Cigarette Taxes and Older Adult Smoking: Evidence from the Health and Retirement Study

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Abstract

In this study we use the Health and Retirement Study (HRS) to test whether older adult smokers, defined as those 50 years and older, respond to cigarette tax increases. Our preferred specifications show that older adult smokers respond modestly to tax increases: a $1.00 (131.6%) tax increase leads to a 3.8% to 5.2% reduction in cigarettes smoked per day (implied tax elasticity = -0.03 to -0.04). We identify heterogeneity in tax-elasticity across demographic groups as defined by sex, race/ethnicity, education, and marital status, and by smoking intensity and level of addictive stock. These findings have implications for public health policy implementation in an aging population.

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1. INTRODUCTION

Older adults, defined as those 50 years of age and above, comprise an increasingly large share of the United States population. In 2010 there were 99 million (32% of the population) older adults, an increase of 24% from 1980 (U.S. Census Bureau, 2012). As the population ages, health care costs are high and escalating rapidly. Currently the U.S. spends over $2.7 trillion each year on medical services, and annual per capita health care expenditures increased from $147 to $8,402 between 1960 and 2010 (Centers for Medicare and Medicaid Services, 2011). Because health care costs increase as individuals enter older ages (Alemayehu and Warner, 2004) these two trends raise concerns among fiscal policymakers.

Identifying health behaviors that lead to increased health care costs and developing policies to reduce such behaviors is one strategy to address fiscal concerns. The economic burden of smoking is $237 billion per year (Centers for Disease Control and Prevention, 2008) and suggests that targeting smoking is warranted. Smoking imposes external costs through increased use of publicly provided health insurance (Zhang et al., 1999), higher insurance premiums for smokers and non-smokers (Pearson and Lieber, 2009, Halpern et al., 2009), and exposure to second hand smoke (Institute of Medicine, 2010, U.S. Department of Health and Human Services, 2006). Moreover, clinical work shows health benefits from smoking cessation among older adult smokers (Gellert et al., 2012, Gellert et al., 2013, Taylor et al., 2002).

Taxation is a common health policy utilized to reduce smoking behaviors. The federal government, all 50 states and the District of Columbia, and many local governments tax cigarette purchases. The average per package state cigarette tax in 2012 was $1.48 (Campaign for Tobacco-Free Kids, 2012). Taxation relies on a standard economic principle: raising the price of a good should reduce the quantity demanded. However, cigarettes differ from other goods in important ways, perhaps most notably due to their addictive nature. For tax increases to improve population health and reduce health care costs individuals must respond to the tax increase by reducing their use of cigarettes. If smokers do not reduce their smoking, particularly low income smokers, they will have less income available to purchase other goods (Colman and Remler, 2008, Busch et al., 2004). Because many older adults live on fixed incomes, older adult smokers may be particularly vulnerable to regressive taxes. For example, 46% of unmarried Social Security beneficiaries obtain at least 90% of their income from Social Security income and the average monthly benefit is just $1,262 (Social Security Administration, 2013).

Ex ante, it is not clear if older adult smokers will respond to cigarette tax increases. Various influences at work might make their demand more or less elastic. As we explain in more detail below in Section 3.4, the rational addiction model predicts that greater addiction increases smokers' responsiveness to price changes (see Becker and Murphy 1988 Equation 18, p. 685). If individuals who smoke into older ages are more addicted, the rational addiction model thus predicts that they will respond more to taxes than younger smokers. However, due to their lower labor market attachment older adult smokers may have more time to search for lower price cigarettes, helping insulate them from tax increases and making their demand inelastic. Moreover, inelastic demand for older smokers might also arise from compositional effects. First, smokers with more elastic demand may exit the smoking market in response to previous tax increases, leaving only tax-inelastic smokers. Second, if smoking increases mortality risk then the heaviest and most addicted, and according to the rational addiction model therefore most price-elastic, smokers may no longer be in the smoking market. Lastly, cognitive decline may also influence responsiveness among the oldest smokers.

In this study we use the Health and Retirement Study (HRS) to test whether older adult smokers reduce their cigarette smoking in response to cigarette tax increases. While previous studies often focus on segments of the population that might be better described as middle age than older adults, we examine a sample of adults 50 years of age and older. The recent literature on tax responsiveness among older adult smokers has examined the extensive margins of smoking (e.g., any smoking, cessation, relapse). We offer new evidence on the intensive margin: number of cigarettes smoked per day. Interestingly no work has examined this important margin of smoking among older adults although clinical research suggests reductions in the number of cigarettes smoked may improve health, even if a smoker does not fully transition to smoking abstinence (Gerber et al., 2012). Moreover, we use HRS smoking history information to provide new evidence on addiction. In extensions we examine the impact of another standard smoking policy on older adult smoking (venue-specific smoking bans), and heterogeneity in cigarette tax-responsiveness by important demographic characteristics and smoking intensity.

2. METHODS

2.2 Literature Search

A large body of economic research investigates the impact of cigarette taxes and prices on smoking behaviors among youth and the general population of adults. In a widely cited review article, Chaloupka and Warner (2000) report a mean price elasticity of adult cigarette demand of -0.40. Subsequent studies using more recent data mainly support this relationship (Farrelly et al., 2001, Farrelly et al., 2004, Colman and Remler, 2008, Lovenheim, 2008, Liu, 2010). However, a complete consensus has not yet been reached with some studies calling into question the ability of cigarette taxes and prices to substantially reduce youth smoking (DeCicca et al., 2002, DeCicca et al., 2008a, DeCicca et al., 2008b, Carpenter and Cook, 2008, Nonnemaker and Farrelly, 2011) or adult smoking outcomes (Maclean et al., 2014, Callison and Kaestner, 2014). Few studies have examined the impact of cigarette taxes or prices among older adult smokers, and the results are decidedly mixed. Cross study differences may be driven by different definitions of older adults, time periods, and empirical strategies. Regardless of the cause of the ambiguity, the current body of work does not offer clear direction for health policy.

Lewitt and Coate (1982) estimate the price elasticity of demand among adults age 35 years and older using the 1976 National Health Interview Survey (NHIS). The authors estimate a participation price elasticity of -0.15, and a price elasticity of -0.45 for number of cigarettes smoked in the past 30 days. Evans and Farrelly (1998) use two waves of the NHIS (1976 and 1987) and find evidence that adults 40 years and above reduce the number of cigarettes smoked in response to tax increases. Farrelly et al. (2001) pool 14 years of NHIS data to test the impact of tax increases on smoking participation and the number of cigarettes smoked in the past 30 days among adults 40 years and above. The authors find no impact of taxes on either the extensive or intensive margin among older adult smokers. Because these studies rely on older data, in particular data series that ended before the wave of large cigarette tax increases that began with the 1998 Master Settlement Agreement, and examine "young" older adults, it is not clear how applicable these findings are to the current cohort of older adult smokers.

Two recent studies (DeCicca and McLeod, 2008, Liu, 2010) examine extensive margins of smoking among samples that meet more conceptually appealing definitions of older adults. DeCicca and McLeod (2008) pool the 2000 to 2005 Behavioral Risk Factor Surveillance System to assess the impact of cigarette taxes on smoking participation among adults ages 45 to 59 and find that a $1.00 increase in the cigarette tax leads to a 6% to 8% decrease in daily smoking. In an extension, the authors find similar estimates among the elderly. Using the Current Population Survey Tobacco Use Supplements (TUS) between 1992 and 2003, Liu (2010) shows that cigarette price increases lead to increases in the probability of cessation among adults 45 to 64 years and the elderly (65 years and older), but price increases lead to reductions in the probability of any smoking among adults 45 to 64 years only. The cessation tax elasticity ranges from 0.19 to 0.67 and the participation elasticity is approximately -0.20.

2.3 Data

We draw data from the Health and Retirement Study (HRS) with state identifiers. The HRS is a nationally representative longitudinal survey of older adults that has been administered biennially since 1992. We use the RAND HRS Version J. For more details on the HRS see National Institute on Aging (2007). By 2008 the HRS interviewed 30,548 older persons. We exclude respondents under age 50 and with missing smoking information.[4] Our analysis sample includes 14,891 unique individuals and 119,935 person/year observations. Because the central contribution of our study is to examine the impact of cigarette taxation on the intensive margin of smoking (proxied by cigarettes smoked per day) we focus the majority of our attention on the sample of 4,956 unique smokers and 22,279 smoker/year observations.

2.4 Smoking Behavior

We consider two smoking outcomes. First, we examine a measure of any smoking at the time of the HRS survey which is coded 1 if the respondent indicates that he currently smokes and zero otherwise (participation or extensive margin). Our second measure of smoking behavior is the number of cigarettes smoked per day (conditional demand or intensive margin). Current smokers are asked how many cigarettes they smoke on days that they smoke. Respondents can report in either cigarettes or packs, and we convert packs to cigarettes (1 pack=20 cigarettes). The constructed variable ranges from 0 to 140 cigarettes. There are few respondents who report zero cigarettes smoked per day (1.5% of the analysis sample, *n*=355). Presumably these respondents are very light smokers who smoke less than one cigarette per day. Results are highly robust if we exclude these respondents from the analysis. We report results using the untransformed variable, but results are consistent if we use the logarithm of cigarettes smoked per day.

Our smoking measures do not capture all aspects of smoking behavior, most notably

[4] We exclude the AHEAD birth cohort from our analyses.

smoking frequency or carcinogen consumption. However they likely provide a reasonable proxy for tobacco use as any smoking is viewed as harmful to health. Self-reported smoking is measured with error, but studies suggest that past 30 day reports, such as we utilize here, are suitable for statistical analysis (Patrick et al., 1994).

2.4 State-level Variables

Our key right hand side variable is the cigarette tax. We merge annual state level cigarette tax in dollars from the Tax Burden on Tobacco (Orzechowski and Walker, 2012) into the HRS data set on state and year. The economics literature has not yet reached consensus on whether taxes or prices should be included in cigarette demand equations. We include taxes in our regression models, but results are comparable if we use prices. Because we examine more recent data than DeCicca and McLeod (2008) (2000 to 2005) and Liu (2010) (1992 to 2003), we are able to take advantage of additional tax increases. For example, between 2006 and 2008 there were 20 state increases in cigarette taxes. We merge venue-specific smoking ban data from the ImpacTeen project (ImpacTeen.org, 2009) into the HRS data set on state and year. ImpacTeen contains data on venue-specific smoking bans at twelve separate locations.[5] The bans range from 0 to either 3 or 5, with higher scores indicating more restrictive bans. We sum across venues to create an index that ranges from 0 to 49. We next include price proxies for important related goods: alcohol, soda, and unhealthy food. Specifically, we include the state beer tax for a gallon of packaged beer from the Brewer's Almanac (The Beer Institute, 2012), and the state average price of a two-liter bottle of Coca Cola and the price of a medium pizza (a proxy for unhealthy food)[6] from the American Chamber of Commerce Research Association (ACCRA) Cost of Living Index (The

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[5] Venues include government and private worksites, child care centers, health care facilities, restaurants, recreational facilities, cultural facilities, public transit, shopping malls, public schools, private schools, and free standing bars.

[6] The price pertains to 12'' to 13'' thin crust cheese pizza between 1992 and 1994, and an 11'' to 12'' thin crust pizza between 1995 and 2008, from either Pizza Hut or Pizza Inn. Between 1994 and 1995 ACCRA administrators changed the surveyed product.

Council for Community and Economic Research, 2012). Lastly, we merge in annual state unemployment rate data from the Bureau of Labor Statistics. We convert all nominal variables to 2008 dollars using the Consumer Price Index (CPI).

2.5 Other Control Variables

In our regression models we control for a quadratic in age, sex (female with male as the omitted category), race/ethnicity (African American, Hispanic, and other race with white as the omitted category), education (years of schooling), marital status (divorced, separated, widowed, and never married with married or cohabitating as the omitted category), and annual household income quintiles (we convert household income to 2008 dollars using the CPI, observations with negative or no household income are assigned a value of $1, and we construct a set of 5 indicator variables for household income groups, with the 1st household income quintile as the omitted category).[7] [8] To preserve sample size, we utilize conditional mean imputation for observations with missing information on control variables and include indicator variables for missingness in our regression models (Little, 1992).[9]

2.6 Empirical Model

In our core models, we apply a two-part model of cigarette demand (Cragg, 1971):

(1) $$P(S_{ist} = 1) = \Phi(\alpha_0 + \alpha_1 Tax_{st} + P_{st}\alpha_3 + X_{ist}\alpha_4 + S_s + D_t)$$

(2) $$E[C_{ist}|S_{ist} = 1] = \beta_0 + \beta_1 Tax_{st} + P_{st}\beta_3 + X_{ist}\beta_4 + S_s + D_t + \varepsilon_{ist}$$

Equation (1) models the probability of any smoking (participation equation or extensive margin) using a probit model, and Equation (2) models the number of cigarettes smoked per day

[7] The annual household income ranges by category are: less than or equal $16,201; $16,202 to $ 30,060; $30,061 to $48,112; $48,113 to $79,940; and greater than $79,940. Results are robust if we instead utilize a linear measure of household income or the logarithm of household income.
[8] Our findings are qualitatively the same if we include an indicator of fair or poor self-reported health to proxy health-related individual heterogeneity in our regression models.
[9] Results are highly robust if we utilize listwise deletion or multiple imputation to address observations with missing information. Work by Little (1992) shows that these methods of addressing missingness do not lead to bias under plausible assumptions regarding the process generating missingness in the data.

conditional on any smoking (conditional demand equation or intensive margin) using least squares. We focus the majority of our attention on Equation (2) as the central contribution of our study is to examine the intensive smoking margin, but we report coefficient estimates generated in Equation (1) and overall results calculated using the predicted probability estimated in Equation (1) and the conditional expectation estimated in Equation (2) for completeness.

S_{ist} is an binary variable that indicates whether individual *i* residing in state *s* in year *t* smokes or not and C_{ist} measures the number of cigarettes smoked per day among smokers. The key explanatory variable is Tax_{st}, the cigarette tax in state *s* in year *t*. P_{st} is a vector of state level smoking policies and characteristics for state *s* in time *t* that predict smoking outcomes and potentially the state cigarette tax. X_{ist} is a vector of personal characteristics. S_s and D_D are vectors of state and year fixed effects. Inclusion of state fixed effects implies that within state variation in cigarette taxes is utilized to identify smoking effects and addresses bias driven by difficult-to-observe time invariant state characteristics. The year fixed effects capture national trends in smoking and cigarette taxes. ε_{ist} is the error term.

We estimate two alternative specifications to assess the robustness of our findings. First, we model between-state differences with a measure of time variant state-specific smoking sentiment (DeCicca et al., 2008b). The sentiment variable is constructed from smoking attitudes reported in the 1992 to 2007 TUS. We assign the 2007 value to the 2008 HRS interview. Second, we replace the state fixed-effects with state-specific linear time trends. This second specification is able to control for time-varying difficult-to-observe variables at the state level. We cluster the standard errors around the state of residence to account for correlation within states.[10] We report unweighted results throughout, but weighted results are consistent.

3. RESULTS

[10] Standard errors estimates do not change appreciably if we cluster at the primary sampling unit, state/year, or year level.

3.1 Sample Characteristics

Figure 1 documents the average number of cigarettes smoked per day among smokers between 1992 and 2008. In 1992, the average number of cigarettes smoked per day was 21.0 and this number declined to 14.0 by 2008 ($p \leq 0.01$). Table 1 reports summary statistics for both the unconditional sample (smokers and non-smokers) and conditional sample (smokers only). 19% of the sample smokes at the time of the survey, and the mean number of cigarettes smoked per day is 3.14 in the unconditional sample and 16.9 in the conditional sample. The average cigarette tax is $0.76. Mean smoking ban severity is 15.41 and the mean value of smoking sentiment is 0.13 (higher values indicate higher levels of anti-smoking sentiment). The average state beer tax per gallon is $0.33, the mean state price for a 2 liter Coca Cola and medium pizza is $1.22 and $9.61 respectively, and the mean state unemployment rate is 4.76%.

3.2 Regression Results

Our core findings are reported in Table 2. Each column contains estimates from a separate regression. We first use no control for difficult-to-observe between state characteristics (Column 1). Next we enter state fixed effects into the regression model (Column 2), model between state differences with state smoking sentiment (Column 3), and include state-specific linear time trends (Column 4). As noted earlier, we focus on the extensive margin (cigarettes smoked per day) as this is the central contribution of our study. However, we report results for participation and overall results (i.e., combining participation and conditional demand equations) for completeness.

Findings are consistent in sign, although the magnitude changes to some extent, across the four specifications: a $1.00 increase in the cigarette tax leads to a reduction of 1.03, 0.65, 0.89, and 0.80 cigarettes per day (6.1%, 3.8%, 5.2%, and 4.7%) in conditional demand models that include no controls for difficult-to-observe between state differences, state fixed effects, state smoking sentiment, and state-specific linear time trends, respectively. The implied tax elasticities range from -0.03 to -0.05. We do not find strong evidence that cigarette taxes are linked with smoking participation: coefficients generated in the participation equation are indistinguishable from zero (moreover, in two of four regressions the coefficients carry the wrong – positive – sign). Indeed, the coefficient estimates and implied tax elasticities are generally smaller in magnitude and less precise when we estimate overall estimates (i.e., combining intensive and extensive margins).

Consistent with recent studies of the general population of adults, we find little evidence that older adult smokers substantially change their smoking patterns in response to more restrictive smoking bans (Bitler et al., 2010): in the conditional demand equations the coefficient on the smoking ban index is small in all regressions and is statistically indistinguishable from zero in three of four regressions. An exception is Model 3 that controls for smoking sentiment: in this specification a 1 unit increase in the smoking ban index leads to an *increase* of 0.047 cigarettes (0.28%) smoked per day. Moreover, on the extensive margin (participation) we find evidence that more restrictive bans are associated with *increased* probability of any smoking in all regressions (and the coefficient is statistically distinguishable from zero in three of four regressions). These findings are at odds with the objectives of smoking bans. For brevity, in the remainder of the study we present results from models that include state fixed effects, state smoking sentiment, and state-specific linear time trends, and focus on tax effects.

A perennial concern in state policy evaluations is collinearity between the state-level variables. High levels of collinearity can inflate standard errors and lead to ill-conditioning, and fragile parameter estimates where small changes in the data or specification lead to different inferences (Anderson and Wells, 2008). We assess the extent of collinearity in our data using variance inflations factors (VIF). VIFs greater than 10 are viewed as evidence of problematic collinearity (Kennedy, 1994). The VIF ranges from 1.1 to 10.5,[11] suggesting a moderate degree of collinearity in our data but perhaps not enough to cast doubt on the quality of our estimates.[12]

3.3 Addiction

Economic theories of addiction (Becker and Murphy, 1988) predict that more addicted consumers are more responsive to permanent tax increases (Equation 18, p. 685). Addicted smokers incorporate future smoking behavior into their decisions and, because they realize that they will smoke in the future at the higher price, are more responsive to contemporaneous tax increases. We proxy addictive stock, admittedly imperfectly, by years smoked across the life course. We construct the years smoked variable using historical smoking information in the HRS. We first locate the year of initiation, and second take the difference between the initiation year and the survey year. We subtract off non-smoking years using cessation and relapse information in each round, but are not able to capture the majority of quit and relapse behavior before the HRS commenced in 1992. We are able to construct smoking histories for 15,491 person/years. On average, older adult smokers in our sample report smoking 42.4 years and the mean number of cigarettes smoked per day is 16.9.

We interact the addictive stock proxy with the cigarette tax and re-estimate the core models (we include the main effect, years smoked across the life course, in the regressions). We do not include the addictive stock variable in the participation equation as this variable should not

[11] We calculate VIFs with the formula: $VIF = 1/(1 - R^2_{Tax})$. R^2_{Tax} is the unadjusted R^2 from a regression of the cigarette tax on other covariates. The VIF is larger than 10 only in the model with state-specific linear time trends.
[12] In unreported analyses that are available on request, we consider the importance of two sources of bias in our regression models: cross-border smuggling and policy endogeneity. First, smokers may purchase their cigarettes in lower-price states following a tax increase and this behavior may confound our tax elasticity estimates. To address this source of bias, we include a variable in our regression models that takes a count of the number of higher full price (i.e., price plus tax) states in a given year (this variable ranges from zero to six). Second, public policies such as cigarette taxes are not randomly assigned; instead such policies are determined within the political economy of the state and are therefore potentially endogenous. To address this source of bias we re-estimate our regressions on a sample of across state movers in the HRS. In this sample variation in cigarette taxes is driven by across state moves and not within state tax changes. We assume that respondents to not make moving decisions based on cigarette taxes. Findings from both sensitivity checks are broadly consistent with the findings presented here. The sample of across state movers is small (*n*=657) and estimates generated in this sample are generally imprecise.

predict participation, rather it should only predict conditional demand. Results are robust, however, if we include the addictive stock variable in both the participation and conditional demand equations. If more addicted smokers are more responsive to tax increases than less addicted smokers, we would expect to see a negative sign on the interaction term between taxes and addictive stock. Results are reported in Table 3.

Although the estimates are imprecise they are consistent with predictions from economic models of addiction: the coefficient on our proxy for addictive stock (years smoked across the life course) is positive but small in magnitude (an additional year of smoking is associated with roughly 0.18 more cigarettes smoked per day in each model), and the coefficient on the interaction term is negative and suggests that older adult smokers with higher addictive stock are more responsive to cigarette taxes in two of three regressions. At the sample average level of addiction a $1.00 increase in the tax leads to a 0.61 to 0.85 reduction in cigarettes smoked per day.

3.6 Extensions

This section presents results from extensions to the core analyses. We consider tax responsiveness among elderly smokers (65 years and older), and assess heterogeneity in tax-responsiveness by important demographic characteristics and smoking intensity.

3.6.1 The Elderly

Understanding smoking determinants among the elderly is particularly important as they place a direct financial burden on the American tax payer through their access to public health insurance (i.e., Medicare). We re-estimate our core models among the elderly. Results are reported in Appendix Table A. The regression results are consistent in terms of sign, magnitude, and statistical significance with our core models and suggest that cigarette tax increases lead to reductions in the number of cigarettes smoked per day among the elderly. A $1.00 increase in the cigarette tax leads to a reduction of 0.41 to 1.28 (2.7% to 8.5%) cigarettes smoked per day. The implied tax elasticities range from -0.02 to -0.07.

3.6.2 Heterogeneity by Demographic Characteristics

We next consider heterogeneity in cigarette tax-responsiveness by important demographic characteristics. To this end, we stratify the sample based on sex (men, women), race/ethnicity (White, non-White), education (less than high school, a high school degree or higher), and marital status (cohabitating as measured by married or partnered, non-cohabitating). A caveat to this analysis is that we reduce our sample size when we stratify the sample based on demographics, and this may impede our ability to precisely estimate effects in some regressions.

Given differences in the costs and benefits of smoking across these groups, it is natural to consider whether we observe heterogeneity in the estimated tax elasticities. For example, because women live longer than men on average, at each age women have a higher return on health investments than men. Cohabitating individuals who continue to smoke in the face of higher cigarette taxes reduce disposable household income for both themselves and their partner. Previous research suggests differences by race/ethnicity in tax responsiveness (DeCicca et al., 2000, Chaloupka and Pacula, 1999). Moreover, recent work suggests that cigarette taxation is regressive (Colman and Remler, 2008, Busch et al., 2004) and thus estimating tax elasticity for higher and lower socioeconomic (SES) groups (we view education and race/ethnicity as proxies for SES) allows us to speak to these questions. Lastly, the Grossman (1972) health demand model predicts that more highly educated individuals are better producers of health, thus we might expect that older smokers with more education are more likely to respond to cigarette tax increases by reducing the number of cigarettes they smoke.

Results are reported in Appendix Table B. We find evidence that women maybe more responsive to cigarette tax increases than men: the tax-elasticity among women (men) is -0.04 (-0.03). Whites appear to be more responsive to tax increases than non-Whites (tax elasticities of -

0.03 and -0.02 respectively) while those with less education appear to be more responsive to such increases than those with more education (tax elasticies of -0.06 and -0.02 respectively). Lastly, we find that non-cohabiting individuals are more responsive to tax increases than cohabitating individuals: the tax-elasticity among non-cohabitating (cohabitating) respondents is -0.05 (-0.02).

3.6.3 Heterogeneity by Smoking Intensity

We next estimate quantile regression models to explore how cigarette tax responsiveness varies across smoking intensity (as proxied by the number of cigarettes smoked per day). Given the heaped nature of the cigarettes smoked per day variable (i.e., this variable does not approximate a smooth variable, instead there are disproportionately high frequencies at certain values such as 5, 10, 15, 20, etc.) we estimate a quantile regression for counts developed by Machado and Silva (2005) rather than standard quantile regression.[13] This model allows us to estimate separate coefficients for specific quantiles of the smoking distribution. The model overcomes the problem of a non-differentiable sample objective function with a discrete dependent variable by artificially imposing smoothness on the data through the use of jitters, in particular by adding a uniformly distributed noise to the data. Interested readers can see Machado and Silva (2005) for more details. For tractability, we do not estimate the quantile regression with a two-part model and instead focus exclusively on the intensive margin.

We report results for the 10th, 25th, 50th, 75th, and 90th quantiles in Appendix Table C. Following Machado and Silva (2005) we utilize 10,000 jitters to estimate parameters and standard errors. For brevity, we report results in models that control for between-state differences with state smoking sentiment but results are comparable, but somewhat smaller in magnitude and less precisely estimated at higher quantiles, if we instead include state fixed-effects or state-specific linear time trends. Although our results suggest that smokers at all intensity levels

[13] Some HRS smokers report a non-integer value for the number of cigarettes smoked per day. We round such responses to the nearest integer to estimate the quantile regression for counts. Results are robust if we exclude these respondents from the analysis sample, however.

studied here respond modestly to tax increases by reducing the number of cigarettes smoked, the lightest smokers (at the 10th quantile) are the most responsive and tax-responsiveness declines nearly monotonically through to the heaviest smokers (at the 90th quantile).

It is somewhat surprising that we find the largest effects among the lightest smokers: the tax elasticity at the 10th quantile is -0.05 while the tax elasticity at the 90th quantile is -0.002. This pattern of results is inconsistent with theories of rational addiction (discussed in Section 3.4) and our findings reported in Table 3. There are several, non-mutually exclusive, possible explanations for these inconsistent results. First, our measure of addictive stock (years smoked across the lifecourse) may be a poor proxy for addiction. Second, selective mortality may have removed the most addicted smokers from the sample. In unreported analyses, we correlated the number of cigarettes smoked per day with self-reported health and the number of chronic conditions among smokers. Higher numbers of cigarettes smoked per day correlated with better health (i.e., higher self-reported health and fewer chronic conditions) providing some, albeit suggestive, support for this hypothesis.[14] Third, cognitive decline may impede the ability of older, perhaps heavier and more addicted, smokers to correctly recall their smoking patterns. Fourth, the coefficient estimates on the addiction variable in Table 3 are imprecise and our 95% confidence intervals cannot rule out positive effects (suggesting that more addicted smokers – according to our proxy for addictive stock – are less responsive to tax increases). Moreover, in one of the three regressions in Table 3 the coefficient on the interaction term is positive, suggesting that more addicted smokers are less responsive to cigarette tax increases. None of these explanations is particularly satisfactory and we note this as a limitation of our study. Perhaps future work could more rigorously study this question.

[14] Put differently, if smoking lowers health then we would expect heavier, and perhaps more addicted, smokers to have worse health (i.e., lower self-reported health and more chronic conditions in our example) than lighter smokers. We observe the opposite pattern in our data: heavier smokers have better health than lighter smokers. One interpretation of this pattern of results is that the heaviest, and perhaps most addicted, smokers have died (perhaps due to their heavy smoking) and this muddles the negative association between smoking and health.

4. DISCUSSION

In this study we test cigarette tax responsiveness on the extensive margin (number of cigarettes smoked per day) among older adults using the HRS between 1992 and 2008. We find that older adult smokers reduce their smoking modestly when faced with a cigarette tax increase. Our preferred specification suggest that a $1.00 (131.6%) increase in the cigarette tax leads to a 3.8% to 5.2% reduction in the number of cigarettes smoked per day (implied tax elasticities of -0.03 to -0.05). Although imprecise, we find some suggestive evidence consistent with economic models of addiction (Becker and Murphy, 1988): smokers with higher levels of addictive stock may be more responsive to tax increases. Consistent with studies of the general population (Bitler et al., 2010), we do not find strong evidence that older adult smokers reduce their smoking when faced with more restrictive venue-specific smoking bans. Our analysis of heterogeneity yields differences in tax responsiveness by demographic characteristics and smoking intensity. Unlike previous work, we find only imprecise evidence that cigarette tax increases impact the probability of smoking among older adults. We suspect that our relatively small sample size in the HRS precludes us from precisely estimating such effects.

Our study provides new information on the effectiveness of a standard health policy lever in a growing segment of the U.S. population at a critical time. The federal government is currently proposing to increase the federal cigarette tax by 94 cents, nearly doubling the current rate ($1.01). Our results suggest that this tax increase, although the largest increase in the federal cigarette tax history, will not lead to substantial reductions in smoking among the majority of older adult smokers. Instead, because older adult smokers have relatively inelastic demand this tax it may lead older adult smokers to allocate a larger share of the income to cigarette purchases and perhaps crowd out consumption of other goods and services (Busch et al., 2004, Colman and Remler, 2008). Older adults often live on fixed incomes (Social Security Administration, 2013) and the proposed tax could lead some income constrained older adult smokers to reduce consumption of other goods or other unintended consequences. For example, older adult smokers may opt to move in with their adult children and families, which may lead to increases in secondhand smoke exposure and family strain. Alternative policies such as provision of reduced cost smoking cessation products or financial incentives to stop smoking may be more effective (Volpp et al., 2009) and equitable than tax increases.

In summary, our findings shed new light on older adult smoker tax responsiveness and highlight the need for careful consideration of the full impacts of public health policy particularly as the U.S. experiences demographic shifts in its population.

Table 1. Summary Statistics

	Unconditional Sample		Conditional Sample	
	Mean	Standard Deviation	Mean	Standard Deviation
Smoking Variables				
Smoke	0.19	0.39	--	--
Cigarettes smoked per day	3.14	8.45	16.9	12.3
State-level Variables				
Cigarette tax (dollars)	0.76	0.57	0.76	0.57
Smoking ban index	15.41	11.91	15.41	11.91
Smoking sentiment	0.13	0.18	0.13	0.18
Beer tax (dollars)	0.33	0.29	0.33	0.29
Soda price (dollars)	1.22	0.18	1.22	0.18
Pizza price (dollars)	9.61	1.13	9.61	1.13
Unemployment rate	4.76	1.20	4.76	1.20
Personal Characteristics				
Age (years)	62.8	7.63	60.5	6.64
Female	0.54	0.50	0.51	0.50
Male	0.46	0.50	0.49	0.50
White	0.74	0.44	0.73	0.45
African American	0.15	0.36	0.17	0.38
Hispanic	0.089	0.29	0.077	0.27
Other race	0.023	0.15	0.025	0.16
Years of education	12.3	3.23	11.6	3.03
Married	0.71	0.46	0.60	0.49
Never married	0.031	0.17	0.034	0.18
Separated	0.018	0.13	0.033	0.18
Partnered	0.029	0.17	0.047	0.21
Divorced	0.12	0.32	0.19	0.39
Widowed	0.11	0.32	0.13	0.33
1st household income quintile	0.20	0.40	0.28	0.45
2nd household income quintile	0.20	0.40	0.22	0.41
3rd household income quintile	0.20	0.40	0.20	0.40
4th household income quintile	0.20	0.40	0.18	0.38
5th household income quintile	0.20	0.40	0.12	0.33
N	119,935		22,279	

Notes: Unweighted summary statistics. State-level variables summary statistics based on state year data for survey interview waves, not the HRS sample. All dollar values are reported in 2008 values. The annual household income ranges by category are: less than or equal $16,201; $16,202 to $ 30,060; $30,061 to $48,112; $48,113 to $79,940; and greater than $79,940.

Table 2. Effect of Cigarette Taxes on Cigarettes Smoked per Day among Older Adult Smokers, 2 Part Model

Specification:	**(1)**	**(2)**	**(3)**	**(4)**
Part 1 of 2 part model				
Sample proportion smoke	0.19	0.19	0.19	0.19
Cigarette tax	-0.0080	0.0293	-0.0045	0.0079
	(0.0217)	(0.0187)	(0.0229)	(0.0147)
Smoking ban index	0.0023***	0.0003	0.0030***	0.0013*
	(0.0006)	(0.0006)	(0.0008)	(0.0007)
N	119,935	119,935	119,935	119,935
Part 2 of 2 part model				
Sample mean cigarettes smoked per day, conditional sample	16.9	16.9	16.9	16.9
Cigarette tax	-1.0263***	-0.6457**	-0.8851***	-0.7955**
	(0.3815)	(0.3105)	(0.2878)	(0.3436)
Smoking ban index	0.0287	-0.0129	0.0474***	0.0056
	(0.0193)	(0.0111)	(0.0183)	(0.0135)
N	22,279	22,279	22,279	22,279
Implied tax elasticity	-0.05	-0.03	-0.04	-0.04
Marginal effects calculated using both parts of 2 part model				
Sample mean cigarettes smoked per day, unconditional sample	3.14	3.14	3.14	3.14
Cigarette tax	-0.2235	-0.0006	-0.1828*	-0.1158
	(-0.1131)	(0.0954)	(0.1069)	(0.0874)
Smoking ban index	0.0150***	-0.0014	-1.3115***	0.0064
	(0.0044)	(0.0032)	(0.5044)	(0.0039)
N	119,935	119,935	119,935	119,935
Implied tax elasticity	-0.05	-0.0002	-0.04	-0.03
Year fixed effects	Yes	Yes	Yes	Yes
State fixed effects	No	Yes	No	Yes
State smoking sentiment	No	No	Yes	No
State-specific linear time trend	No	No	No	Yes

Notes: All regressions estimated with least squares, and control for state beer tax, state soda price, state pizza price, state unemployment rate, age, sex, race/ethnicity, education, marital status, and household income quintiles. Standard errors are clustered around the state and are reported in parentheses. Beta coefficients reported in probit models.

***; **; and *=statistically different from zero at the 1%; 5%; and 10% confidence level.

Table 3. Effect of Cigarette Taxes on Cigarettes Smoked per Day among Older Adult Smokers, 2 Part Model: The Role of Addiction

Specification:	**(1)**	**(2)**	**(3)**
Part 1 of 2 part model			
Sample proportion smoke	0.19	0.19	0.19
Cigarette tax	0.0275	-0.0024	0.0028
	(0.0182)	(0.0224)	(0.0130)
N	104,740	104,740	104,740
Part 2 of 2 part model			
Sample mean cigarettes smoked per day, conditional sample	16.9	16.9	16.9
Average years smoked across the life course	42.4	42.4	42.4
Cigarette tax	-0.6871	-0.4444	-0.6733
	(1.5020)	(1.3450)	(1.521)
Cigarette tax * years smoked across the life course	-0.0038	-0.0087	0.0015
	(0.0325)	(0.0310)	(0.0339)
Years smoked across the life course	0.1840***	0.1858***	0.1815***
	(0.0330)	(0.0312)	(0.0337)
N	15,491	15,491	15,491
Implied tax elasticity	-0.03	-0.02	-0.03
Marginal effect estimated at mean addictive stock	-0.85	-0.81	-0.61
Marginal effects calculated using both parts of 2 part model			
Sample mean cigarettes smoked per day, unconditional sample	2.9	2.9	2.9
Cigarette tax	-0.0474	-0.0901	-0.1083
	(0.2851)	(0.2598)	(0.2866)
N	104,740	104,740	104,740
Implied tax elasticity	-0.02	-0.05	-0.03
Year fixed effects	Yes	Yes	Yes
State fixed effects	Yes	No	Yes
State smoking sentiment	No	Yes	No
State-specific linear time trend	No	No	Yes

Notes: All regressions estimated with least squares, and control for state beer tax, state soda price, state pizza price, state unemployment rate, state smoking ban index, age, sex, race/ethnicity, education, marital status, and household income quintiles. Standard errors are clustered around the state and are reported in parentheses. Beta coefficients reported in probit models. Participation and overall models do not include the addiction proxy (years smoked across the lifecourse) as this variable should only impact conditional demand (cigarettes smoked per day). ***; **; and *=statistically different from zero at the 1%; 5%; and 10% confidence level.

Appendix Table A. Effect of Cigarette Taxes on Cigarettes Smoked per Day among Older Adult Smokers, 2 Part Model: Elderly Sample

Specification:	**(1)**	**(2)**	**(3)**
Part 1 of 2 part model			
Sample proportion smoke	0.13	0.13	0.13
Cigarette Tax	-0.0050	-0.0306	-0.0313
	(0.0272)	(0.0332)	(0.0378)
N	46,101	46,101	46,101
Part 2 of 2 part model			
Sample mean cigarettes smoked per day, conditional sample	15.0	15.0	15.0
Cigarette Tax	-0.8300*	-0.4054	-1.2770**
	(0.4653)	(0.4328)	(0.5056)
N	5,656	5,656	5,656
Implied tax elasticity	-0.04	-0.02	-0.06
Marginal effects calculated using both parts of 2 part model			
Sample mean cigarettes smoked per day, unconditional sample	1.8	1.8	1.8
Cigarette Tax	-0.1160	-0.1367	-0.2446*
	(0.0956)	(0.1070)	(0.1229)
N	46,101	46,101	46,101
Implied tax elasticity	-0.05	-0.06	-0.10
Year fixed effects	Yes	Yes	Yes
State fixed effects	Yes	No	Yes
State smoking sentiment	No	Yes	No
State-specific linear time trend	No	No	Yes

Notes: The elderly are defined as respondents ages 65 years and older. All regressions estimated with least squares, and control for state beer tax, state soda price, state pizza price, state unemployment rate, state smoking ban index, age, sex, race/ethnicity, education, marital status, and household income quintiles. Standard errors are clustered around the state and are reported in parentheses. Beta coefficients reported in probit models.
***; **; and *=statistically different from zero at the 1%; 5%; and 10% confidence level.

Appendix Table B. Effect of Cigarette Taxes on Cigarettes Smoked per Day among Older Adult Smokers, 2 Part Model: Heterogeneity by Demographic Characteristics

Demographic characteristic	Sex		Race/ethnicity		Education		Marital status	
	Men	**Women**	**White**	**Non-white**	**< High school**	**≥ High school**	**Cohabit**	**Non-cohabit**
Part 1 of 2 part model								
Sample proportion smoke	0.20	0.17	0.18	0.19	0.23	0.16	0.16	0.24
Cigarette tax	-0.0125	0.0604***	0.0514***	-0.0185	0.0358	0.0341*	0.0162	0.0364
	(0.0254)	(0.0208)	(0.0188)	(0.0347)	(0.0342)	(0.0204)	(0.0262)	(0.0243)
N	54,862	65,015	88,687	31,205	24,531	89,231	88,222	31,671
Part 2 of 2 part model								
Sample mean cigarettes smoked per day, conditional sample	18.3	15.0	18.5	11.9	16.8	16.5	17.2	15.6
Cigarette tax	-0.7680**	-0.7496*	-0.7657**	-0.3422	-1.3041	-0.4880	-0.3955	-1.0997***
	(0.3888)	(0.4044)	(0.3502)	(0.3784)	(0.8567)	(0.3030)	(0.4904)	(0.3483)
N	10,838	11,441	16,162	6,117	5,774	14,799	14,508	7,771
Implied tax elasticity	-0.03	-0.04	-0.03	-0.02	-0.06	-0.02	-0.02	-0.053
Marginal effects calculated using both parts of 2 part model								
Sample mean cigarettes smoked per day, unconditional sample	3.5	2.5	3.2	2.2	3.8	2.6	2.7	3.7
Cigarette tax	-0.2093	0.0845	0.0866	-0.1222	-0.1436	0.0485	-0.0014	-0.1075
	(0.1402)	(0.1028)	(0.1040)	(0.1271)	(0.2548)	(0.0920)	(0.1306)	(0.1379)
N	54,862	65,015	88,687	31,205	24,531	89,231	88,222	31,671
Implied tax elasticity	-0.05	0.03	0.02	-0.04	-0.03	0.01	-0.0004	-0.02

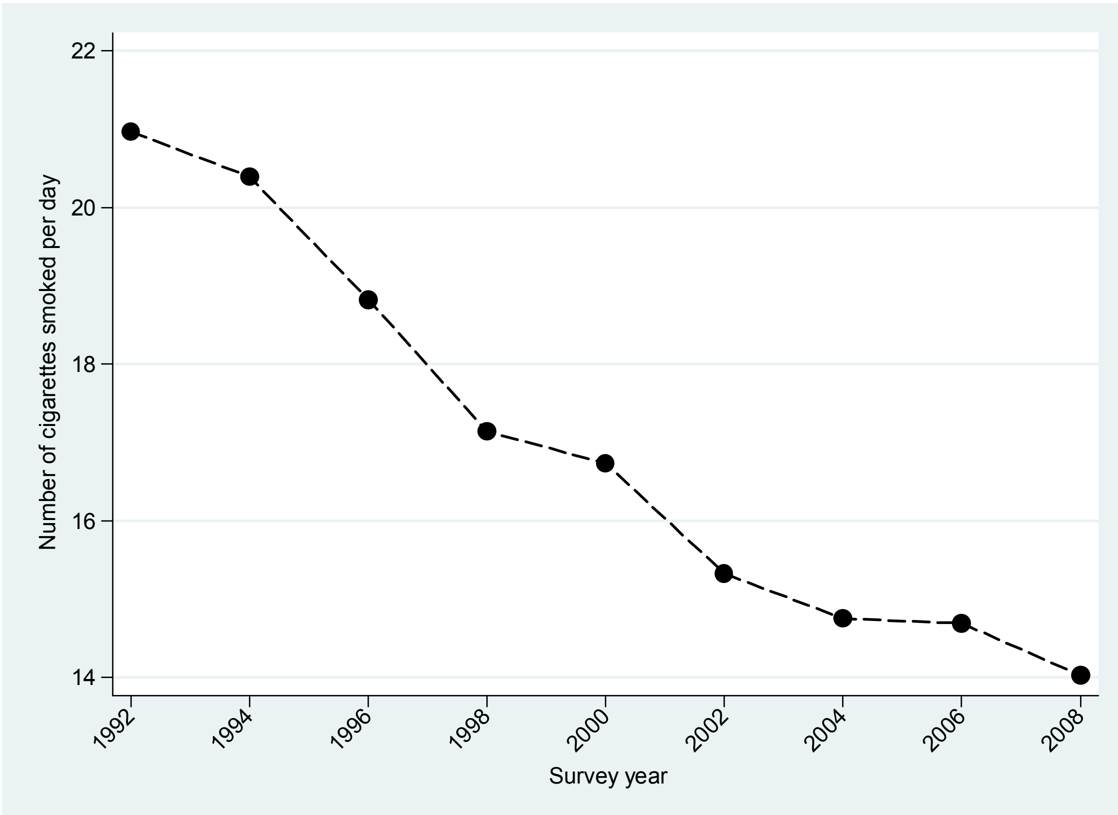
Notes: All regressions estimated with least squares, and control for state beer tax, state soda price, state pizza price, state unemployment rate, age, sex, race/ethnicity, education, marital status, household income quintiles, and state and year fixed effects. Standard errors are clustered around the state and are reported in parentheses. Beta coefficients reported in probit models.
***; **; and *=statistically different from zero at the 1%; 5%; and 10% confidence level.

Appendix Table C. Effect of Cigarette Taxes on Cigarettes Smoked per Day among Older Adult Smokers: Heterogeneity by Smoking Intensity

Quantile:	**10th quantile**	**25th quantile**	**50th quantile**	**75th quantile**	**90th quantile**
Sample quantile cigarettes smoked per day	3	10	18	20	30
Cigarette tax	-0.2018***	-0.0575**	-0.1060***	-0.0330**	-0.0679***
	(0.0631)	(0.0279)	(0.0198)	(0.0157)	(0.0199)
Implied tax elasticity	-0.05	-0.004	-0.004	-0.001	-0.002
Year fixed effects	Yes	Yes	Yes	Yes	Yes
State smoking sentiment	Yes	Yes	Yes	Yes	Yes
N	22,279	22,279	22,279	22,279	22,279

Notes: All regressions estimated with a quantile regression model for count data proposed by Machado and Silva (2005), and control for state beer tax, state soda tax, state pizza tax, state unemployment rate, state per capita income, age, sex, race/ethnicity, education, marital status, and income quintiles. Smoothness is imposed on the data with 10,000 jitters. Standard errors are reported in parentheses.
***; **; and *=statistically different from zero at the 1%; 5%; and 10% confidence level.

Figure 1. Average Number of Cigarettes Smoked per Day among Older Adult Smokers, Conditional Sample



Notes: Data source is 1992 to 2008 HRS. Difference between the 1992 and 2008 values is statistically significant ($p \leq 0.01$).

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