The Causal Effects of Youth Cigarette Addiction and Education

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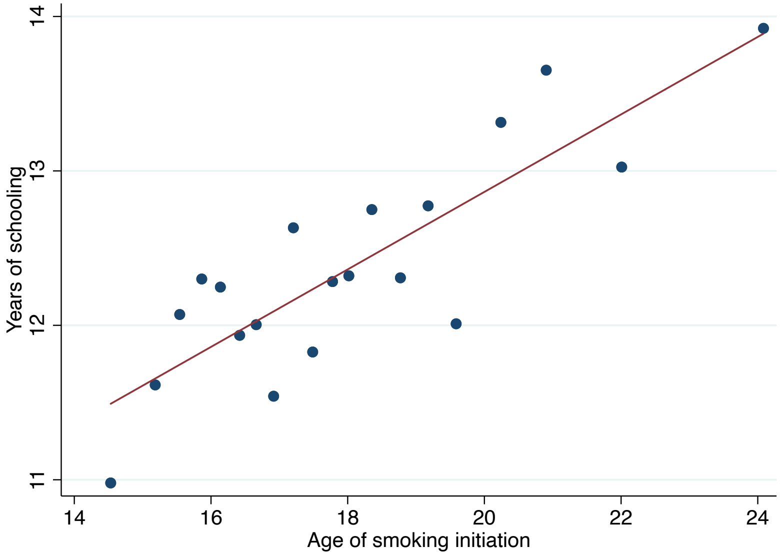
Introduction

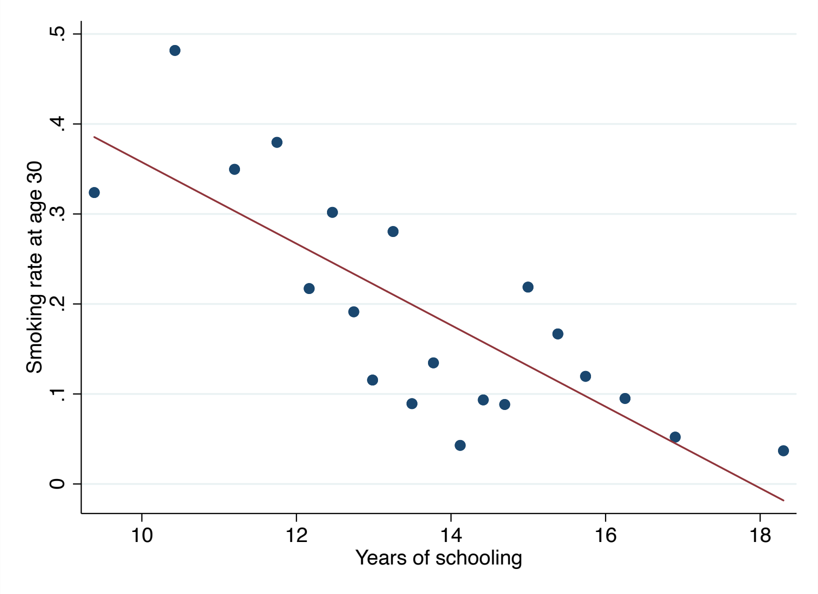
Motivation

- Research questions:
  - Does addiction to cigarettes reduce educational attainment?
  - Does education impact cigarette addiction?
- Relevance and Importance:
  - Understanding the long-term impact of addictive substances on human capital helps policymakers determine their posture towards regulation and taxation of addictive substances
  - If education helps reduce addiction, then it is another important benefit of education not presently considered in education policy.

The earlier a youth starts smoking, the less education he obtain



The more a person is educated, the lower is the probability that he smokes



Empirical Challenges and Our Strategy

- A host of observable and unobservable characteristics can simultaneously determine education and cigarette smoking choices of young men (i.e., selection may be important).
- Once individuals choose education and/or addiction, their preferences regarding future investment in human capital evolves based on their past choices (i.e., dynamic selection).
- We build and estimate a life-cycle model that allows joint decision of schooling and smoking addiction, with the aid of two literature:
  - Rational addiction model of Becker and Murphy (1988): agents rationally choose to become addicted due to their preferences and continue to make optimal consumption decisions
  - Life-cycle models of educational choices (Keane and Wolpin (1997, 2001))

Preview of Key Findings

- An additional year of schooling at age 20 reduces the smoking by four percentage points (21%) at age 20 (short-run effect) and by eight percentage points (31%) at age 30 (long-run effect).
- Eliminating the possibility of smoking increases the college attendance rate by three percentage points, from 59 percentage points in the benchmark model to 62 percentage points in the counterfactual scenario.
- A revenue-neutral excise tax policy that impose additional 40% taxes on cigarette can increase college attendance rate to the same level as the rate in the counterfactual above where we eliminated smoking as a choice.

Model

Model: Decision Variables

- At every age $t = 15, \ldots, 64$ an individual makes decisions on:
  - consumption c_t and next period's stock of savings s_{t+1}
  - whether or not to smoke $d_{q,t} \in \{0, 1\}$
  - whether to go to school $d_{e,t} \in \{0, 1\}$
  - whether to work part time while in school $d_{p,t} \in \{0, 1\}$
- Agents derive utility or disutility over the aforementioned four choices.
- Agents can borrow up to their natural borrowing limits and hence the stock of savings in a period can be negative.
- Schooling choice ends before age 29.
- After leaving school, individuals are fully attached to the labor market and always work
- Starting age 65, agents retire and only make consumption and savings decisions till age 80.

Model: Rational addiction and Endogenous Discount Factor

- Past cigarette consumption affects individuals' current utility of smoking through an "addiction stock" q_t.

$$q_t = (1-\delta_q)q_{t-1} + d_{q,t-1}, \quad t \geq 1, \tag{1}$$

where the stock depreciates at rate $\delta_q \in [0,1]$ and $q_{t_0} = 0$.

- Discount factor

$$\beta(q,e,t,\boldsymbol{\theta}) := \underbrace{\exp(-\phi_{e,t})}_{\text{survival rate}} \underbrace{\exp(-\kappa_q q)}_{\text{addiction effect}} \underbrace{\exp(-\kappa_r + \kappa_c\theta_c + \kappa_n\theta_n)}_{\text{endowed discount factor}}. \tag{2}$$

  - $\exp(-\phi_{e,t})$: the education and age-specific survival rate from data.
  - $\kappa_q \geq 0$: the subjective belief of the harmful effects of addiction in increasing the probability of death. As κ_q increases, addicted youths become more myopic and less patient.

Model: Flow Utility

Individuals have separable preferences over a composite good c_t, smoking $d_{q,t}$, schooling in a period $d_{e,t}$, and part-time work while in school $d_{p,t}$.

$$U(c_t, \boldsymbol{d}_t; q_t, e_t, \boldsymbol{\theta}, \boldsymbol{X}_t, \epsilon_t) = \frac{{c_t}^{1-\gamma} - 1}{1-\gamma} + \underbrace{u_q(d_{q,t}; q_t, e_t, \boldsymbol{\theta}, \varepsilon_{q,t})}_{\text{Smoking utility}} + \underbrace{u_e(d_{e,t}, d_{p,t}; \boldsymbol{X}_t, \boldsymbol{\theta}, \varepsilon_{e,t})}_{\text{Schooling utility}}$$

- Smoking flow utility:

$$u_q(\cdot) = d_{q,t} \cdot (\nu_0 + \nu_q q_t + \nu_e e_t + \boldsymbol{\nu}_\theta \boldsymbol{\theta} + \boldsymbol{\epsilon}_{q,t}) + \nu_{q^2} q_t^2$$

- Schooling flow utility:

$$u_e(\cdot) = d_{e,t} \cdot (\xi_p d_{p,t} + \boldsymbol{\xi}_e \boldsymbol{X}_t + \boldsymbol{\xi}_\theta \boldsymbol{\theta} + \boldsymbol{\epsilon}_{e,t})$$

The vector $\boldsymbol{X}_t$ includes age, previous period's enrollment status $d_{e,t-1}$, indicator variables for a full-set of schooling levels and their interactions with age, and parental educational level e_{pr}.

Model: Budget Constraint and Prices

An individual's optimization problem from initial age $t_0 = 15$ to age $T = 64$ is:

$$V_t(\Omega_t) \quad = \max_{\{\boldsymbol{d}_t, c_t, s_{t+1}\}} \left\{ U(c_t, \boldsymbol{d}_t; q_t, e_t, \boldsymbol{\theta}, \boldsymbol{X}_t, \boldsymbol{\epsilon}_t) + \beta(q_t, e_t, t, \boldsymbol{\theta}) \cdot \mathbb{E}_t \left[V_{t+1}(\Omega_{t+1}) \middle| \Omega_t \right] \right\}$$

Budget constraint:

$$\underbrace{s_{t+1} - s_t \cdot (1 + r(s_t))}_{\text{Savings in period } t} \quad = \quad \underbrace{Y_t + T_t + G_t}_{\text{Earnings, transfers}} - \underbrace{(c_t + p_t \cdot d_{q,t} + m_{e_{t+1}} \cdot d_{e,t})}_{\text{Consumption, addiction, education costs}}$$

- Ω_t is the relevant information set at time t
- Transfers from parents (T_t) and government (G_t).
- $m_{e_{t+1}}$: net tuition and fees cost associated with education level e_{t+1}.
- p_t: monetary cost of smoking
  - Variations in p_t help to identify the model's smoking preference parameters.
  - Individuals take prices as given and form expectations as follows:

$$\ln p_{t+1} - \ln p_t = \Delta_p + \varepsilon_{p,t+1}$$

where $\varepsilon_{q,t+1}$ is an i.i.d. forecasting error.

Model: Borrowing Constraint and Earnings Function

- Borrowing constraint based on student loan and natural borrowing limits

$$s_{t+1} \geq \underline{S}_{t+1}$$

- An augmented Mincer earnings function for full time earnings:

$$\begin{aligned}
&\ln Y(e_t, k_t, t, \boldsymbol{\theta}, \varepsilon_{y,t}) \\
&= \omega_0 + \omega_{k,1} k_t + \omega_{k,2} k_t^2 + \underbrace{\omega_{k,3} k_t \mathbf{1}(e_t \geq 16)}_{\text{Higher return to experience by education}} + \underbrace{\omega_c \theta_c + \omega_n \theta_n}_{\text{Reward to ability}} \\
&+ \underbrace{(\omega_{e,1} \mathbf{1}_{(e_t \geq 12)} + \omega_{e,2} \mathbf{1}_{(e_t < 12)})(e_t - 12) + \omega_{e,3} \mathbf{1}_{(12 \leq e_t < 16)} + (\omega_{e,4} + \omega_{e,5}(e_t - 16)) \mathbf{1}_{(e_t \geq 16)}}_{\text{Effect by education level}} \\
&+ \underbrace{\omega_{a,1}(18 - t)\mathbf{1}(t < 18) + \omega_{a,2}(20 - t)\mathbf{1}(18 \leq t \leq 20)}_{\text{Age effect}} + \varepsilon_{y,t},
\end{aligned}$$

Model's Initial Condition and Ability Measurement (θ_c, θ_n)

- Cognitive ability and noncognitive ability are not directly observed. Instead, we observe proxies.
  - Measures of cognitive ability $Z_{c,j}$:
    - Armed Services Vocational Aptitude Battery (ASVAB) four subscores (arithmetic reasoning, mathematics knowledge, paragraph comprehension, and word knowledge).
  - Measures of non-cognitive ability $Z_{n,j}$:
    - Achenbach's Youth Self Report (YSR) questions: "unhappy, sad, or depressed," "lie or cheat," "don't get along with other kids," and "have trouble concentrating or paying attention."
    - Adverse behaviors: whether had violent behavior; whether had stolen something

- Dedicated measurement equations:

$$Z^*_{k,j} = \mu_{z,k,j} + \alpha_{z,k,j}\theta_k + \boldsymbol{x}'_z\boldsymbol{\beta}_{z,k,j} + \varepsilon_{z,k,j}$$

$$Z_{k,j} = \begin{cases} Z^*_{k,j} & \text{if } Z_{k,j} \text{ is continuous} \\ \mathbf{1}(Z^*_{k,j} > 0) & \text{if } Z_{k,j} \text{ is an indicator variable} \\ \mathbf{1}(Z^*_{k,j} > 0) + \mathbf{1}(Z^*_{k,j} > \text{cutoff}_{k,j}) & \text{if } Z_{k,j} \text{ takes values } \{0,1,2\} \end{cases}$$

- The initial distribution of cognitive and non-cognitive abilities are assumed to be jointly normal.

Summarizing the Model

Our model allows multiple channels for educational attainment and addiction to affect each other.

- First, the subjective discount factor changes based on addiction or education level: addiction increases myopia, and education decreases it.
- Second, education reduces the flow utility of smoking, forcing rational agents to choose between education and smoking.
- Third, the monetary cost of smoking (i.e. cigarette costs) is not negligible, especially for low-income youth. Thus, budget constraints may reduce valuable financial resources towards schooling or vice-versa.
- Finally, higher education leads to higher income, which shifts the budget constraint.

Empirical Strategy: Empirical Strategy: Data, Identification, and Estimation

Data

Our main data is the National Longitudinal Survey of Youth 1997 (NLSY97).

Panel A: Youth smoking by education (age 30)				
	High school or less	College and more	difference	p-value of difference
Smoking	0.30	0.10	-0.20	0.00
Years smoked	4.88	1.64	-3.24	0.00
Never smoked	0.39	0.70	0.31	0.00

Panel B: Age-30 education by youth smoking history				
	Smoked before age 20	Never smoked before age 20	difference	p-value of difference
Years of schooling (age 30)	12.13	14.34	2.21	0.00
College and more (age 30)	0.34	0.68	0.34	0.00

Panel C: Key Variables By Age (NLSY97)				
	Age 15	Age 20	Age 25	Age 30
Years smoked as of t-1	0.00	0.71	1.80	2.90
Never smoked as of t-1	1.00	0.71	0.63	0.58
School enrollment	0.97	0.35	0.09	0.00
Working part-time while in school	0.13	0.26	0.06	0.00
Years of schooling	8.46	12.21	13.36	13.60
Earnings after leaving school	$2,488	$17,244	$29,957	$40,570

Identification

- Identification of Parameters on Measurement System of Abilities:
  - Normalization that set the location and scale of the factors
  - Three or more measures per factor
- Identification of Smoking-Specific Parameters:
  - An auxiliary model below:

    $$d_{q,t} = b_0 + b_p p_t + b_{q,-1} d_{q,t-1} + b_{q,+1} d_{q,t+1} + b_{q,e} e_t + b_{q,c} \theta_c + b_{q,n} \theta_n + \varepsilon_{q,t}$$

    where we instrument $(d_{q,t-1}, d_{q,t+1})$ with the lags and leads of excise taxes and cigarette prices following Chaloupka (1991) and Becker et al. (1994).
  - Exploiting age as an exclusion restriction in smoking preferences.
- Identification of Parameters on Risk Aversion, Earnings, and Schooling Preferences:
  - Applying standard arguments in the education literature

Estimation Method

- First step: MLE

$$\max \Pi_i \int_{\theta_c,\theta_n} f(Z_{i,c}, Z_{i,n}; \boldsymbol{x}_{i,z}, \theta_c, \theta_n) dF(\theta_c, \theta_n), \tag{3}$$

- Second step: Simulated Method of Moments

$$J := \min \; (\hat{M}_N - M_{\tilde{N}}(\text{parameters}))' \hat{W}_N (\hat{M}_N - M_{\tilde{N}}(\text{parameters})). \tag{4}$$

  The weighting matrix is the inverse of the diagonal of the variance-covariance matrix of the data moments Altonji and Segal (1996). In total, we estimate 44 parameters in the second step, including parameters for the discount factor, preferences over smoking and schooling, and the earnings function. We have 105 targeted empirical moments.

Estimation Results and Goodness-of-Fit

Addiction Stock Depreciation and Subjective Discount Factor

Description	Symbol	Estimate	Standard Error
Depreciation Rate of Addiction Stock	δ_q	0.4330	0.0049
Subjective discount rate terms:			
Subjective discounting rate	κ_r	0.0249	0.0009
Myopia effect of addiction stock	κ_q	0.00038	0.000046
Effect of cognitive ability on subjective discount factor	κ_c	0.0097	0.0013
Effect of non-cognitive ability on subjective discount factor	κ_n	0.0113	0.0019

- Addiction stock depletes over a bit more than two years.
- The subjective discount factor is 0.975 among young non-addicts with average cognitive and non-cognitive abilities.
- Smoking decreases the cumulative discounted utility by 0.95% from age 15 to age 80, assuming unit income and consumption.

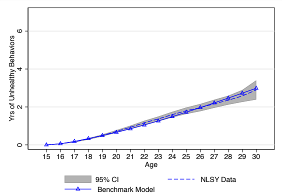
Addiction Parameter Estimates

Description	Symbol	Estimate	Standard Error
Addiction Stock	ν_q	0.0205	0.0014
Addiction Stock Squared	ν_{q^2}	-0.0022	0.0009
Yrs of Schooling -9	ν_e	-0.0048	0.0004
Cognitive Ability	ν_c	-0.00001	0.0016
Non-cognitive Ability	ν_n	-0.00816	0.0020
Intercept	ν_0	0.0030	0.0028
S.D. of Preference Shock to Smoking	σ_q	0.0238	0.0022

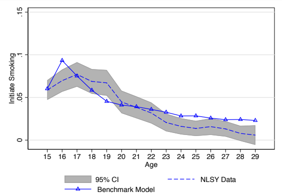
- A 18-year old median smoker receives more than three times additional utility from cigarettes than from composite good consumption at the median c_t level.
- The addictive effects of one year of smoking is offset by four additional years of education.
- A one standard deviation increase in non-cognitive ability reduces the addictive effects of one year of smoking by about 20%.
- Cognitive ability, separate from education, does not have a direct impact on smoking preferences.

Goodness-of-Fit of the model

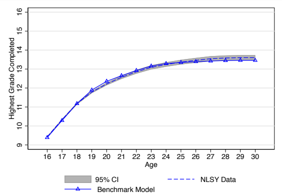
Our model fits the data well. Among the 105 targeted moments, the average distance between the data moment and the corresponding model generated moment is 1.58 times the standard error of the corresponding data moment.



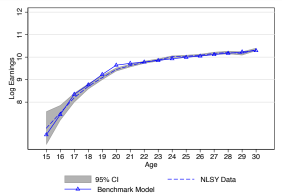
(a) Mean years of smoked over age



(b) Rate of smoking initiation over age



(c) Mean years of schooling over age



(d) Mean logarithm of earnings over age

Model Fit: Coefficients of Regressions for Smoking and Net Worth

	Panel A: Smoking Participation 2SLS Regression			
	Data	Model	SE of Data	$\frac{\lvert\text{Data-Model}\rvert}{\text{SE of Data}}$
Smoking at $t-1$ ($d_{q,t-1}$)	0.5415	0.7348	0.2018	0.9577
Smoking at $t+1$ ($d_{q,t+1}$)	0.3654	0.2254	0.2545	0.5502
Years of Schooling	-0.0057	-0.0027	0.0074	0.3921
Cognitive Ability	0.0010	-0.0063	0.0054	1.3545
Non-cognitive Ability	-0.0038	-0.0188	0.0095	1.5767
Log Cigarette Cost ($logp_{q,t}$)	-0.0094	-0.0050	0.0205	0.2150

	Panel B: Log Net Worth OLS Regression			
	Data	Model	SE of Data	$\frac{\lvert\text{Data-Model}\rvert}{\text{SE of Data}}$
Cognitive Ability	0.4012	0.4066	0.0625	0.0854
Non-cognitive Ability	0.2508	0.2728	0.0915	0.2402

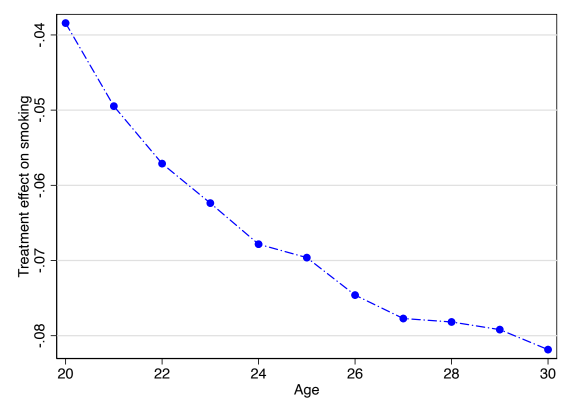
Policy Simulations: Effects of Education and Smoking

Causal Effects of Education on Smoking: Policy Simulation Design

Questions: if a youth's years of schooling is increased by one additional year, how would his smoking probability change in the current period (short-run treatment effect) and over the long run? Does the treatment effect depend on the endowment distribution?

- We conduct a counterfactual simulation where we assign each individual one extra year of schooling at age 20 compared to the benchmark model and then solve each individual's optimal choices at age 20 and onward in the counterfactual simulation.
- The treatment effects of increasing education by one extra year are measured by the differences between the outcomes of the counterfactual simulations and the benchmark model from age 20 onward.

Causal Effects of Education on Smoking Rate over Age



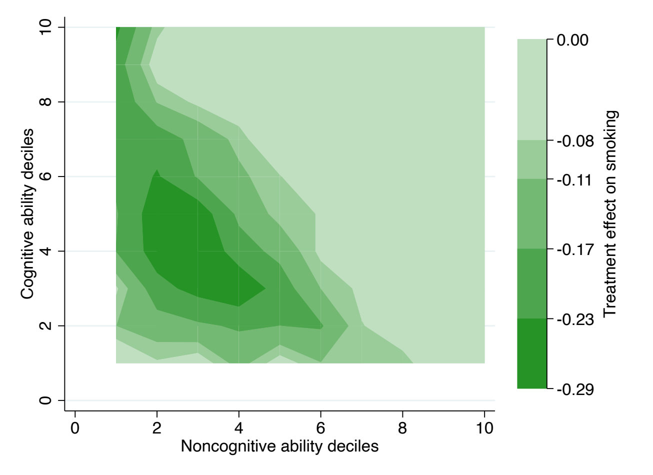
One extra year of schooling at age 20 reduces the smoking rate by 4 percentage points (21%) at age 20 and by 8 percentage points (31%) at age 30.

Who quits smoking?

- In this counterfactual simulation, from among the age-30 smokers in the benchmark model, 32 percent quit smoking.
- Who quits smoking?

	Increasing Education	Excise Tax (40%)
	(1)	(2)
Initial years of schooling	0.145***	0.030***
	(0.004)	(0.004)
Cognitive ability	0.014	0.065***
	(0.010)	(0.004)
Non-cognitive ability	0.282***	0.122***
	(0.013)	(0.008)
Mean dependent variable	0.32	0.11
Observations	12,884	12,884
Pseudo R^2	0.238	0.053

Does the effect of education on smoking differ by ability?



Effect of Youth Smoking on Education: Policy Simulation Design

The literature on cigarette addiction often focuses on the negative health consequences of smoking at later ages.

Not much attention has been given to investigating the potentially harmful impact of smoking and addiction at early ages from a human capital investment perspective.

To evaluate the negative impact of smoking on educational choices, we conduct a counterfactual simulation.

- We assign a very large negative number to the preference parameter of smoking v_q, so that no one in the model will find smoking attractive.
- The difference in college attendance rates between this counterfactual simulation (where it is never attractive to smoke) and the fitted/benchmark model simulation (where some youths obtain utility from smoking) is one measure of the loss in educational attainment due to smoking.

The effects of eliminating smoking on college attendance decisions

Panel A: College attendance rates in different simulations

	Benchmark (1)	No Smoking (2)
(1) Benchmark non-college smokers	0.00	0.09
(2) Benchmark smokers	0.30	0.36
(3) All youths	0.59	0.62

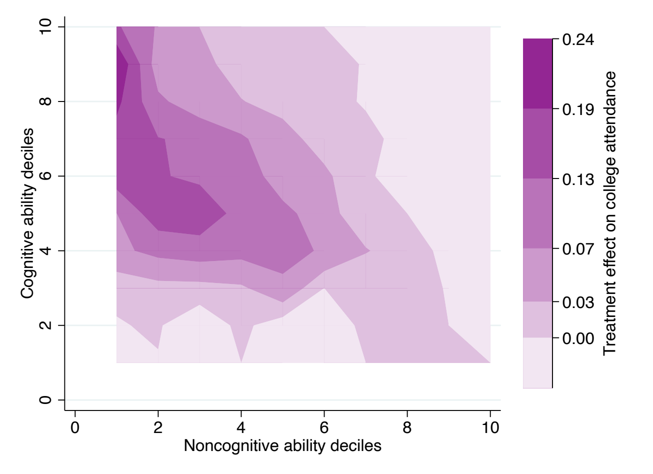
Panel B: College attendance regressions

	Benchmark (1)	No Smoking (2)
Cognitive Ability	0.921***	0.850***
	(0.008)	(0.008)
Noncognitive Ability	0.501***	0.316***
	(0.007)	(0.006)
Parents are 4-year college graduates	0.897***	0.702***
	(0.011)	(0.009)
Mean dependent variable	0.59	0.62
Observations	48,150	48,150
Pseudo R^2	0.638	0.627

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Does the treatment effect of eliminating smoking on college attendance differ by ability?



Note: The figure plots changes in college attendance rates before age 30 between the counterfactual simulation where smoking is eliminated and the benchmark simulation.

Effects of Corrective Excise Taxes: Policy Simulation Design

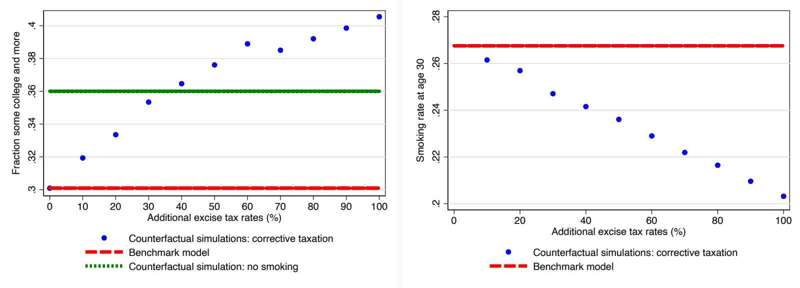
We evaluate the impact on education of a more practical policy—an excise tax on cigarettes.

- Such taxation does not increase smokers' perceived utility; smokers' choices are after all, rational.
- Nevertheless, a benevolent social planner may choose to promote flourishing lives through human capital investment. In that case, excise taxes may be attractive.

Our counterfactual experiment evaluates the effect of an additional excise tax τ on cigarettes, that is passed on to customers completely so as to increase the cost of smoking to $(1+\tau)p_{q,t}$.

To keep the tax policy revenue neutral, we assume that the tax revenues are redistributed as a lump-sum transfer per period to the agents who attend high school (i.e., tuition subsidy).

Effects of Corrective Excise Taxes: Results



The left panel plots the rate of college attendance by age 30 under different counterfactual simulations among the youths who have smoked before age 30 in the benchmark model (i.e. benchmark model smokers). The right panel plots the rates of daily smoking participation at age 30 under different corrective excise tax rates. The red line indicates values in the benchmark model where there is no additional excise tax.

Who goes to college?

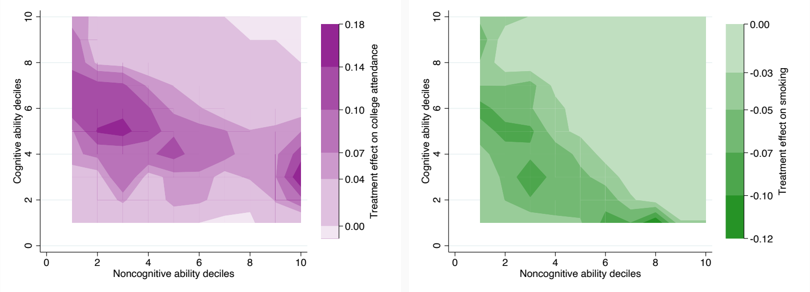
Panel A: College attendance rates in different simulations			
	Benchmark (1)	No Smoking (2)	Excise Tax (40%) (3)
(1) Benchmark non-college smokers	0.00	0.09	0.09
(2) Benchmark smokers	0.30	0.36	0.36
(3) All youths	0.59	0.62	0.63

Panel B: College attendance regressions			
	Benchmark (1)	No Smoking (2)	Excise Tax (40%) (3)
Cognitive Ability	0.921***	0.850***	0.748***
	(0.008)	(0.008)	(0.008)
Noncognitive Ability	0.501***	0.316***	0.380***
	(0.007)	(0.006)	(0.006)
Parents are 4-year college graduates	0.897***	0.702***	0.721***
	(0.011)	(0.009)	(0.009)
Mean dependent variable	0.59	0.62	0.63
Observations	48,150	48,150	48,150
Pseudo R^2	0.638	0.627	0.643

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Does the causal effects of corrective taxation differ by ability?



Note: The figure plots changes in college attendance rate and changes in age-30 smoking rate under 40% additional excise tax rate.

Conclusion

Conclusion

- Findings of this paper:
  - The decision to consume an addictive substance in the formative years of life can have long term consequences on human capital.
  - Education reduces addiction.
- Future work:
  - opioid addiction and human capital accumulation
  - inter-generational mobility and the role of harmful habits/addiction
  - life-cycle inequality in health behaviors, education, and wealth by race

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