

Tobacco Policy in Unstable Friendship Networks

[Empirical Analysis of Peer Effects and Public Policy
in the Case of Adolescent Smoking]

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- The views expressed herein are those of the author and not necessarily those of the Federal Reserve Board.

Tobacco smoking, adolescents and peer effects

- The single greatest preventable cause of death: (WHO, 2015; Surgeon General, 2014; NCHS, 2015)
- Adolescent smoking is important: (??).
 - 80% of adults who are smokers started smoking before they were 18.
- Peer influence among the major determinants of adolescents' decisions to smoke.
 - Implication for the design of efficient public policies (especially those that are likely to change the social norm)
 - What if the social fabric responds to the public policy?

Socio-economic background, tobacco smoking and friendships

- Smoking rates vary substantially by socio-economic backgrounds:
 - Blacks smoke much less than Whites.
 - Younger students smoke much less than older ones.
- Friendship patterns are shaped by socio-economic backgrounds:
 - Blacks tend to be friends with Blacks.
 - Older students tend to be friends with older students.
- Smoking and friendship selection are interrelated:

| | | NOMINEE | |
|-----------|------------|------------------|-------------------|
| | | Smoker | Not smoker |
| NOMINATOR | Smoker | 42% (304) | 58% (418) |
| | Not smoker | 16% (499) | 84% (2562) |

The National Longitudinal Study of Adolescent Health (Add Health) - Wave I, 1994-95 school year; 14 schools, 1125 students, 21% smokers.

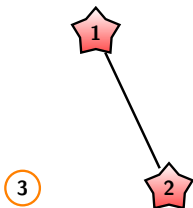
Policy making in an endogenous friendship network: Three empirical questions

- A. Does the social network respond to policies targeting smoking? If yes, does this response catalyze the intended effect of a policy targeting smoking?
- Endogenous vs fixed friendship network: direct effect of price increase
 - Endogenous vs fixed friendship network: indirect (ripple) effect of price increase
- B. Does school racial composition affect overall smoking rate?
- Will students with different socio-economic backgrounds mix?
 - Whose preferences will dominate: smokers will stop smoking or vice versa?
- C. Decompose the variation between smoking patterns across different races (preferences vs conformity)?

Policy making in an endogenous friendship network: Selected empirical results

- A. Does the social network respond to policies targeting smoking? If yes, does this response catalyze the intended effect of a policy targeting smoking?
- Endogenous vs fixed friendship network: direct effect of price increase
 - Endogenous vs fixed friendship network: indirect (ripple) effect
 - Yes—magnifies the intended effect of price changes by extra 2 – 3 ppt.
 - Medium size anti-smoking campaigns have a spillover factor of around 2.
- B. Does school racial composition affect overall smoking rate?
- Will students with different socio-economic backgrounds mix?
 - Whose preferences will dominate: smokers will stop smoking or vice versa?
 - Yes—promoting racial diversity reduces smoking $\approx 10\%$.
- C. Preferences vs conformity & Estimates & Lack of network data:
- $\approx 50\%$ of the differential between white and black males smoking is due to social pressure, the fact that blacks are surrounded by blacks who are not smokers themselves (8 ppt out of 18 ppt).
 - the peer effect complementarities are substantially stronger between smokers compared to between non-smokers.

Example: a network with $n = 3$ individuals



- Each player in $I = \{1, 2, 3\}$ is depicted as a vertex and a friendship is depicted as an edge, e.g., players 1 and 2 are friends.
- The star-shaped shaded nodes denote players who smoke tobacco, e.g., players 1 and 2 are smokers.
- In the subsequent notation, $a_1 = a_2 = 1$, $a_3 = 0$, $g_{12} = 1$, and $g_{13} = g_{23} = 0$.

An example of equilibrium networks



- Would like to capture situations where both outcomes are equilibrium but public policies affect their relative probabilities.

Methods overview (challenges)

- How to model both decisions to smoke and make friends?
 - Fundamentally different decisions: self-interest vs consent
 - Traditional Game theory rules out communication, cooperation, and coordination
- What is the notion of an equilibrium outcome?
 - To simulate counterfactuals (what ifs) need microfounded econometric framework
 - Single agent decision problem
- How to handle equilibrium selection?
 - Peer effects capture particular externalities
 - Complementarities create scope for coordination and multiplicity
 - Need to rank the equilibria in a probabilistic sense
- Computational complexity
 - Challenging to estimate graph type of models
 - With known coefficients, challenge to simulate hypothetical equilibrium outcomes

Utility/Payoff

- Let $u_i : \mathbf{S} \times \mathbf{X} \rightarrow \mathbb{R}$ be given as

$$\begin{aligned}
 u_i(S, X) = & a_i v_i + \underbrace{a_i \phi \sum_{j \neq i} a_j}_{\text{aggr. externalities}} \\
 & + \underbrace{\phi_S \sum_j g_{ij} a_i a_j + \phi_N \sum_j g_{ij} (1 - a_i)(1 - a_j)}_{\text{local externalities}} \\
 & + \sum_j g_{ij} w_{ij} + \underbrace{q_{ijk} \sum_{\substack{j,k \\ j < k}} g_{ij} g_{jk} g_{ki}}_{\text{clustering}} - \psi \left(\underbrace{\frac{1}{2}(d_i^2 + d_i) + \sum_{j \neq i} g_{ij} d_j}_{(\text{convex}) \text{ cost}_i(d_i, \{d_j\}_{j: g_{ij}=1})} \right)
 \end{aligned}$$

A statistical model

The statistical framework can be likened to a couple of simultaneous regressions:

- The incremental utility of changing i 's action choice is

$$\Delta_{a_i} u_i(S, X) = v_i + \phi \sum_{j \neq i} a_j + \phi_S \sum_{j \neq i} g_{ij} a_j - \phi_N \sum_{j \neq i} g_{ij} (1 - a_j).$$

- The incremental utility of changing i 's friendship with j is:

$$\Delta_{g_{ij}} u_i(S, X) = w_{ij} + q_{ijk} \sum_k g_{ik} g_{jk} - \psi(d_i + d_j) + \phi_S a_i a_j + \phi_N (1 - a_i)(1 - a_j).$$

The Add Health Data

- Nationally representative sample of adolescents in 7-12 grade
- Wave I, In-home data (94/95 school year)
- In 16 out of the 80 schools *all* students eligible for in-home interview (saturated sample)
- Student and parent questionnaires

- ✓ Data on risky behaviors
- ✓ Complete friendship network
- ✓ Home environment, demographic and parental characteristics

| | Overall | Min | Max | Median |
|-------------|---------|--------|--------|--------|
| Students | 1342 | 110 | 234 | 162 |
| Smoking | 0.41 | 0.12 | 0.54 | 0.44 |
| Male | 0.52 | 0.41 | 0.58 | 0.53 |
| Whites | 0.92 | 0.42 | 0.99 | 0.98 |
| Blacks | 0.05 | 0.00 | 0.45 | 0.00 |
| As-Hi-Ot | 0.03 | 0.00 | 0.13 | 0.02 |
| Price | 164.99 | 137.31 | 220.09 | 160.06 |
| Avg income | 83.90 | 47.25 | 145.85 | 71.55 |
| Mom edu | 0.73 | 0.56 | 0.84 | 0.74 |
| HH smokes | 0.48 | 0.25 | 0.61 | 0.51 |
| Num friends | 0.97 | 0.29 | 1.53 | 0.88 |

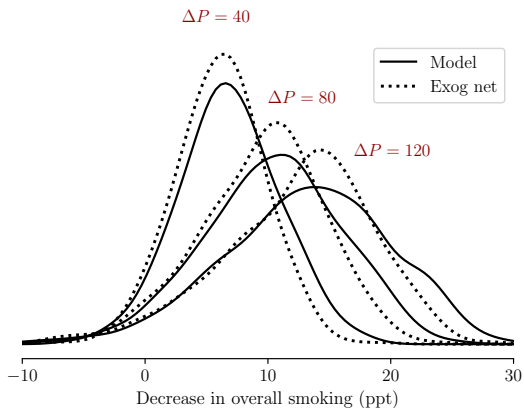
| Parameter | <i>Utility of smoking</i> | | | | |
|--|-------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| | Prior | No net data | Exog net | No PE | Model |
| Baseline probability of smoking | 0.20 (0.10) | 0.12 [0.10, 0.15] | 0.17 [0.15, 0.20] | 0.21 [0.19, 0.23] | 0.18 [0.15, 0.22] |
| Price ×100 | -0.50 (1.00) | -0.17 [-0.36, 0.01] | -0.21 [-0.42, 0.01] | -0.61 [-0.87, -0.37] | -0.24 [-0.48, -0.01] |
| Mom edu (HS&CO) ^{MP} | -0.05 (0.05) | -0.04 [-0.05, -0.02] | -0.05 [-0.06, -0.03] | -0.05 [-0.07, -0.03] | -0.05 [-0.07, -0.03] |
| HH smokes ^{MP} | 0.10 (0.10) | 0.11 [0.08, 0.13] | 0.13 [0.11, 0.16] | 0.16 [0.13, 0.18] | 0.14 [0.11, 0.17] |
| Grade 9+ ^{MP} | 0.20 (0.20) | 0.18 [0.14, 0.21] | 0.16 [0.12, 0.20] | 0.24 [0.20, 0.28] | 0.16 [0.11, 0.20] |
| Blacks ^{MP} | -0.20 (0.20) | -0.30 [-0.34, -0.26] | -0.30 [-0.35, -0.26] | -0.35 [-0.39, -0.31] | -0.31 [-0.37, -0.26] |
| 30% of the school smokes ^{MP} | 0.05 (0.10) | 0.07 [0.06, 0.08] | 0.05 [0.04, 0.07] | | 0.05 [0.03, 0.08] |
| Parameter | <i>Utility of friendships</i> | | | | |
| | Prior | No net data | Exog net | No PE | Model |
| Baseline number of friends | 3.00 (2.00) | | | 4.63 [4.09, 5.29] | 3.40 [2.88, 3.88] |
| Different sex ^{MP%} | -0.70 (0.50) | | | -0.72 [-0.77, -0.67] | -0.72 [-0.77, -0.66] |
| Different grades ^{MP%} | -0.70 (0.50) | | | -0.89 [-0.92, -0.86] | -0.89 [-0.92, -0.86] |
| Different race ^{MP%} | -0.50 (0.50) | | | -0.33 [-0.58, -0.08] | -0.39 [-0.56, -0.24] |
| Cost/Economy of scale | 0.00 (0.50) | | | -0.21 [-0.24, -0.18] | -0.22 [-0.24, -0.19] |
| Triangles ^{MP%} | 0.00 (2.00) | | | 1.18 [0.93, 1.45] | 1.22 [0.98, 1.45] |
| ϕ_{smoke}^{MP} | 0.05 (0.05) | | 0.04 [0.04, 0.05] | | 0.05 [0.04, 0.06] |
| $\phi_{nosmoke}^{MP}$ | 0.05 (0.05) | | 0.03 [0.03, 0.04] | | 0.04 [0.03, 0.05] |

A. Changes in the price of tobacco

| Price increase | Model | Exog net | No net data |
|----------------|-------|----------|-------------|
| 20 | 2.5 | 2.2 | 1.3 |
| 40 | 4.7 | 4.2 | 2.6 |
| 60 | 6.9 | 6.1 | 3.9 |
| 80 | 8.7 | 7.9 | 5.1 |
| 100 | 10.3 | 9.4 | 6.2 |
| 120 | 11.8 | 10.9 | 7.4 |
| 140 | 13.1 | 12.3 | 8.4 |
| 160 | 14.3 | 13.5 | 9.5 |

Note: The first column shows proposed increases in tobacco prices in cents. The average price of a pack of cigarettes is \$1.67 so that 20 cents is approximately 10%. The second through fourth columns show the predicted increase in the overall smoking (baseline 41%) in ppt from the full model, from the model when the friendship network is fixed, and from the model when no social network data is available (i.e., $\phi_S = \phi_N = 0$).

Effect on overall smoking rates



- Model with exogenous friendships: underestimates both the mean smoking rates and the amount of uncertainty associated with the policy intervention.

B. Changes in the racial composition of schools

| Same-race cap (%) | School White | School Black | Overall |
|----------------------|-----------------|-----------------|---------|
| None | 32.9 | 4.5 | 18.7 |
| 90 | 29.2 | 6.7 | 17.9 |
| 80 | 25.6 | 9.3 | 17.4 |
| 70 | 23.6 | 11.1 | 17.4 |
| 60 | 18.8 | 15.0 | 16.9 |
| 50 | 17.0 | 16.8 | 16.9 |

Note: A cap of $x\%$ same-race students is implemented with a swap of $(100 - x)\%$ students. The last column shows the predicted changes in overall smoking under different same-race caps. The policy induces statistically significant changes in the overall smoking as suggested by the statistical tests in appendix D.

C. Cascade effects of an anti-smoking campaign

Table: Spillovers

| Campaign (%) | Smoking | Predicted effect proportional | Actual effect | Multiplier |
|--------------|---------|-------------------------------|---------------|------------|
| - | 42.1 | - | - | |
| 3 | 39.6 | 1.3 | 2.6 | 2.0 |
| 5 | 38.2 | 2.1 | 3.9 | 1.9 |
| 10 | 34.6 | 4.2 | 7.5 | 1.8 |
| 20 | 28.7 | 8.4 | 13.4 | 1.6 |
| 30 | 23.5 | 12.6 | 18.6 | 1.5 |
| 50 | 15.1 | 21.1 | 27.0 | 1.3 |

Note: The first column lists the various treatment rates (proportion of treated). The second and third columns display the smoking rate and the change in smoking rate respectively if only treated were to stop smoking (i.e., a baseline without peer effects).

The fourth column reports the overall equilibrium effect. Finally, the last column displays the multiplier computed as the ratio between columns three and four. Note that the treatment is random and does not target smokers. The policy is simulated 10^3 times, where each time a new random draw of attendees is being considered.

Conclusion

- Adolescents choose to smoke or not but also with whom to hang out:
 - (a.) Friendships are result of a choice not chance,
 - (b.) Friendships may evolve and impact behaviors.
- Apply the framework to empirically study high school smoking behaviors:
 - (a.) Social network responds to policies targeting smoking and magnifies their intended effect,
 - (b.) School racial composition systematically affect overall smoking rate,
 - (c.) Peer pressure (conformity vs preferences) generates half of the differential between black and white male smoking prevalences.
 - (d.) Substantial social spillovers from treated to untreated in the context of adolescent smoking.
- Can we leverage this research in designing efficient public policies?
 - (a.) Social network may facilitate public policy (implication for efficient design),
 - (b.) New tools for public policy: instead of targeting narrowly risky behaviors, target the social fabric—the patterns of friendships between individuals with varying preferences for risky behaviors.