Work SFA Law	0.0265**	-0.0086	-0.0144***	-0.0035				
	(2.4655)	(-1.2543)	(-3.3728)	(-1.4896)				
Rst or Bar SFA Law					0.0242**	-0.0067	-0.0132***	-0.0042*
					(2.0034)	(-0.8835)	(-2.7093)	(-1.6501)
Adjusted R^2	0.124				0.124			
Num Obs.	33201				33201			
Brant Test Chi^2	1536.876				1536.390			
Brant Test P-Value	0.00000				0.00000			
Brant Test Chi^2 for Taxes	3.951				4.291			
Brant Test P-Value for Taxes	0.13871				0.11700			

Notes:
The dependent variable is an ordered categorical variable taking the values 1 (0 cigarettes smoked per day); 2 (greater than 0 but less than or equal to 10 cigarettes smoked per day); 3 (greater than 10 but less than or equal to 20 cigarettes smoked per day); and 4 (greater than 20 cigarettes smoked per day). The coefficients are transformed into marginal effects, and t-statistics, shown in parentheses, are calculated from standard errors clustered at the state level. The regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the tax/price and the nearest lower tax/price in another state, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Appendix Table 1.1
Complete Results for Linear Probability, OLS, and Quantile Regression Results of the Impact of Tobacco Control Policies on the Average Number of Cigarettes Smoked Per Day

			Quantile Regressions						
	Prevalence	**OLS Results**	**5th Quantile**	**10th Quantile**	**25th Quantile**	**50th Quantile**	**75th Quantile**	**90th Quantile**	**95th Quantile**
Average Cigarette Price	-0.0071	-1.6907***	-0.0028	-0.2134	-0.8017*	-0.6352	-1.6704*	-3.8173***	-4.3146***
	(-0.649)	(-2.804)	(-0.011)	(-0.564)	(-1.690)	(-1.061)	(-1.822)	(-2.979)	(-2.587)
Any Work SFA Law	-0.0255**	-0.4947	-0.0298	-0.3209	-0.4458	-0.7257	-0.3580	0.8219	2.7677
	(-2.196)	(-1.149)	(-0.105)	(-0.841)	(-0.787)	(-1.004)	(-0.475)	(0.552)	(1.442)
Anti-Smoking Sentiment	0.0263	1.0370	1.1850	1.3773	1.6060	-1.2591	-0.3118	-3.5027	-8.9642
	(0.516)	(0.540)	(1.073)	(0.893)	(0.749)	(-0.501)	(-0.095)	(-0.723)	(-1.296)
Price Difference	0.0164	1.7716*	0.3485	0.8747*	0.8215	0.8666	0.8764	1.6754	3.5416
	(1.227)	(1.819)	(0.873)	(1.691)	(1.286)	(1.146)	(0.741)	(0.935)	(1.444)
Female	-0.0820***	-0.5464**	0.1959	0.3467*	0.0951	-0.0595	-0.3738	-1.1317	-1.3785
	(-8.836)	(-2.074)	(1.308)	(1.674)	(0.338)	(-0.173)	(-0.722)	(-1.464)	(-1.398)
Age	0.0173***	0.6427***	0.0635***	0.1679***	0.3995***	0.5753***	0.7723***	0.8233***	0.8016***
	(18.554)	(11.236)	(2.722)	(4.976)	(9.108)	(12.076)	(11.114)	(8.127)	(6.280)
Age Squared	-0.0216***	-0.5881***	-0.0570**	-0.1549***	-0.3710***	-0.5184***	-0.6842***	-0.7320***	-0.6971***
	(-19.486)	(-9.305)	(-2.339)	(-4.265)	(-7.956)	(-10.069)	(-9.448)	(-6.921)	(-5.150)
Height	0.0061***	0.2469***	0.0180	0.0789**	0.1465***	0.2333***	0.3190***	0.2889***	0.3293**
	(6.253)	(5.939)	(0.786)	(2.534)	(3.649)	(4.776)	(4.733)	(3.010)	(2.338)
Black	-0.0285**	-7.6935***	-0.6277***	-2.0091***	-4.9195***	-8.2309***	-8.9506***	-12.2001***	-11.7642***
	(-2.218)	(-19.099)	(-2.724)	(-6.286)	(-14.363)	(-26.131)	(-19.051)	(-18.485)	(-13.450)
Hispanic	-0.1212***	-9.4159***	-1.4707***	-3.1851***	-7.1621***	-10.6375***	-10.5828***	-13.2483***	-14.0012***
	(-10.449)	(-16.621)	(-6.185)	(-10.568)	(-20.606)	(-26.939)	(-19.618)	(-15.240)	(-13.052)
Married	-0.0846***	0.1575	-0.0225	-0.0035	0.2731	0.2000	0.5216	-0.3328	-1.5434**
	(-14.010)	(0.762)	(-0.214)	(-0.022)	(1.353)	(0.821)	(1.345)	(-0.589)	(-2.107)
Missing Married Info	-0.0501***	-0.1086	-0.2040	-0.3357	-0.5894	-0.1716	0.7414	0.4985	-3.0221
	(-2.883)	(-0.107)	(-0.381)	(-0.366)	(-0.407)	(-0.114)	(0.466)	(0.202)	(-0.890)
Income to Poverty Ratio	-0.0240***	-0.1102	-0.0411	-0.0449	-0.1542*	-0.0878	0.0630	-0.0316	-0.0999
	(-10.925)	(-1.065)	(-0.997)	(-0.709)	(-1.811)	(-1.004)	(0.470)	(-0.171)	(-0.409)
B.A. Degree	-0.2057***	-4.5111***	-1.1158***	-2.7384***	-3.9402***	-3.7753***	-4.3060***	-4.2128***	-4.8658***
	(-13.119)	(-8.468)	(-4.013)	(-6.740)	(-6.926)	(-6.665)	(-5.223)	(-3.277)	(-3.475)
Some College	-0.1112***	-1.9037***	-0.5428***	-0.7257***	-1.1574***	-1.2719***	-1.2778**	-2.4963***	-2.7620***
	(-10.482)	(-5.605)	(-3.138)	(-3.107)	(-3.876)	(-3.668)	(-2.439)	(-3.422)	(-2.861)
H.S. Degree	-0.0459***	-0.9271***	-0.1324	-0.1766	0.2568	-0.5311**	-0.4380	-1.2860**	-1.6516**
	(-4.496)	(-3.062)	(-0.999)	(-0.955)	(0.971)	(-2.072)	(-1.056)	(-2.066)	(-1.982)
State Unemployment Rate	-0.0038	0.2074	-0.0336	-0.0324	0.0202	-0.0640	0.0378	0.4585	0.2149
	(-0.773)	(1.152)	(-0.282)	(-0.219)	(0.093)	(-0.301)	(0.112)	(0.889)	(0.324)
Exam Q2	-0.0005	1.1257**	0.1383	0.3080	0.3555	1.1077***	1.5802**	1.8577**	1.6597
	(-0.057)	(2.088)	(0.874)	(1.234)	(0.939)	(2.578)	(2.105)	(1.975)	(1.340)
Exam Q3	0.0056	0.6606	-0.2828	0.0457	-0.0322	0.9922*	1.6993*	1.8070	1.3982
	(0.639)	(1.016)	(-1.211)	(0.137)	(-0.065)	(1.846)	(1.903)	(1.562)	(0.968)
Exam Q4	-0.0095	1.0499**	0.1429	0.5214***	0.5264*	0.8837***	1.0875*	1.4998*	1.3994
	(-1.414)	(2.106)	(0.940)	(2.617)	(1.736)	(2.620)	(1.773)	(1.758)	(1.443)
Exam Afternoon	0.0043	-0.3680	-0.0655	-0.1719	-0.4565**	-0.5089**	-0.1204	0.1675	0.2792
	(0.903)	(-1.562)	(-0.576)	(-1.025)	(-2.042)	(-2.023)	(-0.287)	(0.308)	(0.382)
Exam Evening	-0.0110	-0.4403	-0.0414	-0.1967	-0.8435***	-0.2539	-0.3072	-0.7853	0.3609
	(-1.058)	(-1.304)	(-0.276)	(-0.787)	(-2.635)	(-0.729)	(-0.580)	(-1.049)	(0.349)
Exam on Weekend	-0.0110*	-0.3748	0.1621	0.2293	0.0942	-0.0618	-0.6640	-1.0275*	-1.0946
	(-1.941)	(-1.297)	(1.344)	(1.326)	(0.390)	(-0.246)	(-1.625)	(-1.773)	(-1.417)
Adjusted/Pseudo R^2	0.118	0.220	0.035	0.066	0.121	0.167	0.098	0.168	0.159
Num. Obs	33201	7874	7874	7874	7874	7874	7874	7874	7874
Mean/Quantiles of Cigs per Day	0.25	14.37	1.00	1.33	5.00	10.00	20.00	30.00	40.00

Notes:
The dependent variable in the first column is an indicator variable for whether an individual is a current smoker. The dependent variable in all other columns is the cigarettes smoked per day, conditional on smoking participation. T-statistics are shown in parentheses, and are calculated from standard errors clustered at the state level for column 1 and from bootstrapped standard errors using 299 replications in columns 2-8. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the tax/price and the nearest lower tax/price in another state, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Appendix Table 1.2
Complete Results for Linear Probability, OLS, and Quantile Regression Results of the Impact of Tobacco Control Policies on Serum Cotinine Concentrations

			Quantile Regressions						
	Prevalence	**OLS Results**	**5th Quantile**	**10th Quantile**	**25th Quantile**	**50th Quantile**	**75th Quantile**	**90th Quantile**	**95th Quantile**
Average Cigarette Price	-0.0071	-7.9701	-9.7633*	-14.8563	-7.3128	-8.5147	-8.4810	3.7974	2.4483
	(-0.649)	(-1.367)	(-1.764)	(-1.611)	(-0.863)	(-0.887)	(-0.656)	(0.234)	(0.115)
Any Work SFA Law	-0.0255**	5.1106	-3.9506	-2.2354	-5.3132	-3.3749	10.0985	22.5358	15.3473
	(-2.196)	(0.836)	(-0.620)	(-0.276)	(-0.558)	(-0.330)	(0.765)	(1.282)	(0.712)
Anti-Smoking Sentiment	0.0263	-12.9012	5.2138	13.8734	6.9253	4.0016	-56.9144	-72.0192	-14.9606
	(0.516)	(-0.467)	(0.217)	(0.486)	(0.211)	(0.102)	(-1.279)	(-1.116)	(-0.184)
Price Difference	0.0164	21.8330**	23.6762***	28.2688**	24.5025**	20.8487	24.9600	13.0658	8.3314
	(1.227)	(2.094)	(3.219)	(2.364)	(2.051)	(1.553)	(1.488)	(0.605)	(0.303)
Female	-0.0820***	-13.9301**	-1.4978	-4.4622	-10.2646**	-10.3206*	-18.6224***	-23.8890***	-30.1913**
	(-8.836)	(-2.551)	(-0.483)	(-1.076)	(-2.131)	(-1.932)	(-2.768)	(-2.598)	(-2.152)
Age	0.0173***	9.0777***	1.5006***	3.4506***	7.3410***	9.4248***	11.2052***	9.9856***	12.5134***
	(18.554)	(13.482)	(3.147)	(5.422)	(11.270)	(13.585)	(12.070)	(7.945)	(7.399)
Age Squared	-0.0216***	-8.8853***	-1.3118***	-3.2954***	-6.9959***	-8.9906***	-11.1569***	-9.8212***	-12.6243***
	(-19.486)	(-11.891)	(-2.628)	(-4.940)	(-10.067)	(-12.206)	(-11.310)	(-7.733)	(-7.162)
Height	0.0061***	0.2537	0.2526	0.0324	0.9304	1.2408*	-0.5418	-0.2906	0.5656
	(6.253)	(0.348)	(0.551)	(0.054)	(1.327)	(1.655)	(-0.587)	(-0.222)	(0.297)
Black	-0.0285**	28.8332***	3.3846	4.1865	5.4370	25.9459***	45.7377***	56.6504***	69.8075***
	(-2.218)	(8.588)	(0.791)	(0.722)	(1.045)	(4.605)	(7.187)	(6.990)	(5.421)
Hispanic	-0.1212***	-94.0208***	-30.0563***	-56.2344***	-96.5830***	-104.7527***	-107.8073***	-87.2273***	-87.9721***
	(-10.449)	(-15.904)	(-7.706)	(-10.930)	(-19.473)	(-16.465)	(-13.541)	(-9.918)	(-7.298)
Married	-0.0846***	0.1420	-3.3935	-0.3205	-1.4047	1.1673	-4.5180	-0.0682	-0.2942
	(-14.010)	(0.039)	(-1.503)	(-0.092)	(-0.427)	(0.293)	(-0.912)	(-0.010)	(-0.030)
Missing Married Info	-0.0501***	5.0273	2.6159	8.6552	-8.9068	10.4168	10.1744	-20.4525	-37.3562
	(-2.883)	(0.247)	(0.209)	(0.579)	(-0.507)	(0.446)	(0.384)	(-0.793)	(-0.826)
Income to Poverty Ratio	-0.0240***	-1.8973	-0.6784	-1.1246	-0.5692	-1.0146	-2.8444*	-4.9001**	-4.3559
	(-10.925)	(-1.546)	(-0.782)	(-0.864)	(-0.467)	(-0.675)	(-1.669)	(-2.147)	(-1.586)
B.A. Degree	-0.2057***	-40.7287***	-30.2457***	-47.8275***	-58.2698***	-41.0598***	-34.9917***	-18.0563	-23.4501
	(-13.119)	(-5.202)	(-6.013)	(-7.578)	(-6.914)	(-4.857)	(-3.404)	(-1.335)	(-1.543)
Some College	-0.1112***	-17.3508***	-11.0798***	-15.8123***	-17.0584***	-16.4388***	-17.0203**	-8.8291	-18.6391*
	(-10.482)	(-4.416)	(-3.052)	(-3.240)	(-3.613)	(-2.842)	(-2.512)	(-1.009)	(-1.699)
H.S. Degree	-0.0459***	-3.1929	-5.1983	-1.0894	3.6214	-4.5034	-3.5391	1.3962	-0.5053
	(-4.496)	(-1.155)	(-1.626)	(-0.278)	(0.960)	(-1.041)	(-0.638)	(0.167)	(-0.049)
State Unemployment Rate	-0.0038	-2.2140	4.0047*	3.7612	-0.6031	-7.0329*	-3.6895	-10.4579*	-7.7603
	(-0.773)	(-0.683)	(1.944)	(1.264)	(-0.177)	(-1.938)	(-0.821)	(-1.737)	(-0.990)
Exam Q2	-0.0005	14.1834*	6.1362*	6.0914	5.9018	13.1403*	23.5656**	30.0593**	6.9862
	(-0.057)	(1.972)	(1.781)	(1.093)	(0.885)	(1.764)	(2.466)	(2.279)	(0.467)
Exam Q3	0.0056	1.4116	-0.1551	1.4326	0.1977	-2.6187	2.0195	21.0737	-5.0502
	(0.639)	(0.200)	(-0.030)	(0.183)	(0.026)	(-0.282)	(0.186)	(1.467)	(-0.279)
Exam Q4	-0.0095	2.0285	-0.1281	0.4246	0.0692	0.0007	6.3482	13.3105	-6.8187
	(-1.414)	(0.364)	(-0.042)	(0.089)	(0.014)	(0.000)	(0.671)	(1.218)	(-0.500)
Exam Afternoon	0.0043	2.7296	0.2459	-0.4991	1.6818	-0.2115	4.6581	10.4775	18.3730**
	(0.903)	(0.968)	(0.097)	(-0.145)	(0.481)	(-0.048)	(0.850)	(1.432)	(1.990)
Exam Evening	-0.0110	10.4924**	-0.5374	-4.5022	4.5261	17.9102***	14.9815**	8.7661	17.1281
	(-1.058)	(2.089)	(-0.167)	(-0.940)	(0.841)	(2.883)	(2.239)	(0.923)	(1.424)
Exam on Weekend	-0.0110*	3.8128	2.7178	2.3403	2.2820	4.8276	0.8731	1.4259	-3.4886
	(-1.941)	(0.903)	(0.984)	(0.658)	(0.619)	(1.044)	(0.158)	(0.202)	(-0.406)
Adjusted/Pseudo R^2	0.118	0.176	0.047	0.082	0.125	0.118	0.104	0.105	0.107
Num. Obs	33201	7874	7874	7874	7874	7874	7874	7874	7874
Mean/Quantiles of Serum Cotinine Concentration	0.251	215.090	6.110	25.900	104.500	204.000	307.000	406.000	467.000

Notes:
The dependent variable in the first column is an indicator variable for whether an individual is a current smoker. The dependent variable in all other columns is the serum cotinine concentration, measured in ng/ml, conditional on smoking participation. T-statistics are shown in parentheses, and are calculated from standard errors clustered at the state level for column 1 and from bootstrapped standard errors using 299 replications in columns 2-8. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, income-to-poverty ratio, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state anti-smoking sentiment, state unemployment rate, the difference between the tax/price and the nearest lower tax/price in another state, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Chapter 2

Do Tobacco Control Policies Reduce Secondhand Smoke Exposure in the Workplace?

Erik Nesson *

Abstract

This paper estimates the effects of tobacco control policies on non-smoking workers' exposure to secondhand smoke at their jobs. I use a novel measure of workers' self-reported exposure to secondhand smoke at their jobs from the National Health and Nutritional Examination Surveys and combine this self-reported measure with a biomarker of individuals' recent nicotine exposure to test whether any decrease in self-reported secondhand smoke exposure translates to reduced overall nicotine exposure. While I find little evidence that cigarette excise taxes or prices reduce workers' exposure to secondhand smoke, I find evidence that workplace and restaurant or bar smoke-free air laws reduce secondhand smoke exposure and these reductions translate into reduced overall nicotine exposure. I more directly test whether workplace and restaurant or bar smoke-free air laws reduce overall secondhand smoke exposure through changes in work exposure by estimating specifications which interact the level of reported workplace exposure with tobacco control policies. I find some evidence that this reduction in nicotine exposure comes from reductions in secondhand exposure at work and evidence that smoke-free air laws reduce secondhand smoke exposure through other pathways as well.

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2.1. Introduction

Almost 50 percent of adult non-smokers are exposed to secondhand smoke, and this exposure can have serious consequences, including lung cancer and coronary heart disease (USDHHS 2006, 1986). One of the main focuses of tobacco control policies, including cigarette excise taxes and smoke-free air laws, is to reduce secondhand smoke exposure. Indoor workplaces that allow smoking are one of the biggest venues where nonsmokers are exposed to secondhand smoke, and concentrations of secondhand smoke in offices allowing smoking are often greater than or equal to concentrations of secondhand smoke in the homes of smokers (Siegel 1993; Hammond et al. 1995).

A host of papers in the public health literature estimate the effects of tobacco control policies, particularly smoke-free air laws, on secondhand smoke exposure (e.g. Akbar-Khanzadeh et al. 2004; Ellingsen et al. 2006; Farrelly et al. 2005; CDC 2007). Although most of these papers find large negative associations between smoke-free air laws and secondhand smoke exposure, these papers suffer from small, possibly unrepresentative samples which may lead to biased coefficients or non-generalizable results. Recently, a few papers in the economics literature have used larger samples to estimate the effects of tobacco control policies on non-smokers' exposure to secondhand smoke, but these papers arrive at mixed conclusions (Adda and Cornaglia 2010; Anger, Kvasnicka, and Siedler 2011; Carpenter, Postolek, and Warman 2011; Carpenter 2009; Sims et al. 2012).

This paper provides new evidence of the effectiveness of tobacco control policies, in particular cigarette excise taxes and smoke-free air laws, in reducing workers' exposure to secondhand smoke at work. I use data from the National Health and Nutritional Examination Surveys (NHANES), which contain two measures of individuals' exposure to secondhand smoke at work. First, NHANES contains a self-reported measure of the number of hours employees are exposed to tobacco smoke at work. Second, NHANES contains a measure of individuals' serum cotinine levels. Cotinine is a metabolite of nicotine and has been widely used in the medical literature to measure smokers' smoking levels and non-smokers' exposure to secondhand smoke (U.S. Department of Health and Human Services 1986, 2006). Cotinine has also been used in a few recent economics studies (Adda and Cornaglia 2006, 2010).

I find evidence that workplace and restaurant or bar smoke-free air laws reduce employees' self-reported exposure to secondhand smoke at work, although collinearity between the smoke-free air laws in my sample hinders some inference. These reductions are most pronounced in blue-collar workers. I also find that these self-reported reductions in exposure to secondhand smoke translate to reductions in serum cotinine concentrations. Additionally, I estimate specifications which test whether reductions in serum cotinine levels arise from reductions in workplace exposure or through another channel, and I find that workplace and restaurant or bar smoke-free air laws reduce secondhand smoke exposure both through reduced workplace exposure and other pathways. I find little evidence that cigarette excise taxes reduce either self-reported exposure to secondhand smoke or reductions in serum cotinine concentrations, and I run numerous specification checks to test my results against misspecification and political endogeneity.

My main contribution is to measure the effects of tobacco control policies on workplace secondhand smoke exposure in the United States using a large, nationally representative dataset and a novel, direct measure of employees' self-reported exposure to secondhand smoke at work. This measure is notable in that it does not only ask about the presence of secondhand smoke exposure at work but also the hours of exposure per day. I complement the self-reported measure of exposure with serum cotinine concentrations, a biomarker of nicotine exposure. Cotinine is the major metabolite of nicotine, and serum cotinine levels are the biomarker of choice for measuring secondhand smoke exposure (Benowitz 1996; U.S. Department of Health and Human Services 2006, 1986). I use the two measures of secondhand smoke exposure to estimate how tobacco control policies change both the overall level of exposure and the amount of exposure at work.

The rest of the paper is outlined as follows. Section 2.2 provides a summary of the medical and economic research surrounding secondhand smoke exposure at work, Section 2.3 summarizes the data, Section 2.4 reviews the methodology, Section 2.5 outlines the results, and Section 2.6 concludes.

2.2. Background

The majority of economic studies examining tobacco control policies examine the policies' effects on smoking behaviors. The first studies mainly focus on the effects of cigarette taxes on smoking behaviors, and the vast majority of these studies find that tobacco control policies reduce smoking (for a review see Chaloupka and Warner 2000). More recently, research has also investigated other tobacco control policies, mainly smoking restrictions in private workplaces, restaurants, and bars. Earlier papers tend to find that smoking restrictions are effective at reducing smoking behaviors (Chaloupka and Saffer 1992; Chaloupka 1992; Evans, Farrelly, and Montgomery 1999; Farrelly, Evans, and Sfekas 1999; Tauras 2005, 2006). However, later papers find less evidence that smoke-free air laws reduce smoking (Bitler, Carpenter, and Zavodny 2010; Adda and Cornaglia 2010; Carpenter, Postolek, and Warman 2011; Carpenter 2009; Anger, Kvasnicka, and Siedler 2011).

However, an explicit goal of smoke-free air laws is often to reduce non-smokers' (and smokers') exposure to secondhand smoke. Exposure to secondhand smoke leads to annual economic costs of $10 billion in the United States, and these costs stem from an estimated 2000 annual lung cancer deaths and 30,000 annual coronary heart disease deaths attributable to secondhand smoke (Centers for Disease Control and Prevention 2008; Behan, Eriksen, and Lin 2005). Many workplace environments where smoking is allowed have high concentrations of secondhand smoke. Hammond et al. (1995) examine a variety of workplaces and find that secondhand smoke levels at companies that allow smoking can be several orders of magnitude higher than concentrations in homes where smoking is permitted. Their results are corroborated by a number of other studies, including Muramatsu et al. (1984), Siegel (1993) and Jarvis, Foulds, and Feyerabend (1992). In terms of carcinogen intake, Hammond et al. (1995) estimate that secondhand smoke exposure in smoking offices is equivalent to smoking one to four cigarettes in each eight hour period.

Little research into tobacco control policies investigates the effects of tobacco control policies on secondhand smoke exposure. A number of papers in the public health literature study measures of secondhand smoke exposure in a small number of workers before and after the implementation of smoke-free air laws. For example, Farrelly et al. (2005) find that a 2003 New York State smoking ban in bars and restaurants reduced secondhand smoke exposure among restaurant and bar employees, and a CDC MMWR

Report find that the ban reduced secondhand smoke exposure among the population in general (CDC 2007). Other studies examining restaurant or bar bans in Massachusetts, Washington, D.C., Scotland, Ireland, Sweden, and Norway find similar results (Larsson et al. 2008; Siegel et al. 2004; Menzies et al. 2006; Ellingsen et al. 2006; Pearson et al. 2009; Mulcahy et al. 2005). Research also suggests that the strength of smoke-free air laws influences their effectiveness. Akbar-Khanzadeh et al. (2004) find that airflow between smoking and non-smoking sections of restaurants and bars reduces the effectiveness of laws mandating restaurants and bars have smoking and non-smoking sections. Two studies in Massachusetts and one in Sydney, Australia also support these results, finding that more stringent laws are associated with less secondhand smoke exposure and reduced smoking outcomes for adolescents (Siegel et al. 2004; Albers et al. 2004; Cains et al. 2004).

Research also suggests important differences between different measurement techniques of secondhand smoke exposure. Jenkins et al. (1996) find differences between self-reported measures of secondhand smoke and objective measures such as personal air monitors. Although the personal air monitors showed the secondhand smoke exposure inside homes where cigarettes were smoked was about four times as high as in workplaces where smoking was allowed, respondents reported twice as much exposure at work as away from work.[1] Coultas et al. (1990) find moderate positive associations between various self-reported, personal monitoring, and biomarker measures of

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[1] Barnes, Hammond, and Glantz (2006) raise concerns about the finding in Jenkins et al. (1996) that secondhand smoke exposure in the workplace is markedly less than exposure away from work. Specifically, Barnes, Hammond, and Glantz (2006) question the classification of smoking workplaces, noting that more than 50 percent of the workplaces classified as smoking workplaces had smoking restrictions. Of these workplaces where smoking was allowed in restricted areas, less than one third of respondents observed smoking. However, it is not clear how this classification would affect the observed relationship between self-reported secondhand smoke exposure.

workplace secondhand smoke exposure. The authors conclude that, "no single method should be considered as optimal for studying the workplace."

Recently, a few papers have employed larger samples to examine the effects of smoke-free air laws on secondhand smoke exposure, but this literature arrives at mixed conclusions. Bitler, Carpenter, and Zavodny (2010) examine the effects of 12 venue-specific clean indoor laws on smoking behavior and workplace compliance as measured by employees reporting workplace smoking restrictions. They find that although bar clean indoor air laws cause bartenders to report increased smoking restrictions, other venue-specific bans do not affect workers' reports of smoking restrictions. Adda and Cornaglia (2010) use data from NHANES and serum cotinine concentrations and find little evidence that smoke-free air laws reduce individuals' exposure to secondhand smoke. In fact, they find evidence that smoke-free air laws increase secondhand smoke exposure in children in smoking families, as laws induce the adult smokers to smoke more at home and spend less time at restaurants and bars.

Two recent papers use data from Canada and find that smoking restrictions in Ottawa reduced secondhand smoke exposure for certain populations. Carpenter (2009) examines local workplace smoking restrictions in Ontario, Canada from 1997 to 2004 and finds that these restrictions reduced various measures of secondhand smoke exposure for blue-collar workers by more than 28 to 33 percent. However, he finds little effects of these local bans on secondhand smoke exposure for white collar workers. Carpenter, Postolek, and Warman (2011) use questions asking about secondhand smoke exposure in a variety of places and find that smoke-free air laws reduce non-smokers' exposure to secondhand smoke in a variety of public places, with little evidence of displacement inside homes and cars. Similarly, Sims et al. (2012) examine whether a 2007 law banning smoking in nearly all indoor public places and workplaces in England affected non-smokers' exposure to secondhand smoke. The authors use data from the Health Survey of England which contain serum cotinine levels. They find that the law both reduced the probability that individuals had a measurable level of cotinine in their systems and reduced cotinine levels. The authors find that the effects are most concentrated in higher socioeconomic status households and in households with no smokers.

In this paper, I build on these results in a number of ways. First, I measure the effects of tobacco control policies on workplace secondhand smoke exposure in the United States using a large, nationally representative dataset. Second, I use two measures of employees' exposure to secondhand smoke at work, one self-reported measure and one biomarker of recent nicotine exposure. Examining these measures together provides a broader picture of secondhand smoke exposure than in previous studies. I use the two measures of secondhand smoke exposure to estimate how tobacco control policies change both the overall level of exposure and the amount of exposure at work. Third, I use the two measures of secondhand smoke exposure to examine whether smoke-free air laws reduce secondhand smoke exposure in the workplace or through another avenue. Fourth, I test the effectiveness of different levels of smoke-free air laws in different venues by combining two different sources of smoke-free air law information. Lastly, I explicitly control for possible spurious correlation driven by unobservable anti-smoking sentiment.

2.3. Data

I use four waves of the NHANES data sets covering 1988 to 1994 and 1999 to 2004.[2] NHANES is a cross-sectional survey of health and nutritional information conducted by the CDC which combines surveys, physical examinations, and laboratory measurements. NHANES III, conducted between 1988 and 1994, consists of about 33,000 respondents. Starting in 1999, NHANES switched to releasing waves every two years. Each wave is nationally representative and contains about 10,000 individuals.

I construct two main variables to measure workers' exposure to secondhand smoke. First, I construct a self-reported measure of how much secondhand smoke respondents are exposed to at work. NHANES asks respondents, "… how many hours per day can you smell the smoke from other people's cigarettes, cigars, and/or pipes?" Figure 2.1 shows a tabulation of the number of hours that employees report secondhand smoke exposure. Approximately 30 percent of the sample report exposure to secondhand smoke at the workplace and approximately 10 percent report exposure for at least 8 hours per day. Secondhand smoke exposure at work varies depending on respondents' occupations. Figure 2.1 also plots the number of hours that employees report secondhand smoke exposure for white collar and blue collar occupations. While almost 80 percent of white collar workers report no exposure to secondhand smoke at work, only 65 percent of blue collar workers report no exposure to secondhand smoke at work. Likewise, almost twice as many blue collar workers are exposed to secondhand smoke in the workplace for at least 8 hours each day.

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[2] Although later waves of the NHANES data are available, the 2005-2006 and 2007-2008 survey waves do not contain information on an individual's occupation or secondhand smoke exposure in the workplace and I do not use them in this analysis.

Table 2.1 shows nonsmokers' average daily hours of workplace secondhand smoke exposure for the different occupations in NHANES. Food service workers report the most exposure, with waiters and waitress reporting an average of just over three hours of secondhand smoke exposure per day and other food preparation jobs reporting over two hours of daily exposure on average. Manufacturing, construction and transportation workers also report significant exposure totaling between an average of one and a half and two hours per day. However, exposure is not limited to blue collar occupations. For example, sales workers report almost one and a half hours of average daily exposure and health services operations workers report 1.25 hours of average exposure.

The second variable I use to measure secondhand smoke exposure is respondents' levels of serum cotinine. Cotinine is the major metabolite of nicotine, and approximately 70 percent of ingested nicotine is converted into cotinine (Benowitz and Jacob 1994; Benowitz et al. 1994). Although nicotine is rapidly metabolized by the body, with a half-life of about two hours, cotinine has a much longer half-life of about 16 to 20 hours. The cotinine samples are collected by NHANES and measured in nanograms per milliliter. NHANES collects blood samples from individuals age three and older as part of its examinations, and the samples are sent to the CDC for analysis. Serum cotinine levels as low as 0.035 ng/ml can be detected in the NHANES data. About one third of the sample has a cotinine level at or below the detectable limit, and the average cotinine concentration is about 0.29 ng/ml. Figure 2.2 shows the distribution of observable cotinine concentrations among workers, shown in log levels for convenience as the distribution of cotinine levels is highly skewed. Panel A shows the distribution for individuals residing in smoking versus non-smoking homes, and Panel B shows the distribution for individuals reporting some versus no secondhand smoke exposure at work. The panels indicate that self-reported measures of secondhand smoke exposure at home and at work translate into clear shifts in the distribution of secondhand smoke exposure as measured by cotinine levels.

Since I want to focus on exposure to secondhand smoke, I exclude smokers from the analysis. I define a respondent as a non-smoker if the respondent is not a self-reported smoker or user of any other tobacco products and has a cotinine concentration below 10 ng/ml, a common cutoff established in the medical literature for distinguishing between smokers and non-smokers (Perez-Stable, Benowitz, and Marin 1995).

NHANES provides detailed demographic characteristics, and using these I include variables for gender, age, race, ethnicity, height, marital status, family income, and education. NHANES also contains detailed occupation information, and I use this information to separate workers into white collar and blue collar occupations. Appendix 2.A lists the different occupation categories and their classification. State and county of residence information for the NHANES data is available through the NCHS Restricted Data Center which allows me to merge the tobacco control policy information and geographic characteristics with the individual level data. In addition to the individual level controls contained in the NHANES data, I also include controls for the state unemployment rate, state anti-smoking sentiment, and the state smoking prevalence lagged one year.[3]

[3] Previous research suggests that omitting state anti-smoking sentiment may bias the coefficients of tobacco control policies, as anti-smoking sentiment may both drive the adoption of tobacco control policies and reductions in smoking outcomes (DeCicca et al. 2008). Likewise, it is possible that anti-smoking sentiment could drive the adoption of smoke-free air laws and private, unobservable measures that lower exposure to secondhand smoke. I follow the methodology of DeCicca et al. (2008) to construct a measure of state anti-smoking sentiment, and I include this measure in all models. I use questions about attitudes towards smoking in various places to measure anti-smoking sentiment from the 1992-1993, 1995-1996, 1998-1999,

The key independent variables in this paper are state-level measures of the monetary cost of cigarettes and venue-specific smoke-free air laws. I use state-level cigarette price and excise tax data compiled by the Tax Burden on Tobacco (TBOT) output by Orzechowski and Walker (2009).[4] I transform the cigarette prices into the real (2009 dollars) average annual price paid for a pack of cigarettes. I transform the taxes into the real quarterly state cigarette excise taxes paid on a pack of cigarettes and add imputed taxes from the 1998 Master Settlement Agreement between state attorneys general and tobacco manufacturers (Lillard and Sfekas 2010).[5] Cigarette prices are the most direct measure of cigarette cost and include more information than cigarette excise taxes (Chou, Grossman, and Saffer 2006, 2004). However, prices may be endogenously related to aggregate state characteristics that determine cigarette demand (Gruber and Frakes 2006). Cigarette excise taxes, while potentially politically endogenous, likely suffer from less bias than cigarette prices. Moreover, the effects of cigarette excise taxes on smoking behaviors measure what policy makers control.

2000-2001, 2002-2003, and 2006-2007 waves of the Current Population Survey Tobacco Use Supplement (TUS-CPS). The TUS-CPS is a nationally representative sample of tobacco use covering about 240,000 individuals in each survey period. For restaurants, bars and cocktail lounges, work places, and sporting events, respondents answer whether they think smoking should be allowed in all areas, allowed in some areas, or not allowed at all. Lastly, respondents answer whether smoking is allowed anywhere inside their home, in certain areas inside their home, or not allowed at all inside their home. I combine the answers to these questions into one latent variable using factor analysis, and I find that one latent factor best explains the variation of the five smoking attitude questions. I compute this latent variable for each respondent, take the average of the latent variable for each state and year, and linearly impute missing year and state observations. DeCicca et al. (2008) also include questions pertaining to smoking in hospitals and shopping malls, as well as whether cigarette companies should be allowed to give away free samples or advertise. However, more recent versions of the TUS-CPS do not consistently ask these questions. To check whether using five variables rather than nine materially changed results, I ran a regression of the anti-smoking index using the nine variables on the anti-smoking index using the five variables. The t-statistic on the five variable index is 73.46 and the r-squared is 0.97.

[4] I add city taxes for municipalities and counties which make up large proportions of their respective state populations. I add excise taxes for the five counties which comprise New York City, NY; Cook County, IL; Anchorage and Juneau, AK; Arlington and Fairfax Counties, VA; and Cuyahoga County, OH.

[5] The Master Settlement Agreement required cigarette manufacturers to pay into an escrow account an amount proportional to the number of cigarettes they sell. As Lillard and Sfekas point out, including the implicit taxes from the MSA will not change the tax coefficients if year fixed effects are included in the model, but they will affect calculated elasticities.

I construct two sets of variables to measure smoke-free air laws. First, I use data from the American Non-Smokers' Rights Foundation (ANRF). ANRF records the date at which municipalities, cities, counties and states passed 100 percent smoke-free area laws in private workplaces, bars, and restaurants. Using the estimated populations of these geographic areas, I create variables measuring the percent of each state's population living under 100 percent smoke-free air laws in private workplaces and bars or restaurants in each quarter. ANRF defines 100 percent laws as those that do not have exemptions for attached bars, ventilated rooms, or minimum size requirements. Thus, although the ANRF variables capture variation in laws passed at the local level, the variables only measure the strictest form of smoke-free air laws. As Akbar-Khanzadeh et al. (2004), Albers et al. (2004), and Cains et al. (2004) suggest, the strength of smoke-free air laws affects their effectiveness. To test the robustness of the ANRF smoking bans and test whether the strength of smoke-free air laws affects their effectiveness, I use a second set of smoke-free air law information from Project ImpacTeen. ImpacTeen collects the presence and strength of smoke-free air laws in different venues for each state. I focus on smoke-free air laws in private workplaces, restaurants and bars, and I create indicator variables denoting whether a state has smoking restrictions in each venue in each year and whether those restrictions are 100 percent smoke-free air laws.[6]

Table 2.2 shows summary statistics for the sample. My sample consists of 8,736 non-smoking, employed individuals over age 18. On average, workers are exposed to just over one hour of secondhand smoke per day, and blue collar workers are exposed to over one and a half hours per day. Workers serum cotinine concentrations follow a similar

[6] The ImpacTeen data is available at http://www.impacteen.org/tobaccodata.htm. I aggregate the restaurant and bar SFA laws because all states with bar SFA laws also have restaurant SFA laws.

pattern. On average, workers have a concentration of about 0.4 ng/ml, but the concentration for blue collar workers is nearly 0.5 ng/ml while the concentration for white collar workers is 0.3 ng/ml. About one third of the individuals live under some sort of smoke-free air law, although restrictions on smoking are much more prevalent than smoking bans.

2.4. Methods

To identify the effects of changes in tobacco control policies on secondhand smoke exposure, I estimate a reduced form model where exposure to secondhand smoke at work is a function of cigarette cost, smoke-free air laws, individual and geographic characteristics, and state, year, and quarter effects. Thus, for individual i in state j, quarter q and year t, I estimate:

$$ETS_{ijqt} = \theta_0 + \theta_1 P_{jqt} + \theta_2 SFA_{jqt} + \theta_3 X_{ijqt} + \mu_s + \delta_t + \gamma_q + e_{ijqt}, \qquad (1)$$

where ETS is a measure of secondhand smoke exposure, P_{jqt} is a measure of the monetary price of smoking, SFA_{jqt} is a measure of smoke-free air laws, X_{ijqt} is a matrix of individual and geographic characteristics, and μ_s, δ_t, and γ_q are state, year and quarter fixed effects.

The characteristics of the two measures of secondhand smoke exposure at work require careful estimation strategies. First, the distribution of the reported number of hours a worker is exposed to secondhand smoke, as illustrated in Figures 1 and 2, suggests that an ordered model may be the most appropriate estimation strategy. In my main results, I split the dependent variable into three categories measuring no secondhand smoke exposure (zero hours per day), some secondhand smoke exposure (one to six hours per day), and constant secondhand smoke exposure (more than seven hours per day), and estimate an ordered Logit model. I correct the standard errors for within-state clustering. I test the robustness of this estimation strategy by considering two additional estimation strategies. First, I estimate a Poisson model, treating the number of self-reported hours of secondhand smoke as a count variable. Second, I transform the hours of secondhand smoke exposure into a binary variable measuring any versus no secondhand smoke exposure and estimate Logit models.

With respect to serum cotinine concentrations, a large portion of the sample does not have an identifiable level of cotinine concentration. Thus, I use a two-part model which separates the effects of tobacco control policies on cotinine concentrations into two parts. The first part estimates whether tobacco control policies affect the probability of an individual having an observable level of cotinine, and the second part estimates whether tobacco control policies affect the level of cotinine concentrations for individuals with observable levels of cotinine. Not accounting for this mass of "zeros" could lead to biased and inconsistent estimates. Moreover, the two-part model allows me to examine whether tobacco control policies affect secondhand smoke exposure through the extensive margin or the intensive margin, that is, any exposure to secondhand smoke compared to the level of secondhand smoke exposure conditional on exposure.

The first part of the model estimates a linear probability model of whether an individual is exposed to secondhand smoke:

$$P\left(ObCot_{ijqt} = 1|x\right) \qquad (2)$$

$$= \alpha_0 + \alpha_1 P_{jqt} + \alpha_2 SFA_{jqt} + \alpha_3 X_{ijqt} + \mu_s + \delta_t + \gamma_q + e_{ijqt},$$

where $ObCot_{ijqt}$ is an indicator for whether an individual has an observable cotinine concentration, and the other variables are as defined above. Next, I model the level of serum cotinine concentration, given an observable cotinine level, using an ordinary least squares regression model conditional on smoking participation:

$$E\left(Cot_{ijqt}|ObCot_{ijqt} = 1; x\right) \tag{3}$$

$$= \beta_0 + \beta_1 P_{jqt} + \beta_2 SFA_{jqt} + \beta_3 X_{ijqt} + \mu_s + \delta_t + \gamma_q \text{ ,}$$

where all variables are as defined above. Since cotinine concentrations are positively skewed, I use the natural log of cotinine concentrations as the dependent variable in the regressions. I cluster the standard errors at the state level in all linear probability and ordinary least squares specifications (Bertrand, Duflo, and Mullainathan 2004). I estimate each model both using NHANES survey weights and without using survey weights.

2.5. Results

2.5.1. Self-Reported Exposure to Secondhand Smoke

Tables 2.3 and 2.4 show regressions estimating the effects of tobacco control policies on non-smokers' self-reported ETS exposure at work. The dependent variable in all specifications is the self-reported number of hours a worker is exposed to secondhand smoke at work every day, split into three categories of exposure. The coefficients in each model are odds ratios, and t-statistics are shown in parentheses. Table 2.3 shows results using smoke-free air laws variables from the ANRF, and Table 2.4 shows results using smoke-free air law variables from Project ImpacTeen. In addition to the coefficients shown, all models control for gender, age, age squared (divided by 100), race, ethnicity, marital status, income to poverty ratio, education, family size, home size, the number of cigarettes smoked inside the home each day, the state unemployment rate, state anti-smoking sentiment, and the state smoking prevalence lagged one year. The first column in each series shows results for all private employees, the next column shows results for white collar employees, and the final column shows results for blue collar employees. The models run over all workers include controls for manual occupations, with white collar occupations as the omitted category. The top panel of each table shows results using NHANES survey weights, and the bottom panel shows unweighted results.

In preliminary models not shown, I included smoke-free air laws variables in both private workplaces and restaurants or bars. However, tests indicated a high degree of collinearity between the smoke-free air laws. The variance inflation factors for workplace and restaurant or bar 100 percent smoke-free air laws are 6 and 8, respectively, while in the variance inflation factors for the private workplace restrictions and bans and restaurant or bar restrictions and bans are 47, 13, 30, and 23, respectively. Given the high degree of collinearity between the smoke-free air law variables, the sets of results shown include each venue of smoke-free air law separately.

Both Tables 2.3 and 2.4 show little evidence that cigarette excise taxes reduce employees' secondhand smoke exposure at work, as the coefficients are wrong-signed and statistically insignificant across nearly all specifications.[7] Both venues of smoke-free air laws are associated with reductions in reported workplace secondhand smoke exposure. In Table 2.3, every percentage point increase in workplace or restaurant/bar 100 percent smoke-free air law coverage leads to a small decrease in the odds of seven or

[7] Results using cigarette prices instead of cigarette taxes arrived at similar conclusions and are available upon request.

more hours of secondhand smoke exposure versus some or no exposure for all workers. For every 10 percentage point increase in workplace (restaurant or bar) 100 percent smoke-free air law coverage, the odds of seven or more hours of secondhand smoke exposure versus some or no exposure are 0.92 to 0.94 (0.94 to 0.96) lower for all workers.[8] Table 2.4 shows similar results. Both restrictions and bans are associated with reduced secondhand smoke exposure. If a state implements a workplace (restaurant or bar) smoke-free air restriction, the odds of seven or more hours of secondhand smoke exposure versus some or no exposure are 0.64 to 0.73 (0.66 to 0.73) less. More stringent smoke-free air laws are also associated with larger decreases in secondhand smoke exposure. Workplace (restaurant or bar) smoke-free air bans are associated with odds of seven or more hours of secondhand smoke exposure versus some or no exposure that are 0.26 to 0.39 (0.42 to 0.57) less.

To examine whether the results in Tables 2.3 and 2.4 are affected by employment categories, I estimate models separately for white collar and blue collar professions. The results are generally driven by blue collar workers, as white collar workers are more likely to work in offices that restricted or banned smoking prior to the passage of smoke-free air laws. The odds ratios for white collar workers are generally larger and significant at the 10 percent level while the odds ratios for blue collar workers are smaller and significant at the 5 percent level. These results confirm previous studies (e.g. Carpenter, Postolek, and Warman 2011; Carpenter 2009).

As a robustness check to the Ordered Logit models, I re-estimate the Tables 2.3 and 2.4 using two additional specifications. First, I estimate a Poisson Quasi-Maximum Likelihood Model, using the number of hours of reported secondhand smoke exposure as

[8] Note that $0.92 = \exp[\ln(0.9913)*10]$.

the dependent variable. The Poisson model is consistent regardless of whether the counts follow a Poisson distribution as long as the conditional mean is correctly specified, and I correct the standard errors for possible over-dispersion and within-state clustering (Wooldridge 1997). Second, I estimate a Logit model using an indicator for whether an individual reports any secondhand smoke exposure as the dependent variable.[9] Tables 2.5 and 2.6 show results from these regressions. As in Tables 2.3 and 2.4, both workplace and restaurant or bar smoke-free air laws are associated with reductions in reported secondhand smoke exposure at work, and using the ImpacTeen smoke-free air law variables, stronger laws are associated with larger decreases in exposure.

2.5.2. Serum Cotinine Levels

Tables 2.7 through 2.10 show results from regressions estimating the effects of tobacco control policies on the log of non-smokers' serum cotinine concentrations. Tables 2.7 and 2.8 show results for Logit models estimating the probability that an individual has an observable level of cotinine in their system (the extensive margin of secondhand smoke exposure), and Tables 2.9 and 2.10 show OLS models estimating the level of logged cotinine, conditional on an observable level (the intensive margin of secondhand smoke exposure). Tables 2.7 through 2.10 have the same general layout as Tables 2.3 and 2.4, and all models include the same controls. Additionally, Tables 2.7 through 2.10 control for the time of day and day of the week on which the cotinine sample was drawn. In the Logit models, the coefficients are odds-ratios, t-statistics calculated from standard errors clustered at the state level are shown in parentheses, and

[9] The number of observations in the logit models are slightly less, as some successes or failures are completely determined by the independent variables.

marginal effects are shown in brackets. In the intensive margin tables, the coefficients represent semi-elasticities, and t-statistics are shown in parentheses.

As with self-reported secondhand smoke exposure, cigarette excise taxes have little effect on serum cotinine concentrations at either the extensive or intensive margin. Also as in Table 2.2, workplace smoke-free air laws and restaurant or bar smoke-free air laws reduce workers' exposure to second hand smoke. In Table 2.7, a 10 percentage point increase in the coverage of workplace (restaurant or bar) 100 percent smoke-free air laws decreases the probability that an individual has an observable level of cotinine by 1.2 to 1.7 (1.0 to 1.8) percentage points. Similarly, the results in Table 2.8 indicate the both workplace restrictions and bans are associated with reduced exposure, but bans are associated with larger reductions than restrictions. Restaurant and bar restrictions are not associated with reductions in observable cotinine levels, but bans are associated with reductions in the probability of observable cotinine levels.

On the intensive margin, both workplace and restaurant or bar smoke-free air laws reduce cotinine levels. In Table 2.9, every 10 percentage point increase in workplace (restaurant or bar) 100 percent smoke-free air law coverage decreases cotinine levels by 3.5 to 5.1 (2.2 to 4.1) percent. In Table 2.10, more restrictive smoke-free air laws are also related to larger cotinine reductions.

2.5.3. Connecting Self-Reported Exposure to Serum Cotinine Levels

The results from the previous sections show that smoke-free air laws lead to reductions in secondhand smoke exposure at work as measured by self-reported exposure and serum cotinine levels. One major difference between the results from the self-reported measures of secondhand smoke exposure and serum cotinine levels is that the reductions in serum cotinine associated with smoke-free air laws are not driven by blue collar workers. In fact, the coefficients and t-statistics for the smoke-free air laws are larger in the white collar workers' specifications than in the blue collar workers' specifications. Several factors could be driving this difference. First, the contribution of workplace secondhand smoke exposure to overall secondhand smoke exposure may be smaller for blue collar workers. However, from Table 2.2, the secondhand smoke exposure for blue collar workers is almost three times the secondhand smoke exposure for white collar workers, while cotinine concentrations are not even twice as high. Relatedly, blue collar and white collar workers may perceive workplace secondhand smoke exposure differently.

In this section, I more directly test whether the reductions in serum cotinine levels in response to smoke-free air laws arise from reductions in secondhand smoke exposure at the workplace. I modify equations (2) and (3), adding as independent variables the daily number of hours of secondhand smoke exposure at work and interactions with the tobacco control policies. Thus, I estimate the following two equations:

$$P\left(ObCot_{ijqt} = 1 | x\right)$$
$$= \alpha_0 + \alpha_1 P_{jqt} + \alpha_2 SFA_{jqt} + \alpha_3 SmkHrs_{ijqt} + \alpha \quad P_{jqt} \times SmkHrs_{ijqt} \qquad (4)$$
$$+ \alpha_5 SFA_{jqt} \times SmkHrs_{ijqt} + \alpha_6 X_{ijqt} + \mu_s + \delta_t + \gamma_q + e_{ijqt},$$

and

$$E\left(Cot_{ijqt} | ObCot_{ijqt} = 1; x\right)$$
$$= \beta_0 + \beta_1 P_{jqt} + \beta_2 SFA_{jqt} + \beta_3 SmkHrs_{ijqt} + \beta \quad P_{jqt} \times SmkHrs_{ijqt} \qquad (5)$$
$$+ \beta_5 SFA_{jqt} \times SmkHrs_{ijqt} + \beta_6 X_{ijqt} + \mu_s + \delta_t + \gamma_q + e_{ijqt}.$$

In equations (4) and (5), the partial derivatives of serum cotinine levels with respect to workplace secondhand smoke exposure are now:

$$\frac{\partial P\left(ObCot_{ijqt}=1;x\right)}{\partial SmkHrs_{ijqt}} = \alpha_3 + P_{jqt} \times \alpha \quad + SFA_{jqt} \times \alpha_5$$
$$\frac{\partial P\left(Cot_{ijqt}|ObCot_{ijqt}=1;x\right)}{\partial SmkHrs_{ijqt}} = \beta_3 + P_{jqt} \times \beta \quad + SFA_{jqt} \times \beta_5. \tag{6}$$

Put another way, the contribution of workplace secondhand smoke exposure, as measured by hours of secondhand smoke exposure, to overall secondhand smoke exposure, as measured by serum cotinine levels, now depends on tobacco control policies. Likewise, the effects of tobacco control policies on overall secondhand smoke exposure depend on the composition of secondhand smoke exposure. The partial derivatives of serum cotinine levels with respect to the monetary price of cigarettes and smoke-free air laws are:

$$\frac{\partial P\left(ObCot_{ijqt}=1;x\right)}{\partial P_{jqt}} = \alpha_1 + SmkHrs_{ijqt} \times \alpha_4$$
$$\frac{\partial P\left(Cot_{ijqt}|ObCot_{ijqt}=1;x\right)}{\partial P_{jqt}} = \beta_1 + SmkHrs_{ijqt} \times \beta_4, \tag{7}$$

and

$$\frac{\partial P\left(ObCot_{ijqt}=1;x\right)}{\partial SFA_{jqt}} = \alpha_2 + SmkHrs_{ijqt} \times \alpha_5$$
$$\frac{\partial P\left(Cot_{ijqt}|ObCot_{ijqt}=1;x\right)}{\partial SFA_{jqt}} = \beta_2 + SmkHrs_{ijqt} \times \beta_5. \tag{8}$$

If smoke-free air laws do lead to reductions in workplace secondhand smoke exposure, then the coefficients on the interaction terms, α_5 and β_5 in equations (4) and (5) should be negative, indicating that an increase in smoke-free air laws reduces the contribution of workplace secondhand smoke exposure to overall secondhand smoke exposure.

Tables 2.11 through 2.14 show results from these regressions. Tables 2.11 and 2.12 show results for the extensive margin and Tables 2.13 and 2.14 show results from the intensive margin. These tables are organized similar to Tables 2.7 and 2.8 and contain the same set of controls. Tables 2.11a and 2.11b show weighted and un-weighted results for the probability of observable cotinine levels using the ANRF smoke-free air laws. Both Tables suggest that, for blue collar workers, workplace and restaurant or bar SFA laws reduce the presence of secondhand smoke exposure through reductions in workplace exposure. However, for white collar workers, workplace and restaurant or bar smoke-free air laws reduce secondhand smoke exposure directly. Tables 2.12a and 2.12b show weighted and un-weighted results using the Project ImpacTeen variables. Unlike the results using the ANRF variables, the interaction terms are wrong signed and significant in some specifications.

Tables 2.13 and 2.14 show results for logged cotinine concentrations, conditional on observability. In Table 2.13, as in Tables 2.11a and 2.11b, the coefficients on the interaction between the smoke-free air laws and the hours of workplace secondhand smoke exposure are negative and significant, indicating that decreases in secondhand smoke exposure from smoke-free air laws operate through decreases in workplace exposure. The coefficients on the smoke-free air laws are also negative and significant, indicating that reductions in workplace exposure are not the only avenue by which smoke-free air laws reduce secondhand smoke exposure. In Table 2.14, the interactions between workplace smoke-free air laws and the hours of workplace secondhand smoke exposure are generally insignificant. However, the interaction terms between restaurant or bar smoke-free air laws and the hours of workplace secondhand smoke exposure are generally negative and statistically significant. As in Table 2.13, the direct coefficients on the smoke-free air laws are generally negative and statistically significant, indicating reductions in secondhand smoke exposure outside of the workplace.

2.5.4. Policy Endogeneity

A major concern is that the adoption of tobacco control policies is caused by unobservable factors that separately influence smoking behaviors and secondhand smoke exposure. For example, if anti-smoking sentiment drives the adoption of tobacco control policies and also influences smokers to reduce their smoking and smoke in private instead of in public, the observed negative relationships between smoke-free air laws and secondhand smoke exposure could be due to spurious correlation. In all previous models, I include state fixed effects and time fixed effects to control for unobservable time-invariant state characteristics and aggregate trends. Additionally, I include lagged smoking prevalence to control for the aggregate level of secondhand smoke. Lastly, I control for anti-smoking sentiment more directly through the inclusion of a measure of state-level anti-smoking sentiment based on DeCicca et al. (2008).

To check whether additional policy endogeneity may affect my results, I re-ran the previous regressions including three year lags and leads of the tobacco control policies. If unmeasurable anti-smoking sentiment is creating a spurious correlation, I would expect the leaded policy variables to be negative and statistically significant and cotemporaneous policy variables to be insignificant. Tables 2.15 through 2.17 show basic results from these regressions. The full results are available upon request, but are not shown for brevity. Although the leaded policy variables are significant in some specifications, the cotemporaneous variables remain of similar magnitude to the previous results and statistically significant.

2.6. Conclusion

This paper estimates the effect of tobacco control policies on non-smoking workers' exposure to secondhand smoke at their jobs. Although smoke-free air laws were intended to alleviate the externality of secondhand smoke, little economic research investigates the effects of smoke-free air laws on secondhand smoke exposure. I use a novel estimate of workers' self-reported exposure to secondhand smoke at their jobs from NHANES and combine this self-reported measure with a biomarker of individual's exposure to nicotine to test whether any decrease in self-reported secondhand smoke exposure translates to reduced nicotine exposure.

I find evidence that workplace and restaurant or bar smoke-free air laws reduce employees' self-reported exposure to secondhand smoke at work, and the effects are pronounced. A 10 percentage point increase in the coverage of strict workplace or restaurant/bar smoke-free air laws decreases the odds of constant secondhand smoke exposure at the workplace by between 0.92 to 0.96. In terms of semi-elasticities from Poisson regressions, a 10 percentage point increase in coverage decreases the hours of daily workplace secondhand smoke exposure by 14 to 17 percent. These decreases in self-reported workplace coverage correspond with decreases in serum cotinine levels, a measure of overall secondhand smoke exposure. Every 10 percentage point increase in smoke-free air law coverage decreases the probability of an observable level of cotinine by 1.0 to 1.8 percentage points and observable levels of cotinine by 4 to 6 percent. I find little evidence that cigarette excise taxes reduce either self-reported exposure to secondhand smoke or serum cotinine concentrations.

The reductions in self-reported exposure are most pronounced in blue-collar workers, however, the reductions in overall exposure, as measured by serum cotinine levels, are most concentrated in white collar workers. I estimate models of how the overall contribution of workplace secondhand smoke exposure changes with the adoption of smoke-free air laws. These models find evidence consistent with smoke-free air laws reducing secondhand smoke exposure through reductions in exposure at work.

My results generally corroborate previous studies showing a negative relationship between smoke-free air laws and secondhand smoke exposure at work (Carpenter, Postolek, and Warman 2011; Carpenter 2009; Sims et al. 2012). Moreover, my results also partially corroborate Carpenter (2009) in finding that these reductions in secondhand smoke exposure are concentrated among blue collar workers. Similar to Carpenter (2009), I find that decreases in self-reported secondhand smoke exposure associated with smoke-free air laws are largest among blue collar workers, but I find that white collar workers show the largest decreases when using cotinine as the measure of secondhand smoke exposure. One possible reason for this difference may be compensating behavior and other sources of secondhand smoke exposure, as suggested in Adda and Cornaglia (2010). An avenue for future research is to further connect sources of secondhand smoke exposure to biomarkers of overall exposure to provide a fuller picture of how tobacco control policies affect overall secondhand smoke exposure and the composition of that exposure.

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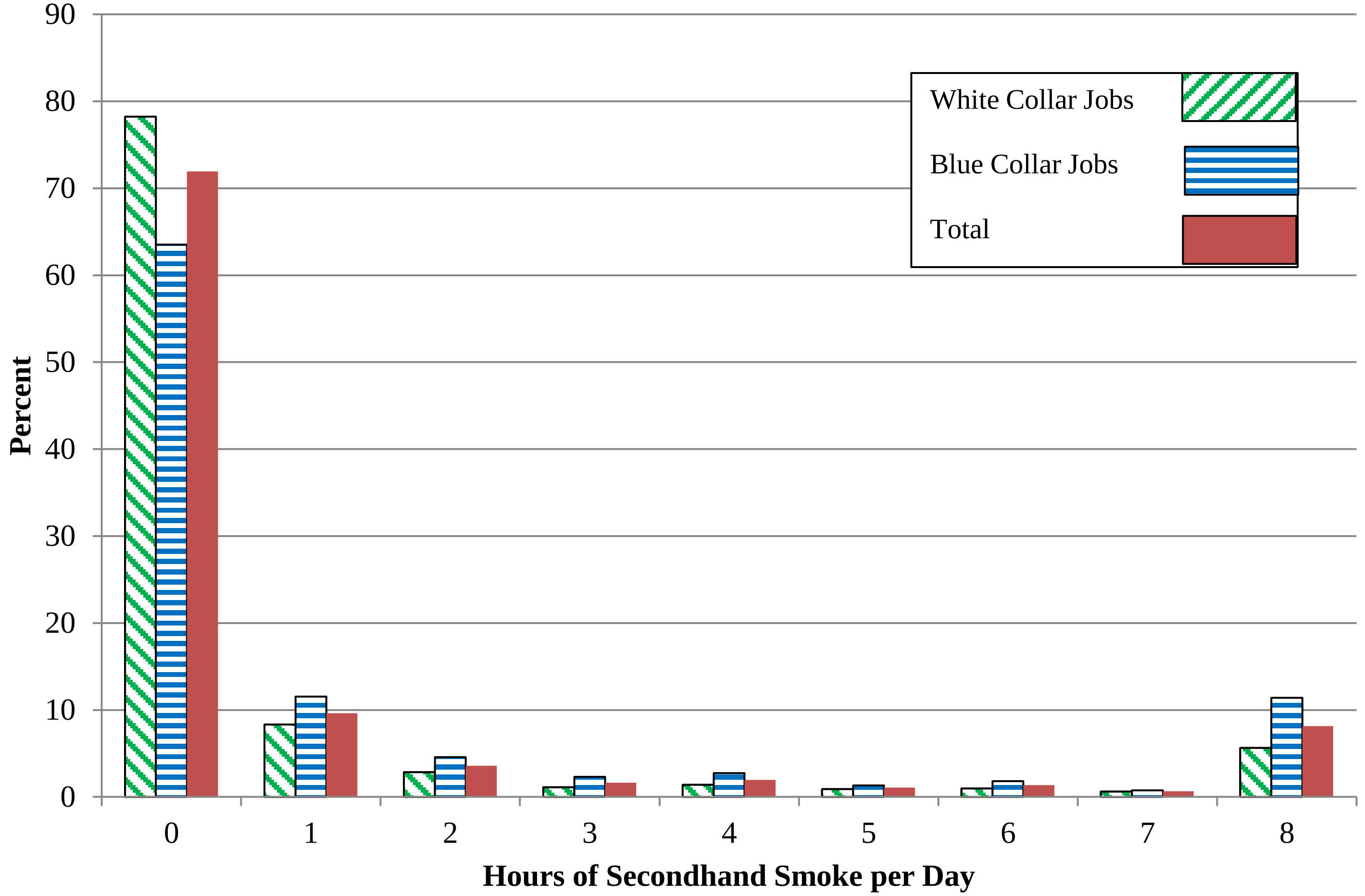
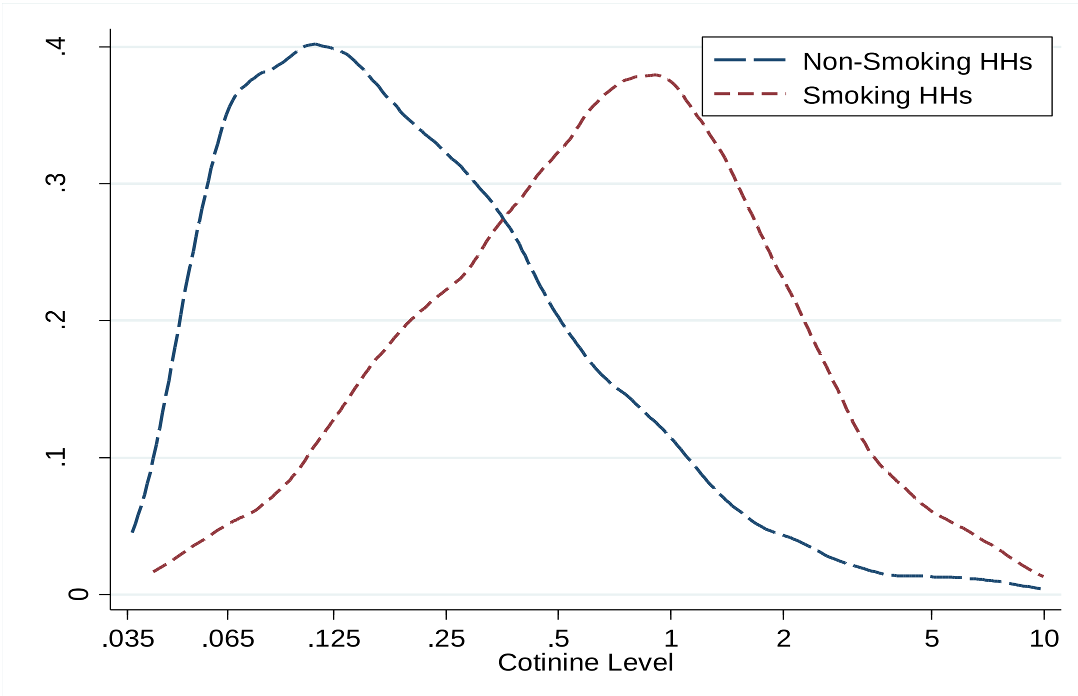
Figure 2.1
Tabulation of Self-Reported Secondhand Smoke Exposure at Work by Job Category



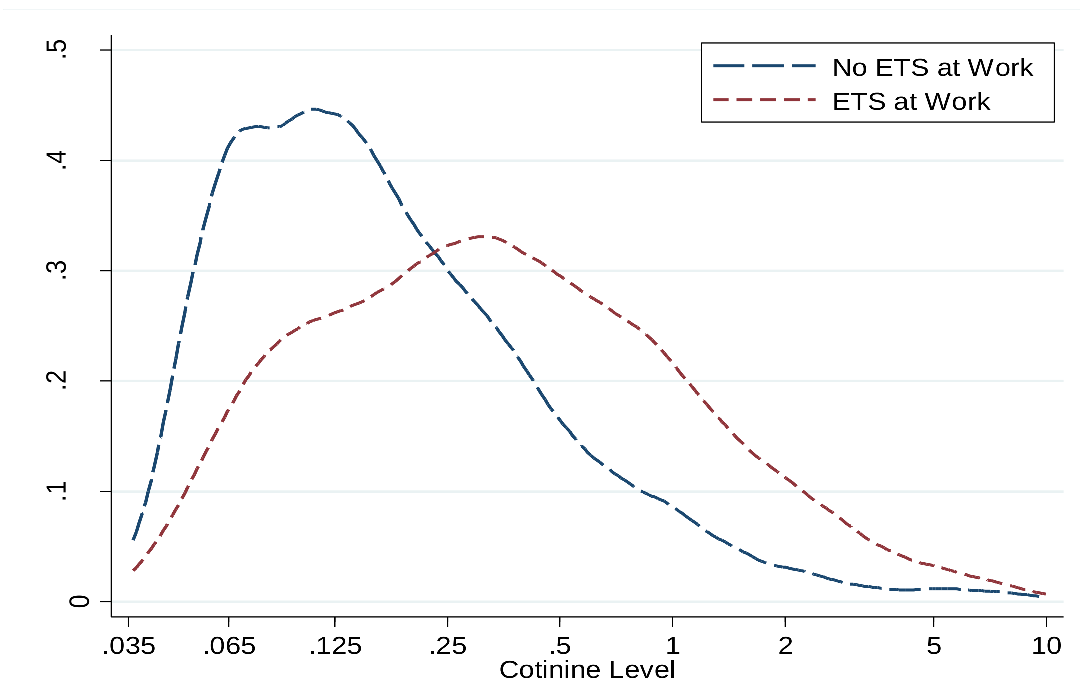
Notes:
Data from NHANES III and NHANES 1999/2000 - NHANES 2003/2004. The values of self-reported workplace secondhand smoke exposure are top-coded at 8 hours for convenience of exposition.

Figure 2.2
Distribution of Observable Logged Cotinine Concentrations

Panel A. Cotinine Concentrations by Household Smoking



Panel B. Cotinine Concentrations by Workplace Smoking



Notes:
Data from NHANES III and NHANES 1999/2000 - NHANES 2003/2004.

Table 2.1
Number of Hours per Day of Self-Reported Secondhand Smoke Exposure at Work by Occupation

Job Category	Mean	Std. Dev.	Num.
Waiters and waitresses	3.12	3.14	109
Miscellaneous food preparation and service occupations	2.24	3.14	191
Vehicle and mobile equipment mechanics and repairers	2.11	3.19	95
Construction trades	2.06	3.00	338
Freight, stock, and material movers, hand	1.98	3.52	125
Other transportation and material moving occupations	1.76	3.30	78
Machine operators, assorted materials	1.74	3.18	324
Extractive and precision production occupations	1.67	3.33	285
Laborers, except construction	1.67	2.89	57
Fabricators, assemblers, inspectors, and samplers	1.64	2.94	225
Material recording, scheduling, and distributing clerks	1.60	2.90	160
Other mechanics and repairers	1.51	2.66	166
Textile, apparel, and furnishings machine operators	1.51	2.83	182
Cleaning and building service occupations	1.47	2.61	337
Sales workers, retail and personal services	1.44	2.73	443
Protective service occupations	1.43	2.54	169
Cooks	1.41	2.74	198
Supervisors and proprietors, sales occupations	1.40	2.90	211
Personal service occupations	1.37	2.97	228
Construction laborers	1.33	2.59	88
Health service occupations	1.25	2.74	274
Motor vehicle operators	1.20	2.31	303
Related agricultural, forestry, and fishing occupations	1.10	2.48	122
Executive, administrators, and managers	0.96	2.36	714
Other helpers, equipment cleaners, hand packagers and laborers	0.96	2.10	112
Information clerks	0.93	2.26	151
Writers, artists, entertainers, and athletes	0.84	2.11	160
Sales representatives, finance, business, & commodities ex. retail	0.84	2.10	239
Farm and nursery workers	0.81	2.12	141
Miscellaneous administrative support occupations	0.73	2.01	618
Secretaries, stenographers, and typists	0.68	2.01	224
Records processing occupations	0.67	1.96	268
Management related occupations	0.64	1.98	279
Technicians and related support occupations	0.64	1.76	277
Engineers, architects and scientists	0.56	1.72	220
Health diagnosing, assessing and treating occupations	0.56	1.81	235
Private household occupations	0.51	1.70	158
Other professional specialty occupations	0.40	1.52	275
Farm operators, managers, and supervisors	0.34	1.38	102
Teachers	0.22	0.95	381
Total	**1.15**	**2.52**	**9268**

Notes:
Data from NHANES III and NHANES 1999/2000 - NHANES 2003/2004.

Table 2.2
Summary Statistics

	All Workers (N=8736)		White Collar Workers (N=4825)		Blue Collar Workers (N=3729)		
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	T-Test
Hours Smell Smoke at Work	0.827	2.133	0.537	1.716	1.413	1.413	0.000
Observable Cotinine Level	0.630	0.483	0.571	0.495	0.749	0.749	0.000
Cotinine Concentration	0.289	0.720	0.232	0.646	0.403	0.403	0.000
Cigarette Excise Tax	1.266	0.643	1.268	0.633	1.266	1.266	0.826
Average Cigarette Price	3.675	0.960	3.686	0.953	3.661	3.661	0.308
Work 100% SFA Law	8.450	2.075	8.692	2.368	7.997	7.997	0.360
Rest or Bar 100% SFA Law	14.012	33.739	14.453	34.177	13.024	13.024	0.262
Work SFA Restriction	0.403	0.491	0.410	0.492	0.388	0.388	0.252
Work SFA Ban	0.050	0.218	0.051	0.220	0.049	0.049	0.714
Rest/Bar SFA Restriction	0.428	0.495	0.443	0.497	0.397	0.397	0.008
Rest/Bar SFA Ban	0.135	0.342	0.139	0.346	0.125	0.125	0.269
Female	0.504	0.500	0.586	0.493	0.327	0.327	0.000
Black	0.103	0.304	0.092	0.290	0.121	0.121	0.000
Hispanic	0.118	0.322	0.074	0.262	0.201	0.201	0.000
Married	0.656	0.475	0.664	0.472	0.645	0.645	0.127
Missing Marital Info	0.046	0.210	0.046	0.210	0.045	0.045	0.903
Income to Poverty Ratio	3.219	1.645	3.573	1.556	2.569	2.569	0.000
B.A. Degree	0.325	0.468	0.446	0.497	0.089	0.089	0.000
Some College	0.306	0.461	0.316	0.465	0.291	0.291	0.053
H.S. Degree	0.244	0.430	0.192	0.394	0.345	0.345	0.000
Less than H.S.	0.125	0.331	0.045	0.208	0.276	0.276	0.000
Family Size	3.145	1.515	3.002	1.407	3.425	3.425	0.000
Rooms in Home	6.319	2.126	6.569	2.190	5.868	5.868	0.000
Job: White Collar	0.658	0.475					
Job: Manual	0.329	0.470					
Num Cigs Smoked in Home	1.039	4.597	0.783	3.989	1.568	1.568	0.000
State Unemployment Rate	5.460	1.488	5.436	1.479	5.503	5.503	0.171
Lagged Smoking Prevalence	23.210	2.788	23.180	2.806	23.284	23.284	0.344

Notes

Data from NHANES III and NHANES 1999/2000 through NHANES 2003/2004, the Tax Burden on Tobacco, the American Non-Smokers' Rights Foundation, Project ImpacTeen, Lillard and Sfekas (2010), U.S. Census, and the Bureau for Labor Statistics. Summary statistics are weighted by NHANES sample weights.

Table 2.3
Ordered Logit Estimation of the Effects of Tobacco Control Policies on Self-Reported Secondhand Smoke Exposure at Work Using ANRF Smoke-Free Air Law Variables

	Workplace Smoking Laws			Restaurant/Bar Smoking Laws		
	All Workers	White Collar Workers	Blue Collar Workers	All Workers	White Collar Workers	Blue Collar Workers
Using Sample Weights						
Cigarette Excise Tax	1.2457	1.3831*	1.1547	1.1744	1.3201	1.0727
	(1.2397)	(1.6469)	(0.4198)	(0.8459)	(1.4501)	(0.1984)
Work 100% SFA Law	0.9913***	0.9955	0.9862***			
	(-3.7441)	(-1.0917)	(-3.4684)			
Rest or Bar 100% SFA Law				0.9937***	0.9977	0.9892***
				(-3.4996)	(-0.9132)	(-3.3798)
Job: Manual	1.8039***			1.8006***		
	(6.1459)			(6.1163)		
cut1	1.0712	2.2877	0.1626	0.8207	1.9605	0.1179
	(0.0529)	(0.5612)	(-0.9278)	(-0.1546)	(0.4425)	(-1.1403)
cut2	7.3041	16.3336*	1.1323	5.5972	14.0012*	0.8215
	(1.5246)	(1.9203)	(0.0630)	(1.3554)	(1.7654)	(-0.1044)
Adjusted R-Squared	0.151	0.157	0.121	0.151	0.157	0.121
No Sample Weights						
Cigarette Excise Tax	1.1021	1.1456	1.0554	1.0558	1.1284	0.9920
	(0.6364)	(0.8271)	(0.1911)	(0.3432)	(0.8792)	(-0.0287)
Work 100% SFA Law	0.9936***	0.9964	0.9914**			
	(-2.6777)	(-0.9173)	(-2.1484)			
Rest or Bar 100% SFA Law				0.9958**	0.9962	0.9953**
				(-2.2268)	(-1.6135)	(-2.0243)
Job: Manual	1.6266***			1.6250***		
	(6.7468)			(6.6811)		
cut1	4.7876*	1.9694	5.3784	3.7594	1.4818	4.3402
	(1.7362)	(0.7959)	(1.1822)	(1.4705)	(0.4197)	(1.0730)
cut2	22.6154***	9.4517***	26.0381**	17.7604***	7.1144**	21.0086**
	(3.4463)	(2.6815)	(2.2715)	(3.2063)	(2.1443)	(2.2107)
Adjusted R-Squared	0.100	0.106	0.081	0.100	0.106	0.081
Num Obs.	8736	4825	3729	8736	4825	3729

Notes

The dependent variable in all columns is a categorical variable measuring the number of hours each indiviual reports secondhand smoke exposure at work each day: no secondhand smoke exposure (zero hours per day), some secondhand smoke exposure (one to six hours per day), and constant secondhand smoke exposure (more than seven hours per day). The coefficients represent odds-ratios, and t-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.4
Ordered Logit Estimation of the Effects of Tobacco Control Policies on Self-Reported Secondhand Smoke Exposure at Work Using Project ImpacTeen Smoke-Free Air Law Variables

	Workplace Smoking Laws			Restaurant/Bar Smoking Laws		
	All Workers	**White Collar Workers**	**Blue Collar Workers**	**All Workers**	**White Collar Workers**	**Blue Collar Workers**
Using Sample Weights						
Cigarette Excise Tax	1.2744	1.4112*	1.1933	1.1240	1.2351	1.0548
	(1.4657)	(1.8132)	(0.5156)	(0.6986)	(1.1982)	(0.1601)
Work SFA Restriction	0.6309**	0.6546	0.6278			
	(-2.0595)	(-1.3127)	(-1.1085)			
Work SFA Ban	0.2582***	0.3866*	0.1579***			
	(-4.7122)	(-1.8120)	(-2.7750)			
Rest/Bar SFA Restriction				0.6550**	0.6082*	0.6941
				(-2.1031)	(-1.7797)	(-1.2170)
Rest/Bar SFA Ban				0.4164***	0.6054	0.2619***
				(-3.6592)	(-1.4834)	(-3.1845)
Job: Manual	1.7919***			1.7890***		
	(6.0695)			(6.0787)		
cut1	0.8062	1.7412	0.1285	0.5079	1.1763	0.0755
	(-0.1954)	(0.3968)	(-1.2165)	(-0.6188)	(0.1118)	(-1.6092)
cut2	5.5087	12.4507*	0.8980	3.4734	8.4232	0.5273
	(1.5573)	(1.8474)	(-0.0632)	(1.1446)	(1.5024)	(-0.3948)
Adjusted R-Squared	0.152	0.158	0.122	0.152	0.158	0.122
No Sample Weights						
Cigarette Excise Tax	1.1190	1.1485	1.0909	1.0092	1.0828	0.9578
	(0.8392)	(0.8820)	(0.3299)	(0.0681)	(0.5825)	(-0.1664)
Work SFA Restriction	0.7328*	0.7350	0.7382			
	(-1.6522)	(-1.4262)	(-1.1856)			
Work SFA Ban	0.3937***	0.5263	0.2982***			
	(-3.9445)	(-1.6172)	(-2.6881)			
Rest/Bar SFA Restriction				0.7262*	0.7824	0.7125
				(-1.6822)	(-1.3129)	(-1.3259)
Rest/Bar SFA Ban				0.5749***	0.6179**	0.5310***
				(-3.1361)	(-2.0089)	(-2.6685)
Job: Manual	1.6224***			1.6188***		
	(6.7170)			(6.7869)		
cut1	3.4653	1.3620	4.0699	2.1972	0.9704	2.4596
	(1.5672)	(0.3151)	(1.1015)	(1.0131)	(-0.0285)	(0.7524)
cut2	16.3793***	6.5388**	19.7244**	10.3908***	4.6609	11.9226**
	(3.5342)	(1.9617)	(2.3205)	(3.0200)	(1.4939)	(2.0542)
Adjusted R-Squared	0.100	0.106	0.081	0.100	0.107	0.081
Num Obs.	8736	4825	3729	8736	4825	3729

Notes

The dependent variable in all columns is a categorical variable measuring the number of hours each indiviual reports secondhand smoke exposure at work each day: no secondhand smoke exposure (zero hours per day), some secondhand smoke exposure (one to six hours per day), and constant secondhand smoke exposure (more than seven hours per day). The coefficients represent odds-ratios, and t-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.5
Poisson Estimation of the Effects of Tobacco Control Policies on Self-Reported Secondhand Smoke Exposure at Work

	Workplace Smoking Laws			Restaurant/Bar Smoking Laws		
	All Workers	Collar Workers	Blue Collar Workers	All Workers	Collar Workers	Blue Collar Workers
Panel A. ANRF Smoke-Free Air Laws						
Using Sample Weights						
Cigarette Excise Tax	0.1524	0.0789	0.1699	0.0324	-0.0249	0.0384
	(1.262)	(0.313)	(0.921)	(0.221)	(-0.098)	(0.208)
Work 100% SFA Law	-0.0168***	-0.0117**	-0.0208***			
	(-7.016)	(-2.246)	(-6.240)			
Rest or Bar 100% SFA Law				-0.0094***	-0.0059*	-0.0119***
				(-3.873)	(-1.725)	(-3.930)
No Sample Weights						
Cigarette Excise Tax	0.1218	0.0446	0.0882	0.0384	-0.0049	0.0002
	(0.951)	(0.213)	(0.472)	(0.240)	(-0.025)	(0.001)
Work 100% SFA Law	-0.0140***	-0.0087*	-0.0163***			
	(-6.173)	(-1.668)	(-4.765)			
Rest or Bar 100% SFA Law				-0.0061***	-0.0051	-0.0066***
				(-3.012)	(-1.623)	(-3.188)
Panel B. Project ImpacTeen Smoke-Free Air Laws						
Using Sample Weights						
Cigarette Excise Tax	0.1937	0.1353	0.1858	0.0016	-0.0957	0.0355
	(1.628)	(0.606)	(0.949)	(0.012)	(-0.443)	(0.194)
Work SFA Restriction	-0.2986**	-0.3701*	-0.1707			
	(-2.202)	(-1.728)	(-0.652)			
Work SFA Ban	-0.8775***	-0.8332***	-0.8905***			
	(-8.583)	(-3.194)	(-5.243)			
Rest/Bar SFA Restriction				-0.2218	-0.3722**	-0.0589
				(-1.317)	(-2.006)	(-0.258)
Rest/Bar SFA Ban				-0.6464***	-0.5399*	-0.6975***
				(-3.652)	(-1.938)	(-4.024)
No Sample Weights						
Cigarette Excise Tax	0.1660	0.1153	0.1105	0.0173	-0.0359	-0.0051
	(1.461)	(0.613)	(0.589)	(0.127)	(-0.209)	(-0.027)
Work SFA Restriction	-0.2150	-0.2596*	-0.1368			
	(-1.521)	(-1.754)	(-0.593)			
Work SFA Ban	-0.8297***	-0.7699***	-0.8390***			
	(-8.919)	(-3.297)	(-4.904)			
Rest/Bar SFA Restriction				-0.1935	-0.2555*	-0.1017
				(-1.252)	(-1.716)	(-0.472)
Rest/Bar SFA Ban				-0.4964***	-0.4859**	-0.4931***
				(-3.078)	(-2.133)	(-2.806)
Num Obs.	8736	4825	3729	8736	4825	3729

Notes

The dependent variable in all columns is the number of hours each indiviual reports secondhand smoke exposure at work each day. The coefficients represent semi-elasticities, and t-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.6
Logit Estimation of the Effects of Tobacco Control Policies on Self-Reported Secondhand Smoke Exposure at Work

	Workplace Smoking Laws			Restaurant/Bar Smoking Laws		
	All Workers	White Collar Workers	Blue Collar Workers	All Workers	White Collar Workers	Blue Collar Workers
Panel A. ANRF Smoke-Free Air Laws						
Using Sample Weights						
Cigarette Excise Tax	1.2595	1.4474*	1.1270	1.1975	1.3719*	1.0790
	(1.194)	(1.833)	(0.323)	(0.890)	(1.646)	(0.200)
	[0.0339]	[0.0390]	[0.0266]	[0.0265]	[0.0334]	[0.0169]
Work 100% SFA Law	0.9921***	0.9951	0.9879***			
	(-3.164)	(-1.152)	(-2.605)			
	[-0.0012]	[-0.0005]	[-0.0027]			
Rest or Bar 100% SFA Law				0.9940***	0.9976	0.9894***
				(-3.162)	(-0.933)	(-2.681)
				[-0.0009]	[-0.0003]	[-0.0024]
No Sample Weights						
Cigarette Excise Tax	1.0791	1.1573	1.0122	1.0386	1.1353	0.9680
	(0.463)	(0.869)	(0.042)	(0.231)	(0.929)	(-0.118)
	[0.0140]	[0.0212]	[0.0027]	[0.0070]	[0.0184]	[-0.0074]
Work 100% SFA Law	0.9945**	0.9965	0.9924*			
	(-2.292)	(-0.863)	(-1.757)			
	[-0.0010]	[-0.0005]	[-0.0017]			
Rest or Bar 100% SFA Law				0.9963*	0.9966	0.9949*
				(-1.810)	(-1.446)	(-1.955)
				[-0.0007]	[-0.0005]	[-0.0012]
Panel B. Project ImpacTeen Smoke-Free Air Laws						
Using Sample Weights						
Cigarette Excise Tax	1.2849	1.4799*	1.1572	1.1396	1.2926	1.0439
	(1.368)	(1.950)	(0.396)	(0.725)	(1.442)	(0.120)
	[0.0368]	[0.0413]	[0.0325]	[0.0192]	[0.0271]	[0.0096]
Work SFA Restriction	0.6170**	0.6972	0.5284			
	(-1.987)	(-1.132)	(-1.347)			
	[-0.0688]	[-0.0372]	[-0.1377]			
Work SFA Ban	0.2731***	0.3935*	0.1624**			
	(-4.206)	(-1.722)	(-2.404)			
	[-0.1286]	[-0.0716]	[-0.2721]			
Rest/Bar SFA Restriction				0.6244**	0.6297*	0.6044*
				(-2.288)	(-1.678)	(-1.664)
				[-0.0678]	[-0.0480]	[-0.1096]
Rest/Bar SFA Ban				0.4123***	0.6026	0.2426***
				(-3.685)	(-1.528)	(-2.861)
				[-0.1053]	[-0.0466]	[-0.2482]
No Sample Weights						
Cigarette Excise Tax	1.0948	1.1592	1.0444	0.9898	1.0994	0.9250
	(0.600)	(0.863)	(0.160)	(-0.072)	(0.681)	(-0.299)
	[0.0166]	[0.0214]	[0.0099]	[-0.0019]	[0.0137]	[-0.0177]
Work SFA Restriction	0.7522	0.7904	0.6798			
	(-1.412)	(-1.036)	(-1.426)			
	[-0.0509]	[-0.0332]	[-0.0852]			
Work SFA Ban	0.4315***	0.5686	0.3046**			
	(-3.417)	(-1.382)	(-2.443)			
	[-0.1224]	[-0.0684]	[-0.2103]			
Rest/Bar SFA Restriction				0.7231*	0.8237	0.6774
				(-1.654)	(-0.944)	(-1.515)
				[-0.0578]	[-0.0277]	[-0.0857]
Rest/Bar SFA Ban				0.5955***	0.6468*	0.4971***
				(-2.689)	(-1.741)	(-2.891)
				[-0.0845]	[-0.0561]	[-0.1418]
Num Obs.	8721	4819	3720	8721	4819	3720

Notes
The dependent variable in all columns is an indicator variable measuring whether an indiviual reports secondhand smoke exposure at work. The coefficients represent odds-ratios, with marginal effects in brackets below, and t-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.7
Logit Estimation of the Effects of Tobacco Control Policies on the Probability of Observable Cotine Levels Using ANRF Smoke-Free Air Law Variables

	Workplace Smoking Laws			Restaurant/Bar Smoking Laws		
	All Workers	White Collar Workers	Blue Collar Workers	All Workers	White Collar Workers	Blue Collar Workers
Using Sample Weights						
Cigarette Excise Tax	1.0095	0.9868	1.1048	1.0132	0.9678	1.1316
	(0.083)	(-0.080)	(0.419)	(0.103)	(-0.173)	(0.545)
	[0.0015]	[-0.0023]	[0.0083]	[0.0020]	[-0.0058]	[0.0104]
Work 100% SFA Law	0.9894***	0.9861***	0.9984			
	(-2.760)	(-3.051)	(-0.407)			
	[-0.0017]	[-0.0025]	[-0.0001]			
Rest or Bar 100% SFA Law				0.9884***	0.9861***	0.9966
				(-3.381)	(-3.902)	(-1.003)
				[-0.0018]	[-0.0025]	[-0.0003]
Num Cigs Smoked in Home	2.1327***	2.9749***	1.7842***	2.1325***	3.0028***	1.7856***
	(3.519)	(2.824)	(3.320)	(3.495)	(2.793)	(3.342)
	[0.1176]	[0.1931]	[0.0484]	[0.1180]	[0.1944]	[0.0487]
Pseudo R-Squared	0.262	0.249	0.282	0.263	0.251	0.282
No Sample Weights						
Cigarette Excise Tax	1.0357	0.9592	1.0707	0.9906	0.8919	1.0253
	(0.420)	(-0.316)	(0.401)	(-0.098)	(-0.707)	(0.169)
	[0.0034]	[-0.0039]	[0.0042]	[-0.0009]	[-0.0108]	[0.0015]
Work 100% SFA Law	0.9873***	0.9850***	0.9936*			
	(-4.467)	(-5.103)	(-1.808)			
	[-0.0012]	[-0.0014]	[-0.0004]			
Rest or Bar 100% SFA Law				0.9894***	0.9878***	0.9961*
				(-6.343)	(-6.906)	(-1.840)
				[-0.0010]	[-0.0012]	[-0.0002]
Num Cigs Smoked in Home	1.5908***	2.4363***	1.4763***	1.5882***	2.4390***	1.4758***
	(4.875)	(5.030)	(3.775)	(4.871)	(4.991)	(3.749)
	[0.0451]	[0.0837]	[0.0237]	[0.0452]	[0.0839]	[0.0238]
Pseudo R-Squared	0.295	0.289	0.316	0.296	0.290	0.316
Num Obs.	8736	4810	3729	8736	4810	3729

Notes
The dependent variable in all columns is an indicator for whether the individual had an observable level of serum cotinine, and each model is estimated using a Logit model. The coefficients represent odds-ratios, and the corresponding marginal effects are shown in brackets. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, the time of day when the cotinine sample was drawn, whether the sample was drawn on a weekday or weekend, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.8
Logit Estimation of the Effects of Tobacco Control Policies on the Probability of Observable Cotine Levels Using Project ImpacTeen Smoke-Free Air Law Variables

	Workplace Smoking Laws			Restaurant/Bar Smoking Laws		
	All Workers	White Collar Workers	Blue Collar Workers	All Workers	White Collar Workers	Blue Collar Workers
Using Sample Weights						
Cigarette Excise Tax	0.9685	0.9477	1.0300	0.9813	0.9092	1.1516
	(-0.259)	(-0.304)	(0.126)	(-0.150)	(-0.523)	(0.617)
	[-0.0050]	[-0.0094]	[0.0024]	[-0.0029]	[-0.0168]	[0.0117]
Work SFA Restriction	0.4041**	0.2584***	1.7762			
	(-2.508)	(-4.432)	(0.843)			
	[-0.1482]	[-0.2509]	[0.0452]			
Work SFA Ban	0.1948***	0.0788***	2.6121			
	(-2.898)	(-4.332)	(1.148)			
	[-0.3496]	[-0.5611]	[0.0561]			
Rest/Bar SFA Restriction				0.7328	0.5078**	2.3205
				(-1.598)	(-2.084)	(1.348)
				[-0.0491]	[-0.1216]	[0.0658]
Rest/Bar SFA Ban				0.2744***	0.1613***	1.7258
				(-3.629)	(-4.849)	(0.801)
				[-0.2553]	[-0.4005]	[0.0385]
Num Cigs Smoked in Home	2.1354***	3.0094***	1.7824***	2.1313***	3.0179***	1.7860***
	(3.511)	(2.802)	(3.253)	(3.488)	(2.772)	(3.339)
	[0.1176]	[0.1938]	[0.0477]	[0.1179]	[0.1946]	[0.0481]
Pseudo R-Squared	0.262	0.252	0.283	0.264	0.253	0.283
No Sample Weights						
Cigarette Excise Tax	0.9817	0.9293	0.9610	0.9740	0.8684	1.0397
	(-0.208)	(-0.544)	(-0.230)	(-0.268)	(-0.890)	(0.256)
	[-0.0018]	[-0.0069]	[-0.0024]	[-0.0026]	[-0.0133]	[0.0024]
Work SFA Restriction	0.5044***	0.4208***	1.0683			
	(-3.182)	(-3.729)	(0.191)			
	[-0.0736]	[-0.0916]	[0.0040]			
Work SFA Ban	0.2028***	0.1136***	0.9664			
	(-5.112)	(-6.499)	(-0.071)			
	[-0.2623]	[-0.3931]	[-0.0021]			
Rest/Bar SFA Restriction				0.9646	0.8732	1.4435
				(-0.211)	(-0.538)	(1.033)
				[-0.0035]	[-0.0130]	[0.0209]
Rest/Bar SFA Ban				0.3821***	0.2940***	0.9576
				(-5.608)	(-5.695)	(-0.135)
				[-0.1270]	[-0.1686]	[-0.0027]
Num Cigs Smoked in Home	1.5882***	2.4387***	1.4742***	1.5870***	2.4369***	1.4759***
	(4.867)	(4.997)	(3.755)	(4.883)	(4.980)	(3.760)
	[0.0449]	[0.0834]	[0.0235]	[0.0451]	[0.0839]	[0.0237]
Pseudo R-Squared	0.295	0.291	0.315	0.295	0.290	0.316
Num Obs.	8736	4810	3729	8736	4810	3729

Notes

The dependent variable in all columns is an indicator for whether the individual had an observable level of serum cotinine, and each model is estimated using a Logit model. The coefficients represent odds-ratios, and the corresponding marginal effects are shown in brackets. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, the time of day when the cotinine sample was drawn, whether the sample was drawn on a weekday or weekend, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.9
The Effects of Tobacco Control Policies on Non-Smokers' Logged Cotinine Concentrations Using ANRF Smoke-Free Air Law Variables

	Workplace Smoking Laws			Restaurant/Bar Smoking Laws		
	All Workers	White Collar Workers	Blue Collar Workers	All Workers	White Collar Workers	Blue Collar Workers
Using Sample Weights						
Cigarette Excise Tax	0.0476	0.1468	-0.1169	0.0241	0.1132	-0.1372
	(0.755)	(1.602)	(-0.891)	(0.340)	(1.146)	(-1.236)
Work 100% SFA Law	-0.0051***	-0.0057***	-0.0054			
	(-4.123)	(-3.820)	(-1.212)			
Rest or Bar 100% SFA Law				-0.0041***	-0.0041***	-0.0044
				(-3.428)	(-3.709)	(-1.384)
Num Cigs Smoked in Home	0.0668***	0.0669***	0.0659***	0.0669***	0.0669***	0.0662***
	(12.311)	(11.398)	(9.209)	(12.392)	(11.444)	(9.331)
Adjusted R-Squared	0.243	0.234	0.254	0.243	0.233	0.254
No Sample Weights						
Cigarette Excise Tax	0.0207	0.0541	-0.0585	-0.0073	0.0179	-0.0838
	(0.353)	(0.858)	(-0.662)	(-0.106)	(0.252)	(-0.921)
Work 100% SFA Law	-0.0036***	-0.0041***	-0.0036*			
	(-3.336)	(-3.315)	(-1.735)			
Rest or Bar 100% SFA Law				-0.0022**	-0.0020	-0.0024*
				(-2.304)	(-1.609)	(-1.820)
Num Cigs Smoked in Home	0.0593***	0.0648***	0.0544***	0.0593***	0.0647***	0.0545***
	(16.106)	(15.914)	(10.392)	(16.116)	(15.881)	(10.436)
Adjusted R-Squared	0.270	0.262	0.264	0.270	0.262	0.264
Num Obs.	6517	3390	3003	6517	3390	3003

Notes

The dependent variable in all columns is the log of an individual's serum cotinine level, conditional on an observable level of serum cotinine. Each model is estimated using OLS, and coefficients represent semi-elasticities with coefficients pertaining to indicator variables transformed by exp[b]-1. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, the time of day when the cotinine sample was drawn, whether the sample was drawn on a weekday or weekend, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.10
The Effects of Tobacco Control Policies on Non-Smokers' Logged Cotinine Concentrations Using Project ImpacTeen Smoke-Free Air Law Variables

	Workplace Smoking Laws			Restaurant/Bar Smoking Laws		
	All Workers	White Collar Workers	Blue Collar Workers	All Workers	White Collar Workers	Blue Collar Workers
Using Sample Weights						
Cigarette Excise Tax	0.0513	0.1415	-0.1040	-0.0001	0.0724	-0.1505
	(0.873)	(1.677)	(-0.830)	(-0.002)	(0.843)	(-1.295)
Work SFA Restriction	-0.2221***	-0.2691***	-0.1727			
	(-3.467)	(-3.558)	(-1.514)			
Work SFA Ban	-0.5177***	-0.5477***	-0.5273**			
	(-5.978)	(-4.920)	(-2.343)			
Rest/Bar SFA Restriction				-0.2008**	-0.2573***	-0.1827
				(-2.458)	(-3.354)	(-1.188)
Rest/Bar SFA Ban				-0.4045***	-0.4167***	-0.4348**
				(-3.773)	(-3.960)	(-2.407)
Num Cigs Smoked in Home	0.0665***	0.0665***	0.0657***	0.0666***	0.0664***	0.0660***
	(12.022)	(11.203)	(8.997)	(12.153)	(11.236)	(9.197)
Adjusted R-Squared	0.244	0.235	0.255	0.244	0.234	0.255
No Sample Weights						
Cigarette Excise Tax	0.0326	0.0569	-0.0396	-0.0360	-0.0176	-0.1067
	(0.581)	(0.963)	(-0.472)	(-0.519)	(-0.264)	(-1.112)
Work SFA Restriction	-0.1667**	-0.1983**	-0.0968			
	(-2.357)	(-2.356)	(-0.844)			
Work SFA Ban	-0.4357***	-0.4490***	-0.4173**			
	(-4.102)	(-3.798)	(-2.598)			
Rest/Bar SFA Restriction				-0.1681**	-0.1795**	-0.1608
				(-2.440)	(-2.489)	(-1.124)
Rest/Bar SFA Ban				-0.2486**	-0.2262*	-0.2713*
				(-2.199)	(-1.867)	(-1.977)
Num Cigs Smoked in Home	0.0592***	0.0646***	0.0543***	0.0592***	0.0645***	0.0543***
	(15.769)	(15.809)	(10.277)	(15.765)	(15.804)	(10.269)
Adjusted R-Squared	0.271	0.263	0.264	0.270	0.262	0.264
Num Obs.	6517	3390	3003	6517	3390	3003

Notes

The dependent variable in all columns is the log of an individual's serum cotinine level, conditional on an observable level of serum cotinine. Each model is estimated using OLS, and coefficients represent semi-elasticities with coefficients pertaining to indicator variables transformed by exp[b]-1. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, the time of day when the cotinine sample was drawn, whether the sample was drawn on a weekday or weekend, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.11a
Logit Estimation of the Effects of Tobacco Control Policies on the Probability of Observable Cotine Levels
Using ANRF Smoke-Free Air Law Variables and NHANES Sample Weights

	Workplace Smoking Laws			Restaurant/Bar Smoking Laws		
	All Workers	White Collar Workers	Blue Collar Workers	All Workers	White Collar Workers	Blue Collar Workers
Cigarette Excise Tax	0.9442	0.9274	1.0279	0.9426	0.9119	1.0342
	(-0.362)	(-0.420)	(0.089)	(-0.358)	(-0.480)	(0.109)
	[-0.0085]	[-0.0131]	[0.0020]	[-0.0088]	[-0.0160]	[0.0025]
Tax x Work Smk	0.9335	0.9397	0.9611	0.9327	0.9465	0.9439
	(-0.943)	(-0.960)	(-0.363)	(-0.892)	(-0.805)	(-0.516)
	[-0.0102]	[-0.0108]	[-0.0029]	[-0.0103]	[-0.0095]	[-0.0043]
Work 100% SFA Law	0.9874**	0.9832**	0.9976			
	(-2.466)	(-2.355)	(-0.581)			
	[-0.0019]	[-0.0029]	[-0.0002]			
Work 100% SFA Law x Work Smk	0.9975	0.9971	0.9966**			
	(-0.891)	(-0.641)	(-2.085)			
	[-0.0004]	[-0.0005]	[-0.0003]			
Rest or Bar 100% SFA Law				0.9880***	0.9849***	0.9981
				(-3.350)	(-3.755)	(-0.629)
				[-0.0018]	[-0.0026]	[-0.0001]
Rest/Bar 100% SFA Law x Work Smk				0.9989*	0.9986	0.9987*
				(-1.731)	(-1.538)	(-1.650)
				[-0.0002]	[-0.0002]	[-0.0001]
Hours Smell Smoke at Work	1.2699***	1.2163***	1.3157***	1.2723***	1.2186***	1.3257***
	(4.990)	(3.275)	(4.151)	(4.979)	(3.268)	(4.187)
	[0.0354]	[0.0340]	[0.0203]	[0.0358]	[0.0343]	[0.0209]
Num Cigs Smoked in Home	2.1404***	2.9800***	1.7971***	2.1413***	3.0063***	1.7987***
	(3.457)	(2.759)	(3.283)	(3.445)	(2.741)	(3.310)
	[0.1127]	[0.1896]	[0.0434]	[0.1131]	[0.1907]	[0.0434]
Pseudo R-Squared	0.273	0.256	0.306	0.275	0.257	0.306
Num Obs.	8736	4810	3729	8736	4810	3729

Notes

The dependent variable in all columns is an indicator for whether the individual had an observable level of serum cotinine, and each model is estimated using a Logit model. The coefficients represent odds-ratios, and the corresponding marginal effects are shown in brackets. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, the time of day when the cotinine sample was drawn, whether the sample was drawn on a weekday or weekend, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.11b
Logit Estimation of the Effects of Tobacco Control Policies on the Probability of Observable Cotine Levels
Using ANRF Smoke-Free Air Law Variables

	Workplace Smoking Laws			Restaurant/Bar Smoking Laws		
	All Workers	**White Collar Workers**	**Blue Collar Workers**	**All Workers**	**White Collar Workers**	**Blue Collar Workers**
Cigarette Excise Tax	0.9991	0.9039	1.0540	0.9491	0.8500	0.9889
	(-0.008)	(-0.822)	(0.220)	(-0.475)	(-1.037)	(-0.050)
	[-0.0001]	[-0.0090]	[0.0029]	[-0.0048]	[-0.0146]	[-0.0006]
Tax x Work Smk	0.9605	0.9378*	0.9898	0.9568	0.9525	0.9665
	(-0.751)	(-1.653)	(-0.100)	(-0.781)	(-1.255)	(-0.316)
	[-0.0037]	[-0.0058]	[-0.0006]	[-0.0041]	[-0.0044]	[-0.0019]
Work 100% SFA Law	0.9850***	0.9820***	0.9921**			
	(-3.803)	(-3.293)	(-2.152)			
	[-0.0014]	[-0.0016]	[-0.0004]			
Work 100% SFA Law x Work Smk	0.9971	0.9969	0.9969*			
	(-1.337)	(-0.803)	(-1.794)			
	[-0.0003]	[-0.0003]	[-0.0002]			
Rest or Bar 100% SFA Law				0.9894***	0.9868***	0.9968
				(-6.387)	(-6.676)	(-1.550)
				[-0.0010]	[-0.0012]	[-0.0002]
Rest/Bar 100% SFA Law x Work Smk				0.9992*	0.9986*	0.9995
				(-1.730)	(-1.727)	(-0.598)
				[-0.0001]	[-0.0001]	[-0.0000]
Hours Smell Smoke at Work	1.1964***	1.2037***	1.1894***	1.1974***	1.2037***	1.1911***
	(8.538)	(4.795)	(5.620)	(8.163)	(4.508)	(4.912)
	[0.0163]	[0.0166]	[0.0097]	[0.0165]	[0.0167]	[0.0098]
Num Cigs Smoked in Home	1.5927***	2.4357***	1.4798***	1.5905***	2.4381***	1.4802***
	(4.843)	(5.043)	(3.761)	(4.846)	(5.026)	(3.758)
	[0.0424]	[0.0797]	[0.0218]	[0.0426]	[0.0801]	[0.0219]
Pseudo R-Squared	0.305	0.298	0.328	0.306	0.299	0.328
Num Obs.	8736	4810	3729	8736	4810	3729

Notes

The dependent variable in all columns is an indicator for whether the individual had an observable level of serum cotinine, and each model is estimated using a Logit model. The coefficients represent odds-ratios, and the corresponding marginal effects are shown in brackets. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, the time of day when the cotinine sample was drawn, whether the sample was drawn on a weekday or weekend, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.12a
Logit Estimation of the Effects of Tobacco Control Policies on the Probability of Observable Cotine Levels
Using Project ImpacTeen Smoke-Free Air Law Variables and NHANES Sample Weights

	Workplace Smoking Laws			Restaurant/Bar Smoking Laws		
	All Workers	White Collar Workers	Blue Collar Workers	All Workers	White Collar Workers	Blue Collar Workers
Cigarette Excise Tax	0.8626	0.8382	0.9258	0.9100	0.8499	1.0509
	(-1.041)	(-0.930)	(-0.258)	(-0.591)	(-0.886)	(0.159)
	[-0.0218]	[-0.0303]	[-0.0056]	[-0.0140]	[-0.0281]	[0.0036]
Tax x Work Smk	0.8906**	0.8933**	0.9147	0.9224	0.9303	0.9414
	(-2.144)	(-2.195)	(-0.757)	(-1.060)	(-1.149)	(-0.480)
	[-0.0171]	[-0.0194]	[-0.0065]	[-0.0120]	[-0.0125]	[-0.0044]
Work SFA Restriction	0.4675**	0.3030***	1.9542			
	(-2.113)	(-4.073)	(1.035)			
	[-0.1180]	[-0.2161]	[0.0462]			
Work SFA Restriction x Work Smk	1.0931	1.1423	0.9886			
	(1.272)	(1.301)	(-0.104)			
	[0.0132]	[0.0229]	[-0.0008]			
Work SFA Ban	0.3545*	0.1682**	3.8344			
	(-1.698)	(-2.019)	(1.580)			
	[-0.1981]	[-0.4004]	[0.0605]			
Work SFA Ban x Work Smk	1.6151***	1.9701*	1.1034			
	(3.887)	(1.937)	(0.387)			
	[0.0709]	[0.1165]	[0.0072]			
Rest/Bar SFA Restriction				0.8382	0.5944	2.4607
				(-0.861)	(-1.527)	(1.473)
				[-0.0265]	[-0.0913]	[0.0616]
Rest/Bar SFA Restriction x Work Smk				1.0628	1.0941	0.9823
				(0.665)	(0.817)	(-0.126)
				[0.0090]	[0.0155]	[-0.0013]
Rest/Bar SFA Ban				0.2915***	0.1612***	2.1010
				(-3.192)	(-4.358)	(1.139)
				[-0.2337]	[-0.3973]	[0.0433]
Rest/Bar SFA Ban x Work Smk				0.9451	0.9466	0.8705
				(-0.749)	(-0.637)	(-1.199)
				[-0.0084]	[-0.0095]	[-0.0101]
Hours Smell Smoke at Work	1.2353***	1.1684***	1.3462***	1.2499***	1.1812***	1.3563***
	(4.062)	(2.802)	(5.163)	(3.988)	(2.785)	(4.764)
	[0.0312]	[0.0268]	[0.0217]	[0.0332]	[0.0288]	[0.0222]
Num Cigs Smoked in Home	2.1463***	3.0354***	1.7959***	2.1394***	3.0212***	1.7996***
	(3.472)	(2.774)	(3.241)	(3.440)	(2.726)	(3.306)
	[0.1129]	[0.1908]	[0.0427]	[0.1130]	[0.1910]	[0.0428]
Pseudo R-Squared	0.274	0.259	0.307	0.275	0.259	0.307
Num Obs.	8736	4810	3729	8736	4810	3729

Notes
The dependent variable in all columns is an indicator for whether the individual had an observable level of serum cotinine, and each model is estimated using a Logit model. The coefficients represent odds-ratios, and the corresponding marginal effects are shown in brackets. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, the time of day when the cotinine sample was drawn, whether the sample was drawn on a weekday or weekend, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.12b
Logit Estimation of the Effects of Tobacco Control Policies on the Probability of Observable Cotine Levels
Using Project ImpacTeen Smoke-Free Air Law Variables

	Workplace Smoking Laws			Restaurant/Bar Smoking Laws		
	All Workers	White Collar Workers	Blue Collar Workers	All Workers	White Collar Workers	Blue Collar Workers
Cigarette Excise Tax	0.8989	0.8388	0.8841	0.9179	0.8177	0.9641
	(-1.118)	(-1.478)	(-0.545)	(-0.795)	(-1.386)	(-0.164)
	[-0.0097]	[-0.0156]	[-0.0068]	[-0.0078]	[-0.0180]	[-0.0020]
Tax x Work Smk	0.9018**	0.8903**	0.9012	0.9262	0.9266	0.9102
	(-2.506)	(-2.008)	(-1.246)	(-1.268)	(-1.385)	(-0.939)
	[-0.0094]	[-0.0103]	[-0.0057]	[-0.0070]	[-0.0068]	[-0.0052]
Work SFA Restriction	0.5638***	0.4733***	1.1832			
	(-2.822)	(-3.884)	(0.502)			
	[-0.0567]	[-0.0741]	[0.0090]			
Work SFA Restriction x Work Smk	1.0718**	1.0703	1.0813			
	(1.996)	(0.717)	(1.117)			
	[0.0063]	[0.0060]	[0.0043]			
Work SFA Ban	0.4314***	0.2602***	1.8445			
	(-2.729)	(-4.218)	(1.100)			
	[-0.1042]	[-0.1933]	[0.0262]			
Work SFA Ban x Work Smk	1.9508***	2.1121***	1.7188***			
	(5.741)	(8.452)	(2.694)			
	[0.0606]	[0.0665]	[0.0298]			
Rest/Bar SFA Restriction				1.0932	1.0133	1.5845
				(0.515)	(0.056)	(1.275)
				[0.0081]	[0.0012]	[0.0233]
Rest/Bar SFA Restriction x Work Smk				1.0859	1.0921	1.1226
				(1.212)	(0.838)	(1.328)
				[0.0075]	[0.0079]	[0.0064]
Rest/Bar SFA Ban				0.4136***	0.2920***	1.1070
				(-4.882)	(-5.359)	(0.318)
				[-0.1074]	[-0.1633]	[0.0054]
Rest/Bar SFA Ban x Work Smk				0.9960	0.9219	1.0567
				(-0.068)	(-0.913)	(0.560)
				[-0.0004]	[-0.0073]	[0.0030]
Hours Smell Smoke at Work	1.1744***	1.1830***	1.1640***	1.1752***	1.1847***	1.1574***
	(6.820)	(4.093)	(3.093)	(7.379)	(4.047)	(3.082)
	[0.0146]	[0.0149]	[0.0084]	[0.0148]	[0.0152]	[0.0080]
Num Cigs Smoked in Home	1.5927***	2.4456***	1.4808***	1.5896***	2.4366***	1.4813***
	(4.850)	(5.042)	(3.758)	(4.856)	(5.007)	(3.758)
	[0.0422]	[0.0795]	[0.0216]	[0.0424]	[0.0798]	[0.0216]
Pseudo R-Squared	0.305	0.299	0.328	0.305	0.299	0.329
Num Obs.	8736	4810	3729	8736	4810	3729

Notes

The dependent variable in all columns is an indicator for whether the individual had an observable level of serum cotinine, and each model is estimated using a Logit model. The coefficients represent odds-ratios, and the corresponding marginal effects are shown in brackets. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, the time of day when the cotinine sample was drawn, whether the sample was drawn on a weekday or weekend, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.13
The Effects of Tobacco Control Policies on Non-Smokers' Logged Cotinine Concentrations Using ANRF Smoke-Free Air Law Variables

	Workplace Smoking Laws			Restaurant/Bar Smoking Laws		
	All Workers	Collar Workers	Blue Collar Workers	All Workers	Collar Workers	Blue Collar Workers
Using Sample Weights						
Cigarette Excise Tax	0.0468	0.1071	-0.1102	0.0209	0.0705	-0.1261
	(0.770)	(1.365)	(-0.868)	(0.302)	(0.752)	(-1.126)
Tax x Work Smk	-0.0071	-0.0429**	0.0275	-0.0083	-0.0419**	0.0236
	(-0.463)	(-2.326)	(1.354)	(-0.539)	(-2.645)	(1.166)
Work 100% SFA Law	-0.0075***	-0.0075***	-0.0072*			
	(-4.481)	(-3.311)	(-1.959)			
Work 100% SFA Law x Work Smk	-0.0029**	-0.0017	-0.0039***			
	(-2.746)	(-0.578)	(-3.514)			
Rest or Bar 100% SFA Law				-0.0046***	-0.0048***	-0.0041
				(-4.013)	(-4.982)	(-1.413)
Rest/Bar 100% SFA Law x Work Smk				-0.0012***	-0.0009	-0.0015***
				(-6.249)	(-1.241)	(-6.333)
Hours Smell Smoke at Work	0.0443***	0.0451***	0.0401***	0.0474***	0.0452***	0.0455***
	(5.197)	(2.828)	(3.531)	(6.010)	(4.006)	(4.150)
Num Cigs Smoked in Home	0.0670***	0.0676***	0.0660***	0.0671***	0.0676***	0.0663***
	(12.468)	(11.712)	(9.418)	(12.607)	(11.781)	(9.605)
Adjusted R-Squared	0.259	0.247	0.274	0.259	0.247	0.275
No Sample Weights						
Cigarette Excise Tax	0.0170	0.0269	-0.0503	-0.0092	-0.0113	-0.0699
	(0.301)	(0.439)	(-0.581)	(-0.140)	(-0.161)	(-0.792)
Tax x Work Smk	-0.0087	-0.0289*	0.0120	-0.0060	-0.0263*	0.0142
	(-0.818)	(-1.900)	(0.931)	(-0.673)	(-2.001)	(1.229)
Work 100% SFA Law	-0.0047***	-0.0055**	-0.0043**			
	(-3.341)	(-2.428)	(-2.094)			
Work 100% SFA Law x Work Smk	-0.0015*	-0.0015	-0.0017***			
	(-1.852)	(-0.645)	(-3.317)			
Rest or Bar 100% SFA Law				-0.0026***	-0.0028**	-0.0024*
				(-2.872)	(-2.500)	(-1.947)
Rest/Bar 100% SFA Law x Work Smk				-0.0009***	-0.0012	-0.0009***
				(-5.375)	(-1.680)	(-5.459)
Hours Smell Smoke at Work	0.0485***	0.0457***	0.0486***	0.0481***	0.0430***	0.0491***
	(8.573)	(4.864)	(9.145)	(10.242)	(6.866)	(9.252)
Num Cigs Smoked in Home	0.0585***	0.0648***	0.0535***	0.0585***	0.0648***	0.0535***
	(16.718)	(16.107)	(10.793)	(16.741)	(16.085)	(10.838)
Adjusted R-Squared	0.289	0.280	0.283	0.289	0.280	0.284
Num Obs.	6517	3390	3003	6517	3390	3003

Notes
The dependent variable in all columns is the log of an individual's serum cotinine level, conditional on an observable level of serum cotinine. Each model is estimated using OLS, and coefficients represent semi-elasticities with coefficients pertaining to indicator variables transformed by exp[b]-1. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, the time of day when the cotinine sample was drawn, whether the sample was drawn on a weekday or weekend, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.14
The Effects of Tobacco Control Policies on Non-Smokers' Logged Cotinine Concentrations Using Project ImpacTeen Smoke-Free Air Law Variables

	Workplace Smoking Laws			**Restaurant/Bar Smoking Laws**		
	All Workers	**Collar Workers**	**Blue Collar Workers**	**All Workers**	**Collar Workers**	**Blue Collar Workers**
Using Sample Weights						
Cigarette Excise Tax	0.0338	0.0942	-0.1051	0.0001	0.0350	-0.1362
	(0.544)	(1.304)	(-0.840)	(0.002)	(0.422)	(-1.185)
Tax x Work Smk	-0.0241	-0.0476**	0.0043	-0.0083	-0.0395*	0.0249
	(-1.135)	(-2.383)	(0.158)	(-0.430)	(-1.942)	(0.900)
Work SFA Restriction	-0.2153***	-0.2749***	-0.1709			
	(-3.214)	(-3.153)	(-1.371)			
Work SFA Restriction x	0.0024	-0.0068	-0.0060			
Work Smk	(0.127)	(-0.409)	(-0.216)			
Work SFA Ban	-0.6093**	-0.6491	-0.6886**			
	(-2.358)	(-1.074)	(-2.447)			
Work SFA Ban x Work Smk	0.0496	0.1061	-0.0747			
	(0.257)	(0.159)	(-0.851)			
Rest/Bar SFA Restriction				-0.1873**	-0.2652***	-0.1787
				(-2.197)	(-3.127)	(-1.184)
Rest/Bar SFA Restriction				-0.0021	-0.0145	-0.0029
x Work Smk				(-0.114)	(-0.789)	(-0.093)
Rest/Bar SFA Ban				-0.5365***	-0.5365***	-0.5247**
				(-4.213)	(-5.016)	(-2.210)
Rest/Bar SFA Ban x Work				-0.1109***	-0.0449	-0.1447***
Smk				(-3.869)	(-0.541)	(-4.130)
Hours Smell Smoke at Work	0.0528***	0.0531***	0.0546***	0.0588***	0.0585***	0.0599***
	(4.783)	(3.845)	(4.349)	(4.645)	(4.238)	(3.735)
Num Cigs Smoked in Home	0.0668***	0.0673***	0.0659***	0.0669***	0.0672***	0.0661***
	(12.266)	(11.503)	(9.303)	(12.449)	(11.591)	(9.522)
Adjusted R-Squared	0.258	0.248	0.270	0.259	0.247	0.275
No Sample Weights						
Cigarette Excise Tax	0.0262	0.0347	-0.0353	-0.0352	-0.0430	-0.0901
	(0.463)	(0.606)	(-0.411)	(-0.515)	(-0.664)	(-0.973)
Tax x Work Smk	-0.0131	-0.0272*	0.0042	-0.0070	-0.0253	0.0159
	(-0.966)	(-1.786)	(0.265)	(-0.658)	(-1.707)	(1.114)
Work SFA Restriction	-0.1635**	-0.1978**	-0.0929			
	(-2.338)	(-2.093)	(-0.906)			
Work SFA Restriction x	-0.0073	-0.0203*	-0.0025			
Work Smk	(-0.843)	(-1.923)	(-0.221)			
Work SFA Ban	-0.4617	-0.2837	-0.5287**			
	(-1.424)	(-0.410)	(-2.445)			
Work SFA Ban x Work Smk	0.0597	0.2792	-0.0763			
	(0.267)	(0.428)	(-1.409)			
Rest/Bar SFA Restriction				-0.1619**	-0.1790**	-0.1553
				(-2.381)	(-2.264)	(-1.098)
Rest/Bar SFA Restriction				0.0010	-0.0073	-0.0035
x Work Smk				(0.104)	(-0.546)	(-0.276)
Rest/Bar SFA Ban				-0.3035**	-0.2847**	-0.3040**
				(-2.595)	(-2.345)	(-2.066)
Rest/Bar SFA Ban x Work				-0.0830***	-0.0809	-0.0944***
Smk				(-4.199)	(-1.186)	(-4.280)
Hours Smell Smoke at Work	0.0557***	0.0577***	0.0549***	0.0559***	0.0558***	0.0590***
	(7.229)	(7.697)	(5.611)	(8.330)	(7.732)	(6.056)
Num Cigs Smoked in Home	0.0584***	0.0648***	0.0534***	0.0584***	0.0646***	0.0534***
	(16.408)	(15.986)	(10.711)	(16.420)	(15.977)	(10.711)
Adjusted R-Squared	0.289	0.281	0.283	0.289	0.280	0.284
Num Obs.	6517	3390	3003	6517	3390	3003

Notes
The dependent variable in all columns is the log of an individual's serum cotinine level, conditional on an observable level of serum cotinine. Each model is estimated using OLS, and coefficients represent semi-elasticities with coefficients pertaining to indicator variables transformed by exp[b]-1. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, the time of day when the cotinine sample was drawn, whether the sample was drawn on a weekday or weekend, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.15
Self-Reported Workplace Secondhand Smoke Exposure
Check of Policy Lags and Leads

	Workplace Smoking Laws	Restaurant/Bar Smoking Laws
Cigarette Excise Tax	1.4540*	1.4206*
	(1.8737)	(1.6729)
Lagged Tax	0.7508	0.6881
	(-0.9748)	(-1.2337)
Leaded Tax	0.9103	0.9007
	(-1.1190)	(-1.2086)
Work 100% SFA Law	0.9927**	
	(-1.9977)	
Lagged 100% Work Law	0.9898	
	(-1.0290)	
Leaded 100% Work Law	0.9968*	
	(-1.8565)	
Rest or Bar 100% SFA Law		0.9943**
		(-2.0084)
Lagged 100% Rest/Bar Law		1.0006
		(0.2346)
Leaded 100% Rest/Bar Law		0.9983
		(-0.7959)
Num Cigs Smoked in Home	1.0100**	1.0101**
Num Obs.	8736	8736

Notes

The dependent variable in all columns is a categorical variable measuring the number of hours each indiviual reports secondhand smoke exposure at work each day: no secondhand smoke exposure (zero hours per day), some secondhand smoke exposure (one to six hours per day), and constant secondhand smoke exposure (more than seven hours per day). Each lag and lead period is three years. The coefficients represent odds-ratios, and t-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.16
Observable Cotinine Levels
Check of Policy Lags and Leads

	Workplace Smoking Laws	Restaurant/Bar Smoking Laws
Cigarette Excise Tax	1.0945	0.9050
	(0.461)	(-0.490)
	[0.0140]	[-0.0155]
Lagged Tax	0.9984	1.8087
	(-0.003)	(1.356)
	[-0.0003]	[0.0920]
Leaded Tax	0.8935	0.8826
	(-0.672)	(-0.852)
	[-0.0175]	[-0.0194]
Work 100% SFA Law	0.9920***	
	(-2.994)	
	[-0.0012]	
Lagged 100% Work Law	0.9386***	
	(-5.646)	
	[-0.0098]	
Leaded 100% Work Law	0.9941*	
	(-1.892)	
	[-0.0009]	
Rest or Bar 100% SFA Law		0.9906***
		(-5.489)
		[-0.0015]
Lagged 100% Rest/Bar Law		0.9866***
		(-5.076)
		[-0.0021]
Leaded 100% Rest/Bar Law		0.9940**
		(-2.195)
		[-0.0009]
Num Obs.	8736	8736

Notes
The dependent variable in all columns is an indicator for whether the individual had an observable level of serum cotinine, and each model is estimated using a Logit model. The coefficients represent odds-ratios, and the corresponding marginal effects are shown in brackets. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. Each lag and lead period is three years. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, the time of day when the cotinine sample was drawn, whether the sample was drawn on a weekday or weekend, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.17
Log Cotinine Levels
Check of Policy Lags and Leads

	Workplace Smoking Laws	Restaurant/Bar Smoking Laws
Cigarette Excise Tax	0.0529	0.0686
	(0.740)	(0.932)
Lagged Tax	0.0390	-0.0606
	(0.148)	(-0.221)
Leaded Tax	-0.0085	-0.0013
	(-0.136)	(-0.021)
Work 100% SFA Law	-0.0048**	
	(-2.434)	
Lagged 100% Work Law	-0.0050	
	(-1.027)	
Leaded 100% Work Law	-0.0011	
	(-1.055)	
Rest or Bar 100% SFA Law		-0.0037**
		(-2.344)
Lagged 100% Rest/Bar Law		0.0019
		(1.582)
Leaded 100% Rest/Bar Law		-0.0015
		(-1.234)
Num Obs.	6517	6517

Notes

The dependent variable in all columns is the log of an individual's serum cotinine level, conditional on an observable level of serum cotinine. Each model is estimated using OLS, and coefficients represent semi-elasticities with coefficients pertaining to indicator variables transformed by exp[b]-1. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. The lag and lead period is three years. All regressions also control for gender, age, age squared, race, ethnicity, height, marital status, education, job category, income-to-poverty ratio, household size, the number of cigarettes smoked in the household per day, the time of day when the cotinine sample was drawn, whether the sample was drawn on a weekday or weekend, state anti-smoking sentiment, state unemployment rate, lagged smoking prevalence, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Appendix Table 2.A
Classification of Job Categories

Job Category	White Collar Occupation	Blue Collar Occupation	Misc. Occupation
Executive, administrators, and managers	X		
Management related occupations	X		
Engineers, architects and scientists	X		
Health diagnosing, assessing and treating occupations	X		
Teachers	X		
Writers, artists, entertainers, and athletes	X		
Other professional specialty occupations	X		
Technicians and related support occupations	X		
Supervisors and proprietors, sales occupations	X		
Sales representatives, finance, business, & commodities ex. retail	X		
Sales workers, retail and personal services	X		
Secretaries, stenographers, and typists	X		
Information clerks	X		
Records processing occupations	X		
Material recording, scheduling, and distributing clerks	X		
Miscellaneous administrative support occupations	X		
Health service occupations	X		
Protective service occupations		X	
Waiters and waitresses		X	
Cooks		X	
Miscellaneous food preparation and service occupations		X	
Cleaning and building service occupations		X	
Personal service occupations		X	
Farm operators, managers, and supervisors		X	
Farm and nursery workers		X	
Related agricultural, forestry, and fishing occupations		X	
Vehicle and mobile equipment mechanics and repairers		X	
Other mechanics and repairers		X	
Construction trades		X	
Extractive and precision production occupations		X	
Textile, apparel, and furnishings machine operators		X	
Machine operators, assorted materials		X	
Fabricators, assemblers, inspectors, and samplers		X	
Motor vehicle operators		X	
Other transportation and material moving occupations		X	
Construction laborers		X	
Laborers, except construction		X	
Freight, stock, and material movers, hand		X	
Other helpers, equipment cleaners, hand packagers and laborers		X	
Private household occupations			X
Blank but applicable			X

Notes
Data from NHANES III and NHANES 1999/2000 to NHANES 2003/2004. Job categories come from the question which asks, "What kind of work [were you] doing? (For example: farming, mail clerk, computer specialist.)."

Chapter 3

Do Adolescent Smokers Compensate for Higher Cigarette Taxes?

Erik Nesson *

Abstract

A growing body of economic research suggests that although adult smokers reduce their consumption of cigarettes in response to higher cigarette excise taxes, smokers also compensate by switching to cigarette brands with higher nicotine contents or smoking more intensely. However, no research has examined whether this compensating behavior also occurs with adolescent smokers. This paper provides new evidence on how adolescent smokers change their smoking behavior in response to tobacco control policies and whether adolescent smokers compensate for stricter tobacco control policies. To measure smoking behavior, I use the number of cigarettes smoked per day and a biomarker of recent nicotine intake. I find that higher cigarette excise taxes are associated with reduced nicotine intake among adolescent smokers and these reductions are robust to controls for antismoking sentiment and other youth tobacco laws. In fact, I find some evidence that more stringent tobacco control policies actually lead to reductions in the amount of nicotine that adolescent smokers ingest from each cigarette. Lastly, I use the serum cotinine levels to check whether misreports of smoking status are related to tobacco control policies, which could bias the coefficients in models where the dependent variable is self-reported smoking status. I find some evidence that measures of youth access laws are related to misreports.

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3.1. Introduction

Over 70 percent of adult smokers start regularly smoking cigarettes between the ages of 12 and 19 (USDHHS 1990), and 26 percent of adolescents between the ages of 12 and 19 report trying cigarettes, 11 percent report smoking cigarettes at least once in the past month, and almost 10 percent report smoking in the past 5 days. Policy makers attempt to curb adolescent smoking through a number of policies, including cigarette excise taxes and restrictions on youth tobacco access, and a large body of economic research finds that many of these policies decrease the prevalence of youth smoking and the number of cigarettes that adolescent smokers consume.

However, examining the number of cigarettes consumed by adolescent smokers may tell an incomplete story of how adolescent smokers respond to tobacco control policies. First, self-reported measures of adolescent smoking behavior are often inaccurate. Adolescent smoking is illegal and minors may fear parents or authorities will discover their smoking status through responses to surveys (Murray et al. 1987; Patrick et al. 1994; Caraballo, Giovino and Pechacek 2004; Malcon et al. 2008). Moreover, a large body of epidemiological research shows that adult smokers compensate for reductions in the number of cigarettes smoked by inhaling more deeply, smoking more of each cigarette, or switching brands (Benowitz et al. 1983a; Benowitz and Jacob 1984; Benowitz et al. 1986a; Benowitz et al. 1986b). Recently some economic studies find that compensating behavior by adult smokers in response to cigarette excise taxes may offset all decreases in nicotine intake from reductions in the number of cigarettes smoked (Evans and Farrelly 1998; Adda and Cornaglia 2006). Finally, measuring adolescent smokers' nicotine intake is important. Nicotine is an addictive substance and adolescent smokers with more nicotine exposure are more likely to become addicted (Benowitz and Henningfield 1994; Caraballo, Novak and Asman 2009).

This paper provides new evidence on how adolescent smokers between the ages of 12 and 19 change their smoking behavior in response to tobacco control policies. To measure cigarette smoking, I supplement the commonly used metric of cigarettes smoked per day with serum cotinine levels, a biomarker of nicotine intake and a direct and continuous measure of smokers' intake of harmful chemicals. I use cotinine levels to measure three new aspects of youth smoking: (1) whether adolescents reduce their nicotine intake in response to tobacco control policies, (2) whether adolescents compensate for more stringent tobacco control policies to ingest more nicotine from each cigarette, and (3) whether tobacco control policies affect the misreporting of smoking status.

I find that cigarette excise taxes are associated with reductions in the number of cigarettes adolescents smoke, corresponding to price elasticities between -0.6 and -0.7. However large standard errors translate to insignificance at conventional levels. When measuring smoking behavior through cotinine levels, I find cigarette excise taxes translate into larger reductions in cotinine levels, corresponding to price elasticities between -1.4 and -1.6. In contrast to adult smokers, who compensate for higher cigarette excise taxes by inhaling more nicotine from each cigarette, I find some evidence that adolescent smokers actually reduce the amount of nicotine they ingest from each cigarette in response to higher cigarette excise taxes. I find little evidence that restrictions on youth access are associated with adolescent smokers' cigarette demand or nicotine intake, but I do find a negative relationship between youth smoking restrictions and adolescent smoking prevalence. Lastly, I find little evidence that tobacco control policies affect the misrepresentation of self-reported smoking status.

I use six waves of the National Health and Nutritional Examination Survey (NHANES) covering the years 1988 to 1994 and 1999 to 2008. In addition to measuring smoking behavior using the number of cigarettes smoked per day, NHANES also contains the level of individuals' serum cotinine, a biomarker of nicotine intake commonly used in the epidemiology literature to measure both adult and youth smoking (Williams et al. 1979; Hall et al. 1984; Murray et al. 1987; Benowitz et al. 2009). In addition to the epidemiology literature, cotinine has been used in two recent economic studies to measure adult smoking behavior and non-smokers' exposure to environmental tobacco smoke (Adda and Cornaglia 2006, 2010), but to my knowledge, no study has examined adolescent smokers' compensating behavior using cotinine.

My main contribution is the use of serum cotinine levels to measure adolescent smoking behavior. Cotinine offers several advantages over other self-reported measures of smoking, as it is free of measurement error stemming from self-reports and more closely measures the intake of the harmful and addictive elements of cigarettes (Perez-Stable, Benowitz and Marin 1995; Boffetta et al. 2006). Cotinine levels allow the measurement of three aspects of youth smoking previously unexplored in the literature. First, I test whether tobacco control policies are associated with reductions in adolescents' nicotine intake. As most adult smokers become addicted to smoking and nicotine is the addictive substance in cigarettes, tobacco control policies that reduce cigarette intake but not nicotine levels may not to a reduction in future nicotine addiction. Second, and relatedly, a growing literature suggests that adult smokers do not reduce their nicotine intake in response to more stringent tobacco control policies (Evans and Farrelly 1998; Farrelly et al. 2004; Adda and Cornaglia 2006). I test for the existence of this compensating behavior in adolescent smokers using the logged ratio of the number of cotinine levels to cigarettes smoked per day, a measure of how much nicotine adolescent smokers extract from each cigarette. Third, I examine whether tobacco control policies affect the misreporting of smoking status. Many adolescents apparently misrepresent their smoking status in surveys. As long as this misreporting is unrelated to the outcome variables of interest, it will lead to inflated standard errors but not biased coefficients. However, it is possible that more stringent tobacco control policies or anti-smoking sentiment increases the perceived repercussions of disclosing one's smoking status. Then a decrease in smoking outcomes related to increased tobacco control policies may simply be a decrease in the reporting of tobacco use rather than a decrease in actual tobacco use. Using serum cotinine levels to classify adolescents as likely smokers, I can observe whether tobacco control policies are associated with the probability that likely smokers also self-identify as smokers. In addition to using serum cotinine levels, I add to the growing literature examining the effects of anti-smoking sentiment on youth smoking behavior. Lastly, I examine the effects of two other tobacco control policies aside from cigarette excise taxes designed to limit youth access to cigarettes.

The rest of this paper is organized as follows. Section 3.2 provides an overview of the findings and limitations of the economics literature concerning adolescent smoking, Section 3.3 explains the identification strategy, Section 3.4 summarizes the data set, Sections 3.5 and 3.6 review the results, and Section 3.7 concludes.

3.2. Background

The economics literature examining adolescent smokers focuses on how tobacco policies, in particular taxes and smoking bans, affect adolescent smoking initiation and participation level. The earliest studies largely find that price affects adolescent smoking behavior but find mixed results for other tobacco control policies such as smoking bans (Chaloupka 1991; Chaloupka and Grossman 1996; Chaloupka and Wechsler 1997; Gruber and Zinman 2000). Some more recent papers also investigate other aspects of youth smoking, including cigarette bumming, the relationship between cigarettes and other substances, and the relationship between smoking and body weight (Cawley, Markowitz and Tauras 2004; Powell, Tauras and Ross 2005; Cawley, Markowitz and Tauras 2006; Katzman, Markowitz and McGeary 2007; Markowitz and Tauras 2009; Fletcher 2010). Additionally, a series of papers by Philip DeCicca, Donald Kenkel and Alan Mathios find that prices have no effect on youth smoking initiation and perhaps no effect on the number of cigarettes smoked by youth smokers (DeCicca, Kenkel and Mathios 2002; DeCicca, Kenkel and Mathios 2008; DeCicca et al. 2008), although Carpenter and Cook (2008) and Lillard, Molloy and Sfekas (2011) provide evidence that prices do affect both initiation and smoking levels when controlling for anti-smoking sentiment.

Despite its breadth, the economic literature examining adolescent smoking focuses on measuring smoking behavior using the number of cigarettes smoked. However, the number of cigarettes smoked may not accurately measure adolescents' smoking behavior. First, adolescents may not accurately report the number of cigarettes they smoke. Adolescents may fear reprisals from admitting to illegal behavior or have trouble conceptualizing the amount they smoke in terms of cigarettes per day (Murray et al. 1987; Patrick et al. 1994; Caraballo, Giovino and Pechacek 2004; Malcon et al. 2008).

Moreover, medical and epidemiologic studies suggest that smokers vary their smoking habits by inhaling more deeply or smoking more of each cigarette to extract a preferred amount of nicotine from each cigarette (Benowitz et al. 1983a; Benowitz and Jacob 1984; Benowitz et al. 1986b; Zacny and Stitzer 1988). Often this compensation results in smokers extracting the same amount of tar and nicotine from the lower nicotine and tar cigarettes (Benowitz et al. 1983a). Furthermore, laboratory experiments show that smokers also compensate for reduced quantities of cigarettes by smoking more intensely. Benowitz et al. (1986a) find when smokers who smoked on average 37 cigarettes per day were permitted to smoke only five cigarettes per day, a decrease of over 85 percent, they consumed three times as much nicotine per cigarette compared with their normal smoking exposure, and their nicotine intake only decreased by 50 percent.

Recently, a few economic studies find that in response to increased cigarette taxes, adult smokers compensate by smoking more intensely or switching to brands of cigarettes with higher tar and nicotine levels. Evans and Farrelly (1998) find that although smokers living in states with higher cigarette excise taxes smoke fewer cigarettes, they tend to smoke cigarettes with higher tar and nicotine contents. The increase in tar and nicotine intake per cigarette completely offset the reduction in tar and nicotine intake from smoking fewer cigarettes. Farrelly et al. (2004) use longitudinal data from the COMMIT project and also find that smokers facing higher cigarette prices decrease the number of cigarettes smoked but increase the tar and nicotine content of the cigarettes to keep daily estimated nicotine intake unchanged. Adda and Cornaglia (2006) is the only paper in the economics literature to use cotinine as a measure of smoking behavior. Adda and Cornaglia (2006) use NHANES data from 1988 to 1994 and 1999 to 2000 and serum cotinine as a measure of nicotine intake.[1] They find that while increased cigarette excise taxes decrease the number of cigarettes smoked, cigarette excise taxes do not change the average level of serum cotinine found in smokers. Adda and Cornaglia (2006) also construct a ratio of the serum cotinine level and the number of cigarettes smoked to measure smoking "intensity," and they find that increased cigarette excise taxes increase this measure of smoking intensity.

However, these studies do not address whether adolescent smokers reduce their nicotine consumption in response to tobacco control policies or instead compensate in the same manner as adult smokers. Measuring adolescent smokers' nicotine intake in addition to cigarette intake is important. Nicotine is the addictive substance in cigarettes, and it is nicotine rather than the number of cigarettes smoked per se that causes addiction. Indeed, adolescent smokers with more nicotine exposure are more likely to become addicted (Benowitz and Henningfield 1994; Caraballo, Novak and Asman 2009). Additionally, as noted above, many adolescents misreport smoking status. Whether through misremembering or fear of reprisals, measuring nicotine intake circumvents this misreporting and offers a method of determining whether this misreporting is classical measurement error or a possible source of bias in previous studies.

[1] Adda and Cornaglia use a subsample of publicly-available NHANES data covering 1988 to 1994 from respondents living in counties with more than 500,000 residents. A recent working paper by Abrevaya and Puzzello (2010) finds that Adda and Cornaglia's results are unstable when the sample is increased to all respondents in the applicable NHANES waves.

3.3. Methodology

Since a large portion of my sample does not smoke, a regression specification which does not account for this large mass of "zeros" will possibly lead to biased estimates. Moreover, the two-part model allows me to examine whether tobacco control policies affect smoking behavior through the extensive margin or the intensive margin. To identify the effects of changes in excise taxes on adolescent smoking behavior, I use a two-part model. I split adolescent smoking behavior into an adolescent's decision to smoke, and given that an adolescent smokes, the adolescent's smoking level.

The first part of the model estimates a linear probability model of the decision to smoke:

$$P(Smk = 1|x) = \alpha_0 + \alpha_1 P + \alpha_2 TC + \alpha_3 X + \mu_s + \delta_t + \gamma_q \, , \qquad (1)$$

where Smk is an indicator variable for whether an adolescent currently smokes, P is a measure of the monetary price of smoking, TC measures other youth tobacco control policies, X is a matrix of individual and geographic characteristics, and μ_s, δ_t, and γ_q are region, year and quarter fixed effects. Next, I model the decision of how much to smoke given smoking participation. I first estimate an ordinary least squares regression model conditional on smoking participation:

$$E(Y|Smk = 1; x) = \beta_0 + \beta_1 P + \beta_2 TC + \beta_3 X + \sigma_s + \phi_t + \eta_q \, , \qquad (2)$$

where Y is the smoking behavior of interest for an adolescent conditional on smoking participation and the other variables are as defined above. I cluster the standard errors at the state level in all linear probability and ordinary least squares specifications (Bertrand, Duflo and Mullainathan 2004).

3.4. Data

3.4.1. Tobacco Control Policies

The main independent variable of interest in this paper is a measure of the monetary cost of cigarettes. Cigarette prices are the most direct measure of cigarette cost and include more information than cigarette excise taxes (Chou, Grossman and Saffer 2004, 2006). However, prices may be related to aggregate state characteristics that determine cigarette demand and thus endogenous (Gruber and Frakes 2006). Cigarette excise taxes, while potentially politically endogenous, likely suffer from less bias than cigarette prices. Moreover, the effects of cigarette excise taxes on smoking behaviors measure what policy makers control. Thus, I use state cigarette excise taxes from the 2009 Tax Burden on Tobacco output by Orzechowski and Walker (2009) (TBOT).[2] The TBOT tracks changes in state-level cigarette excise for each state and each year. I transform the taxes into the real quarterly state cigarette excise taxes paid on a pack of cigarettes and add imputed taxes from the 1998 Master Settlement Agreement between state attorneys general and tobacco manufacturers (Lillard and Sfekas 2010).[3]

Although less endogenous than cigarette prices, cigarette excise taxes may be endogenously determined by unobservable anti-smoking sentiment, which may drive both the adoption of higher cigarette taxes and reductions in smoking outcomes. To further account for possible endogeneity, I include state fixed effects in all models, as

[2] I add city taxes for municipalities and counties which make up large proportions of their respective state populations. I add excise taxes for the five counties which comprise New York City, NY; Cook County, IL; Anchorage and Juneau, AK; Arlington and Fairfax Counties, VA; and Cuyahoga County, OH.

[3] The Master Settlement Agreement required cigarette manufacturers to pay into an escrow account an amount proportional to the number of cigarettes they sell. As Lillard and Sfekas point out, including the implicit taxes from the MSA will not change the tax coefficients if year fixed effects are included in the model, but they will affect calculated elasticities.

well as year and quarter fixed effects. Finally, I include a measure of state-level anti-smoking sentiment developed by DeCicca et al. (2008). I use questions about attitudes towards smoking in various places to measure anti-smoking sentiment from the 1992-1993, 1995-1996, 1998-1999, 2000-2001, 2002-2003, and 2006-2007 waves of the Current Population Survey Tobacco Use Supplement (TUS-CPS).[4]

I also include two measures of state-level tobacco regulations recorded by Project ImpacTeen and available between 1991 and 2006. The first, "Minor Tobacco Control Index," is an index ranging from 0 to 3 indicating the number of possession, use, and/or purchase laws in each state and year. The second measure, the "Total Alciati Score" developed by Alciati et al. (1998), measures the extensiveness of state tobacco control youth access laws. The Alciati Score ranges from 0 to 31 based on the presence and severity of youth access laws pertaining to minimum purchase age, cigarette packaging, clerk presence during sales, photo ID requirements, vending machines, free samples, penalties for youth access law violations, random inspections, and statewide enforcement.

Figure 3.1 shows a time series of changes in tobacco control policies from 1991 to 2006. Cigarette excise taxes rose through the sample period, but taxes rose especially rapidly after the Master Settlement Agreement in 1998, rising from $0.83 in 1998 to

[4] For restaurants, bars and cocktail lounges, work places, and sporting events, respondents answer whether they think smoking should be allowed in all areas, allowed in some areas, or not allowed at all. Lastly, respondents answer whether smoking is allowed anywhere inside their home, in certain areas inside their home, or not allowed at all inside their home. I combine the answers to these questions into one latent variable using factor analysis, and I find that one latent factor best explains the variation of the five smoking attitude questions. I compute this latent variable for each respondent, take the average of the latent variable for each state and year, and linearly impute missing year and state observations. DeCicca et al. (2008) also include questions pertaining to smoking in hospitals and shopping malls, as well as whether cigarette companies should be allowed to give away free samples or advertise. However, more recent versions of the TUS-CPS do not consistently ask these questions. To check whether using five variables rather than nine materially changed results, I ran a regression of the anti-smoking index using the nine variables on the anti-smoking index using the five variables. The t-statistic on the five variable index is 73.46 and the r-squared is 0.97.

$1.92 in 2008. As with cigarette excise taxes, the prevalence of youth tobacco control policies increased after the 1998 Master Settlement Agreement. The average Minor Tobacco Control Index rose from under 0.94 in 1996 to 1.8 in 2002, and the average Total Alciati Score rose from 12.8 in 1996 to 17.8 in 2002.

3.4.2. NHANES Data

I use six waves of the NHANES data sets covering 1988 to 1994 and 1999 to 2008. NHANES is a cross-sectional survey of health and nutritional information conducted by the CDC which combines surveys, physical examinations, and laboratory measurements. I define a respondent as a current smoker if the respondent reports he or she has smoked cigarettes in the past 30 days.[5] I construct three main variables to measure smoking behavior among current smokers. First, I measure the average number of cigarettes smoked per day by multiplying the reported number of cigarettes smoked per day on the days a respondent smoked in the past 30 days by the percent of days the respondent smoked in the past 30 days.

Second, I use the level of serum cotinine, collected by NHANES, measured in nanograms per milliliter. NHANES collects blood samples from individuals age three and older as part of its examinations, and the samples are sent to the CDC for analysis. Serum cotinine levels as low as 0.035 ng/ml can be detected in the NHANES data. Serum cotinine levels offer an attractive alternative measure of smoking behavior. Cotinine is the major metabolite of nicotine, and approximately 70 percent of ingested nicotine is

[5] I remove individuals who self-report as non-smokers but have serum cotinine levels above 10 ng/ml, a common cutoff in the medical literature to distinguish between smokers and non-smokers. I retain individuals who self-report as smokers but have serum cotinine levels below 10 ng/ml so as to not remove light smokers from the analysis.

converted into cotinine. (Benowitz and Jacob 1994; Benowitz et al. 1994). Although nicotine is rapidly metabolized by the body with a half-life in the body of about two hours, cotinine has a much longer half-life of about 16 to 20 hours. Smokers often have a fairly stable level of cotinine in their systems which does not vary much during the day or even across days (Kemmeren et al. 1994). Cotinine levels have been used in the epidemiology literature as a biomarker for both adult and adolescent smoking levels since the 1970s (Williams et al. 1979; Benowitz et al. 1983a; Benowitz et al. 1983b; Benowitz and Jacob 1984; McNeill et al. 1987; Blackford et al. 2006; Benowitz et al. 2009) and in two recent economic articles as a measure of adult smoking and exposure to environmental tobacco smoke (Adda and Cornaglia 2006, 2010). Researchers in the epidemiology literature often use cotinine levels to identify the prevalence of underreported smoking status in adolescents (Bauman and Ennett 1994; Patrick et al. 1994; Dolcini et al. 2003; Caraballo, Giovino and Pechacek 2004; Malcon et al. 2008). Moreover, it is nicotine and not the number of cigarettes that cause adolescents to transition from occasional smokers into addicted smokers (Lessov-Schlaggar et al. 2008). Measuring cotinine levels in adolescents provides a direct way to measure adolescents' exposure to nicotine and therefore their risk of addiction.

The main drawback to using cotinine to measure smoking intensity is that cotinine levels fall after smoking cessation. Cotinine levels often fall to non-smoking levels within four to seven days of smoking cessation. For example, imagine a 16 year old smoker who smokes only on the weekends when parents, teachers and other authorities are not present. On Saturday night, after a night of smoking, the adolescent's serum cotinine concentration is 250 ng/mL, about the average cotinine concentration in adult smokers. If the half-life of serum cotinine is 18 hours, it will take about four days for the adolescent's serum cotinine level to fall below 10 ng/mL, a commonly used cutoff for distinguishing adolescent smoking behavior. Thus, it is feasible that adolescents interviewed later in the week may have cotinine concentrations lower than early in the week, and intermittent adolescent smokers may appear as non-smokers using cotinine concentrations.

My third measure of smoking is the logged ratio of serum cotinine concentrations to the number of cigarettes smoked per day, a measure of how much nicotine each smoker ingests from each cigarette. This variable will capture smokers' compensating behavior, accounting for brand switching and changes in inhalation patterns to extract more or less nicotine from each cigarette.

Cotinine levels clearly distinguish non-smokers and smokers. Figure 3.2 shows the densities of logged cotinine levels for smokers and non-smokers, and the vertical dashed line represents a cotinine level of 10 ng/ml. The overall density of cotinine is clearly bi-modal, although a significant portion of self-reported smokers have a cotinine value below the cutoff of 10 ng/ml. Figure 3.3 shows a scatter plot of cotinine levels and cigarettes smoked per day. There is a clear positive relationship between cotinine and cigarettes smoked. Figure 3.3 also demonstrates the differences between the two variables. There is a clear bunching of cigarettes smoked per day around round numbers of cigarettes, for example 10 and 20 cigarettes per day. Additionally, many adolescent smokers who self-report smoking 10 or more cigarettes per day have very low cotinine levels.

NHANES provides detailed demographic characteristics, and using these I include variables for gender, age, race, ethnicity, height, marital status, family income, and education. Additionally, state and county of residence information for the NHANES data is available through the NCHS Restricted Data Center which allows me to merge the tobacco control policy information and geographic characteristics with the individual level data. In addition to the tobacco control policies described earlier, I also include controls for county population density and the state unemployment rate.

Table 3.1 shows summary statistics for the sample. The total number of individuals interviewed in the NHANES surveys is 85,617. After removing all individuals with missing values on demographic controls and all individuals indicating the use of other tobacco products, 10,084 adolescents between ages 12 and 19 remain, 1,299 of which are current smokers. On average, adolescent smokers smoke just over six cigarettes per day. Serum cotinine levels work well at distinguishing smokers from non-smokers. The average cotinine concentration for smokers is just over 100 ng/ml, while non-smokers have an average concentration of only 0.45 ng/ml.

3.5. Results

Table 3.2 shows results from regressions estimating the effects of cigarette excise taxes on adolescent smoking behaviors. Table 3.2 has four columns. The first column shows results from a linear probability model where the dependent variable is an indicator for whether or not the individual currently smokes. The second through fourth columns show results from OLS regressions where the dependent variables are the log of the number of cigarettes the individual smokes per day, the log of the individual's serum cotinine level, and the measure of smoking intensity, respectively, all conditional on smoking participation.

In the baseline model, cigarette excise taxes do not have a statistically significant impact on adolescent smoking prevalence or conditional cigarette demand. A one dollar increase in cigarette taxes is associated with a 20 percent reduction in conditional cigarette demand, but the result is not statistically significant. In column three, a one dollar increase in cigarette excise taxes is associated with a 44 percent decrease in serum cotinine concentrations. In column three, cigarette excise taxes are also negatively related to smoking intensity. Every one dollar increase in cigarette excise taxes reduces smoking intensity by about 25 percent.

In Panel B, I add in the measure of yearly state-level anti-smoking sentiment developed by DeCicca et al. (2008). I scale the coefficients on the anti-smoking sentiment such that the coefficients represent the effects from a one standard deviation increase in anti-smoking sentiment. Including the measure of anti-smoking sentiment causes the coefficient representing the effect of cigarette excise taxes on the number of cigarettes smoked to decrease in magnitude, and the t-statistic remains insignificant. However, the cotinine and smoking intensity coefficients remain statistically significant and of similar magnitude. Similar to the results in DeCicca et al. (2008), anti-smoking sentiment is negative related to cigarette demand, and a one standard deviation increase in anti-smoking sentiment decreases conditional cigarette consumption by about 30 percent.

The last panel of Table 3.2, Panel C, shows results including the additional tobacco controls collected by Project ImpacTeen, the index of minor possession, use, or purchase laws and the Total Alciati Score. The Total Alciati Score is negatively related to smoking participation, although other tobacco control policies are not related to participation. For the log of the number of cigarettes smoked per day, the coefficient on cigarette excise taxes is larger in magnitude to the coefficient in Panel A, but remains statistically insignificant. For the log of serum cotinine concentrations, the coefficient on cigarette excise taxes remains negative, statistically significant, and of similar magnitude to coefficients in Panels A and B.

Table 3.3 shows results for other demographic characteristics. Females are not less likely to smoke or to smoke fewer cigarettes, but they do have lower cotinine concentrations and thus a lower smoking intensity. African Americans are less likely to smoke, and conditional on smoking, report smoking fewer cigarettes per day. However, there is no significant difference in cotinine levels. On the other hand, Hispanics have lower measures of all smoking outcomes. Income is negatively related to measures of smoking, as are married households and adolescents with higher levels of education.

3.6. Robustness Checks

3.6.1. The Effect of Interview Day on Cotinine Results

As serum cotinine has a half-life of 16 to 20 hours, one potential issue with using serum cotinine to measure smoking behavior is the elimination of cotinine from the body. This may be especially true in adolescents who smoke more on the weekends or weekdays. To check the robustness of cotinine as a measure, I re-estimate Table 3.2 for the dependent variables involving serum cotinine: logged of serum cotinine levels and the logged ratio of cotinine to number of cigarettes smoked per day, by whether the cotinine sample was drawn on a weekday or weekend.

Table 3.4 shows results from these regressions. The layout of Table 3.4 is similar to Table 3.2, with Panels A, B and C in Table 3.4 corresponding to Panels A, B and C in Table 3.2. Consistently across specifications, cotinine samples drawn on weekdays are negatively related to cigarette excise taxes while the cotinine samples drawn during the weekends are not related to cigarette excise taxes. For weekday interviews, a one dollar increase in cigarette excise taxes is associated with a 33 to 48 percent decrease in cotinine levels, conditional on smoking participation. Additionally, a one dollar increase in cigarette excise taxes is associated with a 29 to 41 percent reduction in smoking intensity for individuals interviewed on weekdays. When the sample is split, anti-smoking sentiment is negatively related to serum cotinine levels for both weekday and weekend specifications, compared to insignificant coefficients in Table 3.2. Lastly, there is some evidence that the youth access laws reduce smoking intensity for weekday interviews.

3.6.2. The Effect of Tobacco Control Policies on Misreported Smoking Status

Another potential issue pertains to self-reporting bias. As noted above, many adolescents apparently misrepresent their smoking status in surveys. In fact some studies have used serum cotinine measures to validate the self-reports of adolescent smokers (e.g. Caraballo, Giovino and Pechacek 2004). As long as this misreporting is unrelated to the outcome variables of interest, it is classical measurement error and will not bias the coefficients. However, it is possible that misreporting is related to tobacco control policies. If more stringent tobacco control policies or anti-smoking sentiment increase the perceived repercussions of disclosing one's smoking status, then a decrease in smoking outcomes related to increased tobacco control policies may simply be a decrease in the reporting of tobacco use rather than a decrease in actual tobacco use.

To examine whether this potential bias affects my results and possibly the results of other papers examining adolescent smoking, I directly test whether tobacco control policies are related to the misreporting of smoking status. More specifically, I estimate the following equation:

$$P(Smk = 1|CotSmk = 1; x) = \theta_0 + \theta_1 P + \theta_2 TC + \theta_3 X + \mu_s + \delta_t + \gamma_q \, , \qquad (3)$$

where Smk is an indicator for whether the adolescent self-reports as a smoker, $CotSmk$ represents a cotinine level above 10 ng/ml, the cutoff for smoking participation, and the other variables are as defined above. Equation (3) tests whether the probability of self-reporting as a smoker, given a cotinine level indicating smoking participation, is associated with tobacco control policies. For example, if θ_1 is negative, it indicates that as cigarette excise taxes increase, the probability that adolescents with high levels of cotinine self-reporting as a smoker decreases.

Table 3.5 shows the comparison between self-reported smoking status and smoking status according to a serum cotinine value greater than 10 ng/ml. Although generally, self-reported smoking status and cotinine levels agree, almost 28 percent of adolescents with cotinine levels above 10 ng/ml self-report as non-smokers. Almost the same percent of self-reported smokers, 28 percent, have cotinine levels below 10 ng/ml. Table 3.6

shows results from these linear probability models estimating equation (3). Generally, tobacco control policies are not related to the probability of misreporting. However, the coefficient on the Total Alciati Score is negative and statistically significant, indicating that a one unit increase in the index is associated with a 1.3 percentage point increase in misreporting.

3.6.3. Overall Cotinine Levels

Relatedly, to provide some evidence of the overall effect of tobacco control policies on adolescent smoke exposure and remove any possible self-reporting errors, I turn to estimating models only using serum cotinine levels to determine smoking status. I estimate whether tobacco control policies reduce the probability that an adolescent's serum cotinine concentration is above 10 ng/ml, the level considered as a smoking level. I estimate the following equation:

$$P(CotSmk = 1; x) = \phi_0 + \phi_1 P + \phi_2 TC + \phi_3 X + \mu_s + \delta_t + \gamma_q \, , \qquad (4)$$

where $CotSmk$ represents a cotinine level above 10 ng/ml, the cutoff for smoking participation, and the other variables are as defined above.

Table 3.7 shows results from linear probability models estimating equation (4). As with the previous tables, Table 3.6 again shows a negative relationship between cigarette excise taxes and serum cotinine levels. In Panels A and B, a one dollar increase in cigarette excise taxes is associated with a 1.4 to 1.6 percentage point decrease in the probability that an adolescent's serum cotinine level is above 10 ng/ml. Also consistent with previous tables, every unit increase in the Total Alciati Score decreases the probability of a serum cotinine level above 10 ng/ml by 2.9 percentage points.

3.6.4. Other Potential Issues

My results could suffer from a few additional issues. First, the ideal statistical design for examining individuals' responses to tobacco control policies would be a panel of individuals, allowing direct examination of how an individual behaves before and after changes in tobacco control policies. As the NHANES data are a repeated cross section, I cannot observe individuals over time. This is a problem in most papers estimating the effects of tobacco control policies, but it may be an additional problem here since my paper uses a biomarker of nicotine consumption. Unobservable individual differences in nicotine metabolism may add measurement error to the observed cotinine concentrations. However, the medical literature suggests cotinine levels in smokers are fairly consistent across time (Kemmeren et al. 1994). Moreover, the individual differences in cotinine metabolism will not bias my coefficients as long as these differences in nicotine metabolism are unrelated to tobacco control policies. As noted above, there does not seem to be evidence that discrepancies between self-reported smoking status and serum cotinine levels are related to tobacco control policies.

Another potential concern is selection. If more stringent tobacco control policies induce a certain type of smoker to stop smoking or never start smoking, then changes in smoking intensities may be due to a changing pool of smokers, rather than changing behavior by remaining smokers. Because the NHANES data is a repeated cross-section, rather than a panel, completely alleviating this potential concern is beyond the scope of this present analysis. However, the results here do not show any evidence that cigarette excise taxes, the main driver of reduced smoking intensity, affect smoking participation. In all specifications, the coefficients on cigarette excise taxes are very small and statistically insignificant in the smoking prevalence specifications. If a certain type of smoker were removing themselves from the pool of smokers in response to cigarette taxes, I would expect to see this reflected in the smoking prevalence estimates.

3.7. Conclusion

This paper provides new evidence on whether reductions in the number of cigarettes smoked per day in response to higher cigarette prices among adolescents translate into reductions in nicotine ingestion. Previous economic research of adult smoking behavior finds that adult smokers compensate for higher cigarette excise taxes by switching to cigarette brands with higher nicotine contents or smoking each cigarette more intensely. Using data from NHANES, I find that increases in cigarette taxes are associated with reductions in serum cotinine levels and reductions in the amount of nicotine adolescent smokers ingest from each cigarette. Although the association between cigarette excise taxes and the number of cigarettes smoked per day is not robust to the inclusion of a measure of state anti-smoking sentiment, the association between serum cotinine levels and the number of cigarettes smoked per day remains after including the measure of anti-smoking sentiment and other youth tobacco control policies. The coefficients on cigarette excise taxes translate to conditional price elasticities of cigarette demand of -0.6 to -0.7, consistent with previous estimates of adolescent smoking demand (Carpenter and Cook 2008).[6] However, the price elasticities of cotinine levels are significantly larger at -1.4 to -1.6 and in the elastic range. Consequently, the price elasticity of smoking intensity is between -0.7 to -0.9.

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[6] To calculate price elasticities, I use a pass-through rate of 1.11 from Keeler et al. (1996) and the average cigarette price during my sample period of $4.04.

Why do adolescent smokers not compensate while adult smokers do compensate? One possibility is that adolescent smokers are not as addicted to nicotine as adult smokers. Epidemiologic studies have found that adolescent smokers follow a trajectory from initiation to addiction (Caraballo, Novak and Asman 2009). If adolescent smokers enjoy the sensation of smoking an individual cigarette and not necessarily maintaining a level of nicotine in their body, adolescents would be less likely to change smoking behavior to compensate for a reduction in the number of cigarettes smoked. It could also be that an increase in current cigarette taxes induces adolescent smokers to reduce the probability of becoming addicted to nicotine in the future.

I also use cotinine levels to examine possible bias in previous research arising from misreporting of smoking status and a measure of the total effect of tobacco control policies on smoke exposure. I find little evidence that cigarette excise taxes affect misreporting, but I do find that some measures of youth access restrictions affect misreporting. With respect to a total effect of tobacco control policies on smoke exposure, I find some evidence that cigarette excise taxes and youth access restrictions reduce the probability of high levels of cotinine exposure.

The results of this paper provide further guidance to policy makers wishing to reduce youth smoking outcomes. My results add to a large literature suggesting that increased cigarette excise taxes are an effective policy for reducing youth cigarette demand. Importantly, my results also suggest that youth smokers do not compensate for reduced cigarette consumption by inhaling more deeply or switching cigarette brands. In fact, I find some evidence that adolescents reduce the amount of nicotine they consume from each cigarette in response to higher cigarette excise taxes. Combined with the insignificance of the coefficients of other youth tobacco control policies, my results suggest that cigarette excise taxes are an effective means to reduce youth smoking outcomes.

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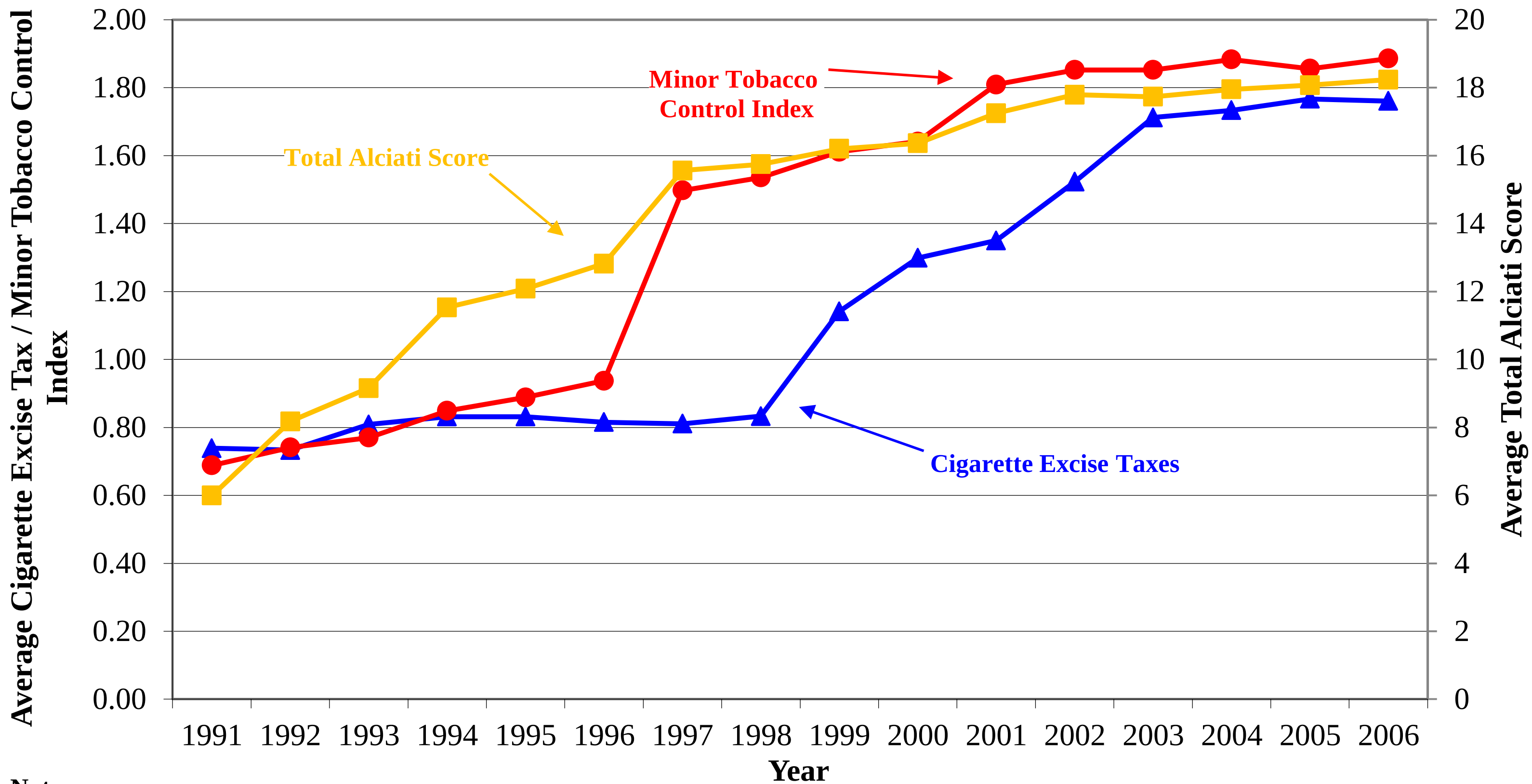
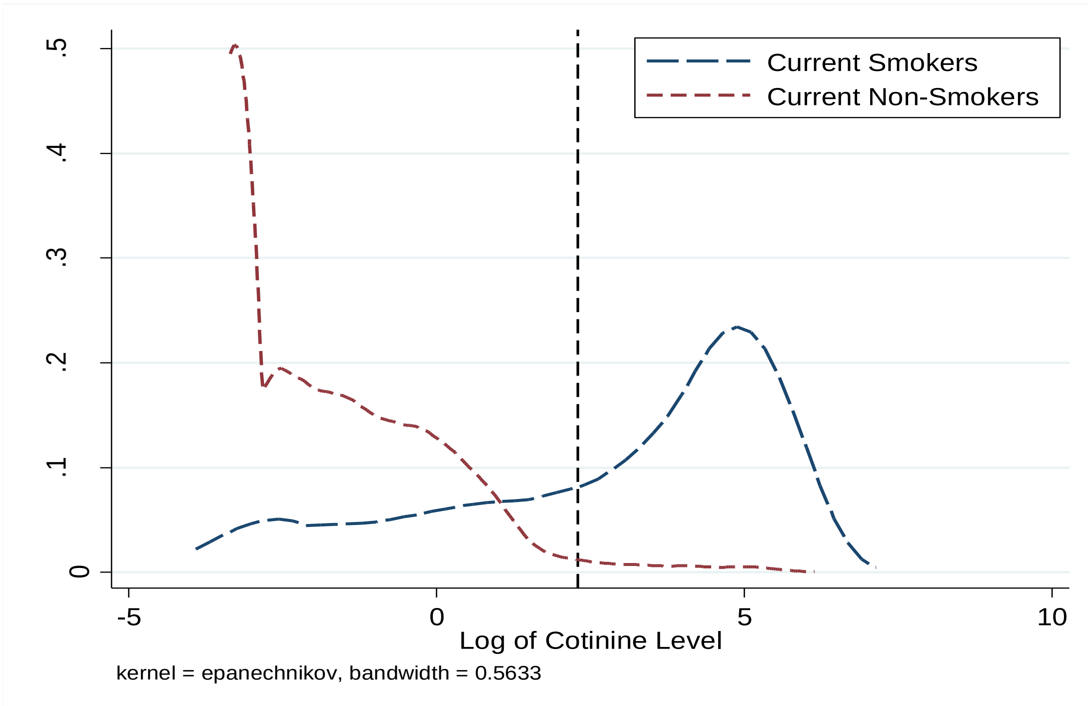
Figure 3.1
Timeseries of Tobacco Control Policies 1991-2006



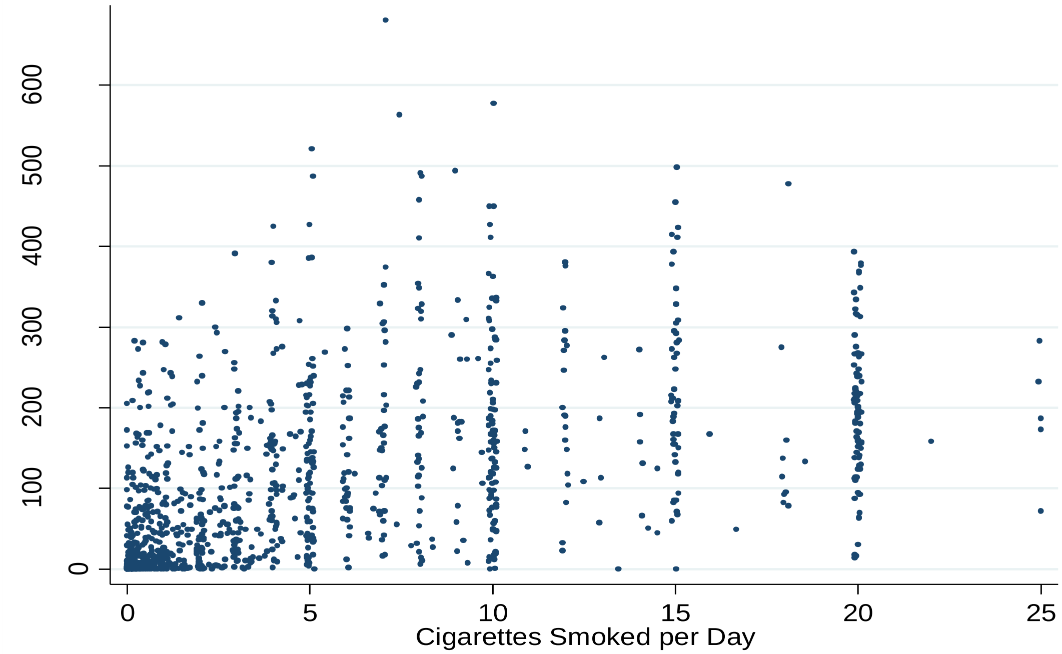
Notes:
Data from the 2009 Tax Burden on Tobacco, output by Orzechowski and Walker, Project ImpacTeen, and Lillard and Sfekas (2010). Cigarette taxes are the state excise tax paid on one pack of cigarettes and are in 2009 dollars. All tobacco control policies are weighted across states by population.

Figure 3.2
Graph of Logged Serum Density by Smoking Status



Notes:
Data from NHANES III and NHANES 1999/2000 - NHANES 2007/2008. Sample includes adolescents age 12 to 19 and do not report use of other tobacco products. Current smoking status is determined by whether the individual identifies as a current smoker.

Figure 3.3
Scatterplot of Serum Cotinine Levels and Cigarettes Smoked per Day



Notes:
Data from NHANES III and NHANES 1999/2000 - NHANES 2007/2008. Sample includes adolescents age 12 to 19 who self-report as smokers and do not report use of other tobacco products.

Table 3.1
Summary Statistics

Variable	Total Sample (N=10,084) Mean	Total Sample (N=10,084) Std. Dev.	Smokers (N=1,299) Mean	Smokers (N=1,299) Std. Dev.	Non-Smokers (N=8,785) Mean	Non-Smokers (N=8,785) Std. Dev.	Diff in Means P-Value
Currently Smoke	0.158	0.365					
Avg Cigs per Day	0.950	3.581	6.017	7.125			
Cotinine Concentration	16.553	57.965	102.491	111.883	0.445	0.972	0.000
Cigarette Excise Tax	1.528	0.705	1.478	0.665	1.537	0.712	0.024
Female	0.509	0.500	0.568	0.496	0.498	0.500	0.000
Height	65.258	4.031	66.311	3.703	65.060	4.060	0.000
Black	0.145	0.353	0.074	0.263	0.159	0.365	0.000
Hispanic	0.168	0.374	0.151	0.358	0.172	0.377	0.066
Education: In School	0.857	0.350	0.721	0.449	0.882	0.322	0.000
Education: H.S. Grad	0.133	0.339	0.249	0.433	0.111	0.314	0.000
Income to Poverty Ratio	2.412	1.667	2.019	1.605	2.486	1.669	0.000
HH: Married	0.639	0.480	0.517	0.500	0.662	0.473	0.000
HH: Divorced	0.196	0.397	0.244	0.430	0.187	0.390	0.001
HH: B.A. Degree	0.206	0.405	0.125	0.331	0.222	0.415	0.000
HH: Some College	0.294	0.455	0.268	0.443	0.298	0.458	0.110
HH: H.S. Degree	0.263	0.440	0.300	0.459	0.255	0.436	0.014
Num Cigs Smoked in Home	3.736	9.313	7.799	13.194	2.974	8.167	0.000
Cty: Pop Density	18.204	55.250	17.481	51.471	18.339	55.932	0.698
State Unemployment Rate	5.338	1.281	5.196	1.274	5.365	1.281	0.001

Notes:
Data from NHANES III and NHANES 1999/2000 through NHANES 2007/2008, the Tax Burden on Tobacco, Project ImpacTeen, Lillard and Sfekas (2010), U.S. Census, and the Bureau for Labor Statistics. Summary statistics are weighted by NHANES sample weights.

Table 3.2
The Impact of Tobacco Control Policies on Adolescent Smoking Outcomes

	Prevalence	Log of Cigarettes per Day	Log of Serum Cotinine	Log Cotinine/ Cigs
A. Baseline Model				
Cigarette Excise Tax	-0.0049	-0.1980	-0.4443***	-0.2464*
	(-0.600)	(-1.582)	(-2.805)	(-1.813)
Adjusted R-Squared	0.157	0.310	0.289	0.120
Num. Obs.	10084	1299	1299	1299
B. Model Including Anti-Smoking Sentiment				
Cigarette Excise Tax	-0.0031	-0.1580	-0.3963**	-0.2385*
	(-0.421)	(-1.226)	(-2.648)	(-1.709)
Anti-Smoking Sentiment	-0.0162	-0.3028*	-0.3634	-0.0598
	(-1.353)	(-1.828)	(-1.134)	(-0.207)
Adjusted R-Squared	0.157	0.310	0.289	0.119
Num. Obs.	10084	1299	1299	1299
C. Model Including Anti-Smoking Sentiment and Other Tobacco Control Policies				
Cigarette Excise Tax	-0.0001	-0.2754	-0.4579**	-0.1820
	(-0.012)	(-1.488)	(-2.443)	(-1.465)
Minor Tobacco Control Index	0.0018	0.0305	0.0619	0.0314
	(0.215)	(0.272)	(0.305)	(0.205)
Total Alciati Score	-0.0024**	0.0142	-0.0116	-0.0258
	(-2.306)	(0.822)	(-0.409)	(-1.032)
Anti-Smoking Sentiment	-0.0149	-0.2154	-0.3234	-0.1065
	(-0.551)	(-0.832)	(-0.831)	(-0.308)
Adjusted R-Squared	0.151	0.292	0.277	0.123
Num. Obs.	8488	1101	1101	1101

Notes:
The dependent variable in the 1st column is an indicator variable for whether an individual is a current smoker, and the dependent variables in the other columns are conditional on smoking participation. The coefficients in columns (2) through (4) represent semi-elasticities, and coefficients pertaining to indicator variables are transformed by exp[b]-1. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, race, ethnicity, height, education, family income-to-poverty ratio, head of household marital status, head of household education, the number of cigarettes smoked in the family home per day, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state unemployment rate, county population density, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3.3
The Impact of Demographic Characteristics on Adolescent Smoking Outcomes

	Prevalence	Log of Cigarettes per Day	Log of Serum Cotinine	Log Cotinine/ Cigs
Female	-0.0039	-0.0478	-0.4673**	-0.4196**
	(-0.377)	(-0.480)	(-2.190)	(-2.478)
Age	-0.1086***	1.8448***	2.6358***	0.7805
	(-5.158)	(4.752)	(3.786)	(1.591)
Age Squared	0.4901***	-4.8383***	-6.8874***	-2.0199
	(7.006)	(-4.042)	(-3.252)	(-1.355)
Height	0.0040***	0.0149	0.0269	0.0120
	(4.084)	(0.914)	(0.870)	(0.543)
Black	-0.1156***	-0.5165***	-0.2127	0.6305***
	(-9.648)	(-4.274)	(-1.448)	(3.145)
Hispanic	-0.0394***	-0.5484***	-0.6965***	-0.3269*
	(-3.702)	(-5.054)	(-3.689)	(-1.940)
Education: In School	-0.0770*	-0.4892***	-0.3481	0.2793
	(-1.913)	(-3.745)	(-1.414)	(0.882)
Education: H.S. Grad	-0.1347***	-0.5457***	-0.5801**	-0.0726
	(-3.135)	(-4.151)	(-2.684)	(-0.267)
Income to Poverty Ratio	-0.0057*	-0.0262	-0.1351**	-0.1089***
	(-1.914)	(-0.524)	(-2.628)	(-3.163)
HH: Married	-0.0376***	-0.2146**	-0.3903***	-0.2230**
	(-3.464)	(-2.342)	(-3.461)	(-2.552)
HH: Divorced	0.0055	-0.0700	0.1233	0.2089
	(0.506)	(-0.638)	(0.680)	(1.492)
HH: B.A. Degree	-0.0308***	0.1298	-0.2933	-0.3750**
	(-2.916)	(0.860)	(-1.593)	(-2.629)
HH: Some College	-0.0164	0.2395	-0.1777	-0.3370***
	(-1.577)	(1.513)	(-1.203)	(-5.308)
HH: H.S. Degree	0.0040	0.0193	-0.0667	-0.0848
	(0.446)	(0.198)	(-0.346)	(-0.585)
Num Cigs Smoked in Home	0.0063***	0.0282***	0.0393***	0.0111***
	(12.258)	(6.484)	(6.713)	(3.507)
Cty: Pop Density	-0.0001	-0.0009*	0.0001	0.0010*
	(-1.471)	(-1.704)	(0.099)	(1.720)
Exam Afternoon	0.0112	-0.1871**	-0.2738**	-0.1060
	(0.976)	(-2.392)	(-2.398)	(-1.145)
Exam Evening	-0.0131	-0.2016*	-0.2380	-0.0449
	(-1.608)	(-1.978)	(-1.649)	(-0.377)
Exam on Weekend	-0.0265**	-0.1981*	-0.0293	0.2117**
	(-2.187)	(-1.947)	(-0.187)	(2.403)
Adjusted R-Squared	0.157	0.310	0.289	0.120
Num. Obs.	10084	1299	1299	1299

Notes:
The dependent variable in the 1st column is an indicator variable for whether an individual is a current smoker, and the dependent variables in the other columns are conditional on smoking participation. The coefficients in columns (2) through (4) represent semi-elasticities, and coefficients pertaining to indicator variables are transformed by exp[b]-1. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for cigarette excise taxes and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3.4
The Impact of Tobacco Control Policies On Adolescent Smoking Outcomes By Interview Day

	Log of Serum Cotinine		Log Cotinine/ Cigs	
	Weekend	**Weekday**	**Weekend**	**Weekday**
A. Baseline Model				
Cigarette Excise Tax	-0.0225	-0.4774**	0.1203	-0.3177**
	(-0.114)	(-2.657)	(0.781)	(-2.489)
Adjusted R-Squared	0.287	0.307	0.130	0.123
Num. Obs.	596	703	596	703
B. Model Including Anti-Smoking Sentiment				
Cigarette Excise Tax	0.1260	-0.3290*	0.1522	-0.2876**
	(0.597)	(-1.735)	(1.023)	(-2.348)
Anti-Smoking Sentiment	-0.5171**	-0.5435*	-0.1110	-0.1101
	(-2.216)	(-1.764)	(-0.550)	(-0.489)
Adjusted R-Squared	0.289	0.310	0.129	0.122
Num. Obs.	596	703	596	703
C. Model Including Anti-Smoking Sentiment and Other Tobacco Control Policies				
Cigarette Excise Tax	0.1237	-0.4660**	0.1503	-0.4137***
	(0.494)	(-2.176)	(0.783)	(-3.084)
Minor Tobacco Control Index	-0.1439	-0.1551	-0.0473	-0.0680
	(-1.141)	(-1.635)	(-0.438)	(-0.877)
Total Alciati Score	-0.0255	-0.0257	-0.0227	-0.0236*
	(-1.232)	(-1.585)	(-1.314)	(-1.802)
Anti-Smoking Sentiment	-0.3366	-0.4890	0.1089	0.1410
	(-1.023)	(-1.022)	(0.399)	(0.444)
Adjusted R-Squared	0.285	0.291	0.122	0.125
Num. Obs.	509	592	509	592

Notes

The dependent variable in columns one and two is the logged cotinine concentration, conditional on smoking participation, and the dependent variable in columns three and four is the logged ratio of cotinine concentrations to cigarettes smoked per day, conditional on smoking participation. The coefficients represent semi-elasticities, and coefficients pertaining to indicator variables are transformed by exp[b]-1T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, education, family income-to-poverty ratio, head of household marital status, head of household education, the number of cigarettes smoked in the family home per day, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state unemployment rate, county population density, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3.5
Comparison of Self-Reporting Smoking Status and Serum Cotinine Levels

		Self-Reported Smoker		
		No	**Yes**	**Total**
Cotinine Level >10 ng/ml	**No**	84.9%	3.2%	88.2%
	Yes	3.3%	8.6%	11.8%
	Total	**88.2%**	**11.8%**	**100.0%**

Percent of Adolescents With Cotinine >10 ng/ml reporting as Non-Smokers	**27.6%**
Percent of Adolescents With Cotinine <10 ng/ml reporting as Smokers	**27.5%**

Notes:
Data from NHANES. Sample includes adolescents age 12 to 19 not reporting use of other tobacco products.

Table 3.6
Relationship Between Tobacco Control Policies And Misreporting of Smoking Status

A. Baseline Model	
Cigarette Excise Tax	0.0883 (0.946)
Adjusted R-Squared	0.208
Num. Obs.	616
B. Model Including Anti-Smoking Sentiment	
Cigarette Excise Tax	0.0836 (0.894)
Anti-Smoking Sentiment	0.037 (0.413)
Adjusted R-Squared	0.207
Num. Obs.	616
C. Model Including Anti-Smoking Sentiment and Other Tobacco Control Policies	
Cigarette Excise Tax	-0.0646 (-0.749)
Minor Tobacco Control Ind	-0.0228 (-0.490)
Total Alciati Score	-0.0128* (-1.840)
Anti-Smoking Sentiment	0.201 (1.209)
Adjusted R-Squared	0.192
Num. Obs.	510

Notes:
The sample contains all individuals with a serum cotinine level higher than 10 ng/ml, a common cutuoff in the medical literature to determine smoking status. The dependent variable in all columns is an indicator variable for whether an individual self-reports as a current smoker. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, education, family income-to-poverty ratio, head of household marital status, head of household education, the number of cigarettes smoked in the family home per day, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state unemployment rate, county population density, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3.7
Relationship Between Tobacco Control Policies And High Cotinine Levels

A. Baseline Model	
Cigarette Excise Tax	-0.0164**
	(-2.313)
Adjusted R-Squared	0.148
Num. Obs.	10362
B. Model Including Anti-Smoking Sentiment	
Cigarette Excise Tax	-0.0140**
	(-2.336)
Anti-Smoking Sentiment	-0.0207
	(-1.351)
Adjusted R-Squared	0.148
Num. Obs.	10362
C. Model Including Anti-Smoking Sentiment and Other Tobacco Control Policies	
Cigarette Excise Tax	-0.0084
	(-0.962)
Minor Tobacco Control Ind	0.0029
	(0.361)
Total Alciati Score	-0.0029***
	(-2.924)
Anti-Smoking Sentiment	-0.0415*
	(-1.853)
Adjusted R-Squared	0.147
Num. Obs.	8701

Notes:
The dependent variable in all columns is an indicator variable for whether an individual has a serum cotinine level higher than 10 ng/ml, a common cutuoff in the medical literature. T-statistics calculated from standard errors clustered at the state level are shown in parentheses. All regressions also control for gender, age, age squared, race, ethnicity, height, education, family income-to-poverty ratio, head of household marital status, head of household education, the number of cigarettes smoked in the family home per day, whether examination was on a weekday or weekend, time of day when the serum cotinine sample was drawn (morning, afternoon, or evening), state unemployment rate, county population density, and state, year and quarter fixed effects. Stars denote statistical significance: * Significant at 10%; ** significant at 5%; *** significant at 1%.