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TOBACCO USE, TAXATION AND SELF CONTROL IN ADOLESCENCE

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ABSTRACT

Recent literature has suggested that higher taxes on addictive goods could increase welfare by assisting individuals with self control problems and trouble resisting 'temptation'. In contrast, if individuals continue to use despite increased prices, taxation may serve to reduce the welfare of these individuals while providing no benefits in managing self control nor mitigating externalities. We use data on adolescents from the National Longitudinal Study of Adolescent Health (Add Health) to examine the impact of tobacco taxes on smoking. To account for unobserved heterogeneity in response to taxes we estimate finite mixture models, positing two types of individuals with differential responses to taxes. We find evidence of differential price elasticity for tobacco use across the adolescents groups, and show that individuals with low self control or high discount rates are largely unresponsive to cigarette price. Those who have the least willpower may need the most help in quitting but are unresponsive to taxes, suggesting that policies other than taxation may be needed to reduce adolescent tobacco use.

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Introduction

Tobacco use is one of the leading causes of mortality and morbidy, including an estimated 400,000 annual deaths attributed to smoking and over 8.5 million Americans who live with a serious disease caused by tobacco use (Giovino 2007). A typical economic policy prescription to reduce tobacco use is to increase cigarette prices. While there has generally been strong evidence of behavioral responses to cigarette prices, recent research suggests more nuanced results for many types of addictive goods. For example, for adult alcohol use, Manning et al. (1995) show that heavy drinkers and light drinkers are less price sensitive than moderate drinkers. Ayyagari et al. (2009) also show that light drinkers have an elastic demand for alcohol while heavier drinkers are unresponsive to taxes for older aged individuals, suggesting an important deadweight loss. For tobacco use, authors have found lower responses for the poor (Farrelly and Bray 1998), girls (Lewit et al. 1997), women (Chaloupka and Warner 2001), whites teens (DeCicca et al. 2000) and younger teens (Gruber 2000). There is considerable evidence that the elasticity of smoking participation is larger for youth than adults (Glied 2003, Farrelly and Bray 1998). However, DeCicca et al. (2002) present evidence of a small role for price in youth smoking initiation.

These papers relate to an emerging literature that extends earlier models of rational addiction to incorporate ideas of self control and cue-triggered behaviors. Importantly, these new models that focus on the demand for addictive goods lead to stark differences in policy prescriptions. Models focusing on time-inconsistency, where current and future-selves make different "optimal" consumption choices, often clearly suggest that there are welfare benefits of increasing "sin taxes," which can be used as a method of reducing the problems of self control (Gruber and Koszegi 2001, 2004). In particular, Gruber and Koszegi (2001) suggest that the intrapersonal externalities ("internalities") associated with smoking may be 100 times the costs of the externalities. In contrast, recent theoretical work by Bernheim and Rangel (2004 and 2006) posits an important role of cue-triggered use of addictive goods, and "hot' and "cold" states leading to consumption implies that taxes on these goods may not result in behavioral change and are likely to be welfare reducing.[1] Further, Bernheim and Rangel posit two

[1] See Viscusi (2002-3) for a critique of this line of research.

types of consumption, rational and irrational consumption driven by cues. Gul and Pesendorfer (2004) also offer a behavioral economics model of addiction focusing on the temptation and inability to resist. They also conclude that taxes on addictive goods can harm welfare.

In this paper, we use finite mixture models to examine whether there is evidence of differential cigarette tax elasticities using a national sample of adolescents. We find evidence of a large group of adolescents who are sensitive, but a smaller group who are largely unresponsive. We then show evidence that measures of self control and discount horizons available in the data are strongly related to membership in the "unresponsive" group. Additionally we control for family fixed effects and show the relationships to be qualitatively similar—siblings with low self control or high discounting are more likely to be unresponsive to tobacco prices than their sister or brother. These results suggest that, for teenagers, taxation alone is unlikely to lead to substantial reductions in tobacco use. Further, the results are consistent with the cue-triggered theories of addiction suggesting that additional policies selected might best be based on this model. While we cannot test the validity of the alternative underlying models, we provide some provocative evidence consistent with behavioral economic models on self-control.

We add to the literature in several dimensions. Most importantly we provide evidence relevant to the efficiency of cigarette taxation as applied to youths. We extend the empirical literature to the assessment of the relevance of behavioral economics models that focus on self control problems as a contributing factor in tobacco consumptions by youths tempted to smoke. Use of the finite mixture model allows us to examine the roles of self control and discount in delineating the two latent groups.

Background Literature

An extensive literature has contributed to our understanding of the demand for addictive goods. By the 1980s, the principal focus of this literature was on models of habit formation, where current consumption is predicted to be a function of past consumption choices (Gruber and Koszegi 2001; see Chaloupka and Warner 2001 for a review). Becker and Murphy (1988) shifted the focus towards notions of "rational addiction," where individuals are assumed to recognize the long run tradeoffs between

current consumption and future consumption due to increases in the stock of the addictive good and make rational decisions on consumption levels of addictive goods. Empirical tests of the Becker-Murphy framework have often been positive, but these tests are often difficult to interpret (Gruber and Koszegi 2000). Falsification tests have cast doubt on the rational addiction models (Auld and Grootendorst 2004).

More recently, researchers have developed models that build on rational choice but incorporate "mistakes" of some kind into the determinants of consuming addictive goods. Gruber and Koszegi (2001) extend the literature by allowing individuals to have time-inconsistent preferences. The authors suggest two key features of time-inconsistent individuals: (1) inability to achieve desired future levels of smoking due to a present bias and (2) the use of commitment devices or self-control techniques to overcome this problem. Lack of will power or self control may be particularly relevant for adolescents. For example, 56% of high school seniors who smoke contend that they will not still be smoking in five years but only 31% end up quitting in that time frame (US Department of Health and Human Resources, 1994). Additional suggestive evidence of time-inconsistent behavior is the large number of attempted quits—38 of the 46 million smokers in 1993 had attempted to quit (Harris 1993). An alternative direction in models of the demand for addictive goods is from Bernheim and Rangel (2004), who, instead of time-consistency, focus on "hot" and "cold" states and cue-triggers that lead to consuming addictive goods. As stated above, Gul and Pesendorfer focus on temptation.

Distinctions between the causes of addictive consumption have been shown to have important implications with regard to tax policy. Gruber and Koszegi (2001) and O'Donahue and Rabin (2006) each suggest that taxes could act as a self-control device for smokers; those who are sophisticated about their self control problems and responsive to prices would support higher taxes. Indeed, Gruber and Koszegi suggest the optimal tax on cigarettes is likely at least 50 percent higher than existing tax rates and may be as high as $30 per pack.[2] [3] In subsequent analysis, Gruber and Koszegi (2004) show evidence

[2] The authors also provide a rationale for "overregulating" youth smoking. In their working paper, Gruber and Koszegi (2000) note that for individuals who are naïve about their self control problems, an even higher tax may be warranted because it could assist the self-control problem and a "misperception problem", where the misperception is whether the individual will become addicted with use of the good. The authors therefore recommend a "cautious paternalism" for individuals who know they have self control

that taxes on cigarettes may be either progressive or regressive depending on whether low income individuals have small short term discount factors (less regressive) or lower long term discount factor (more regressive).[4] Hersh (2005) too finds that smokers desire taxes as a precommitment device.

Alternatively, Bernheim and Rangel (2004, 2006) argue that, for some addictive goods, consumption decisions are driven by a visceral motivation—a short circuiting of the rational decision making process, which implies little or no price sensitivity for these decisions. To the extent that the cue based scenario is underlying demand, sin taxes may not be optimal but rather would be regressive. Bernheim and Rangel (2004) suggest that a *subsidy* on addictive goods could be welfare improving if consumption tends to be "spur of the moment" but where the intention to consume the good becomes increasingly important as the stock of the addictive good increases. Taxation may be beneficial for inexpensive addictive goods that individuals regularly use and where individuals typically attempt to quit after cue triggers are established. This would describe smoking-small repeated purchases with a majority of smokers wishing that they could quit. Gul and Pesendorfer (2004) also conclude, based on a model of temptation and addiction, that taxes on addictive goods can harm welfare[5].

The impact of sin taxes on the population of youths depends not only on the underlying model of demand, but also on the responsiveness of demand to taxes. If much of the population is responsive to taxes and there are important externalities or internalities, then welfare could be enhanced by increasing taxes. However, if a significant proportion is unresponsive, the welfare gains would be mitigated. Heterogeneity in self control of individuals may account for potential differences in responsiveness to taxes. For some, self control may be least available in 'hot' states

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problems and a "short leashed" policy for those who do not know they have a self control problem. An underlying assumption, though, is that naifs respond to price similarly to other individuals.

[3] O'Donahue and Rabin (2006, p 1835) caveat their analysis by stating that if people with self-control problems do not respond to tax increases, then a sin tax would merely redistribute income away from these individuals without any corresponding benefits.

[4] Gruber and Koszegi (2004) show that individuals in the lowest income quartiles are most sensitive to cigarette prices (-1.1) and those in the highest quartile are least sensitive (-.0.38). They also find differences by consumption quartiles and education groups, with higher elasticities for low consumption and education groups.

[5] Other areas of ongoing related research include psychologists that are making strides in teaching self control (Muraven and Baumeister 2000, Mischel and Mischel, 1983, Mischel et al. 1996).

motivated by cues to desire to smoke. We suggest that heterogeneity in demand extends beyond simple differences in addiction to include differences in self control as well.

The behavioral economics literature has opened up opportunities to consider taxation not only as a mechanism to raise revenue and target externalities, but also to help people who want help controlling their consumption of addictive goods. Behavioral economics literature on 'asymmetric paternalism' (Cameron et al, 2003) 'optimal paternalism (O'Donaghue and Rabin (2003) and others (Bernheim et al 2005) has opened the way for economists to consider self-control issues in discussions of optimal tax policy. Applications of these concepts to youths may not be as controversial as when applied to adults as there is a common belief, and evidence (see above), that youths are not yet able to perfectly assess and balance short run gains versus long run costs.

In this paper, we build on the behavioral economics literature on addiction to conduct empirical analyses of adolescents to examine whether there are "types" of adolescents who differentially respond to cigarettes taxes. We then attempt to tie these "types" with individual characteristics such as self control and time preference in assessing whether cigarette taxation curbs self control problems or whether taxation is simply acting as a fee on individuals prone to "visceral decisions"[6].

Data Description

The data for this study come from the confidential version of the National Longitudinal Study of Adolescent Health (Add Health). Add Health is a school-based, longitudinal study of the health-related behaviors of adolescents and their outcomes in young adulthood. Beginning with an in-school questionnaire administered to a nationally representative sample of students in grades 7 through 12 in 1994-95, the study follows up with a series of in-home interviews of students approximately one year and then six years later. Other sources of data include questionnaires for parents, siblings, fellow students, and school administrators. By design, the Add Health survey included a sample stratified

[6] It should be stressed that the differentiation of individuals into "types" is based on low-dimensional, latent factors. We are able to provide evidence of some of the complex characteristics of the factors but cannot provide a complete characterization. Similarly, in describing the latent groups, we can use key words, but cannot completely characterize the complex groups. We will use key words as a descriptive necessity.

by region, urbanicity, school type, ethnic mix, and size. Preexisting databases (e.g. census data) have been linked with the individuals in the sample and provide information about neighborhoods and communities.[7]

We use the first wave of data because cigarette taxes have been appended at the state level only to this wave and to focus on adolescents. For our tobacco use measure, we use the answer to the following question: "During the past 30 days, on the days you smoked, how many cigarettes did you smoke each day? The tax measure that is included in the first wave of data is the state-level excise tax on cigarettes (per pack, in cents) in 1995. Full descriptive statistics are presented in Table 1.

We follow DeCicca et al. (2002) and other authors by using a standard set of control variables in our analysis, including age, gender, race, family income, parental education and employment, family structure, religiosity, and urban/rural status. In Appendix Table 1A, we present descriptive statistics for the sibling sample used later in the analysis. While there are several statistically significant differences in the descriptive statistics between the full and the sibling sample, few differences are large in magnitude.

We estimate the posterior odds of group ("type") composition as a function of a set of socio-economic variables as well as the proxies for self-control and individual's discount rate. For our measure of self control, we follow Nagin and Pogarsky (2004) and use the answer to, "When making decisions, you usually go with your gut feeling without thinking too much about the consequences of each alternative." This question proxies for impulsivity, which psychologists posit is akin to self-control or will power. The answers include five categories from "strongly agree" through "strongly disagree" (the neutral response is the omitted category). For our proxy measure of discounting the future[8], we again follow Nagin and Pogarsky (2004) and use the answer to, "What do you think are the chances that you will live to age 35?" The answers include five categories: "almost no chance" "some chance, but probably not" "50-50 chance" "good chance" and "almost certain" (the omitted category). The distributions of these measures are also presented in Table 1.

Empirical Models

[7] See Harris (2008) for full description of the Add Health data set.
[8] While this measure is likely useful to characterize time preference/discounting due to uncertainty over future mortality, we lack a measure of present bias.

We begin our empirical analysis by estimating the relationship between cigarette taxes at the state level and cigarette consumption. Specifically, we estimate several baseline specifications, including OLS, Poisson, and negative binomial regressions, to examine the tax response where the number of cigarettes consumed is the outcome of interest and we situate individuals (*i*) in schools (*s*) in states (*g*)[9]:

$$cigarettes_{isg} = \alpha \log(tax)_g + X_{is}\beta + \varepsilon_{isg} \quad (1)$$

Next, we examine whether there is evidence for differential price responses by using finite mixture models. Finite mixture models have received increasing attention in the statistics literature mainly because of the number of areas in which such distributions are encountered (see McLachlan and Peel, 2000, and Lindsay, 1995, for numerous applications and descriptions of statistical properties). Econometric applications of finite mixture models include the seminal work of Heckman and Singer (1984) to labor economics, Wedel, et al. (1993) to marketing data, El-Gamal and Grether (1995) to data from experiments in decision making under uncertainty, and Deb and Trivedi (1997, 2002) to the economics of healthcare.

Although, OLS and Poisson regressions can be used to model differential price responses by observed covariates, they cannot identify differential responses by unobserved characteristics. In the case of cigarette smoking, it is plausible to believe that adolescents can be categorized into "types" on the basis of their level of self control, discount rates and related decision-making characteristics. Further, it is reasonable to analyze whether responses to prices vary by these unobserved types. In the finite mixture model, the random variable *y* is postulated as a draw from a population which is an additive mixture of C distinct classes or subpopulations in proportions π_j such that

$$g(y_i \mid \boldsymbol{\theta}) = \sum_{j=1}^{C} \pi_j f_j(y_i \mid \boldsymbol{\theta}_j), \quad 0 \le \pi_j \le 1, \quad \sum_{j=1}^{C} \pi_j = 1. \quad (3)$$

where the j^{th} density $f_j(y_i \mid \boldsymbol{\theta}_j), j = 1,...,C$ is specified as a negative binomial density (see Deb and Trivedi 1997, for the formula for the density) and $\boldsymbol{\theta}_j$ is the associated set of parameters. The conditional mean for each component is specified as

[9] In our analyses, robust standard errors, clustered at the state-level, are reported.

$$E(cigarettes_{isg} \mid j) = \exp(\alpha_j \log(tax)_g + X_{is}\beta_j) . \quad (4)$$

The finite mixture models are estimated using maximum likelihood. Inference is based on cluster-corrected robust standard errors.

We use our finite mixture parameter estimates to calculate the posterior probability of being in each of the latent classes. Although the models assume that the prior (unconditional) probability of class membership is constant across observations, we can use Bayes Theorem to calculate the posterior probability of membership in each class, conditional on all (both time invariant and variant) observed covariates and outcome, as

$$\Pr(y_i \in k \mid \boldsymbol{\theta}, y_i) = \frac{f_k(y_i \mid \boldsymbol{\theta}_k)}{\sum_{j=1}^{C} \pi_j f_j(y_i \mid \boldsymbol{\theta}_j)}, \forall k = 1, 2, ..., C. \quad (6)$$

Thus, the posterior probability varies across observations. We use the estimated posterior probabilities to explore the determinants of class membership ("type").

While we believe that finite mixture models are a natural way to examine our research question, two potentially attractive alternative econometric strategies are worth discussing: the use of quantile regression methods to examine heterogeneous responses, and the use of two-part models to deal with the large fraction of zeros (current non-smokers). As discussed above, quantile regressions have been used in similar contexts to study heterogeneous responses to treatments, however they have two limitations vis-à-vis finite mixture models. First, quantile regressions are not well behaved in the context of count data. Second, although quantile regression methods may detect heterogeneous responses, they provide no way to characterize the source of the heterogeneity. Whereas in our application of FMM, we can provide suggestive evidence of the observable characteristics of the different "types" of individuals who respond differentially to cigarette taxes.

Two-part models are ubiquitous in the health economics literature and are often used in order to deal with potential heterogeneity between users and non-users when the distribution of the outcome includes a substantial fraction of zeros. Although our data include a substantial fraction of zeros, the two-part model is less attractive than the finite mixture for two reasons. First, the two-part model may be thought of as a special case of the finite mixture model in which one of the components has a degenerate distribution at

zero. Second, if some adolescents are occasional smokers who go back and forth between not smoking and light smoking, the distinction between use and non-use may be less attractive than the distinction between low and high use, which is the distinction that the finite mixture model makes.[10]

Results

Following the standard approach in the literature, the first set of estimates of the tax elasticity are all single equation specifications. Results are displayed for OLS, Poisson and Negative Binomial estimation methods. The OLS results shown in column 1 of table 2 suggest that a 100% tax increase would reduce the number of cigarettes by 0.19 per day. Recall the mean number of cigarettes smoked is 1.7 per day. Other results in column one table 2 are consistent with prior literature—black and Hispanic students smoke fewer cigarettes than white students. Males smoke more than females, and students from more advantaged families (higher family income and mother's education; married parents) smoke fewer cigarettes.

Next, since our outcome is a count variable, we estimate a Poisson specification in column 2 and negative binomial specifications in column 3 to better fit the large number of individuals who do not smoke (approximately 75%)—the latter specification can better handle overdispersion found in the outcome measure. Model selection criteria show the superiority of the negative binomial specification over the Poisson. We find results similar to those obtained using OLS, although a 100% tax increase reduces the number of cigarettes by 0.09 cigarettes per day in the Poisson results and a reduction of 0.11 cigarettes per day in the negative binomial results. Covariates in these latter two sets of estimates have similar effects to that of the OLS. Overall, our baseline results are consistent with prior literature, but like much previous research, these results do not consider the possibility of differential price responses based on adolescent "types".

In our next set of results shown in Table 3, we examine whether there is evidence for differential price responses to taxes by using finite mixture models. Our results suggest the presence of two "types" or latent classes of adolescents. We present results

[10] DeCicca, Kenkel, and Mathios (2008) also point out that in most applications of two-part models of tobacco use, researchers examine current participation as a function of current price; however current participation reflects a series of past decisions and is likely be more appropriately linked to past prices.

for two mixture models, a specification that uses a poisson distribution and a specification that uses a negative binomial distribution. Bayesian information criterion results suggest that the negative binomial model is preferred[11]. In particular the negative binomial model shows evidence for differential responses to cigarette prices—a large class of adolescents (over 85%) are light smokers, with 0.29 cigarettes smoked per day, and react to a 100% increase in taxes by reducing consumption by nearly 0.2 cigarettes. For the second "type" of adolescents, who are relatively heavy smokers (over 5 cigarettes per day), the effect of the cigarette tax is to reduce consumption by less than 1/3 the amount of the first "types". Thus, our results strongly suggest two "types" of adolescents who have quite different responses to one prominent public policy aimed at reducing tobacco use by youths.

Our next goal is to provide suggestive evidence regarding which attributes separate adolescents into types, with a particular focus on self control and time preference. In Table 4, we use OLS specifications to examine the determinants of being classified as the second, "unresponsive type" seen in Table 3. In column 1, we non-parametrically include our proxy measure of self control—the degree of making decisions by "going with your gut." Individuals who neither agree nor disagree with this question are the omitted group. The results suggest a strong positive relationship between this measure of self-control and being allocated to component 2—individuals with lower self control seems to be unresponsive to cigarette taxes. Similarly, coefficients on the proxy for time preference—the respondent's prediction of surviving to age 35— suggest that individuals who do not expect to live past 35 are less likely to respond to cigarette taxes when deciding their cigarette consumption. These results are displayed in column 2. In column 3, we enter both the self control and time preference proxies and confirm both that low self control and high discount rate result in being classified in the "unresponsive group." The results are robust. Since we have shown that the "unresponsive type" of adolescent are also relatively heavy smokers, in column 4, we

[11] We also estimated models that allowed for a third "type" in the mixture models. The results for the poisson specification are presented in the appendix. The BIC suggests that the three-component poisson model is preferred to the two-component model in Table 3. However, the two-component negative binomial model is preferred to both poisson models. Finally, we attempted to estimated three-component negative binomial models, but these specifications failed to converge. Model comparisons are also presented in Table 2A in the appendix

also control for cigarette use and show that the magnitude of the results are reduced somewhat for our self control and time preference measures, although the results are qualitatively similar and still significant. These results suggest that self control and time preference do not purely operate through heavy tobacco use. This implies that while the degree of addiction could account for part of the delineation into groups, it is only one of several factors.

In columns 5 and 6 of Table 4, we re-estimate the specification in column 3 but limit the sample to siblings and twins in the data. Although the siblings and twins sample is smaller, comparing column 3 and column 5, the results suggest that moving to the sibling sample does not alter the associations shown in the full sample. Finally, in column 6 we estimate specifications with family fixed effects in order to control shared family background in terms of nurture and nature, including 50% or more of genetic endowments. Even with these additional controls, we find, within-families, that the sibling who has lower self control is less responsive to prices when making cigarette consumption decisions than their brother or sister with higher self control. The results for the time preference variable are also qualitatively similar within sibling pairs but are insignificant.[12]

Discussion and Conclusions

We add to the literature in several dimensions. Most importantly we provide evidence relevant to the efficiency of tobacco taxation as applied to youths. We extend the empirical literature on taxation to behavioral economics models and factors such as self control. In particular we find that self control proxies are contributing factors in tobacco consumption by youths tempted to smoke. Access to a nationally representative sample with psychological measures and use of the finite mixture model allows us to examine the roles of self control and discount in delineating the two latent groups.

Despite the strengths of this paper, there are, of course, limitations. Key among them may be our inability to measure what physiologists mean to capture by self control, will power or impulsivity. We are constrained by the measures available in Add Health.

[12] We show in the appendix similar results for the two-component poisson model.

None-the-less, we believe that this examination of these concepts paves the way for future studies that better capture the concept of lack of will power.

Our results using finite mixture models suggest that there is a large group of adolescents who are sensitive to price, but a smaller group who are largely unresponsive to increased prices. We then show that proxy measures of self control and discounting are strongly related to membership in the "unresponsive" group. Our results are qualitatively robust across specification, including controlling for family fixed effects. Even given a shared upbringing, siblings with low self control or high discounting are more likely to be unresponsive to tobacco prices than their sister or brother. These results suggest, for teenagers, that taxation alone is unlikely to lead to substantial reductions in tobacco. Further, the results are consistent with the cue-triggered theories of addiction and a role for self control.

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Tables

Table 1
Descriptive Statistics: Full Sample
Add Health Wave 1

Variable	Obs	Mean	Std Dev	Min	Max
Number of Cigarettes	20619	1.71	5.03	0	95
Cigarette Tax	20497	32.88	16.24	2.5	75
Vending Machine Ban	20497	0.84	0.36	0	1
Age	20602	16.15	1.74	12	21
Male	20619	0.49	0.50	0	1
Black	20619	0.23	0.42	0	1
Hispanic	20619	0.17	0.38	0	1
Family Income ($10,000s)	20619	45.15	39.23	0	990
Maternal Education	20619	13.16	2.25	0	17
Married Parents	20619	0.70	0.42	0	1
Mom Smoke	20619	0.47	0.48	0	1
Number of Siblings	20619	1.63	1.48	0	14
Parent Works	20619	0.73	0.41	0	1
Religious Attendance (Times/year)	20619	24.53	20.92	0	50
Urban Status	20619	0.35	0.47	0	1
Rural Status	20619	0.24	0.43	0	1
Missing Family Information	20619	0.35	0.48	0	1
Impulsivity Scale	20437	3.00	1.13	1	5
Go with Gut: Strongly Disagree	20437	0.07	0.26	0	1
Go with Gut: Disagree	20437	0.33	0.47	0	1
Go with Gut: Neither	20437	0.21	0.41	0	1
Go with Gut: Agree	20437	0.29	0.46	0	1
Go with Gut: Strongly Agree	20437	0.09	0.29	0	1
Discount Rate Scale	20468	4.34	0.88	1	5
Almost No Chance Live to Age 35	20468	0.01	0.12	0	1
Some Chance Live to Age 35	20468	0.02	0.15	0	1
50-50 Chance Live to Age 35	20468	0.11	0.32	0	1
A Good Chance Live to Age 35	20468	0.31	0.46	0	1
Almost Certain Live to Age 35	20468	0.54	0.50	0	1

Table 2
Baseline Estimates for Price Response to Cigarette Taxes for Adolescents

Outcome Specification	Number of Cigarettes OLS	Number of Cigarettes Poisson	Number of Cigarettes Negative Binomial
Log (Cigarette Tax)	-0.189**	-0.090**	-0.111**
	(0.076)	(0.039)	(0.045)
Age	0.385***	0.245***	0.287***
	(0.048)	(0.009)	(0.015)
Male	0.278***	0.168***	0.248***
	(0.079)	(0.054)	(0.056)
Black	-1.793***	-1.590***	-1.590***
	(0.169)	(0.080)	(0.106)
Hispanic	-1.282***	-0.816***	-0.689***
	(0.220)	(0.129)	(0.125)
Family Income	-0.003***	-0.002***	-0.001**
	(0.001)	(0.001)	(0.001)
Maternal Education	-0.056**	-0.036**	-0.028
	(0.025)	(0.014)	(0.018)
Mom Smoke	0.903***	0.552***	0.571***
	(0.102)	(0.040)	(0.048)
Married Parents	-0.393***	-0.227***	-0.273***
	(0.098)	(0.046)	(0.059)
Number of Siblings	-0.051**	-0.028*	-0.042**
	(0.022)	(0.016)	(0.017)
Parent Works	0.092	0.054	-0.001
	(0.094)	(0.055)	(0.063)
Religious Attendance	-0.024***	-0.016***	-0.017***
	(0.003)	(0.001)	(0.001)
Urban	0.014	0.009	0.064
	(0.111)	(0.072)	(0.092)
Rural	0.153	0.074	0.048
	(0.131)	(0.067)	(0.071)
Missing Information Dummy	0.186	0.116**	0.069
	(0.116)	(0.059)	(0.069)
Constant	-2.186***	-2.325***	-3.045***
	(0.582)	(0.277)	(0.296)
Observations	20479	20479	20479
		.	.

***1%, **5%, *10%, Robust standard errors clustered at the school level

Table 3
Differential Responses to Cigarette Taxes
Evidence Using Finite Mixture Models

Outcome	Number of Cigarettes	Number of Cigarettes	Number of Cigarettes	Number of Cigarettes
Specification	FMM	FMM	FMM	FMM
Component	First	Second	First	Second
Distribution	Poisson	Poisson	Negative Binomial	Negative Binomial
Proportion of Component	0.86	0.14	0.87	0.13
Mean of Number Cigarettes	0.16	7.94	0.29	5.8
Log (Cigarette Tax)	-0.128*	-0.055	-0.185**	-0.057
	(0.071)	(0.037)	(0.080)	(0.041)
Age	0.175***	0.099***	0.409***	0.184***
	(0.023)	(0.015)	(0.026)	(0.026)
Male	-0.038	0.205***	-0.022	0.326***
	(0.112)	(0.052)	(0.122)	(0.056)
Black	-1.515***	-0.712***	-2.941***	-1.057***
	(0.162)	(0.107)	(0.287)	(0.145)
Hispanic	-0.695**	-0.362***	-1.378**	-0.392***
	(0.274)	(0.057)	(0.564)	(0.081)
Family Income	0.000	-0.001**	-0.002	-0.002**
	(0.001)	(0.000)	(0.001)	(0.001)
Maternal Education	-0.012	-0.013	-0.059*	-0.016
	(0.018)	(0.013)	(0.031)	(0.020)
Mom Smkoe	0.637***	0.206***	1.200***	0.176
	(0.105)	(0.052)	(0.107)	(0.112)
Married Parents	-0.157*	-0.065	-0.376***	-0.174***
	(0.094)	(0.043)	(0.117)	(0.064)
Number of Siblings	0.000	-0.011	-0.009	-0.041
	(0.027)	(0.015)	(0.035)	(0.025)
Parent Works	0.107	-0.025	0.166	-0.068
	(0.114)	(0.041)	(0.112)	(0.070)
Religious Attendance	-0.015***	-0.008***	-0.028***	-0.009***
	(0.002)	(0.001)	(0.004)	(0.002)
Urban	0.017	0.008	-0.016	0.084
	(0.146)	(0.064)	(0.115)	(0.117)
Rural	0.142	0.044	0.129	-0.006
	(0.131)	(0.060)	(0.107)	(0.076)
Missing Information Dummy	0.095	0.064	0.203**	0.034
	(0.102)	(0.053)	(0.097)	(0.077)
Constant	-3.549***	1.135***	-5.258***	-0.236
	(0.600)	(0.385)	(0.617)	(0.522)
Observations	20479	20479	20479	20479
P-value of difference	0.079		0.174	

***1%, **5%, *10%, Robust standard errors clustered at the school level

Table 4
Determinants of Membership in the "Low-Price Response" Group

Outcome	Component 2	Component 2	Component 2	Component 2	Component 2	Component 2
FMM	Neg Bin	Neg Bin	Neg Bin	Neg Bin	Neg Bin	Neg Bin
Specification	OLS	OLS	OLS	OLS	OLS	OLS
Sample	Full	Full	Full	Full	Family	Family
Fixed Effects	None	None	None	None	None	Family
Go with Gut: Strongly Disagree	-0.066***		-0.060***	-0.039***	-0.083***	-0.059*
	(0.011)		(0.011)	(0.006)	(0.021)	(0.034)
Go with Gut: Disagree	-0.036***		-0.032***	-0.016***	-0.037*	-0.032
	(0.006)		(0.007)	(0.005)	(0.021)	(0.023)
Go with Gut: Agree	0.053***		0.053***	0.025***	0.051**	0.001
	(0.006)		(0.006)	(0.005)	(0.023)	(0.023)
Go with Gut: Strongly Agree	0.087***		0.086***	0.025***	0.089***	0.018
	(0.011)		(0.010)	(0.007)	(0.032)	(0.034)
Almost No Chance Live to Age 35		0.070***	0.056**	0.009	0.090	0.018
		(0.024)	(0.022)	(0.015)	(0.055)	(0.066)
Some Chance Live to Age 35		0.121***	0.110***	0.045***	0.120***	0.056
		(0.020)	(0.020)	(0.015)	(0.044)	(0.045)
50-50 Chance Live to Age 35		0.092***	0.083***	0.028***	0.068***	0.041
		(0.009)	(0.009)	(0.006)	(0.020)	(0.027)
A Good Chance Live to Age 35		0.037***	0.035***	0.018***	0.036**	0.019
		(0.008)	(0.007)	(0.005)	(0.014)	(0.018)
Number of Cigarettes				0.073***		0.066***
				(0.003)		(0.003)
Age	0.026***	0.022***	0.024***	0.000	0.022***	-0.004
	(0.003)	(0.003)	(0.003)	(0.001)	(0.003)	(0.005)
Male	-0.027**	-0.022*	-0.029**	-0.031***	-0.020	-0.023
	(0.011)	(0.011)	(0.011)	(0.008)	(0.017)	(0.018)
Black	-0.150***	-0.157***	-0.160***	-0.044***	-0.162***	
	(0.010)	(0.011)	(0.011)	(0.007)	(0.019)	
Hispanic	-0.077***	-0.084***	-0.083***	-0.000	-0.063**	
	(0.022)	(0.024)	(0.023)	(0.013)	(0.024)	
Maternal Education	-0.001	-0.002	-0.000	0.002*	-0.000	
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	
Mom Smoke	0.079***	0.082***	0.079***	0.027***	0.088***	
	(0.006)	(0.006)	(0.006)	(0.006)	(0.014)	
Married Parents	-0.024**	-0.022**	-0.021**	0.001	-0.017	
	(0.009)	(0.009)	(0.009)	(0.006)	(0.016)	
Parent Works	0.016*	0.017*	0.018**	0.009*	0.015	
	(0.008)	(0.009)	(0.008)	(0.005)	(0.012)	
Religious Attendance	-0.002***	-0.002***	-0.002***	-0.000*	-0.002***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Observations	20138	20168	20058	20058	5295	5295
R-squared	0.070	0.063	0.075	0.471	0.082	0.771

***1%, **5%, *10%, Robust standard errors clustered at the school level . Additional Controls: Number of Siblings, Family Income, Urban Status, Rural Status, Missing Information Dummy, Constant

Appendix Tables

Table 1A
Descriptive Statistics: Family Sample
Add Health Wave 1

Variable	Obs	Mean	Std Dev	Min	Max	Difference
Number of Cigarettes	5439	1.76	5.18	0	95	
Cigarette Tax	5408	32.21	16.49	3	75	***
Vending Machine Ban	5408	0.84	0.36	0	1	
Age	5435	16.07	1.75	12	21	***
Male	5439	0.50	0.50	0	1	
Black	5439	0.25	0.43	0	1	***
Hispanic	5439	0.15	0.36	0	1	***
Family Income ($10,000s)	5439	43.80	36.39	0	800	***
Maternal Education	5439	13.10	2.21	0	17	**
Married Parents	5439	0.69	0.43	0	1	**
Mom Smoke	5439	0.48	0.48	0	1	
Number of Siblings	5439	1.91	1.59	0	13	***
Parent Works	5439	0.72	0.42	0	1	**
Religious Attendance	5439	24.80	21.13	0	50	
Urban Status	5439	0.34	0.47	0	1	*
Rural Status	5439	0.26	0.44	0	1	***
Missing Family Information	5439	0.33	0.47	0	1	*
Impulsivity Scale	5393	3.05	1.13	1	5	***
Go with Gut: Strongly Disagree	5393	0.06	0.24	0	1	
Go with Gut: Disagree	5393	0.33	0.47	0	1	
Go with Gut: Neither	5393	0.20	0.40	0	1	
Go with Gut: Agree	5393	0.31	0.46	0	1	
Go with Gut: Strongly Agree	5393	0.09	0.29	0	1	
Discount Rate Scale	5412	4.30	0.90	1	5	
Almost No Chance Live to Age 35	5412	0.02	0.13	0	1	
Some Chance Live to Age 35	5412	0.03	0.16	0	1	
50-50 Chance Live to Age 35	5412	0.12	0.32	0	1	
A Good Chance Live to Age 35	5412	0.31	0.46	0	1	
Almost Certain Live to Age 35	5412	0.53	0.50	0	1	

Final Column Tests for Differences with the Full Sample from Table 1
***1%, **5%, *10%

Table 2A
Model Comparisons

Number	Model	FMM?	Specification	BIC	Shares
1	Poisson	No	Baseline	123254	
2	Negative Binomial	No	Baseline	49647	
3	Poisson	2 component	Baseline	59887	86%, 14%
4	Poisson	3 component	Baseline	52365	76%, 19%, 5%
5	Negative Binomial	2 component	Baseline	49354	87%, 13%
6	Negative Binomial	2 component	no taxes	49351	87%, 13%
7	Negative Binomial	2 component	with vending	49368	87%, 13%

Table 3A
Differential Responses to Cigarette Taxes
Evidence Using a 3-Component Poisson Finite Mixture Model

Outcome	Number of Cigarettes	Number of Cigarettes	Number of Cigarettes
Specification	FMM	FMM	FMM
Component	First	Second	Third
Distribution	Poisson	Poisson	Poisson
Proportion of Component	0.75	0.07	0.19
Mean of Number Cigarettes			
Log (Cigarette Tax)	-0.081	-0.016	-0.037
	(0.062)	(0.015)	(0.042)
Age	0.264***	0.088***	0.220***
	(0.039)	(0.012)	(0.014)
Male	-0.168	0.096***	0.092
	(0.191)	(0.024)	(0.076)
Black	-12.924	-0.705***	-1.565***
	(8.106)	(0.079)	(0.120)
Hispanic	-1.338**	-0.192***	-0.566***
	(0.520)	(0.048)	(0.100)
Family Income	0.001	-0.001***	-0.002***
	(0.001)	(0.000)	(0.001)
Maternal Education	0.010	-0.018*	-0.032*
	(0.039)	(0.009)	(0.019)
Mom Smkoe	1.263***	0.147***	0.473***
	(0.194)	(0.033)	(0.056)
Married Parents	-0.169	-0.039	-0.124
	(0.244)	(0.032)	(0.092)
Number of Siblings	0.042	-0.025*	-0.022
	(0.053)	(0.013)	(0.020)
Parent Works	0.138	-0.015	0.063
	(0.241)	(0.031)	(0.066)
Religious Attendance	-0.020***	-0.005***	-0.012***
	(0.004)	(0.001)	(0.001)
Urban	-0.099	0.001	-0.006
	(0.236)	(0.039)	(0.088)
Rural	0.193	-0.036	0.006
	(0.163)	(0.031)	(0.078)
Missing Information Dummy	0.324**	0.012	0.077
	(0.138)	(0.023)	(0.051)
Constant	-7.360***	1.556***	-1.770***
	(1.149)	(0.207)	(0.472)
Observations	20257	20257	20257
P-value of difference			
BIC			

***1%, **5%, *10%, Robust standard errors clustered at the school level

Table 4A
Determinants of Membership in the "Low-Price Response" Group for Poisson FMM

Outcome	Component 2	Component 2	Component 2	Component 2	Component 2	Component 2
FMM	Poisson	Poisson	Poisson	Poisson	Poisson	Poisson
Specification	OLS	OLS	OLS	OLS	OLS	OLS
Sample	Full	Full	Full	Full	Family	Family
Fixed Effects	None	None	None	None	None	Family
Go with Gut: Strongly Disagree	-0.047***		-0.042***	-0.021***	-0.044**	-0.027
	(0.009)		(0.009)	(0.006)	(0.017)	(0.024)
Go with Gut: Disagree	-0.031***		-0.027***	-0.010**	-0.027*	-0.026
	(0.006)		(0.007)	(0.004)	(0.014)	(0.017)
Go with Gut: Agree	0.042***		0.042***	0.013***	0.053***	0.012
	(0.006)		(0.006)	(0.004)	(0.016)	(0.018)
Go with Gut: Strongly Agree	0.064***		0.062***	-0.001	0.054**	-0.016
	(0.011)		(0.011)	(0.006)	(0.025)	(0.026)
Almost No Chance Live to Age 35		0.076***	0.064***	0.015	0.108*	0.045
		(0.024)	(0.023)	(0.014)	(0.060)	(0.049)
Some Chance Live to Age 35		0.105***	0.096***	0.030**	0.119***	0.009
		(0.016)	(0.016)	(0.012)	(0.033)	(0.040)
50-50 Chance Live to Age 35		0.082***	0.075***	0.019***	0.051***	0.003
		(0.010)	(0.010)	(0.006)	(0.019)	(0.022)
A Good Chance Live to Age 35		0.028***	0.026***	0.009**	0.028**	0.017
		(0.008)	(0.007)	(0.004)	(0.011)	(0.014)
Number of Cigarettes				0.075***		0.071***
				(0.002)		(0.003)
Age	0.024***	0.021***	0.023***	-0.002	0.022***	-0.005
	(0.003)	(0.003)	(0.003)	(0.001)	(0.003)	(0.004)
Male	-0.014	-0.011	-0.016	-0.018***	-0.008	-0.011
	(0.009)	(0.009)	(0.009)	(0.005)	(0.014)	(0.013)
Black	-0.093***	-0.100***	-0.102***	0.017***	-0.099***	
	(0.010)	(0.011)	(0.011)	(0.005)	(0.016)	
Hispanic	-0.051***	-0.057***	-0.056***	0.028***	-0.038**	
	(0.017)	(0.018)	(0.017)	(0.007)	(0.016)	
Maternal Education	-0.002	-0.002	-0.001	0.002*	-0.000	
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	
Mom Smoke	0.046***	0.048***	0.045***	-0.008**	0.054***	
	(0.005)	(0.005)	(0.005)	(0.004)	(0.012)	
Married Parents	-0.019**	-0.017**	-0.016**	0.006	-0.005	
	(0.007)	(0.007)	(0.007)	(0.004)	(0.013)	
Parent Works	0.011	0.012	0.013	0.003	0.009	
	(0.008)	(0.008)	(0.008)	(0.004)	(0.010)	
Religious Attendance	-0.001***	-0.001***	-0.001***	0.000***	-0.001***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	20138	20168	20058	20058	5295	5295
R-squared	0.048	0.044	0.053	0.622	0.058	0.822

***1%, **5%, *10%, Robust standard errors clustered at the school level . Additional Controls: Number of Siblings, Family Income, Urban Status, Rural Status, Missing Information Dummy, Constant