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Exposure to Cigarette Taxes as a Teenager and the Persistence of Smoking into Adulthood
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ABSTRACT

Are teenage and adult smoking causally related? Recent anti-tobacco policy is predicated on the assumption that preventing teenagers from smoking will ensure that fewer adults smoke, but direct evidence in support of this assumption is scant. Using data from three nationally representative sources and cigarette taxes experienced as a teenager as an instrument, we document a strong, positive relationship between teenage and adult smoking: specifically, deterring 10 teenagers from smoking through raising cigarette taxes roughly translates into 5 or 6 fewer eventual adult smokers. We conclude that efforts to reduce teenage smoking can have important, long-lasting consequences on smoking participation and, presumably, health.

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1. INTRODUCTION

A wide variety of anti-tobacco policies have been adopted by state and local governments, but their effects on adult smoking appear to be limited, perhaps because nicotine is so addictive.[1] For instance, adult smoking participation is inelastic with respect to cigarette prices and taxes, with most studies producing elasticities in the range of -0.1 to -0.3 (DeCicca and McLeod 2008; Callison and Kaestner 2014; DeCicca et al. 2020). Bans on smoking in workplaces, bars, and restaurants, have, at most, small and difficult-to-discern effects on adult smoking participation and intensity (Boes et al. 2015; Richards et al. 2017; DeCicca et al. 2020).

By contrast, there is stronger evidence that teenage smoking can be prevented. Studies of the effects of cigarette taxes on youth smoking participation have produced elasticities in the range of -0.3 to -0.6 (Carpenter and Cook 2008; Hansen et al. 2017; Anderson et al. 2020). Raising the minimum legal purchase age (MLPA) for tobacco products to 21 appears to reduce the use of both traditional and e-cigarettes among 18- through 20-year-olds (Friedman et al. 2019; Bryan et al. 2020). Moreover, there is evidence that raising the MLPA from 18 to 21 even discourages 16- and 17-year-olds from smoking, presumably through disrupting the "social market" for cigarettes (Bryan et al. 2020).[2]

[1] Laboratory experiments have shown that nicotine has similar neurochemical and metabolic effects to cocaine, amphetamine, and morphine (Pontieri et al. 1996; Pich et al. 1997).

[2] To date, 33 states and the District of Columbia have increased their MLPA for tobacco products to 21. See the Preventing Tobacco Addiction Foundation website (https://tobacco21.org/) for up-to-date information on MLPAs at the state and local levels. See Callaghan et al. (2018) for evidence that the Canadian MLPA for tobacco products is effective. The "social market" refers to informal methods of obtaining cigarettes such as third-party purchases, bumming or borrowing from older peers, and stealing. Katzman et al. (2007) and Hansen et al. (2013) describe and analyze the social market for cigarettes. Hansen et al. (2013) report that more than three-fourths of 16-to-17-year-old smokers obtain their cigarettes through the social market.

Whether teenagers can be prevented from becoming life-long smokers is still an open question. Most smokers do, in fact, take up the habit before reaching the age of 20 (Lillard et al. 2013; Holford et al. 2014), and smoking as a teenager is strongly correlated with smoking later in life (Chassin et al. 1996, Gruber 2001; Glied 2002; Gilleskie and Strumpf 2005). There are, however, several reasons why the naïve correlation between teenage and adult smoking could be spurious. According to the theory of rational addiction (Becker and Murphy 1988), individuals are forward looking, have stable preferences, and base their decision to smoke (or engage in any other addictive behavior) upon its expected lifetime costs and benefits. Under this theory, smoking as a teenager simply reflects, but does not in and of itself alter, an individual's preferences and expectations.[3] More generally, any factor that influences smoking and persists from adolescence into adulthood—including difficult-to-measure individual-level factors like discount rates, risk tolerance, preferences, and peers—could confound the naïve association between youth and adult smoking.

Drawing on data from the Panel Study of Income Dynamics (PSID), the Tobacco Use Supplement to the Current Population Survey (TUS-CPS), and the Behavioral Risk Factor Surveillance System (BRFSS), the current study provides evidence on the causal relationship between teenage and adult smoking. We begin by exploring the relationship between cigarette taxes and youth smoking. Confirming the results of previous studies, including Carpenter and Cook (2008) and Lillard et al. (2013), we find that teenage smoking was highly sensitive to cigarette taxes imposed in the 1970s through the 1990s.

[3] See DeCicca et al. (2020, p. 25) for a description of the "canonical" theory of rational addiction and its influence on other researchers. See also Cawley and Ruhm (2012, pp. 114-121).

Our principal contribution is to document the causal relationship between teenage and adult smoking by exploiting arguably exogenous, cigarette tax-induced changes in smoking participation at ages 11-19. We find that deterring 10 teenagers from smoking through raising state cigarette taxes leads to roughly 5 or 6 fewer adult smokers. Strikingly, our instrumental variables (IV) estimates of the effect of teenage smoking on adult smoking are quite similar to the ordinary least squares (OLS) estimates, which do not account for persistent, unobserved heterogeneity such as smoking preferences. This similarity suggests that teenage smoking, rather than reflecting risk tolerance that persists into adulthood, in and of itself shapes lifelong smoking preferences and echoes the results from other recent work suggesting that adolescent consumption patterns determine adult preferences (Bronnenberg and Dubé 2017; Keung and Yakovlev 2020).

The remainder of the paper is organized as follows. In Section 2, we briefly summarize the literatures on cigarette taxes and smoking and on dynamic models of smoking. In Section 3, we describe our identification strategy and data. Section 4 presents our estimates, and Section 5 concludes.

2. BACKGROUND AND CONTRIBUTION

Cigarette taxes serve multiple purposes. In addition to generating revenue for the government, they, along with other so-called "sin" taxes, can be welfare improving for individuals who have time-inconsistent preferences (Gruber and Kőszegi 2004; O'Donoghue and Rabin 2006; Allcott et al. 2019). Among public health experts and policymakers, cigarette taxes are viewed as a crucial component of the ongoing campaign to discourage tobacco use and reduce exposure to second-hand smoke, both of which are associated with a wide array of

maladies including, but certainly not limited to, asthma, emphysema, heart disease, and stroke (Cook and Strachan 1999; Hofhuis et al. 2003; Wehby et al. 2011; Centers for Disease Control and Prevention 2014; Simon 2016).

Despite decades of research by economists on smoking and its relationship to taxation, very little is known about the long-run effects of cigarette taxes experienced as a youth, nor do we fully understand why youth and adult smoking are so highly correlated. With only a handful of exceptions, discussed below, previous studies in this literature provide estimates of the immediate impact of cigarette taxes and/or prices on smoking, which we call the "contemporaneous relationship."

These studies provide evidence that smokers can respond to taxes and prices on multiple margins. For instance, there is evidence that newly imposed cigarette taxes shift purchases to low-tax jurisdictions (Harding et al. 2012), increase smoking intensity (Adda and Cornaglia 2006), and encourage the consumption of cigarettes with higher tar, nicotine, and carbon monoxide content (Cotti et al. 2016). Our analysis focuses on the extensive margin—i.e., whether an individual chooses to smoke regularly, which we label smoking participation. Studying the extensive margin is appealing because it is easy to measure and because lifelong smoking participation is associated with substantial reductions in longevity (Doll et al. 2004; Darden et al. 2018).

As noted in the introduction, there is strong evidence that adult smoking participation is not particularly responsive to changes in prices and taxes (DeCicca et al. 2020, pp. 41-43). For instance, using data from the TUS-CPS for the period 1995-2007, Callison and Kaestner (2014), found that a 10 percent increase in the cigarette tax is associated with a 0.2 to 0.4 percent

decrease in smoking participation among adults ages 35-54.[4] Other studies have examined how youth respond to cigarette taxes, producing larger smoking participation elasticities in the range of -0.3 to -0.6 (Carpenter and Cook 2008; Lillard et al. 2013; Hansen et al. 2017), although there is evidence that more recent cigarette tax increases have done little to discourage youth from smoking (Hansen et al. 2017). No previous study has produced estimates of the effects of cigarette taxes on both youth and adult smoking participation using the same empirical design and data source.

At least three studies have, however, gone beyond estimating what we are characterizing as the contemporaneous relationship between cigarette taxes and smoking (Glied 2002; Auld and Zarrabi 2015; Friedson et al. 2021). Glied (2002) used data from the 1979 National Longitudinal Survey of Youth to estimate the longer-run effects of cigarette taxes. She found that taxes at age 14 were not significantly associated with smoking at age 39, and concluded that focusing on dissuading youth, as opposed to adults, from smoking was therefore unwarranted. However, because Glied (2002) did not include state fixed effects on the right-hand side of her regressions, she was unable to distinguish between the effects of cigarette taxes and potentially persistent state-level unobservables such as anti-smoking sentiment. As noted by DeCicca et al. (2002) and others, the cross-sectional relationship between cigarette taxes and smoking is likely confounded by state-level unobservables.[5]

[4] DeCicca et al. (2020) review the modern literature (i.e., since 2000) on cigarette taxes and adult smoking participation. These authors conclude that most studies estimate price elasticities of adult smoking participation between -0.1 and -0.3.

[5] Glied (2002) controlled for the personal characteristics of the respondent (e.g., age, sex, race, marital status, and educational attainment) but did not include state-level covariates aside from cigarette taxes. Glied (2002) restricted her analysis to NLSY respondents who were surveyed in four years (1979, 1984, 1992, and 1994), resulting in a sample size of approximately only 7,600, which may have made it difficult to detect statistically significant long-run effects.

Building on the work of Glied (2002), Auld and Zarrabi (2015) used data from the Canadian Community Health Survey to explore the effects of cigarette prices on teenage smoking and longer-run outcomes.[6] These authors found that teenage cigarette prices were negatively associated with adult smoking participation (defined as daily smoking) and, among male smokers, the number of cigarettes consumed per day. Their estimated effects, however, were small and often statistically insignificant at conventional levels. For instance, Auld and Zarrabi (2015) found that exposure to a 10 percent increase in prices as a 14- though 16-year-old led to a (statistically insignificant) 0.1 percent decrease in smoking participation among adult males.

Finally, Friedson et al. (2021) used data from the TUS-CPS to explore the reduced-form relationship between cigarette taxes experienced as a teenager and adult smoking participation. These authors found that a one-dollar increase in teenage cigarette taxes was associated with an 8 percent reduction in adult smoking participation but did not use cigarette taxes to isolate plausibly exogenous changes in teenage behavior.[7]

Beyond the literature on smoking and taxation, dynamic models of smoking behavior provide a link between youth and adult smoking. These models suggest that, on the one hand, the decision to take up smoking as a youth has important, long-run implications for adult smoking behavior. On the other hand, they suggest that persistent, unobserved heterogeneity

[6] Cigarette prices were averaged across ages 14-18 and ages 12-18. The authors included province fixed effects and contemporaneous (i.e., adult) cigarette prices on the right-hand side of their regressions.

[7] In addition, using vital statistics data, Friedson et al. (2021) found that a one-dollar increase in teenage cigarette taxes was 6 percent reduction in mortality. They concluded that anti-smoking efforts can have long-lasting effects on smoking behavior and health. See also Gruber and Zinman (2001) and Hoehn-Velasco et al. (2021), who used data from birth certificates to estimate the association between teenage cigarette taxes and smoking during pregnancy.

influences both youth and adult smoking, so the association between these two outcomes is potentially confounded.

Two studies, Darden (2017) and Darden et al. (2018), estimate dynamic, stochastic models of smoking behaviors and health over the life cycle using data from the Framingham Heart Study (FHS). The FHS began in 1948 with a sample of approximately 5,000 respondents, all of whom lived in Framingham, Massachusetts. Darden et al. (2018) focused on male FHS participants belonging to the original cohort, while Darden (2017) focused on their offspring.

Darden (2017) found that diagnostic information shocks (e.g., diagnoses of high blood pressure or high cholesterol) had small, and often statistically insignificant, effects on smoking, which is consistent with what we know about the addictiveness of tobacco. Darden (2017) and Darden et al. (2018) found that accounting for selection into smoking meaningfully lowers the magnitude of its estimated effect on mortality, suggesting that medical studies such as Taylor et al. (2002) and Doll et al. (2004) overestimate the long-run health costs of smoking. The results of Darden (2017) and Darden et al. (2018) highlight the importance of relying on arguably exogenous shifts in behavior (as opposed to behavioral differences that potentially reflect underlying characteristics) when measuring the effects of anti-tobacco policies in the long run. Discouraging teenagers from smoking could permanently shift their lifetime trajectory of cigarette consumption; the health ramifications of such a shift may not be felt until much later in life because many smoking-related illnesses often take decades to manifest.

3. METHODS

Our goal is to gauge the long-run effects of teenage taxes and smoking. We are motivated by the fact that nicotine is highly addictive (Pontieri et al. 1996; Pich et al.

1997) and the often-voiced argument that preventing teenagers from taking up smoking will result in lifelong health benefits (Wang and Michael 2015).

3.1. Estimating equations

To measure the causal relationship between youth and adult smoking, we estimate the following two-stage least squares (2SLS) model:

$$Teen\ Smoking_{iys} = \alpha_1 Teen\ Tax_{iys} + \alpha_2 Tax_{st} + \boldsymbol{X}_{it}\alpha_3 + \boldsymbol{W}_{st}\alpha_4 + \boldsymbol{W}_{iys}^{teen}\alpha_5 + \mu_s + \nu_y + \eta_t + \epsilon_{iys} \quad (1)$$

$$Adult\ Smoking_{iyst} = \beta_1 Teen\ Smoking_{iys} + \beta_2 Tax_{st} + \boldsymbol{X}_{it}\beta_3 + \boldsymbol{W}_{st}\beta_4 + \boldsymbol{W}_{iys}^{teen}\beta_5 + \theta_s + \upsilon_y + \gamma_t + u_{iyst}, \quad (2)$$

where *i* indexes individuals born in year y living in state s, and the second-stage outcome, $Adult\ Smoking_{iyst}$, is measured in survey year t. The endogenous regressor in equation (2), $Teen\ Smoking_{iys}$, is an indicator for smoking participation between the ages of 11 and 19 and is therefore time invariant. In the PSID, it is constructed from a mix of contemporaneous and retrospective self-reports; in the TUS-CPS and BRFSS, it is based on retrospective self-reports. The excluded instrument is $Teen\ Tax_{iys}$, which we assume affects smoking as a teenager but has no direct effect on adult smoking. It reflects the average tax rate i faced between ages 11-19 and is also time invariant. The parameter of interest is β_1, which, under identification conditions discussed below, can be interpreted as the cigarette tax-induced average effect of teenage smoking on adult smoking in year *t*.

We control for individual-level characteristics measured in year *t* (represented by the vector $\boldsymbol{X}_{it}$), survey-year state-level observables (represented by the vector $\boldsymbol{W}_{st}$), and fixed

effects for state (μ_s, θ_s), year of birth (ν_y, υ_y), and survey year (η_t, γ_t). We do not control for age because it is perfectly collinear with the year of birth and survey year fixed effects. The individual-level characteristics include indicators for gender, race, and education. State-level observables include the unemployment rate in year *t*, minimum legal cigarette purchase age (MLPA) for tobacco products, and an indicator for whether there was a comprehensive ban on smoking in public areas. We also control for state-level observables when i was a teenager ($\boldsymbol{W}_{iys}^{teen}$), which are discussed below. Note that adult taxes (Tax_{st}) and adult-dated variables ($\boldsymbol{X}_{it}, \eta_t$) appear on the right-hand side of our first-stage regression because it is required for 2SLS consistency, not because we expect (future) adult taxes to influence teenage smoking.

Equations (1) and (2) are estimated jointly using 2SLS because $Teen\ Smoking_{iys}$ is potentially endogenous in the sense that ϵ_{iys} and u_{iyst} are correlated. These error terms are the unobserved determinants of teenage and adult smoking, respectively. They include idiosyncratic factors that could, in theory, put *i* on a new smoking trajectory such as experiencing a stressful event. They also include potentially persistent but unobserved factors such as *i*'s risk preferences, discount rate, health knowledge, and family environment. If persistent, these factors can generate a correlation between ϵ_{iys} and u_{iyst}. If ϵ_{iys} and u_{iyst} are correlated, then the "naïve" OLS estimate of equation (2) will be biased and inconsistent, although it can serve as a useful benchmark, allowing us to assess whether the unobserved determinants of teenage and adult smoking are in fact correlated.

3.2. Identification

Equations (1) and (2) represent a two-stage least squares system and will produce consistent estimates provided that our instrument, $Teen\ Tax_{iys}$, satisfies three conditions: an exclusion restriction, quasi-exogeneity, and relevance. According to the exclusion restriction, $Teen\ Tax_{iys}$ indirectly affects adult smoking through smoking as a teenager (and no other route). Indirect dependence is implied by dynamic models in which smoking decisions depend upon current prices and the accumulated stock of addiction capital. Importantly, it does not rule out long causal chains. For example, the exclusion restriction allows teenage smoking to affect smoking at age 20, which in turn affects smoking at age 21, and so forth through adulthood. Our IV estimate of β_1 captures the net accumulated impact of tax-induced changes in teenage smoking participation. The quasi-exogeneity condition means that cigarette taxes experienced as a teenager are uncorrelated with difficult-to-measure determinants of $Adult\ Smoking_{iyst}$ conditional on the individual- and state-level observables ($\boldsymbol{X}_{it}$, $\boldsymbol{W}_{st}$) and the fixed effects. Including state and year-of-birth fixed effects (μ_s, ν_y) on the right-hand side of (1) ensures that identification of α_1 is from within-state, cross-cohort differences in the real cigarette tax.

Although state fixed effects (μ_s, θ_s) do not account for time-varying, state-specific anti-tobacco sentiment, we include cigarette taxes in year *t* and state *s* on the right-hand side of equations (1) and (2). In addition, we control for the unemployment rate in state *s* and year *t,* whether smoking was banned in public areas (i.e., worksites, restaurants, and bars), and the MLPA. These controls are described in Section 4 below. Survey year fixed effects (η_t, γ_t) account for nationwide shifts in anti-smoking sentiment and policy, including federal cigarette taxes and restrictions on advertising and marketing introduced with the 1998 Masters Settlement. By controlling for the state cigarette tax in year *t* (i.e., the contemporaneous

cigarette tax faced by adults), we account for the possibility that $Teen\ Tax_{iys}$ is correlated with $Adult\ Smoking_{iyst}$ simply because respondents who experienced higher state cigarette taxes as a teenager also experienced higher state cigarette taxes as an adult.[8]

The relevance condition requires that $Teen\ Tax_{iys}$ affects $Teen\ Smoking_{iys}$. Strong evidence for this condition comes from Carpenter and Cook (2008), Lillard et al. (2013), and Hansen et al. (2017). In Section 5, we provide new estimates of the relationship between $Teen\ Tax_{iys}$ and teenage smoking using data from the TUS-CPS and PSID. These estimates are consistent with those of previous studies: in the 1970s through the 1990s, imposing new cigarette taxes clearly deterred American teenagers from smoking.

3.3. Details on inference

Because Tax_{st} varies at the state-year level, we estimate and report standard errors that are robust to both arbitrary heteroskedasticity and within-state autocorrelation. In addition to the cluster- and heteroskedasticity-robust standard errors, we report the "tF" standard errors for the IV estimates as suggested by Lee et al. (2020). The idea of the "tF" standard errors is that, with potentially weak instruments, classical hypothesis tests over-reject the null, with an over-rejection rate that depends on the strength of the instruments (weaker instruments with lower F statistics over-reject more often). To

[8] In dynamic smoking models, smoking at one age depends on the entire history of taxes faced. Therefore, we experimented with controlling not only for the contemporaneous cigarette tax but also its average over the prior three-years. Appendix Table 4 shows that our results are not sensitive to including this additional control, implying that these dynamics do not bias our estimates.

correct for this over-rejection, the "tF" standard errors are rescaled so that conventional critical values can be used.[9]

4. DATA AND MEASURES

4.1. Data sets and sample selection

Our primary data come from three surveys: the TUS-CPS, the PSID, and BRFSS. The TUS-CPS is a National Cancer Institute-sponsored cross-sectional survey, administered every 3-4 years since 1992-1993 as a part of the CPS. It collects nationally representative data from U.S. adults and can be used to monitor smoking trends and assess the effectiveness of tobacco-related policies and programs. Each wave of the TUS-CPS includes information on approximately 240,000 respondents.

The PSID is a longitudinal survey launched in 1968 to assess President Lyndon Johnson's war on poverty.[10] The PSID collects economic-, social-, and health-related information from thousands of American families. Conducted annually from 1968 through 1997, and then biennially through 2017, the PSID has followed 2,930 families drawn from a nationally representative sampling frame, as well as 1,872 low-income families drawn from an oversample of areas with substantial non-white populations.[11]

[9] The scaling depends upon the F-statistic. For example, with an F statistic of 10, we would scale up our standard errors by 1.63, but with an F-statistic of 100, we would scale up by 1.01. See Lee et al. (2020) for more details.

[10] Information on the PSID in this paragraph is dawn from McGonagle et al. (2012).

[11] In 1990, the PSID was further expanded to include 2,043 Latino households; in 1997, funding cuts reduced the number of PSID respondents. Response rates to the PSID are high, above 95 percent in most waves.

The BRFSS is an annual, cross-sectional survey of U.S. adults administered by the Centers for Disease Control and Prevention. Launched in 1984, it is designed to track the prevalence of health-related risk behaviors and provide data for the evaluation of health promotion and disease prevention programs. The BRFSS became nationally representative in 1993, covering all 50 states, the District of Columbia, and three U.S. territories. Currently, the BRFSS interviews approximately 400,000 adults per year.

Several steps were taken to obtain usable analytic samples from each of our three data sets. The PSID analysis is limited to the years 1986-2017 because PSID respondents were regularly asked smoking-related questions beginning in 1986.[12] Across all three data sets, our analysis is restricted to respondents ages 20 and older who were born in 1959 or later. Respondents residing outside the 50 states and the District of Columbia were excluded from the analysis due to a lack of information on cigarette taxes. We limit the TUS-CPS to U.S.-born respondents because most foreign-born residents migrated to the United States as adults (Camarota and Zeigler 2019). Note that the PSID is already implicitly restricted to individuals residing in the U.S. in 1968 (or their descendants). Finally, we limit each sample to observations with non-missing smoking measures and covariates. Our sample consists of 50,299 observations in the PSID, 538,992 observations in the TUS-CPS, and 3,312,559 observations in the BRFSS. Summary statistics are reported in Table 1.

4.2. Smoking measures

Our primary outcomes are smoking participation as a teenager and then as an adult. We focus on the extensive margin because it is well-measured in all our data sets and because

[12] We use the full range of years available in the BRFSS (1984-2018) and TUS-CPS (1992-2018).

previous studies show that smoking intensity can be difficult to measure. For example, regular smokers respond to cigarette taxes by smoking fewer cigarettes but smoking more of each cigarette and using higher-tar cigarettes (Evans and Farrelly 1998; Adda and Cornaglia 2006; Cotti et al. 2016).

Adult smoking participation (i.e., $Adult\ Smoking_{iyst}$) is an indicator for regular smoking in the TUS-CPS and the BRFSS, defined as smoking "some days" or every day during the survey month. In the PSID, which does not ask about smoking frequency, $Adult\ Smoking_{iyst}$ is equal to 1 if the respondent smoked in the past month (and is equal to 0 otherwise).

The definition of $Teen\ Smoking_{iys}$ also depends upon which data set is being analyzed. TUS-CPS respondents are asked if they have ever smoked and, if this question is answered in the affirmative, when they first started smoking regularly. $Teen\ Smoking_{iys}$ is equal to 1 if i reported regularly smoking at age 19 or younger (and is equal to 0 otherwise). We also experiment with using $Ever\ Smoked_{iyst}$, defined as having smoked at least 100 cigarettes over i's lifetime, to proxy for $Teen\ Smoking_{iys}$. $Ever\ Smoked_{iyst}$ is plainly an imperfect proxy; approximately 7 percent of TUS-CPS report having initiated smoking after the age of 19. However, provided that $Teen\ Tax_{iys}$ affects $Adult\ Smoking_{iyst}$ through $Ever\ Smoked_{iyst}$, and not through any other channel, then our IV estimate of β_1 will still capture the net accumulated impact of tax-induced teenage smoking participation.

PSID respondents (i.e., heads of households and their spouses) are asked about their current and past smoking behaviors across multiple surveys. In 1986, PSID respondents were asked if they had smoked during in the survey month, the age when they first smoked regularly, and the age when they first quit smoking; during the period 1987-1997, smoking questions were

not asked; during the period 1999-2017, PSID respondents were regularly asked about their current and past smoking. In the PSID analysis, $Teen\ Smoking_{iys}$ is equal to 1 if *i* ever reported regularly smoking before the age of 19, or if *i* reported having or quit at age 19 or younger (and is equal to 0 otherwise).

BRFSS respondents were not consistently asked the age at which they began to smoke. They were, however, consistently asked whether they had smoked at least 100 cigarettes over their lifetime. In the BRFSS analysis, $Teen\ Smoking_{iys}$ is always proxied by $Ever\ Smoked_{iyst}$, which is equal 1 if *i* smoked at least 100 cigarettes over their lifetime (and is equal to 0 otherwise).

4.3. Cigarette Taxes

State and federal cigarette taxes come from historical data available in Orzechowski and Walker (2019). The cigarette tax in year *t* (i.e., the adult tax, tax_{st}) is measured as the real (i.e., 2005 dollars) combined state and federal cigarette excise tax in effect in state s and year t. Federal tax changes do not contribute to the estimation of its coefficients, α_2 and β_2, because our models include year fixed effects.

To measure the teenage tax, we would ideally match each respondent to his or her teenage state of residence and measure $Teen\ Tax_{iys}$ as the average cigarette tax in effect while i was between the ages of 11 and 19. This approach, which was used by Friedson et al. (2021), is not possible in the TUS-CPS or BRFSS. When using these data sets, we impute $Teen\ Tax_{iys}$ under the assumption that *i*'s current state of residence (i.e., her state of residence when surveyed as an adult) is where she lived as a teenager. Specifically, we impute $Teen\ Tax_{iys}$ as follows:

$$Teen\ Tax_{iys} = \frac{1}{9}\sum_{a=11}^{a=19} tax_{s,y+a}\ .,$$

where, again, y is year of birth and s the current state of residence. Our measure of $Teen\ Tax_{iys}$ is the average cigarette tax in i's current state between the ages of 11 and 19. We average over these ages rather than examining the effects of cigarette taxes at particular ages (e.g., at age 14, at age 15, etc.) to improve the precision of our estimates and simplify the analysis. When using the PSID, we can measure $Teen\ Tax_{iys}$ as the average cigarette tax in i's actual state residence between the ages of 11 and 19.

Within-state changes in real cigarette taxes occurring between 1970 and 2017 identify the effect of $Teen\ Tax_{iys}$ on $Teen\ Smoking_{iys}$. Most of these changes were modest in terms of magnitude. Cigarette taxes are typically fixed nominal amounts, so inflation leads to small annual changes in most states and years. Legislated changes in the nominal rate also produce changes in the real tax rate. The interquartile range is from \$0.054 to \$0.30 per pack (Appendix Figure 1). However, there is a long right-hand tail to this distribution: there were 32 changes in the per-pack cigarette tax stemming from legislation between \$0.30 and \$0.50; there were 53 changes between \$0.50 and \$1.00; and there were 4 changes between \$1.00 and \$1.58.[13]

Imputing $Teen\ Tax_{iys}$ based on the current state of residence rather than the state of residence between the ages of 11 and 19 creates measurement error. We limit this measurement error by restricting the sample to respondents born in the United States because most foreign-born residents migrated to the United States after their teenage years (Camarota and Zeigler 2019). This likely reduces, but certainly does not eliminate, measurement error. However, we expect that this measurement error is roughly classical, in the sense that we do not think that we

[13] Appendix Figure 2 shows the average per-pack cigarette tax in 2005 dollars during the period 1970-2017.

are systematically over- or under-stating teenage taxes. Therefore, when $Teen\ Tax_{iys}$ is used as an instrument, it will not jeopardize the consistency of our estimates. Intuitively, measurement error attenuates the reduced form and first stage coefficients by equal proportions, leaving their ratio unchanged. To provide evidence on the possible consequences of measurement error for our estimates, we experiment with using the actual state of residence as a teenager to calculate $Teen\ Tax_{iys}$ in the PSID. Information on the distribution of cigarette taxes faced by individuals in our various samples is reported in Table 2.

4.4. Teen-dated policy variables

Our regression models control for a vector of state-level variables corresponding to *i*'s teenage years, $\boldsymbol{W}_{iys}^{teen}$, which, in theory, could be correlated with $Teen\ Tax_{iys}$. The vector $\boldsymbol{W}_{iys}^{teen}$ consists of the unemployment rate, whether smoking was banned in public areas, and the MLPA.[14] We define these analogously to $Teen\ Tax_{iys}$. Specifically, we set teenage-dated state-level variables equal to their average value in individual *i*'s teen stage of residence (PSID sample) or current state of residence (TUS-CPS and BRFSS samples) when *i* was between the ages of 11 and 19. For example, we define $unemp_{iys}^{teen}$, the teenage unemployment rate for respondent i as:

[14] MLPAs for the period 1970-2018 (when the respondents in our sample were between the ages of 11 and 19) are from Downey (1981), Unknown Author (1996), Yan (2014), Committee on the Public Health Implications of Raising the Minimum Age for Purchasing Tobacco Products (2015), and Ballotpedia (2020). State unemployment rates for the period 1976-2018 are from the U.S. Bureau of Labor Statistics' Local Area Unemployment Statistics (https://www.bls.gov/lau/). State unemployment rates for the period 1970-1975 come from U.S. Bureau of the Census (1972, 1974, 1977). Information on comprehensive smoke-free laws for worksites, restaurants, and bars comes from the Centers for Disease Control and Prevention (2020).

$$unemp_{iys}^{teen} = \frac{1}{9}\sum_{a=11}^{a=19} unemp_{s,y+a}\,.$$

5. RESULTS

5.1. OLS benchmarks

OLS estimates of equation (2) are reported in Table 3. These estimates, which can be thought of as benchmarks, give the naïve association between teenage and adult smoking. Estimates based on the TUS-CPS data are reported in columns (1) through (3), and estimates based on the PSID data are reported in columns (4) through (6). Teenage smoking is not directly measured in the BRFSS.

Without adjusting for individual- or state-level covariates, TUS-CPS respondents who smoked as teenagers are 55.2 percentage points more likely to be adult smokers. Adjusting for individual-level covariates such as age and gender reduces the magnitude of this association, but not substantially. Likewise, controlling for state-level covariates, including cigarette taxes as an adult (i.e., in year *t*), has little effect on this estimate: smoking as a teenager is still associated with a 52.0 percentage point increase in adult smoking. In the PSID, smoking as a teenager is associated with a 38.3 to 41.8 percentage point increase in adult smoking, depending upon which controls are included on the right-hand side of equation (2).

Despite the strong association between teenage and adult smoking, the association between adult taxes and smoking is comparatively weak. In the TUS-CPS, a one-dollar increase in cigarette taxes in year t is associated with a (statistically insignificant) 0.2 percentage point decrease in adult smoking, which translates to an elasticity of -0.01 at the sample mean and is broadly consistent with the elasticities reported by DeCicca et al. (2008) and Callison and

Kaestner (2014). In the PSID, a one-dollar increase in cigarette taxes in year t is associated with a (statistically insignificant) 0.9 percentage point decrease in adult smoking, which translates to an elasticity of -0.07 at the sample mean.

The strong, positive association between teenage and adult smoking reported in Table 3 should not be interpreted as evidence that nicotine is addictive, nor should it be used to assess the lifelong health consequences of taking up the habit as a teenager. Persistent unobserved heterogeneity (due to, for instance, socioeconomic status, life expectancy, or risk tolerance) could be driving the results reported in Table 3. The IV estimates reported below will instead exploit arguably exogenous variation in teenage smoking uncorrelated unobserved heterogeneity at the individual level.

5.2. First-stage estimates

Estimates of α_1 from equation (1), the coefficient on $Teen\ Tax_{iys}$, are reported in Table 4. In the TUS-CPS, $Teen\ Tax_{iys}$ is negatively related to smoking as a teenager. Specifically, the estimate of α_1 is -0.047 (with a standard error of 0.014). The first-stage F-statistic is 11, above conventional thresholds but low enough to lead to over-rejection (Lee et al. 2020).[15] Using $Ever\ Smoked_{iyst}$ instead of $Teen\ Smoking_{iys}$ as the endogenous regressor produces almost identical first-stage estimates. The estimate of α_1 in the TUS-CPS corresponds to an elasticity of teenage smoking participation with respect to cigarette taxes of -0.11 (calculated at the sample means). Comparing this estimate to the adult elasticities discussed above, it appears as though

[15] For this reason, tF standard errors for the second-stage estimates are reported in Table 5.

teenage smoking is much more responsive to taxes than is adult smoking. In fact, the teenage elasticity is 10 times larger than the adult elasticity in the TUS-CPS.[16]

Estimates of α_1 based on the PSID are reported in columns (3) and (4) of Table 4. In column (3), we instrument using the actual cigarette tax to which *i* was exposed as a teenager. The estimates of α_1 are statistically significant and considerably larger than in the TUS-CPS, but the F-statistic is below 10. This lack of power is likely due to the sample size. We have 10 times as many observations in the TUS-CPS as in the PSID. In column (4) of Table 4, we report first-stage results using the imputed teenage tax based on *i*'s current state of residence. Reassuringly, using the imputed tax has only a small effect on the first-stage estimate and its standard error.

Finally, we report an estimate of α_1 based on the BRFSS data in column (5) of Table 4. This estimate is smaller than in the TUS-CPS (or the PSID), but precise: a one-dollar increase in the teenage tax is associated with a statistically significant 3 percentage point decrease in $Ever\ Smoked_{iyst}$. The first-stage F-statistic is well above 10, suggesting that the large sample size of the BRFSS (about 66 times as many observations as in the PSID) helps to address the power issue, albeit at the cost of depending upon the less-than-ideal measure of teenage smoking.

5.3. Second-stage estimates from the TUS-CPS and BRFSS

Second-stage estimates are reported in Table 5. In the top panel (Panel A) of Table 5, we begin by reporting full-sample results from the TUS-CPS using $Teen\ Smoking_{iys}$ as the

[16] In the PSID, the teenage elasticity is twice the size of the adult elasticity. Our teenage elasticity estimates are comparable with those produced by other researchers. For instance, using data for the period 1991-2005, Carpenter and Cook (2008) found an elasticity of teen smoking participation to cigarette taxes of -0.106. Hansen et al. (2017) confirmed this result, but found a lower elasticity in later years, when most respondents in our analysis were no longer teenagers.

endogenous regressor. The estimate of β_1 suggests that deterring 10 teenagers from smoking through raising cigarettes taxes translates into 4.56 fewer adult smokers. This estimate is statistically significant at conventional levels even after adjusting its standard error to take into account the first-stage F-statistic of 11.2.

Our second-stage estimate of β_1 is only 12 percent smaller than the benchmark association between teenage and adult smoking in the TUS-CPS, suggesting that OLS estimates are not far from being unbiased. The (potential) bias from using OLS comes from the combined influence of individual-level unobservables that affect both teenage and adult smoking. Examples of such unobservables might include risk aversion and knowledge of personal health risks (such as family health history). The comparison of the second-stage and OLS estimates suggests that their influence is either transitory or unimportant.

In the remaining columns of Table 5, we report TUS-CPS estimates of β_1 for different age groups (i.e., respondents in their 20s, 30s, 40s, and 50s). The effect of teenage smoking is largest for adults in their 20s: deterring 10 teenagers from smoking translates into 6.61 fewer smokers between the ages of 20 and 29. The first-stage F-statistic shrinks dramatically when we focus on the other age groups.[17] In fact, there is so little power that the tF standard errors cannot be calculated for 30- through 39-year-olds and 50- through 59-year-olds. Although we lack the power to estimate most age-specific effects, our results provide evidence that teenage smoking is causally linked to smoking as an adult, and especially to smoking between the ages of 20 and 29; if raising the MLPA to 21 deters teenagers from smoking, it will lead to fewer young adults taking up the habit, which is exactly the argument made by advocates of raising the MLPA for tobacco products to 21 (Steinberg and Delnevo 2013).

[17] In Table 4, we report full-sample estimates of α_1 from equation (1); in Appendix Table 1, we report the corresponding first-stage estimates for each age range, data set, and specification.

In the next panel (Panel B), we present the 2SLS estimate of β_1 in the TUS-CPS, replacing the endogenous regressor $Teen\ Smoking_{iys}$ with $Ever\ Smoked_{iyst}$. The results are very similar to those discussed in the paragraphs immediately above, suggesting that variation in $Ever\ Smoked_{iyst}$ from teenage taxes is, in fact, capturing smoking decisions made as a teenager.

In Panel C of Table 5, we turn our attention to the BRFSS. Because BRFSS respondents are not asked at what age they began to smoke, we rely entirely on $Ever\ Smoked_{iyst}$ as the endogenous regressor. The full-sample estimate of β_1 reported in the first column is imprecise. In fact, the 90 percent confidence interval includes both zero and an effect equal to the TUS-CPS estimates reported in Panels A and B. The estimates of β_1, however, become more precise when we focus on the results by age group. Deterring 10 BRFSS respondents from ever smoking through raising teenage taxes translates into 5.19 fewer smokers between the ages of 20 and 29. Similarly, deterring 10 BRFSS respondents from ever smoking translates into 3.18 fewer smokers between the ages of 30 and 39. Both of these estimates are statistically significant at conventional levels.

5.4. Second-stage estimates from the PSID

Thus far, we have reported and discussed estimates of β_1 based on imputed values of $Teen\ Tax_{iys}$, using i's adult state of residence to assign teenage taxes. This imputation introduces measurement error, potentially reducing the precision of our estimates and, if it is non-classical, potentially jeopardizing their consistency.

We turn to the PSID to assess the importance of this source of measurement error, where we observe i's actual state of residence between the ages of 11 and 19. In the top panel (Panel A) of Table 6, we report estimates of β_1 instrumenting with the imputed teenage tax. Although

the first sage is weak (the F-statistic is 7.9), the estimate of β_1 is positive and significant even after adjusting the standard error: for every 10 teenagers deterred from smoking, there are 6.47 fewer adult smokers.

In Panel B of Table 6, we report the estimate of β_1 based on $Teen\ Tax_{iys}$ measured using *i*'s actual state of residence as a teenager. The first-stage F-statistic is larger (9.9), which is consistent with classical measurement error. The estimate of β_1 is, however, smaller: for every 10 teenagers deterred from smoking, there are 4.72 fewer adult smokers, which is not significantly different from the estimate obtained using imputed teenage taxes, nor is it significantly different from the OLS benchmark estimate reported in Table 3. We conclude that measurement error in our instrument likely weakens the first stage result but does not substantially bias our estimates of the relationship between teenage and adult smoking.

5.5. Additional robustness checks

Thus far, we have shown that tax-induced changes in teenage smoking produce long-lasting effects on adult smoking. This finding is evident across all three of our data sets and is robust to how teenage smoking is measured. In Appendix Tables 2-4, we report results from three additional robustness checks.

We begin by re-estimating equations (1) and (2) using the analytic sampling weights available in the TUS-CPS, the PSID, and BRFSS. For each of these data sets, we report full-sample estimates and estimates by age group (i.e., ages 20-29 and 30-39). In the TUS-CPS and the PSID, the weighted estimates are qualitatively similar to those discussed above (Appendix Table 2). In the BRFSS, the full-sample coefficient of $Teen\ Smoking_{iys}$ (proxied by $Ever\ Smoked_{iyst}$) is now statistically significant and similar in magnitude to the estimates

based on the TUS-CPS and the PSID. The age-specific estimates in the BRFSS are also similar to those reported in Tables 5 and 6.

Next, we adopt an alternative definition of "teenager". Specifically, $Teen\ Smoking_{iys}$ and $Teen\ Tax_{iys}$ are measured for respondents between the ages of 12 and 18 as opposed to those between the ages of 11 and 19. Adopting this alternative definition of teenager has little impact on our full-sample or age-specific estimates (Appendix Table 3).

Finally, we augment our set of controls by including the average cigarette value over the last three years (in addition to the tax in year *t*). Our goal is to account for the possibility that teenage taxes are somehow capturing the effects of future, but not contemporaneous, cigarette taxes. The results of this exercise provide no evidence for the existence of this phenomenon: the estimated coefficients of $Teen\ Tax_{iys}$ and $Teen\ Smoking_{iys}$ are, in fact, almost identical to those reported in Tables 4, 5, and 6 (Appendix Table 4).

6. CONCLUSION

For cohorts of Americans born between 1959 and 1998, we find that the elasticity of teenage smoking participation with respect to cigarette taxes was between -0.11 and -0.16, a range estimates that is broadly consistent with those of previous researchers (Carpenter and Cook 2008; Hansen et al. 2017). These cohorts, however, appear to have been largely unresponsive to cigarette taxes as adults; using the same data sources and samples used to produce the teenage tax elasticities, we find that adult tax elasticities are approximately between one-half and one tenth as large. Thus, raising cigarette taxes would appear to have the immediate effect of reducing teenage smoking while having little effect on adult smoking, at least in the short run.

Nonetheless, our results demonstrate that raising cigarette taxes will eventually translate into fewer adult smokers. Specifically, our IV estimates suggest that adults who were exposed to

higher taxes as teenagers are much less likely to smoke as adults: deterring 10 teenagers from smoking through higher state cigarette taxes translates into roughly 5 or 6 fewer adult smokers, depending upon which of our data sets is used. For instance, in the TUS-CPS, deterring 10 teenagers from smoking translates into 4.56 fewer adult smokers.

Our estimates are largest and most precise for adults in their 20s. For instance, in the TUS-CPS, we find that deterring 10 teenagers from smoking translates into 6.61 fewer smokers between the ages of 20 and 29. Although we lack the power to discern whether teenagers who are deterred from smoking through raising cigarette taxes will continue to be non-smokers into their 40s and 50s, dynamic structural models of lifetime smoking suggest that the estimated effects of teenage smoking among adults in their 20s and 30s will likely persist for decades (Darden 2017; Darden et al. 2018). Moreover, these same models suggest that preventing teenagers from taking up the habit will likely have long-lasting health benefits.

For decades, U.S. anti-smoking policy has been focused on teenagers (Barrington-Trimis et al. 2020). When justifying this focus, policymakers and academics have regularly observed that most smokers take up the habit as teenagers. In a typical argument, Steinberg and Delnevo (2013, p. 558) write, "nearly 90% of adults who smoke on a daily basis had their first cigarette by age 18." They conclude raising the MLPA to 21 will not only deter teenagers from smoking, but will, in fact, prevent them from becoming lifelong smokers. In principle, the strong positive correlation between teenage and adult smoking could be entirely spurious, caused for example by unobservable tastes, attitudes towards risk, and family background. Our results fill in a key step in this argument, providing simple and direct evidence that smoking persists due to the behavior itself and is not simply an artifact of persistent preferences, risk tolerance, or policies.

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Table 1. Summary Statistics

	(1)	(2)	(3)
Sample	TUS-CPS	PSID	BRFSS
Female	0.56	0.57	0.58
White	0.86	0.61	0.80
Black	0.11	0.37	0.10
Age 20-29	0.33	0.28	0.25
Age 30-39	0.40	0.37	0.33
Age 40-49	0.21	0.26	0.29
Age 50+	0.06	0.10	0.13
Adult smoking	0.23	0.22	0.23
Ever Smoked	0.37	0.48	0.41
Teen Smoking	0.31	0.40	.
Observations	538,992	50,299	3,312,559
States	51	51	51

Notes: Table reports summary statistics of demographic variables and smoking rates in the TUS-CPS, the PSID, and the BRFSS. We exclude respondents in Guam and Puerto Rico from the analysis, for whom we lack information on cigarette taxes. Respondents with missing smoking information or missing controls are also excluded from the analysis.

Table 2. Cigarette Taxes Faced by TUS-CPS, PSID and BRFSS Respondents

			Percentile				
	Mean	SD	10	25	50	75	90
			(1)	(2)	(3)	(4)	(5)
Tax (TUS-CPS)	1.39	0.82	0.56	0.76	1.22	1.81	2.48
Teen Tax (TUS-CPS)	0.70	0.27	0.47	0.55	0.65	0.77	0.95
Tax (PSID)	1.83	0.93	0.71	1.21	1.65	2.34	3.06
Teen Tax (PSID)	0.79	0.35	0.45	0.59	0.72	0.89	1.17
Tax (BRFSS)	1.72	0.94	0.64	0.98	1.53	2.27	3.15
Teen Tax (BRFSS)	0.75	0.38	0.47	0.55	0.66	0.80	1.05

Notes: Per-pack cigarette taxes (state and federal) in 2005 dollars are reported. Teen taxes are measures when TUS-CPS, PSID and BRFSS respondents were between the ages of 11 and 19.

Table 3. Benchmark OLS Estimates

	(1)	(2)	(3)	(4)	(5)	(6)
	Adult Smoking	*Adult Smoking*	*Adult Smoking*	*Adult Smoking*	*Adult Smoking*	*Adult Smoking*
Sample	TUS-CPS	TUS-CPS	TUS-CPS	PSID	PSID	PSID
Teen Smoking	0.552***	0.520***	0.520***	0.418***	0.383***	0.383***
	(0.007)	(0.006)	(0.006)	(0.012)	(0.012)	(0.012)
Tax			-0.002			-0.009
			(0.001)			(0.007)
			<-0.011>			<-0.072>
Mean of dependent variable	0.235	0.235	0.235	0.221	0.221	0.221
N	538,992	538,992	538,992	50,299	50,299	50,299
State, birth year, year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Individual-level controls	No	Yes	Yes	No	Yes	Yes
State-level controls	No	No	Yes	No	No	Yes

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: All respondents were at least 20 years of age. *Adult Smoking* is equal to 1 if *i* was a current smoker (and is equal to 0 otherwise). *Teen Smoking* is equal to 1 if *i* started smoking before reaching 20 years of age (and is equal to 0 otherwise). Controls include fixed effects for state, survey year, and birth year; indicators for gender, race, educational attainment; current and teen unemployment rates, current and teen minimum legal purchase age of tobacco, current and teen comprehensive smoking law. In the TUS-CPS, we use the current state of residence to impute state of residence as a teenager. In the PSID, we use the actual state of residence as a teenager. Standard errors are clustered at state level and are reported in parentheses. Elasticities are measured at the sample mean and in angled brackets.

Table 4. First-Stage Estimates

	(1)	(2)	(3)	(4)	(5)
	Teen Smoking	*Ever Smoked*	*Teen Smoking*	*Teen Smoking*	*Ever Smoked*
Sample	TUS-CPS	TUS-CPS	PSID (actual teen state)	PSID (imputed teen state)	BRFSS
Teen Tax	-0.047***	-0.047**	-0.084***	-0.096***	-0.031***
	(0.014)	(0.014)	(0.027)	(0.034)	(0.008)
	<-0.107>	<-0.087>	<-0.164>	<-0.166>	<-0.054>
F-statistic	11.2	11.0	9.9	7.9	14.7
Mean of dep. var.	0.305	0.375	0.405	0.405	0.410
N	538,992	538,992	50,299	50,299	3,312,559

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: All respondents were at least 20 years of age. *Adult Smoking* is equal to 1 if *i* was a current smoker (and is equal to 0 otherwise). *Teen Smoking* is equal to 1 if *i* started smoking before reaching 20 years of age (and is equal to 0 otherwise). *Ever Smoked* is equal to 1 if *i* has smoked at least 100 cigarettes over lifetime (and is equal to 0 otherwise). Controls include fixed effects for state, survey year, and birth year; indicators for gender, race, educational attainment; current and teen unemployment rates, current and teen minimum legal purchase age of tobacco, current and teen comprehensive smoking law. In the TUS-CPS, we use the current state of residence to impute state of residence as a teenager. In the PSID, we use the actual state of residence as a teenager. Elasticities measured at the sample mean are reported in angled brackets. Standard errors corrected for clustering at state level are reported in parentheses.

Table 5. 2SLS Estimates for Full Sample and by Age Group

	(1)	(2)	(3)	(4)	(5)
	Adult Smoking	*Adult Smoking*	*Adult Smoking*	*Adult Smoking*	*Adult Smoking*
Ages	All	20s	30s	40s	50s
Panel A. TUS-CPS sample, X = Teen Smoking					
Teen Smoking	0.456***	0.661***	0.605	0.207	-3.298
	(0.122)	(0.086)	(0.406)	(0.400)	(20.244)
tF Standard Error	[0.205]	[0.105]	.	[1.260]	.
Mean of dependent variable	0.235	0.248	0.239	0.218	0.194
F-statistic	11.2	28.1	1.5	5.1	0.03
N	538,992	175,532	217,738	114,264	31,458
Panel B. TUS-CPS sample, X = Ever Smoked					
Ever Smoked	0.454***	0.682***	0.441*	0.177	2.371
	(0.113)	(0.086)	(0.229)	(0.315)	(9.470)
tF Standard Error	[0.189]	[0.111]	.	[1.186]	.
Mean of dependent variable	0.235	0.248	0.239	0.218	0.194
F-statistic	11.0	22.3	2.8	5.0	0.1
N	538,992	175,532	217,738	114,264	31,458
Panel C. BRFSS sample, X = Ever Smoked					
Ever Smoked	0.179	0.519***	0.318**	0.264	1.168
	(0.150)	(0.070)	(0.123)	(0.540)	(1.180)
tF Standard Error	[0.223]	[0.094]	[0.212]	.	.
Mean of dependent variable	0.226	0.249	0.229	0.214	0.204
F-statistic	14.7	19.1	10.2	0.7	0.4
N	3,312,559	834,470	1,079,969	950,484	447,636

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: All respondents were at least 20 years of age. *Adult Smoking* is equal to 1 if *i* was a current smoker (and is equal to 0 otherwise). *Teen Smoking* is equal to 1 if *i* started smoking before reaching 20 years of age (and is equal to 0 otherwise). *Ever Smoked* is equal to 1 if *i* has smoked at least 100 cigarettes over lifetime (and is equal to 0 otherwise). Controls include fixed effects for state, survey year, and birth year; indicators for gender, race, educational attainment; current and teen unemployment rates, current and teen minimum legal purchase age of tobacco, current and teen comprehensive smoking law. In the TUS-CPS, we use the current state of residence to impute state of residence as a teenager. In the PSID, we use the actual state of residence as a teenager. tF standard errors, calculated based on Lee, McCrary, Moreira, and Porter (2020), are reported in square brackets. tF standard errors are missing when first-stage F-statistic is less than 4. Standard errors corrected for clustering at state level are reported in parentheses.

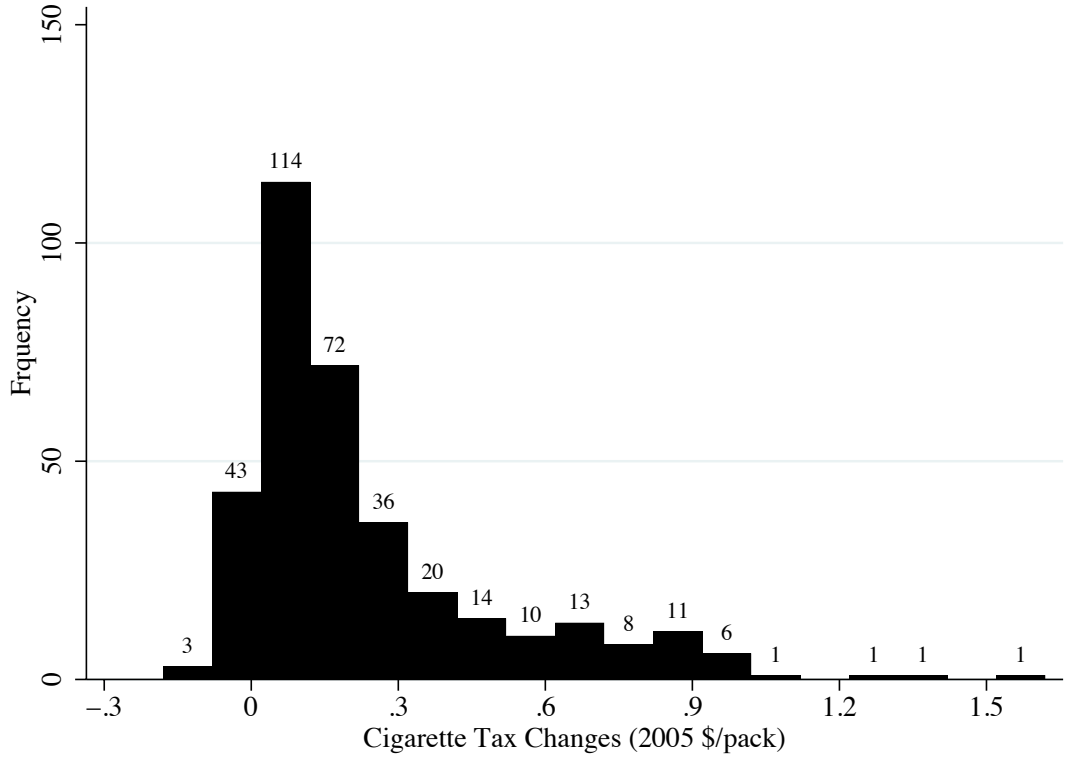
Table 6. PSID Validation

	(1)	(2)	(3)	(4)	(5)
	Adult Smoking	*Adult Smoking*	*Adult Smoking*	*Adult Smoking*	*Adult Smoking*
Ages	All	20s	30s	40s	50s
Panel A. PSID sample, X = Teen Smoking, imputed youth state					
IV estimate					
Teen Smoking	0.647***	0.365	0.352	0.743	0.570
	(0.176)	(0.252)	(0.281)	(0.711)	(0.843)
tF Standard Error	[0.360]	[1.252]	[0.609]	.	.
Mean of dependent variable	0.221	0.250	0.211	0.208	0.208
F-statistic	7.9	4.2	7.5	1.2	0.5
N	50,299	14,068	18,391	12,973	4,863
Panel B. PSID sample, X = Teen Smoking, actual youth state					
IV estimate					
Teen Smoking	0.472***	0.495*	0.317*	-0.571	-0.568
	(0.158)	(0.266)	(0.183)	(1.550)	(0.959)
tF Standard Error	[0.274]	[1.320]	[0.507]	.	.
Mean of dependent variable	0.221	0.250	0.211	0.208	0.208
F-statistic	9.9	4.4	5.6	0.5	1.5
N	50,299	14,068	18,391	12,973	4,863

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

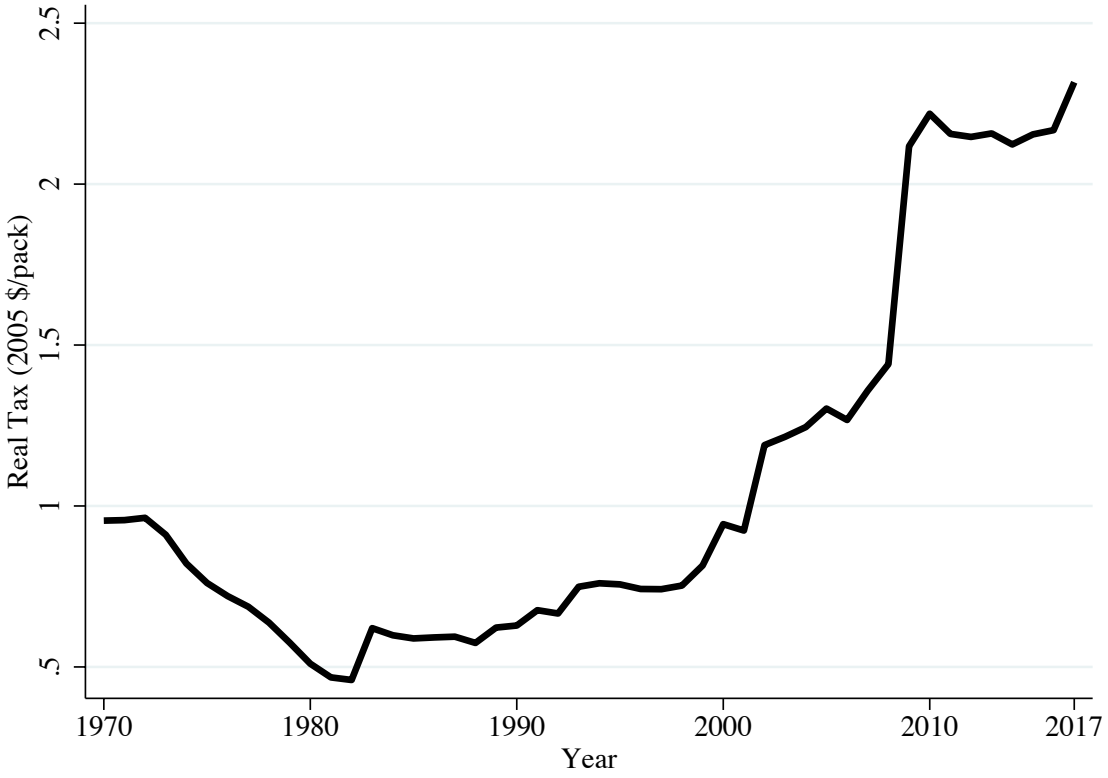
Notes: All respondents were at least 20 years of age. *Adult Smoking* is equal to one if *i* was a current smoker. *Teen Smoking* is equal to one if *i* started smoking before reaching 20 years of age. Controls include fixed effects for state, survey year, and birth year; indicators for gender, race, educational attainment; current and teen unemployment rates, current and teen minimum legal purchase age of tobacco, current and teen comprehensive smoking law. In the TUS-CPS, we use the current state of residence to impute state of residence as a teenager. In the PSID, we use the actual state of residence as a teenager. Robust standard errors are clustered at state level and are reported in parentheses. tF standard errors, calculated based on Lee, McCrary, Moreira, and Porter (2020), are reported in square brackets. tF standard errors are missing when first-stage F-statistic is less than 4. Standard errors corrected for clustering at state level are reported in parentheses.

Appendix Figure 1. Real Cigarette Tax Changes Stemming from Legislation, 1970-2017.



Notes: Cigarette tax data are from Orzechowski and Walker (2019).

Appendix Figure 2. Average Per-pack Cigarette Tax (Population Weighted and in 2005 dollars), 1970-2017



Notes: Cigarette tax data are from Orzechowski and Walker (2019). State populations come from the U.S. Census Bureau State Intercensal Population Tables, available at https://www.census.gov/programs-surveys/popest/data/tables.html.

Appendix Table 1. First-Stage Estimates by Age Group and Data Set

	(1)	(2)	(3)	(4)	(5)
Ages	All	20s	30s	40s	50s
Panel A. TUS-CPS sample, Y = Teen Smoking					
Teen Tax	-0.047***	-0.061***	-0.031	0.080**	0.014
	(0.014)	(0.012)	(0.025)	(0.036)	(0.078)
Mean of dependent variable	0.305	0.306	0.308	0.300	0.298
F-statistic	11.2	28.1	1.5	5.1	0.03
N	538,992	175,532	217,738	114,264	31,458
Panel B. TUS-CPS sample, Y = Ever Smoked					
Teen Tax	-0.047***	-0.060***	-0.043*	0.094**	-0.019
	(0.014)	(0.013)	(0.025)	(0.042)	(0.083)
Mean of dependent variable	0.375	0.349	0.386	0.388	0.391
F-statistic	11.0	22.3	2.8	5.0	0.1
N	538,992	175,532	217,738	114,264	31,458
Panel C. BRFSS sample, Y = Ever Smoked					
Teen Tax	-0.031***	-0.036***	-0.049***	0.028	-0.030
	(0.008)	(0.008)	(0.015)	(0.035)	(0.045)
Mean of dependent variable	0.410	0.373	0.410	0.421	0.454
F-statistic	14.7	19.1	10.2	0.7	0.4
N	3,312,559	834,470	1,079,969	950,484	447,636
Panel D. PSID sample, Y = Teen Smoking, imputed youth state					
Teen Tax	-0.096***	-0.080**	-0.126***	0.205	-0.330
	(0.034)	(0.039)	(0.046)	(0.189)	(0.448)
Mean of dependent variable	0.405	0.412	0.395	0.399	0.441
F-statistic	7.9	4.2	7.5	1.2	0.5
N	50,299	14,068	18,391	12,973	4,863
Panel E. PSID sample, Y = Teen Smoking, actual youth state					
Teen Tax	-0.084***	-0.059**	-0.089**	-0.063	-0.155
	(0.027)	(0.028)	(0.038)	(0.090)	(0.125)
Mean of dependent variable	0.405	0.412	0.395	0.399	0.441
F-statistic	9.9	4.4	5.6	0.5	1.5
N	50,299	14,068	18,391	12,973	4,863

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: All respondents were at least 20 years of age. *Adult Smoking* is equal to 1 if *i* was a current smoker (and is equal to 0 otherwise). *Teen Smoking* is equal to 1 if *i* started smoking before reaching 20 years of age (and is equal to 0 otherwise). *Ever Smoked* is equal to 1 if *i* has smoked at least 100 cigarettes over lifetime (and is equal to 0 otherwise Controls include fixed effects for state, survey year, and birth year; indicators for gender, race, educational attainment; current and teen unemployment rates, current and teen minimum legal purchase age of tobacco, current and teen comprehensive smoking law. Standard errors corrected for clustering at state level are reported in parentheses

Appendix Table 2. Weighted Estimates by Age Group and Data Set

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sample	TUS-CPS	TUS-CPS	TUS-CPS	PSID	PSID	PSID	BRFSS	BRFSS	BRFSS
Ages	All	20s	30s	All	20s	30s	All	20s	30s
First stage									
Teen Tax	-0.045***	-0.052***	-0.047*	-0.085**	-0.044	-0.122**	-0.047***	-0.055***	-0.077**
	(0.015)	(0.014)	(0.028)	(0.041)	(0.035)	(0.055)	(0.013)	(0.013)	(0.030)
	<-0.113>	<-0.152>	<-0.102>	<-0.154>	<-0.101>	<-0.202>	<-0.087>	<-0.127>	<-0.126>
IV estimate									
Teen Smoking/Ever Smoked	0.410***	0.758***	0.493*	0.513*	0.433	0.233	0.400***	0.630***	0.353***
	(0.119)	(0.121)	(0.249)	(0.275)	(0.492)	(0.226)	(0.089)	(0.043)	(0.115)
tF Standard Error	[0.232]	[0.188]	.	[1.368]	.	[0.848]	[0.135]	[0.060]	[0.288]
Mean of dependent variable	0.227	0.237	0.232	0.232	0.263	0.225	0.235	0.252	0.234
F-statistic	8.7	13.2	2.9	4.3	1.6	5.0	13.5	17.1	6.5
N	533,094	173,866	216,216	33,386	10,513	11,813	3,312,559	834,470	1,079,969

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: All respondents were at least 20 years of age. *Adult Smoking* is equal to 1 if *i* was a current smoker (and is equal to 0 otherwise). *Teen Smoking* is equal to 1 if *i* started smoking before reaching 20 years of age (and is equal to 0 otherwise). *Ever Smoked* is used in the BRFSS analysis. *Ever Smoked* is equal to 1 if *i* has smoked at least 100 cigarettes over lifetime (and is equal to 0 otherwise). Controls include fixed effects for state, survey year, and birth year; indicators for gender, race, educational attainment; current and teen unemployment rates, current and teen minimum legal purchase age of tobacco, current and teen comprehensive smoking law. In the TUS-CPS, we use the current state of residence to impute state of residence as a teenager. In the PSID, we use the actual state of residence as a teenager. Robust standard errors are clustered at state level and are reported in parentheses. Elasticities are measured at the sample mean and in angled brackets. tF standard errors, calculated based on Lee, McCrary, Moreira, and Porter (2020), are reported in square brackets. tF standard errors are missing when first-stage F-statistic is less than 4. Standard errors corrected for clustering at state level are reported in parentheses.

Appendix Table 3. Defining Teenage as 12-18 by Age Group and Data Set

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sample	TUS-CPS	TUS-CPS	TUS-CPS	PSID	PSID	PSID	BRFSS	BRFSS	BRFSS
Ages	All	20s	30s	All	20s	30s	All	20s	30s
First stage									
Teen Tax	-0.040***	-0.051***	-0.026	-0.081***	-0.054**	-0.091**	-0.029***	-0.032***	-0.046***
	(0.013)	(0.011)	(0.024)	(0.025)	(0.026)	(0.037)	(0.007)	(0.008)	(0.014)
	<-0.099>	<-0.144>	<-0.058>	<-0.156>	<-0.129>	<-0.166>	<-0.050>	<-0.080>	<-0.073>
IV estimate									
Teen Smoking/Ever Smoked	0.484***	0.730***	0.547	0.467***	0.571**	0.286	0.176	0.523***	0.327**
	(0.131)	(0.088)	(0.458)	(0.158)	(0.256)	(0.190)	(0.149)	(0.072)	(0.123)
tF Standard Error	[0.235]	[0.113]	.	[0.274]	[1.272]	[0.527]	[0.217]	[0.098]	[0.212]
Mean of dependent variable	0.235	0.248	0.239	0.221	0.250	0.211	0.226	0.249	0.229
F-statistics of instrument	9.6	22.9	1.2	10.4	4.2	5.9	15.3	18.3	10.3
N	538,992	175,532	217,738	50,299	14,068	18,391	3,312,559	834,470	1,079,969

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: All respondents were at least 20 years of age. *Adult Smoking* is equal to 1 if *i* was a current smoker (and is equal to 0 otherwise). *Teen Smoking* is equal to 1 if *i* started smoking before reaching 20 years of age (and is equal to 0 otherwise). *Ever Smoked* is used in the BRFSS analysis. *Ever Smoked* is equal to 1 if *i* has smoked at least 100 cigarettes over lifetime (and is equal to 0 otherwise). Controls include fixed effects for state, survey year, and birth year; indicators for gender, race, educational attainment; current and teen unemployment rates, current and teen minimum legal purchase age of tobacco, current and teen comprehensive smoking law. In the TUS-CPS, we use the current state of residence to impute state of residence as a teenager. In the PSID, we use the actual state of residence as a teenager. Robust standard errors are clustered at state level and are reported in parentheses. Elasticities are measured at the sample mean and in angled brackets. tF standard errors, calculated based on Lee, McCrary, Moreira, and Porter (2020), are reported in square brackets. tF standard errors are missing when first-stage F-statistic is less than 4. Standard errors corrected for clustering at state level are reported in parentheses.

Appendix Table 4. Controlling for Lagged Adult Tax by Age Group and Data Set

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sample	TUS-CPS	TUS-CPS	TUS-CPS	PSID	PSID	PSID	BRFSS	BRFSS	BRFSS
Ages	All	20s	30s	All	20s	30s	All	20s	30s
First stage									
Teen Tax	-0.046***	-0.059***	-0.028	-0.084***	-0.057**	-0.089**	-0.029***	-0.030***	-0.044***
	(0.014)	(0.012)	(0.027)	(0.027)	(0.028)	(0.038)	(0.008)	(0.008)	(0.015)
	<-0.105>	<-0.152>	<-0.058>	<-0.164>	<-0.138>	<-0.164>	<-0.051>	<-0.075>	<-0.072>
IV estimate									
Teen Smoking/Ever Smoked	0.444***	0.703***	0.620	0.471***	0.505*	0.316*	0.153	0.501***	0.311**
	(0.126)	(0.098)	(0.478)	(0.159)	(0.273)	(0.182)	(0.166)	(0.086)	(0.137)
tF Standard Error	[0.217]	[0.126]	.	[0.284]	[2.599]	[0.506]	[0.256]	[0.131]	[0.266]
Mean of dependent variable	0.235	0.248	0.239	0.221	0.250	0.211	0.226	0.249	0.229
F-statistics of instrument	10.3	22.9	1.1	9.9	4.1	5.6	13.2	13.7	8.3
N	538,992	175,532	217,738	50,299	14,068	18,391	3,312,559	834,470	1,079,969

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: All respondents were at least 20 years of age. *Adult Smoking* is equal to 1 if *i* was a current smoker (and is equal to 0 otherwise). *Teen Smoking* is equal to 1 if *i* started smoking before reaching 20 years of age (and is equal to 0 otherwise). *Ever Smoked* is used in the BRFSS analysis. *Ever Smoked* is equal to 1 if *i* has smoked at least 100 cigarettes over lifetime (and is equal to 0 otherwise). Controls include the average tax rate over the last years; fixed effects for state, survey year, and birth year; indicators for gender, race, educational attainment; current and teen unemployment rates, current and teen minimum legal purchase age of tobacco, current and teen comprehensive smoking law. In the TUS-CPS, we use the current state of residence to impute state of residence as a teenager. In the PSID, we use the actual state of residence as a teenager. Robust standard errors are clustered at state level and are reported in parentheses. Elasticities are measured at the sample mean and in angled brackets. tF standard errors, calculated based on Lee, McCrary, Moreira, and Porter (2020), are reported in square brackets. tF standard errors are missing when first-stage F-statistic is less than 4. Standard errors corrected for clustering at state level are reported in parentheses.