Flavorants and Addiction

An Empirical Analysis of Tobacco Product Bans and Taxation

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Introduction

Goal: Determine impact of menthol ban.

- Cigarette smoking related to about **one of every five deaths**.
  - 480,000 lives lost each year.
- Black Americans **overwhelmingly prefer** menthol products.
  - Impact of historical racial marketing practices.
- **FDA proposed ban** on Menthol Cigarettes.
  - Menthol makes up about one-third of all sales.
  - Advance health equity among the Black American community.
- FDA considering additional flavor bans on tobacco products.

Research Questions

- How does banning menthol cigarettes impact smoking rates?
  - What about in marginalized communities?
  - Do consumers switch to alternative products?
- Can taxation be as effective?
  - What tax rate results in the same reduction?
  - How does consumer surplus compare to the ban?
- What if the FDA expands the ban to E-cigarette flavorants?
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Approach

Main Idea: Design a model of **consumer demand** and **firm supply**.

- **RCNL** model using Nielsen data from 2015 through July 2019.
  - Incorporate **Retail and Household data** (Grieco et al., 2021).
  - Addiction via **dynamic state dependency** (Tuchman, 2019).
  - Within **category substitution** via nested logit.
  - **Demographic interactions** with **demand** parameters.
- **Supply side model** incorporates dynamic state dependency.
- **Counterfactual simulation** on impact of bans and taxation.
  - Consider merged producers of cigarettes and e-cigarettes.

Past Research and Contribution - Menthol Ban

- **Survey Research:** Chaiton et al. (2020), Fong et al. (2022), Levy et al. (2021a), Levy et al. (2021b), Issabakhsh et al. (2022).
  - Surveys largely focused on Canadian and UK households.
  - We contrast with a structural model of demand and firm response.
- **Structural Model:** Olesiński (2020).
  - We study US markets and consumers.
  - Incorporate **household** and **retail** data.
  - Account for **dynamic state dependence**.
  - Focus on **demographic responsiveness**.

Agenda

- Industry background.
- Data.
- Model.
- Estimates and counterfactual results.
- Summary and conclusion.

Background

History of Tobacco Product Bans

- Tobacco manufacturers **targeted demographic groups**.
  - Filters, ultra slims, menthol, flavored tobacco.
  - Primary motivation for product bans.
- In 2009 outcry over flavored cigarettes pushed Congress to act.
  - The Family Smoking Prevention and Tobacco Control Act.
    - Allowed FDA regulation of cigarette manufactures.
    - Banned flavored cigarettes.

History of Tobacco Product Bans, Cont'd

- E-cigarette popularity exploded early 2018.
  - Youth usage led to flavored **cartridge** ban in January 2020.
  - Research suggests consumers switched to **disposable** e-cigarettes.
- Today, the FDA's focus is on the sale of menthol cigarettes.
  - Correct years of racial marketing practices.

"For too long, tobacco companies have been enabled to promote menthol cigarettes to the Black community, preying particularly on Black youth."

- AMA President Susan R. Bailey, MD

Data

Retail Data

- **Nielsen retail data** from 2015 through July 2019.
  - 26,916 stores active during all years.
  - Weekly price and quantity available at the UPC level.
- Aggregate to products at **category/flavor level**.
  - Standardized to pack size.
  - **3 categories ("nests")** for a total of **6 products**:
    - **Cessation**.
    - **Cigarettes:** regular tobacco and menthol.
    - **E-cigarettes:** regular tobacco, menthol, and flavored (fruity, candy, mint).

Household Data

- Focus on 17,420 **Nielsen households**.
  - Total of 401,718 purchases.
  - Classify by Black and income status.
  - Weekly cigarette smoking rate of 14.7%.

Table: Nielsen Household Panel Joint Distribution of Race and Income[a]

	High Income	**Low Income**	**Total**
Black	**6.02%** (6.89%)	**3.97%** (5.66%)	**9.98%** (12.55%)
Non-Black	**54.63%** (63.92%)	**35.39%** (23.54%)	**90.02%** (87.46%)
Total	**60.64%** (70.81%)	**39.36%** (29.20%)	

[a] U.S. household joint distribution included in parentheses for comparison purposes.

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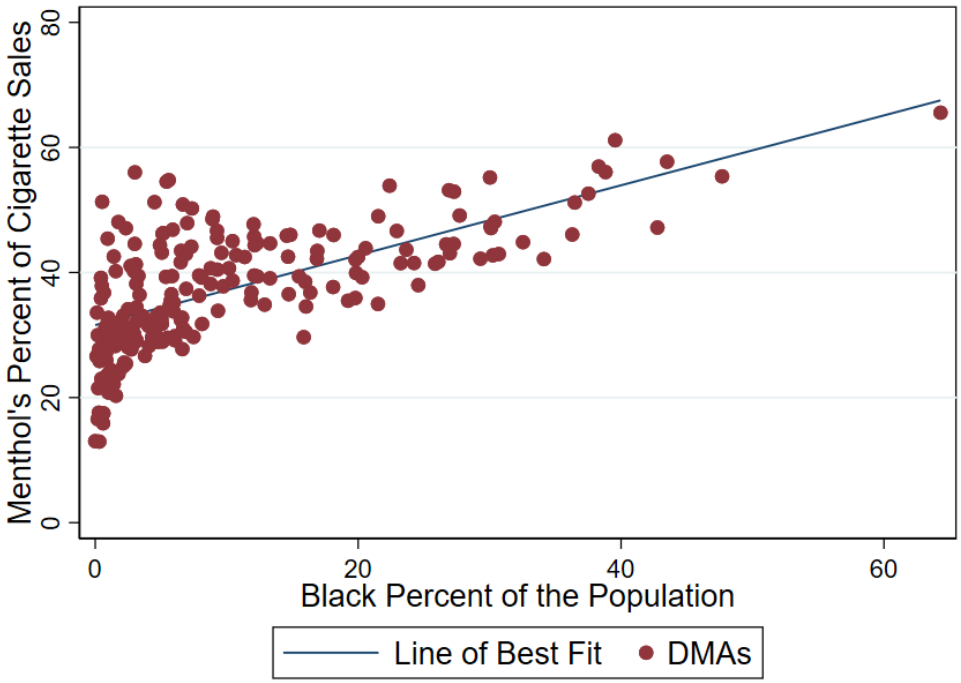
- Form markets at the **DMA/week level**. Appendix
  - 206 DMAs with recorded sales; 100 largest used in model estimation.
  - Sales and quantity weighted prices at the **product/DMA/week level**.
- Form market level product usage rates with sales data.
  - Weight population to best fit expected cigarette smoking rates.
- DMA joint distribution of race and income: 2019 ACS 5-year estimates.

Retail Analysis: Cigarette Flavorant Choice

Black and Menthol Cigarettes



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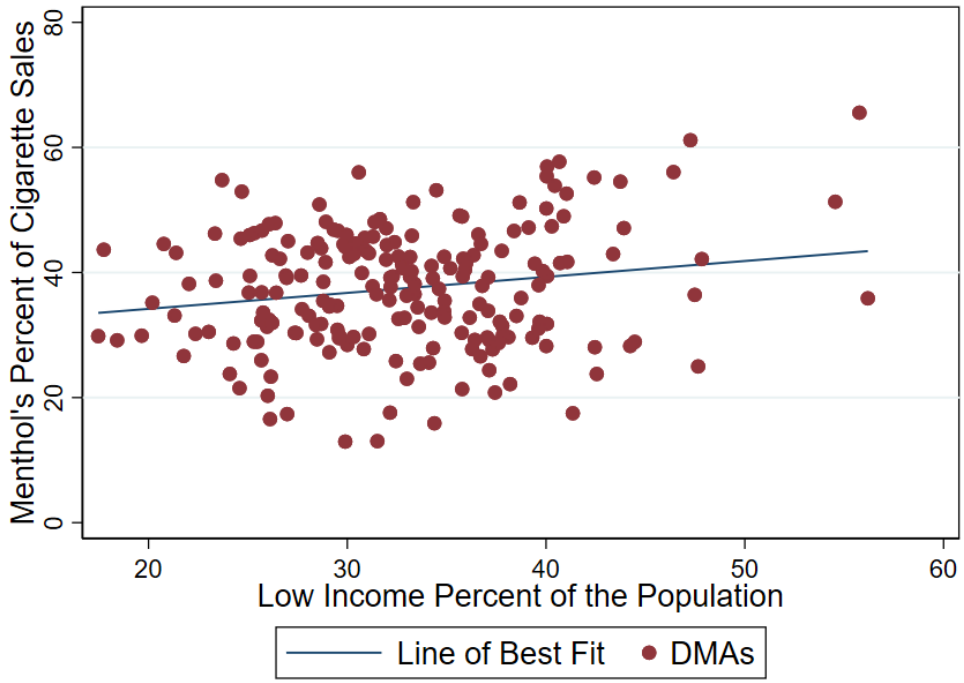
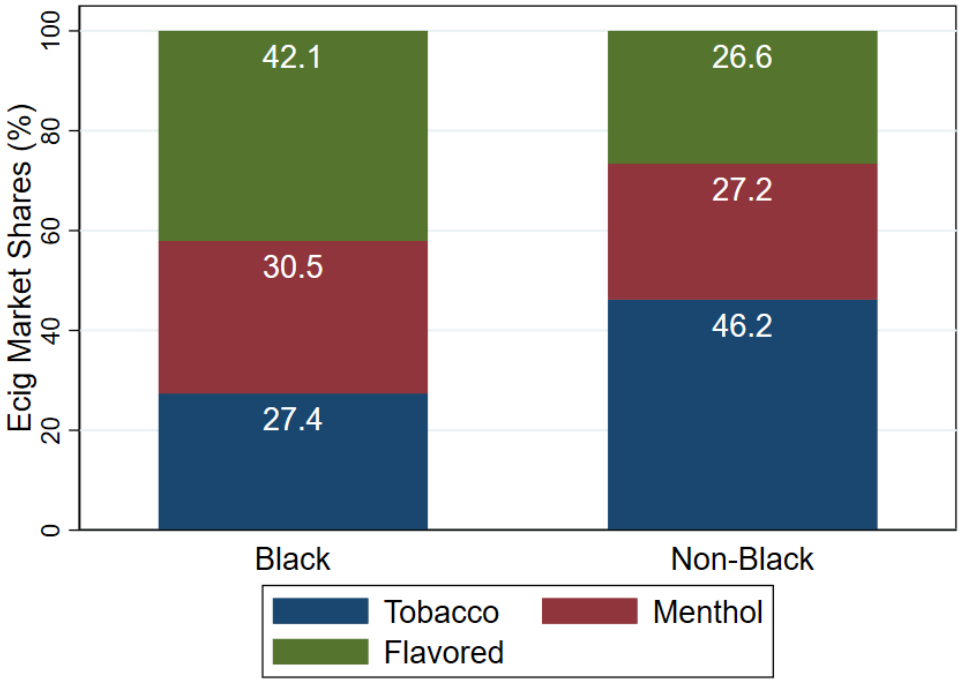


- **Key Findings:**
  - Black population and menthol market share highly correlated.
  - Low income population loosely correlated with menthol.

Household Analysis: E-cigarette Flavorant Choice

Black and E-cigarette Flavor



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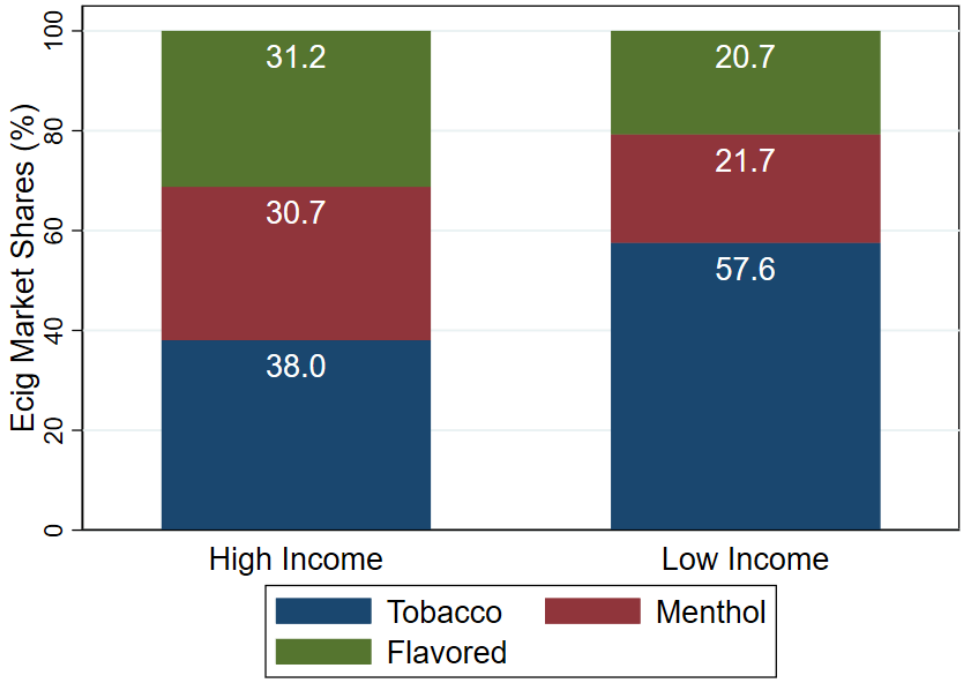

- **Key Findings:**
  - Black households dislike tobacco e-cigs; prefer flavored.
  - Low income prefer tobacco e-cigs.

More: Household: Cig Flav. | Retail: E-cig Flav. | State Depend. | Linear Prob. Model | Product Sub.

Model

Model Setup: Choice and Utility

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$$u_{ijmt} = x_j'\beta_i + \alpha_i p_{jmt} + h_{gmt}'\gamma + \phi \mathbb{I}\Big(\sum_{g' \in \mathcal{G}} C_{ig',t-1} > 0\Big) + \rho_g C_{ig,t-1} + \xi_{jmt} + \bar{\epsilon}_{ijmt}$$

  - x_j: product characteristics.
  - p_{jmt}: retail price.
  - h_{gmt}: fixed effects.
  - $C_{ig,t-1}$: indicator for consumption in group g the prior week.
  - ξ_{jmt}: common demand shocks.
  - $\bar{\epsilon}_{ijmt}$: unobserved individual preferences for products.

Model Overview: Individual Preferences

Main Idea: Individual preference for **characteristics** $\begin{pmatrix} \alpha_i \\ \beta_i \end{pmatrix}$ and **products** $(\bar{\epsilon}_{ijmt})$.

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  - Π: demographic preference.
  - D_i: observed individual demographics.
  - Σ: covariance of unobserved preferences.
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- **Preferences for products** $(\bar{\epsilon}_{ijmt})$: Two-level nested logit.
  - $\lambda_g \in [0, 1]$: nesting parameter for category g.
    - $\lambda_g \to 1$, perfect substitutes within nest.
    - $\lambda_g \to 0$, estimates $\to$ Basic RC model.

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- Let $\Theta = (\Sigma, \Pi, \phi, \rho_q, \rho_c, \rho_e, \lambda_c, \lambda_e) \leftarrow$ **Heterogeneous model parameters**.

Model Overview: Evaluation

- **Decompose indirect utility**: More

$$u_{ijmt} = \delta_{jmt} + \mu_{ijmt}(\Theta) + \bar{\epsilon}_{ijmt}(\Theta)$$

  - Common (mean) Utility: $\delta_{jmt} = x_j'\beta + \alpha p_{jmt} + h_{gmt}'\gamma + \xi_{jmt}$.
  - Individual Utility: $\mu_{ijmt}(\Theta)$ depends on $\mathbf{C}_{i,t-1}$, D_i, and v_i.

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- **Retail Market Simulation:** More
  - Simulate market shares using 200 simulated consumer "types" per market.
    - Random draws from demographic and preference distributions.
  - Evaluate iteratively, over time.
    - Simulate joint distribution of "type" and consumption status.

Two-Step Estimation

- **(Step 1) Maximum Likelihood Estimation:** More
  - For any Θ, there's a **unique** δ where simulated shares equal observed shares.
  - Household log likelihood a function of $\big(\Theta, \delta(\Theta)\big)$.
  - 14,712 households with 2,100,709 weekly observations.
  - Sandwich estimator of covariance for $\widehat{\Theta}$.

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- **(Step 2) Two-Stage Least-Squares:** More
  - $\delta(\widehat{\Theta})$ provides relationship between mean utility and covariates.
    - Regress: $\delta(\widehat{\Theta}) = x_j'\beta + \alpha p_{jmt} + h_{gmt}'\gamma + \xi_{jmt}$.
    - Hausman instruments: average price in excluded DMAs. Compare
  - 135,600 weekly product-level observations.
  - Bootstrapped standard errors for $(\widehat{\beta}, \widehat{\alpha}, \widehat{\gamma})$.

Results

RCNL Demand Estimates

Table: RCNL Demand Estimates.

	Means (β)	**Std. Dev.** (Σ)	**Demographic Interactions (Π)**	
			Low Income	**Black**
Price	-0.759***		-0.017	
	(0.094)		(0.026)	
Cigarette	1.303**	2.036***	0.351**	-0.700***
	(0.606)	(0.028)	(0.164)	(0.090)
E-cigarette	-4.771***	2.281***	0.365*	-1.929***
	(0.352)	(0.075)	(0.220)	(0.329)
Cessation	-1.749**	2.805***		
	(0.889)	(0.086)		
Menthol	-0.718***	1.188***	0.118***	1.055***
	(0.051)	(0.054)	(0.029)	(0.062)
Menthol $\times$ Ecig.	-0.348***			
	(0.042)			
Flavored	0.451***		-0.397*	1.040***
	(0.078)		(0.213)	(0.319)

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Price Elasticity

Table: Price Elasticity of Demand.[a]

Average Level		Own	Cross-Elasticity		
			Same Category	Different Category	All Products
Cigarettes	Tobacco	-4.028	1.682	0.006	0.341
	Menthol	-4.724	2.581	0.006	0.521
	Average	**-4.376**	**2.132**	**0.006**	**0.431**
E-Cigarettes	Tobacco	-4.077	0.854	0.121	0.414
	Menthol	-4.085	0.820	0.178	0.435
	Flavored	-5.153	0.914	0.118	0.436
	Average	**-4.438**	**0.863**	**0.139**	**0.429**
	Cessation	-5.487	-	0.086	0.086

- **Findings:**
  - Cross-elasticities $\Rightarrow$ cigarette types considered closer substitutes.
  - Cessation most responsive to price changes.

Supply Side Model

- Firms max profits over time-periods in sample.
  - Differentiated Bertrand pricing model with **state dependence**.
  - Final weeks biased from simplifying assumption $\rightarrow$ burn last quarter.
- Consider **two versions** of my supply-side model:
  - Independent producers of cigarettes and e-cigarettes.
  - Merged producers of cigarettes and e-cigarettes.

Policy 1:
Menthol Cigarette Ban

Menthol Cigarette Ban Full Model

Table: Average Weekly Percent Change in Product Usage

		Independent	Merged
		% Change	% Change
Cigarettes	Black	-35.12%	-35.13%
	Non-Black	-9.29%	-9.31%
	High Income	-11.32%	-11.33%
	Low Income	-15.24%	-15.27%
	Average	**-12.58%**	**-12.59%**

- **Additional Findings:**
  - 68% of all menthol smokers switch to regular tobacco cigarettes.
    - About 53% of Black menthol smokers switch.
  - Average CS falls by 16%.
    - Black CS falls by about 43%.
  - Patterns similar to Levy et al. (2021b) and Issabakhsh et al. (2022).

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	Average	**-12.58%**	**-12.59%**
E-Cigarettes	Black	+12.23%	+22.74%
	Non-Black	+4.38%	+10.06%
	High Income	+3.75%	+8.96%
	Low Income	+7.48%	+15.21%
	Average	**+4.91%**	**+10.90%**

- **Additional Findings:**
  - Less than 2% of cigarette quitters substitute to e-cigarettes.
  - Patterns similar to Chaiton et al. (2020).

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		Independent	Merged
		% Change	% Change
Cigarettes	Black	-35.12%	-35.13%
	Non-Black	-9.29%	-9.31%
	High Income	-11.32%	-11.33%
	Low Income	-15.24%	-15.27%
	Average	**-12.58%**	**-12.59%**
E-Cigarettes	Black	+12.23%	+22.74%
	Non-Black	+4.38%	+10.06%
	High Income	+3.75%	+8.96%
	Low Income	+7.48%	+15.21%
	Average	**+4.91%**	**+10.90%**
	Cessation	+1.74%	+1.71%

Policy 2:
Cigarette Sales Tax

Cigarette Sales Tax Full Model

- **10.23% sales tax** $\rightarrow$ equivalent reduction in average smoking rates.
- Average CS falls by about 14%.
  - Black CS falls by about 13%.
  - Lower reduction in CS across all households $\Rightarrow$ **more preferred**.
- Expected tax revenue of **$66.1 million a week**.
  - $1.41 billion generated from April 2015 through April 2019.
- Smaller increase in e-cigarette usage compared to Menthol Ban.
- Little impact on cessation product usage.

Policy 3:
Total Flavorant Ban

Total Flavorant Ban Full Model

- Reduction in cigarette consumption **near identical** to menthol ban.
- **Average reduction** in e-cigarette usage of 46%.
- **Impact varies** by flavorant popularity (time).
  - Pre-2018 average reduction is about 40%.
  - Post-2018 average reduction is about 51%.
- Little impact on cessation product usage.

Summary

Summary

- **Combine household and retail data** to evaluate menthol ban.
  - RCNL framework and allow for dynamic state dependency.
- Demand parameters suggest **significant demographic preference**.
  - Black smokers strongly prefer menthol.
  - Low-Income households display greater cigarette preference.
- **Menthol ban** reduces cigarette smoking by 13%.
  - Black cigarette smoking rate falls by 35%.
- **10% sales tax** reduces cigarette smoking equivalently.
  - Expected tax revenue of $66.1 million a week.
- **Expand ban** to menthol and flavored e-cigarettes.
  - 46% decrease in e-cigarette usage.

Questions?

References I

Berry, Steven T. 1994. "Estimating Discrete-Choice Models of Product Differentiation." *The RAND Journal of Economics* 25 (2): 242–262.

Chaiton, Michael, Ismina Papadhima, Robert Schwartz, Joanna E Cohen, Eric K Soule, Bo Zhang, and Thomas Eissenberg. 2020. "Product substitution after a real-world menthol ban: a cohort study." *Tobacco regulatory science* 6 (3): 205.

Fong, Geoffrey T et al. 2022. "Impact of Canada's menthol cigarette ban on quitting among menthol smokers: pooled analysis of pre–post evaluation from the ITC Project and the Ontario Menthol Ban Study and projections of impact in the USA." *Tobacco Control*.

Grieco, Paul LE, Charles Murry, Joris Pinkse, and Stephan Sagl. 2021. "Efficient estimation of random coefficients demand models using product and consumer datasets."Technical report, Working Paper.

References II

Grigolon, Laura, and Frank Verboven. 2014. "Nested Logit or Random Coefficients Logit? A Comparison of Alternative Discrete Choice Models of Product Differentiation." *The Review of Economics and Statistics* 96 (5): 916–935.

Hendel, Igal, and Aviv Nevo. 2006. "Sales and consumer inventory." *RAND Journal of Economics* 37 (3): 543–561.

Issabakhsh, Mona, Rafael Meza, Yameng Li, Zhe Yuan, Luz Maria Sanchez-Romero, and David T Levy. 2022. "Public health impact of a US menthol cigarette ban on the non-Hispanic black population: a simulation study." *Tobacco Control*.

Levy, David T et al. 2021a. "An Expert Elicitation on the Effects of a Ban on Menthol Cigarettes and Cigars in the United States." *Nicotine & Tobacco Research* 23 (11): 1911–1920.

References III

Levy, David T et al. 2021b. "Public health impact of a US ban on menthol in cigarettes and cigars: a simulation study." *Tobacco Control*.

Olesiński, Bartosz. 2020. "The Analysis of the Tobacco Product Bans Using a Random Coefficients Logit Model." *Central European Journal of Economic Modelling and Econometrics* 12 (2): 113–144.

Tuchman, Anna E. 2019. "Advertising and Demand for Addictive Goods: The Effects of E-Cigarette Advertising." *Marketing Science* 38 (6): 994–1022.

Appendix: Stockpiling

Market Formation

Table: Days Until Next Store Trip Regressed on Cigarette Sales occasions

	Coefficient
Sale Occasion	-.093
	(0.083)
Week FEs	Y
HH FEs	Y
Mean DV	3.994
Num HH	10,344
Num Obs	487,307

***p<.01, **p<.05, *p<.1

Standard errors clustered at the household level are included in parentheses.

- We define cigarette sale occasions similar to how they are defined in Hendel and Nevo (2006)—any time in which weekly cigarette price falls at least 5 percent below the modal price in each DMA.

Appendix: Instrument Comparison

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Table: Mean Utility Estimates With and Without Pricing Instrument.[a]

	Mean Utility	
	Price IV	**OLS**
Price	-0.759***	-0.321***
	(0.094)	(0.028)
Cigarette	1.303**	-1.511***
	(0.606)	(0.188)
E-cigarette	-4.771***	-6.701***
	(0.352)	(0.159)
Cessation	-1.749**	-5.687***
	(0.889)	(0.329)
Menthol	-0.718***	-0.789***
	(0.051)	(0.053)
Menthol × Ecig.	-0.348***	-0.272***
	(0.042)	(0.033)
Flavored	0.451***	0.098
	(0.078)	(0.064)
Category × Time FEs	Y	Y
Category × Market FEs	Y	Y

***p<.01, **p<.05, *p<.1

Appendix: Choice Probability

Back

- Decompose indirect consumer utility (common and idiosyncratic components):

$$\delta_{jmt} = x_j'\beta + \alpha p_{jmt} + h_{jmt}'\gamma + \xi_{jmt},$$
$$\mu_{ijmt}(\mathbf{C}_{i,t-1}) = \left[x_j', p_{jmt}\right](\Pi D_i + \Sigma v_i) + \phi \mathbb{I}\Big(\sum_{g' \in \mathcal{G}} C_{ig',t-1} > 0\Big) + \rho_g C_{ig,t-1}, \quad (1)$$

where $\mathbf{C}_{i,t-1} = (C_{i0,t-1}, C_{i1,t-1}, \ldots C_{ig,t-1}, \ldots C_{iG,t-1})'$.

- Household purchase probability for product j in group g:

$$\pi_{ijmt}(\mathbf{C}_{i,t-1}) = \frac{\exp\Big(\frac{\delta_{jmt}+\mu_{ijmt}(\mathbf{C}_{i,t-1})}{(1-\lambda_g)}\Big)}{\exp\Big(\frac{I_{igmt}(\mathbf{C}_{i,t-1})}{(1-\lambda_g)}\Big)} \times \frac{\exp\big(I_{igmt}(\mathbf{C}_{i,t-1})\big)}{\exp\big(I_{imt}(\mathbf{C}_{i,t-1})\big)}, \quad (2)$$

where, after denoting the set of choices available in group g as $\mathcal{J}_g$,

$$I_{igmt}(\mathbf{C}_{i,t-1}) = (1-\lambda_g)\log \sum_{j \in \mathcal{J}_g} \exp\Big(\frac{\delta_{jmt} + \mu_{ijmt}(\mathbf{C}_{i,t-1})}{(1-\lambda_g)}\Big), \quad (3)$$

$$I_{imt}(\mathbf{C}_{i,t-1}) = \log\Big(1 + \sum_{g \in \mathcal{G}} \exp\Big(I_{igmt}(\mathbf{C}_{i,t-1})\Big)\Big). \quad (4)$$

Appendix: Household Likelihood

Back

- Density of a consumer's observed sequence of choices is given by

$$L_i(Y_i|x, p_m, h_m, D_i; \delta, \Theta) = \int \prod_{t=1}^{T_i} \prod_{j=1}^{J} [\pi_{ijmt}(x, p_{mt}, h_{mt}, \delta_{mt}, \mathbf{C}_{i,t-1}, \Theta, D_i, v_i)]^{y_{ijt}} \, dF_v(v_i),$$

where $\delta_{mt} = (\delta_{1mt}, \ldots, \delta_{Jmt})'$, $x = (x_1, \ldots, x_J)', p_{mt} = (p_{1mt}, \ldots, p_{Jmt})'$, and $h_t = (h_{1mt}, \ldots, h_{Jmt})'$.

(5)

- Let $\Theta = (\Sigma, \Pi, \phi, \rho_q, \rho_c, \rho_e, \lambda_c, \lambda_e)$.
- Y_i: observed sequence of choices where $y_{ijt} = 1$ if consumer i, living in market m, chooses product j during time period t.
- Integrate out the distribution of unobserved individual attributes, denoted $F_v(v_i)$.
  - Use 100 Halton draws.

Appendix: Retail Market Shares

Back

- Simulated retail market shares given by

$$s_{jmt} = \int_{v_m} \int_{D_m} \sum_{g=0}^{G} \pi_{ijmt}(C_{ig,t-1} = 1) P(C_{ig,t-1} = 1) dF_D(D_i) dF_v(v_i). \tag{6}$$

  - $P(C_{ig,t-1} = 1)$ signifies the probability that an group g was purchased the prior week.
  - Integrate over the distribution of observable and unobservable consumer attributes denoted $F_D(D_i)$ and $F_v(v_i)$, respectively.

- In practice, we simulate the integrals via R Halton draws. Thus,

$$s_{jmt} = \frac{1}{R} \sum_{R} \sum_{g=0}^{G} \pi_{rjmt}(C_{rg,t-1} = 1) P(C_{rg,t-1} = 1). \tag{7}$$

- Joint distribution of consumption status and heterogeneity evolves accordingly:

$$P(C_{rg,t} = 1) = \sum_{j \in \mathcal{J}_g} \sum_{g'=0}^{G} \pi_{rjmt}(C_{rg',t-1} = 1) P(C_{rg',t-1} = 1). \tag{8}$$

  - During estimation, we require an initial distribution of consumption status.
    - Set $P(C_{rg1} = 1) = 1/(G+1), \ \forall r \in R$, and treat first quarter as burn-in.

Appendix: Maximum Likelihood

Back

- Berry (1994) shows for any value of Θ, there exists a unique vector δ where the simulated retail market shares (Eq. 7) exactly match those observed.
- Thus, Log likelihood of the household data given by

$$\mathcal{L}(Y;\delta,\Theta) = \sum_{i=1}^{H} log[L_i(Y_i|x,p_m,h_m,D_i;\delta(\Theta),\Theta)]. \tag{9}$$

  - $\delta_{jmt}(\Theta)$ is provided by the contraction mapping in Grigolon and Verboven (2014).
    - Contraction mapping is performed using $R = 200$ Halton draws, per market, from the empirical distribution of D and v.
    - Initial consumption status: set $P(C_{rg1} = 1) = 1/(G+1),\ \forall r \in R$, and treat first quarter as burn-in.
- Evaluate the density of a consumer's observed sequence of choices (Eq. 5) using 100 Halton draws.
  - Maximize log likelihood provided numerical gradients: obtain $\widehat{\Theta}$.
  - Sandwich estimator of covariance for $\widehat{\Theta}$.
  - 14,712 households (residing in the 100 markets) with 2,100,709 observations post burn-in.

Appendix: Mean Utility Coefficients

Back

- Relationship between mean utility and covariates.

$$\delta_{jmt}(\widehat{\Theta}) = x_j'\beta + \alpha p_{jmt} + h_{jmt}'\gamma + \xi_{jmt}$$

  - Proceed with Two-Stage Least Squares estimation.
    - Hausman style instruments—prices in other regions correlated via common marginal costs.
  - Standard errors for $(\widehat{\beta}, \widehat{\alpha}, \widehat{\gamma})$ are calculated using a bootstrap procedure.
    - First, take $B = 1000$ draws from the asymptotic distribution of Θ.
    - For each draw, we find $\delta(\Theta_b)$, and sample with replacement from the set $\{(\delta_{111}(\Theta_b), x_1, p_{111}, h_{111}), \ldots, (\delta_{JMT}(\Theta_b), x_J, p_{JMT}, h_{JMT})\}$.
    - We then perform the TSLS regression to estimate $(\beta_b^*, \alpha_b^*, \gamma_b^*)$.
    - The distribution of $(\beta_b^*, \alpha_b^*, \gamma_b^*)$ provides SEs.
  - 100 markets with 226 time periods each (post burn-in), for a total of 135,600 weekly product-level observations.

Appendix: Household Product Substitution

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Table: Product Transition Table

Last Inside Option Purchased	**Current Product Choice**					
		Cigarette		E-cigarette		
	Cessation	Tobacco	Menthol	Tobacco	Menthol	Flavored
Cessation	**75.48**	15.12	8.36	0.61	0.18	0.24
Cig. Tobacco	0.26	**93.10**	6.03	0.37	0.07	0.16
Cig. Menthol	0.24	10.81	**88.36**	0.10	0.31	0.17
Ecig. Tobacco	0.61	22.12	2.91	**66.78**	1.96	5.61
Ecig. Menthol	0.30	7.82	16.20	3.99	**64.68**	7.01
Ecig. Flavored	0.26	14.62	7.21	8.52	7.84	**61.55**

Notes: In the above table, I present the probability of current product choice ("Current Product Choice") conditioned upon the last observed product chosen ("Last Inside Option Purchased").

Appendix: State Dependence

Back

Table: Linear Regression on the Probability of Purchasing

	Coefficient
Purchase in Prior Week	0.104***
	(0.003)
HH FEs	Y
Week FEs	Y
Mean DV	.112
Num HH	17,420
Num Obs	2,622,559

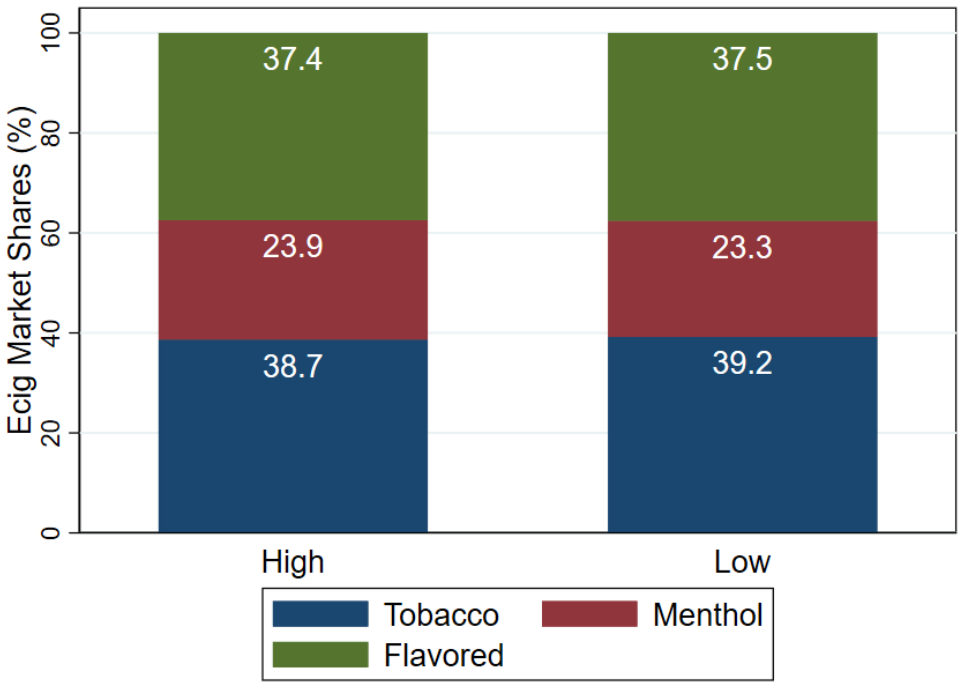
***p<.01, **p<.05, *p<.1

Standard errors clustered at the household level are included in parentheses.

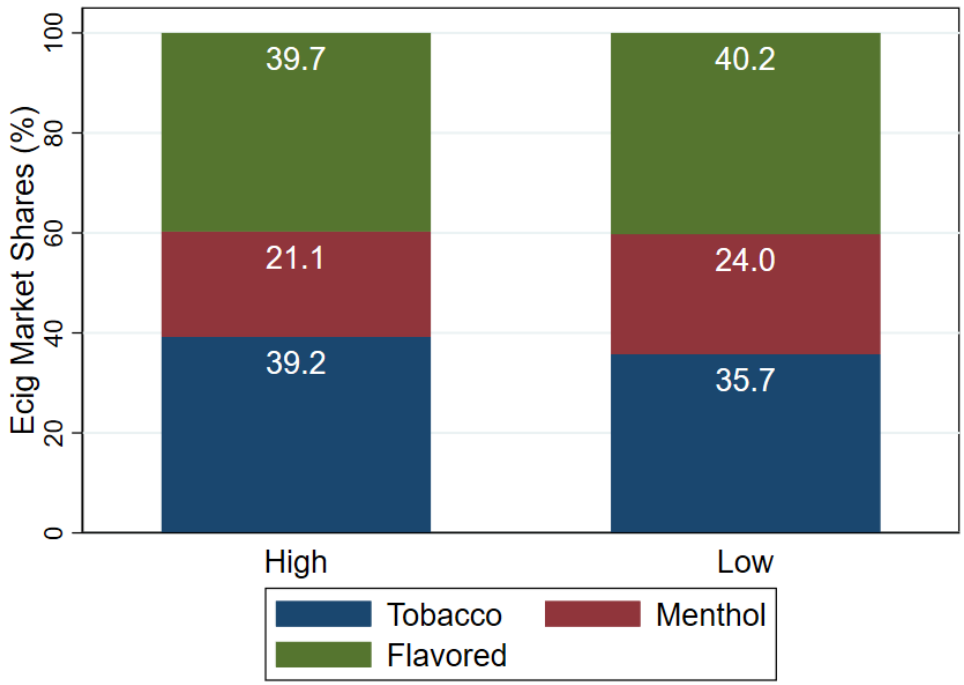
Appendix: Retail E-cigarette Flavorant Choice

Back

Black and E-cigarette Flavor



Low Income and E-cigarette Flavor



Appendix: Household Cigarette Flavorant Choice

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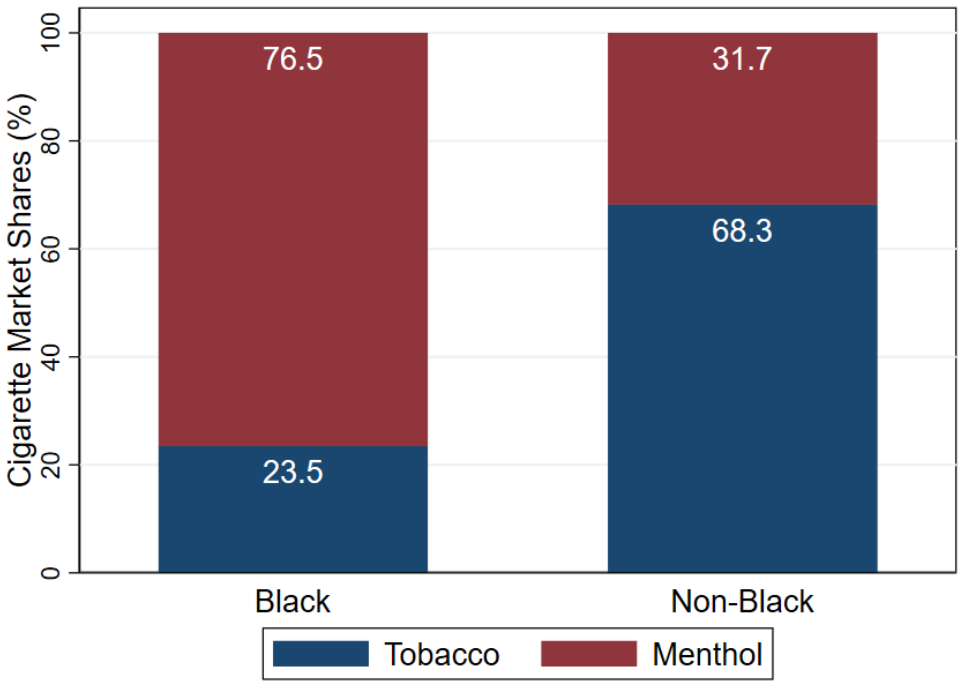
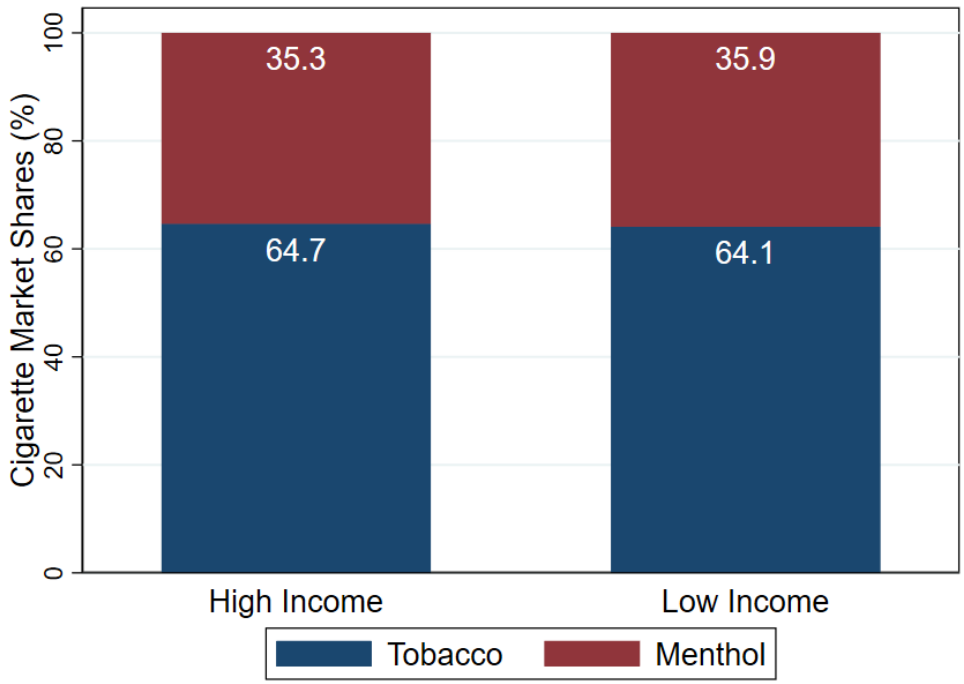
Black and Menthol Cigarettes



Low Income and Menthol Cigarettes



- **Key Findings:**
  - Black households strongly prefer menthol cigarettes.
  - Low income households display little menthol cigarette preference.

Household Analysis: State Dependence

Back

Table: Categorical Purchase Probability by Week

Last Week's Category Choice	**Current Category Choice**			
	Outside Op.	Cessation	Cigarettes	E-cigarettes
Outside Op.	**91.47**	0.14	8.20	0.19
Cessation	78.27	**15.88**	5.58	0.26
Cigarettes	46.52	0.08	**53.09**	0.31
E-Cigarettes	49.57	0.16	12.40	**37.86**

- **Key Findings:**
  - Cessation products encourage Outside Option.
  - Cigarettes experience greatest continuation in usage.
  - Switching between e-cigarettes and cigarettes.

Appendix: Menthol Ban

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Table: Average Weekly Rate of Product Usage: Menthol Cigarette Ban.

			Independent Producers		Merged Producers	
		Without Ban	With Ban	% Change	With Ban	% Change
Cigarettes	Black	15.41%	10.00%	(-35.12%)	9.99%	(-35.13%)
	Non-Black	15.76%	14.30%	(-9.29%)	14.30%	(-9.31%)
	High Income	14.91%	13.22%	(-11.32%)	13.22%	(-11.33%)
	Low Income	17.75%	15.04%	(-15.24%)	15.04%	(-15.27%)
	Average	**15.72%**	**13.74%**	**(-12.58%)**	**13.74%**	**(-12.59%)**
E-Cigarettes	Black	0.23%	0.25%	(+12.23%)	0.28%	(+22.74%)
	Non-Black	0.48%	0.51%	(+4.38%)	0.53%	(+10.06%)
	High Income	0.43%	0.45%	(+3.75%)	0.47%	(+8.96%)
	Low Income	0.49%	0.53%	(+7.48%)	0.0.57%	(+15.21%)
	Average	**0.45%**	**0.47%**	**(+4.91%)**	**0.50%**	**(+10.90%)**
	Cessation	0.47%	0.48%	(+1.74%)	0.48%	(+1.71%)

Appendix: Cigarette Sales Tax (10.23%) Back

Table: Average Weekly Rate of Product Usage: Cigarette Tax (10.23%).

			Independent Producers		Merged Producers	
		Without Tax	With Tax	% Change	With Tax	% Change
Cigarettes	Black	15.41%	13.63%	(-11.52%)	13.64%	(-11.50%)
	Non-Black	15.76%	13.76%	(-12.72%)	13.76%	(-12.71%)
	High Income	14.91%	12.98%	(-12.94%)	12.98%	(-12.93%)
	Low Income	17.75%	15.66%	(-11.78%)	15.66%	(-11.77%)
	Average	**15.72%**	**13.74%**	**(-12.57%)**	**13.74%**	**(-12.56%)**
E-Cigarettes	Black	0.23%	0.23%	(+2.38%)	0.24%	(+6.14%)
	Non-Black	0.48%	0.50%	(+2.79%)	0.52%	(+6.40%)
	High Income	0.43%	0.45%	(+2.60%)	0.46%	(+6.15%)
	Low Income	0.49%	0.51%	(+3.15%)	0.53%	(+6.93%)
	Average	**0.45%**	**0.46%**	**(+2.77%)**	**0.48%**	**(+6.39%)**
	Cessation	0.47%	0.48%	(+1.93%)	0.48%	(+1.93%)

Appendix: Total Flavorant Ban

Back

Table: Average Weekly Rate of Product Usage: Flavorant Ban.

			Independent Producers		Merged Producers	
		Without Ban	With Ban	% Change	With Ban	% Change
Cigarettes	Black	15.41%	10.00%	(-35.09%)	10.02%	(-34.98%)
	Non-Black	15.76%	14.32%	(-9.18%)	14.34%	(-9.05%)
	High Income	14.91%	13.24%	(-11.21%)	13.26%	(-11.08%)
	Low Income	17.75%	15.06%	(-15.15%)	15.08%	(-15.03%)
	Average	**15.72%**	**13.76%**	**(-12.48%)**	**13.78%**	**(-12.35%)**
E-Cigarettes	Black	0.23%	0.06	(-72.41%)	0.07%	(-71.26%)
	Non-Black	0.48%	0.27%	(-44.65%)	0.28%	(-42.89%)
	High Income	0.43%	0.23%	(-46.81%)	0.24%	(-45.06%)
	Low Income	0.49%	0.27%	(-45.67%)	0.28%	(-43.98%)
	Average	**0.45%**	**0.24%**	**(-46.46%)**	**0.25%**	**(-44.73%)**
	Cessation	0.47%	0.48%	(+1.88%)	0.48%	(+1.86%)