

# **Restricting Sales of Flavored Nicotine Vaping Products:**

Effects on Nicotine Vaping Product and Cigarette Sales in Canada

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## **Growing wave of Nicotine Vaping Product (NVP) flavor restrictions:**

- >40 countries ban all NVP sales; 15 have flavor restrictions (World Health Organization, 2025; Campaign for Tobacco-Free Kids, 2025)
- 7 U.S. states + D.C. + 185 localities restrict NVP flavors (Friedman et al., 2026)
- Stated rationale: reduce youth appeal of vaping (Hardie, McCool and Freeman, 2025; Office of the Governor of New Jersey, 2020)

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## **Possible consumer responses**

- 1 Reduce initiation into NVP use
- 2 Exit the tobacco market entirely
- 3 Substitute to unflavored NVPs
- 4 Substitute to combustible tobacco

## Key public health concern:

- Vaping is harmful, but cigarettes are far more deadly
- Average expert: vaping  $\approx$  37% the QALY harm of smoking (Allcott and Rafkin, 2022)
- Smoking reduces life expectancy by **4.3 years** on average (Darden, Gilleskie and Strumpf, 2018)

# Policy Context & Motivation

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**Central question:** Do NVP flavor restrictions cause substitution to combustible cigarettes?

## U.S. evidence is compelling

- Multiple U.S. studies: NVP flavor restrictions  $\Rightarrow$   $\uparrow$  cigarette smoking
- Friedman et al. (2026): 12 extra cigarettes purchased per 1 fewer 0.7mL pod sold
- Begh et al. (2025): 15/21 population studies report an inverse association between NVP availability and youth smoking

# Why Canada? Testing External Validity

## What this paper does

- Leverage provincial variation in NVP flavor restrictions within Canada to estimate the effect on NVP sales and cigarette sales
- First causal evidence **outside the U.S.** on how NVP flavor restrictions shape tobacco product markets

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## Canada's stricter tobacco environment:

- National menthol cigarette ban
- Flavored cigars restricted to wine, rum, port, and whiskey
- Mandatory plain packaging on combustibles
- NVP nicotine limit at 20 mg/mL

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**If substitution persists in Canada despite its stricter tobacco environment, it suggests NVP/cigarette substitution may be generalizable across countries.**

# NVP Flavor Restriction Implementation Dates

| Province         | Effective Date | Restriction                                    | Flavor exemptions |
|------------------|----------------|------------------------------------------------|-------------------|
| Nova Scotia      | April 2020     | Flavored sales prohibited                      | None              |
| Ontario          | July 2020      | Flavored sales limited to specialty vape shops | Mint/menthol      |
| British Columbia | September 2020 | Flavored sales limited to specialty vape shops | None              |
| PEI              | March 2021     | Flavored sales prohibited                      | None              |
| New Brunswick    | September 2021 | Flavored sales prohibited                      | None              |
| Saskatchewan     | September 2021 | Flavored sales limited to specialty vape shops | Mint/menthol      |
| Alberta          | —              | No restriction                                 | —                 |
| Manitoba         | —              | No restriction                                 | —                 |
| New. & Lab.      | —              | No restriction                                 | —                 |
| Quebec           | —              | No restriction                                 | —                 |

## Gas & Convenience NVP Sales (NielsenIQ)

- Retail sales by UPC, province, 4-week period across 5,918 stores (24% of G&C sector)
- Contains 6 panels representing 9 provinces: Alberta, Quebec, British Columbia, Ontario, and two province-groups: the Maritimes (New Brunswick, Nova Scotia, and Prince Edward Island) and Manitoba and Saskatchewan

# Data Sources - July 2018 to June 2023

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## Google Trends

- Monthly province-level Google Search intensity
- “vape shop” searches and searches related to NVP/e-cigarette shopping
- Captures consumer interest beyond G&C stores (vape shops, online)

## TWFE model:

$$Y_{p,t} = \beta_0 + \beta_1 \text{FlavorRestriction}_{p,t} + \pi X_{p,t} + \gamma_p + \theta_t + \varepsilon_{p,t}$$

- $Y_{p,t}$ : log NVP units/capita or log cigarette sticks/capita
- $\text{FlavorRestriction}_{p,t}$  is the proportion of province/panel  $p$  with a flavor restriction in month-year  $t$
- $X_{p,t}$  is a vector of covariates including cigarette taxes, NVP taxes (separate variables for ad valorem rates and excise rates), nicotine concentration limit (20 mg/mL), COVID-19 deaths per capita, two indexes for COVID-19 restrictions (nonessential business closures and internal movement restriction), and a binary indicator for the Atlantic Bubble
- $\gamma_p$ : province FE;  $\theta_t$ : month-year FE

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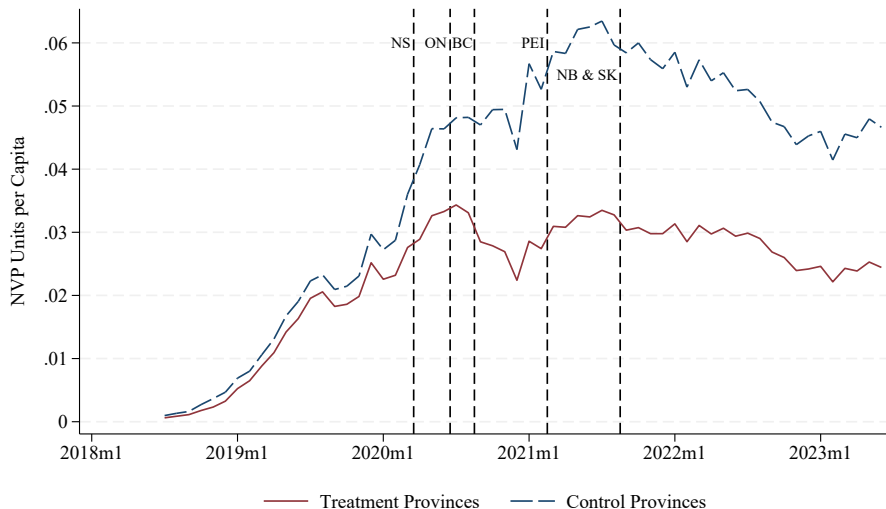
## Stacked DiD (Cengiz et al., 2019):

- Addresses TWFE bias with staggered adoption
- Reconstructs data in event-time per cohort (treatment timing)
- Stack-by-unit and stack-by-event-time FE
- Stack weights from Wing, Freedman and Hollingsworth (2024)

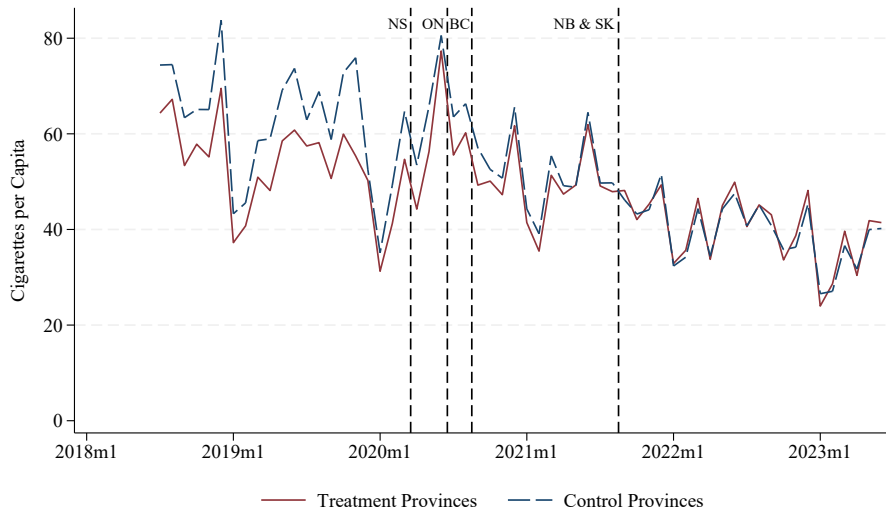
# Empirical Strategy - Robustness & Sensitivity Checks

- Specification checks
  - Volume-standardized NVP sales
  - Exclude March - August 2020
  - Population-weighted estimates
- Identification and inference checks
  - Alternative estimator - Synthetic DiD: reweights comparison provinces to better match pre-policy trends (Arkhangelsky et al., 2021)
  - Few clusters - conventional cluster robust SEs may over-reject null hypothesis: wild-cluster bootstrap (Cameron, Gelbach and Miller, 2008) and placebo tests/randomization inference (MacKinnon and Webb, 2020)

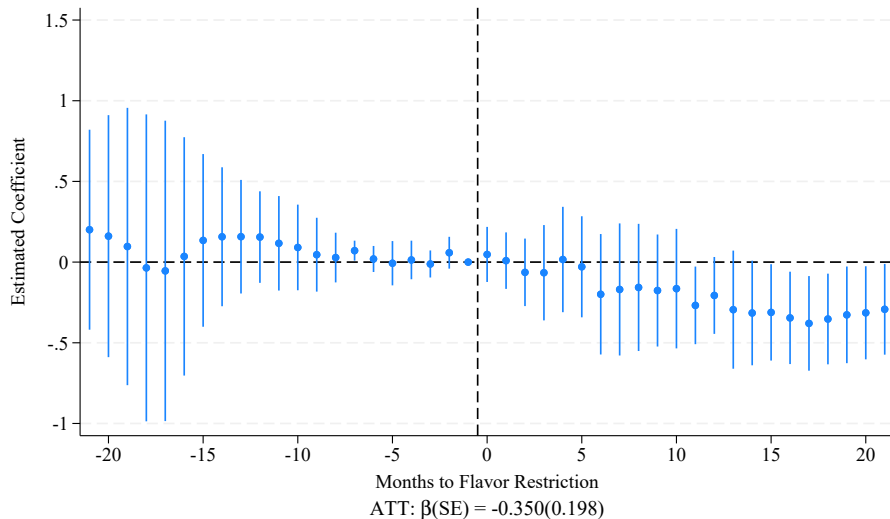
# Descriptive Evidence: G&C NVP Sales Trends



# Descriptive Evidence: Cigarette Sales Trends



G&C Total NVP Sales (logged)  $\approx 29.5\%$  decrease ( $p = 0.138$ )



G&C Flavored NVP Sales (logged)  $\approx 99.9\%$  decrease ( $p < 0.001$ )  
G&C Mint NVP Sales (logged)  $\approx 96.9\%$  decrease ( $p = 0.081$ )

Figure 1: Flavored NVP Sales

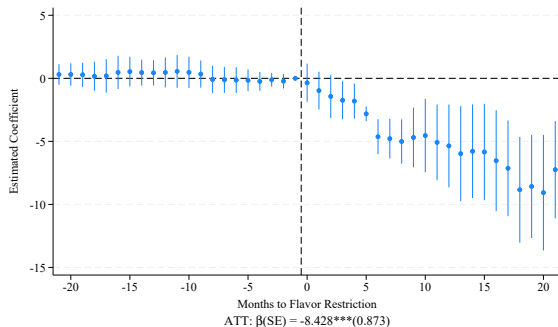
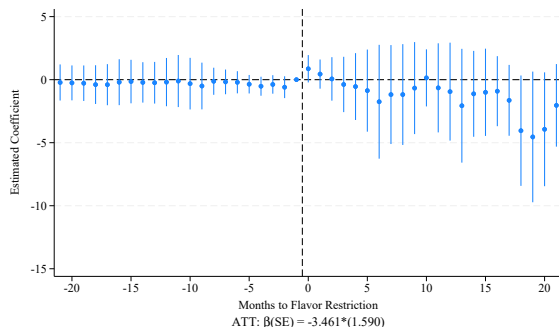
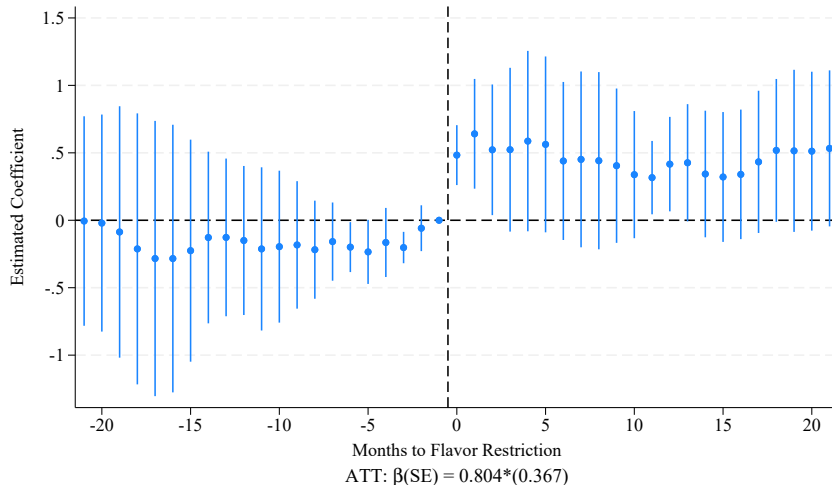


Figure 2: Mint/Mentholated Sales



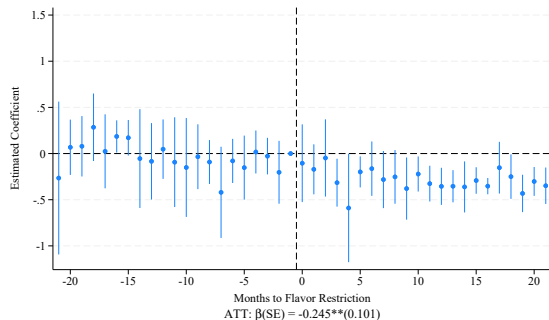
# G&C Tobacco and Unflavored NVP Sales (logged)

$\approx 123.4\%$  increase ( $p = 0.080$ )



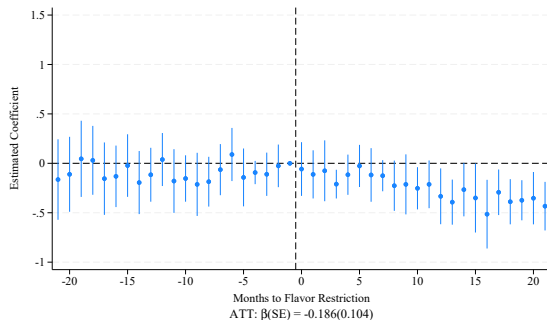
# Google Trends: Online/Vape Shop Displacement?

## NVP Shopping Searches



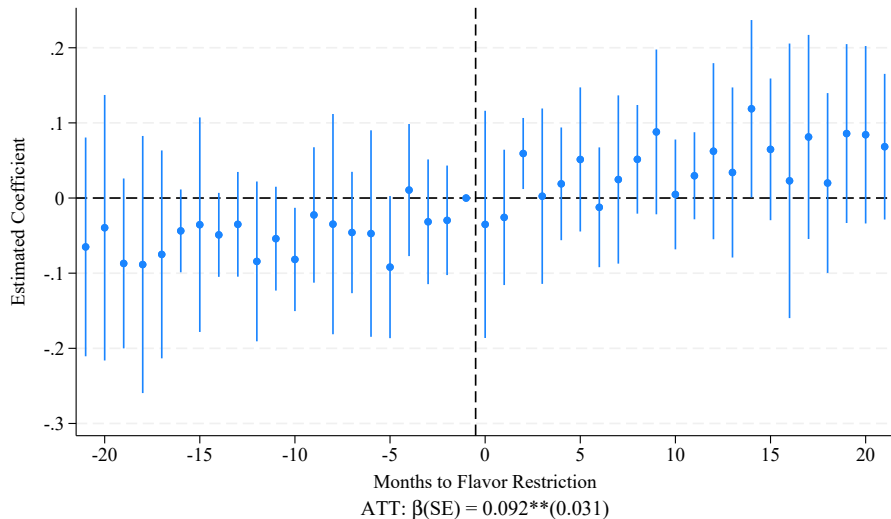
⇒ -21.7% reduction (p-value = 0.042)

## “Vape Shop” Searches

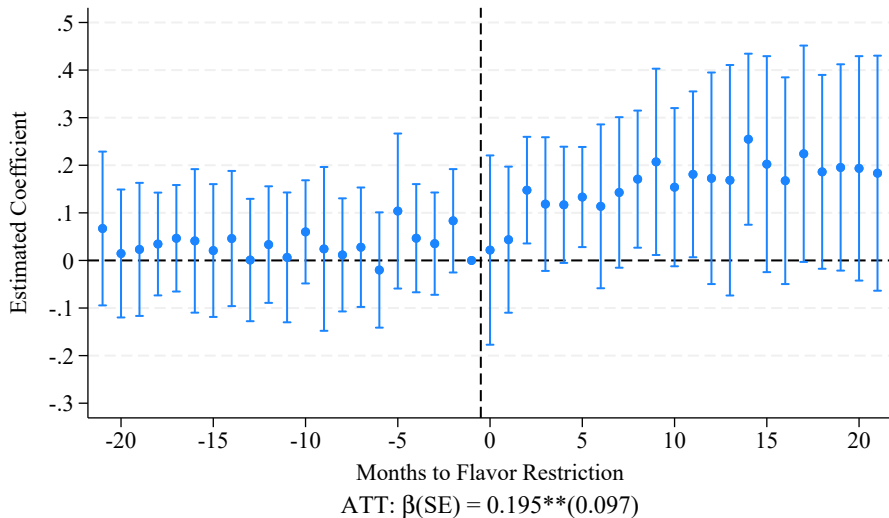


⇒ -17.0% (p-value = 0.112)

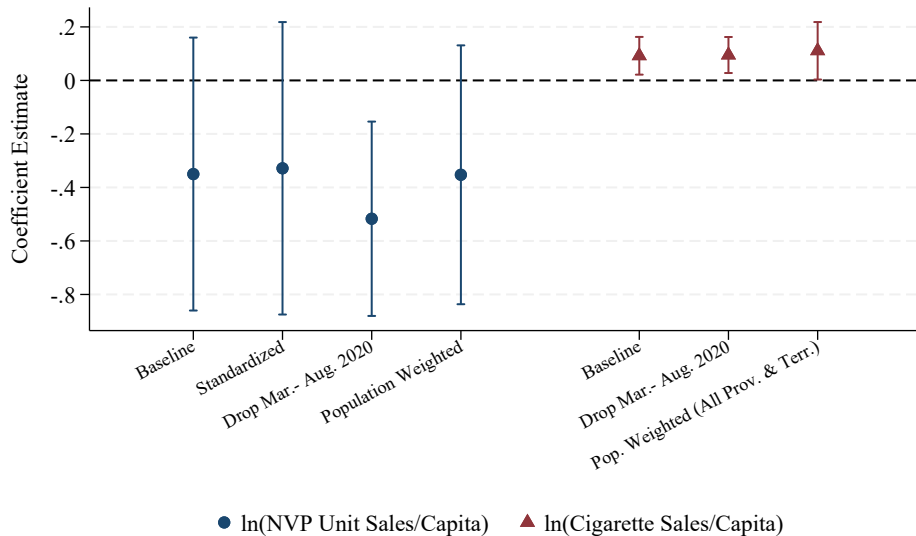
# Cigarette Sales (logged) $\approx 9.6\%$ increase ( $p = 0.017$ )



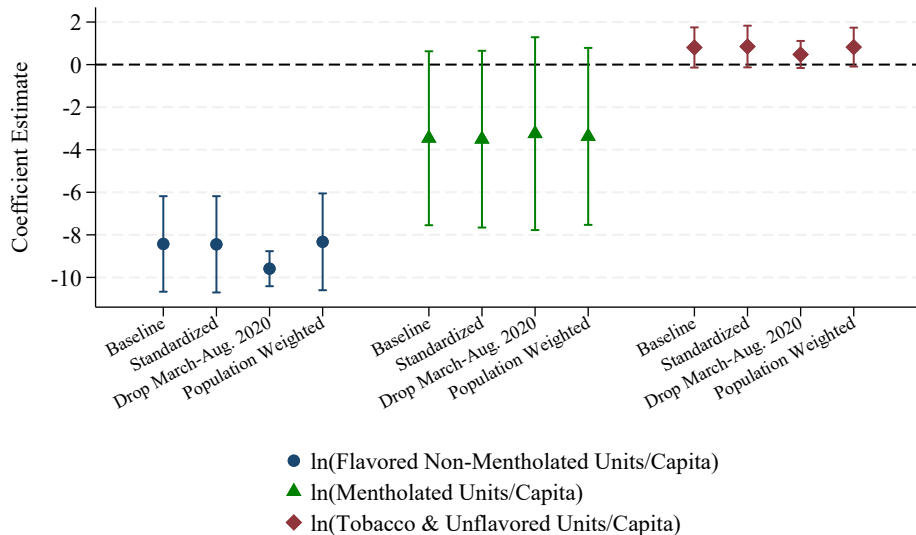
# Synthetic DiD - Cigarette Sales (logged) $\approx 21.5\%$ increase ( $p = 0.048$ )



# Sensitivity Checks



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# Alternative Models: Effect of NVP Flavor Restriction on NVP and Cigarette Sales

|                                    | NVP Units<br>per Capita         | NVP Flavored<br>Non-Mentholated<br>Units per Capita | NVP Mentholated<br>Units per Capita | NVP Tobacco<br>and Unflavored<br>Units per Capita | Cigarette Sticks<br>per Capita |
|------------------------------------|---------------------------------|-----------------------------------------------------|-------------------------------------|---------------------------------------------------|--------------------------------|
|                                    | (1)                             | (2)                                                 | (3)                                 | (4)                                               | (5)                            |
| Baseline<br>(Stacked DiD - Logged) | -0.350<br>(0.198)               | -8.428***<br>(0.873)                                | -3.461*<br>(1.590)                  | 0.804*<br>(0.367)                                 | 0.092**<br>(0.031)             |
| TWFE - Logged                      | -0.329*<br>(0.152)              | -8.643***<br>(0.726)                                | -2.920<br>(1.897)                   | 0.844*<br>(0.372)                                 | 0.090**<br>(0.036)             |
| Synthetic DiD - Logged             | -0.256<br>(0.324)               | -6.233***<br>(1.585)                                | -3.767*<br>(1.946)                  | 0.784*<br>(0.405)                                 | 0.195**<br>(0.097)             |
| Stacked DiD - Levels               | -0.034***<br>(0.008)<br>{0.025} | -0.024***<br>(0.002)<br>{0.013}                     | -0.017**<br>(0.005)<br>{0.009}      | 0.007<br>(0.004)<br>{0.004}                       | 6.930**<br>(2.326)<br>{51.263} |

Notes: Cigarette data are monthly wholesale cigarette sales in each province from July 2018 to June 2023 provided by Health Canada. NVP data are gas and convenience stores unit sales from July 2018 to June 2023 by province and month from NielsenIQ. 0.02% of unit sales are missing flavor. These units are omitted from the flavor-specific analysis. Mentholated units include products labeled as menthol, mint, menthol combined with tobacco, and mint combined with tobacco flavors. Flavored non-mentholated units include flavored products, including those that combine flavors with menthol or mint (e.g., cherry-menthol), but exclude products that are exclusively menthol/mint, exclusively tobacco, or menthol/mint combined with tobacco. Covariates include cigarette taxes, NVP taxes (ad valorem and per mL), NVP nicotine limits, the unemployment rate, COVID-19 deaths per capita, internal movement restrictions index, non-essential retailer restrictions index, and an indicator for the Atlantic Bubble. Fixed effects include month-year and province. For levels, pre-treatment means for the 12 months prior to adoption are in curly brackets. Standard errors are clustered at the province level. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

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# Limitations

- **Sales  $\neq$  use:** cannot distinguish youth versus adults, initiation versus cessation, or participation versus intensity
- **NVP data cover gas and convenience stores:** results may not generalize to sales through other retail channels
- **Policy implementation varies across provinces:** restrictions differ in scope and exemptions.

## Summary of Findings:

- NVP flavor restrictions **nearly eliminated** flavored & menthol NVP sales in G&C stores
- Tobacco/unflavored NVP sales **increased** substantially (+123%)
- **Cigarette sales increased 9.6%**

## Consistency with U.S. findings:

- Friedman et al. (2026): U.S. NVP flavor restrictions ↓ NVP sales and ↑ cigarettes sales
- **Substitution pattern persists in Canada despite its stricter tobacco-control environment**

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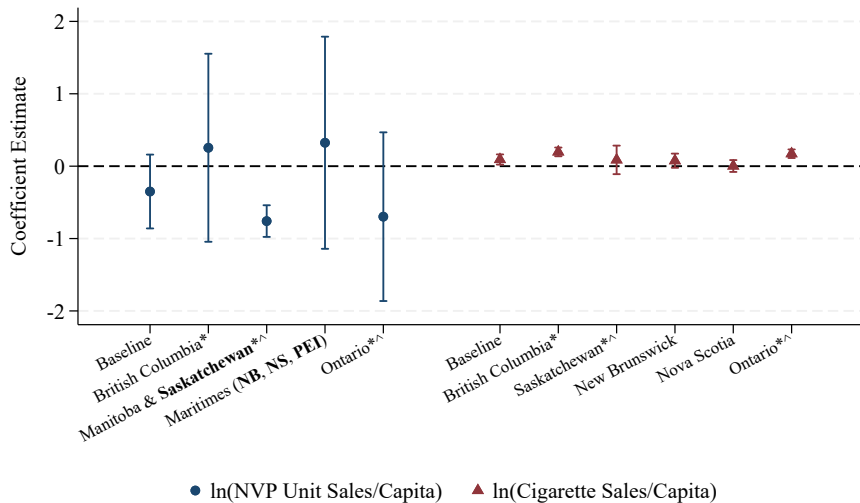
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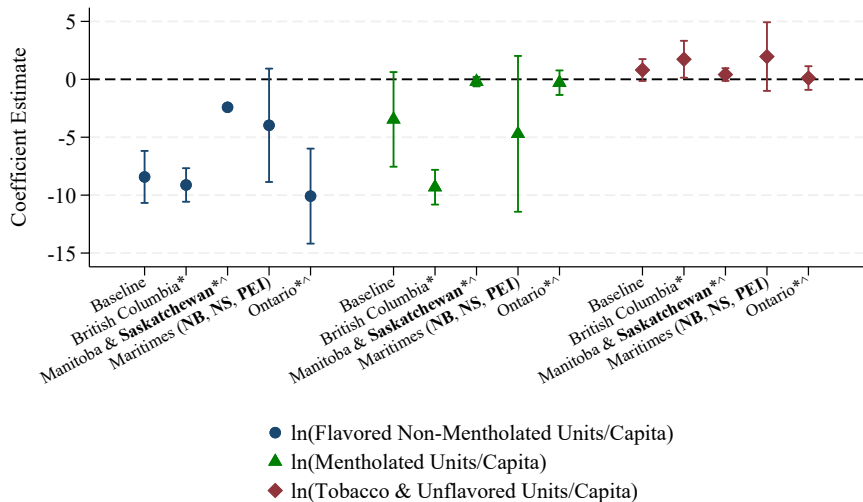
## Policy Implications

- NVP flavor restrictions can shift consumption toward more harmful combustible cigarettes
- Net public-health effects depend on impacts on youth vaping behavior (Haddad et al., 2026; Cotti et al., 2025; Dove, Gee and Tong, 2023)
- Policymakers should proceed with caution: **harm from unintended increases in cigarette consumption may outweigh public health benefits from reduced vaping**

## Appendix: One Province at a Time



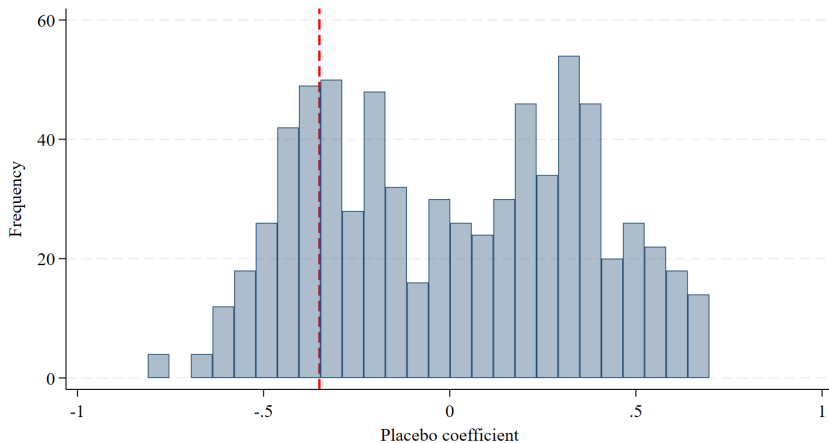
## Appendix: One Province at a Time (NVP Flavor Types)



# Stacked DiD: Effect of NVP Flavor Restriction on NVP and Cigarette Sales

|                        | (1)                                     | (2)                                                     | (3)                                        | (4)                                                   | (5)                                      |
|------------------------|-----------------------------------------|---------------------------------------------------------|--------------------------------------------|-------------------------------------------------------|------------------------------------------|
|                        | ln(NVP Units<br>per Capita)             | ln(NVP Flavored<br>Non-Mentholated<br>Units per Capita) | ln(NVP<br>Mentholated<br>Units per Capita) | ln(NVP Tobacco<br>and Unflavored<br>Units per Capita) | ln(Cigarettes<br>per Capita)             |
| NVP Flavor Restriction | -0.350<br>(0.198)<br>[0.138]<br>{0.625} | -8.428***<br>(0.873)<br>[0.000]<br>{0.031}              | -3.461*<br>(1.590)<br>[0.081]<br>{0.062}   | 0.804*<br>(0.367)<br>[0.080]<br>{0.031}               | 0.092**<br>(0.031)<br>[0.017]<br>{0.032} |
| N                      | 516                                     | 516                                                     | 516                                        | 516                                                   | 903                                      |
| Province-by-Stack FE   | Yes                                     | Yes                                                     | Yes                                        | Yes                                                   | Yes                                      |
| Month-Year-by-Stack FE | Yes                                     | Yes                                                     | Yes                                        | Yes                                                   | Yes                                      |
| Tobacco Policies       | Yes                                     | Yes                                                     | Yes                                        | Yes                                                   | Yes                                      |
| COVID-19 Covariates    | Yes                                     | Yes                                                     | Yes                                        | Yes                                                   | Yes                                      |
| Unemployment Rate      | Yes                                     | Yes                                                     | Yes                                        | Yes                                                   | Yes                                      |

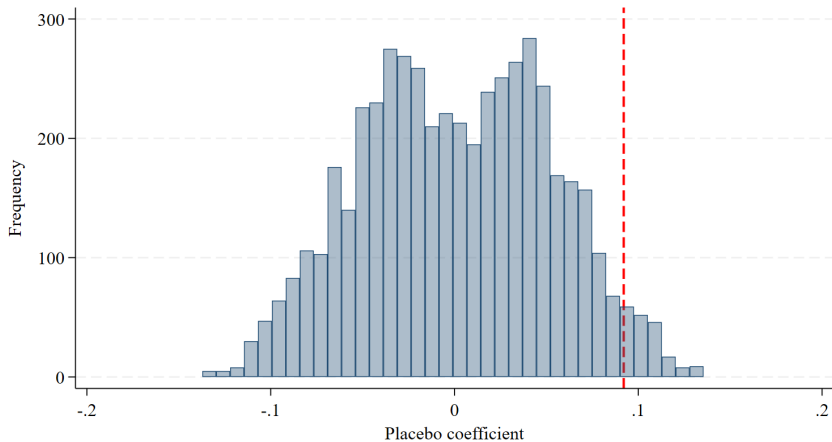
## Appendix: Randomization Inference - NVP Sales



Red line - actual coefficient (se): -0.350 (0.198)

RI-beta one-tailed p-value: 0.213

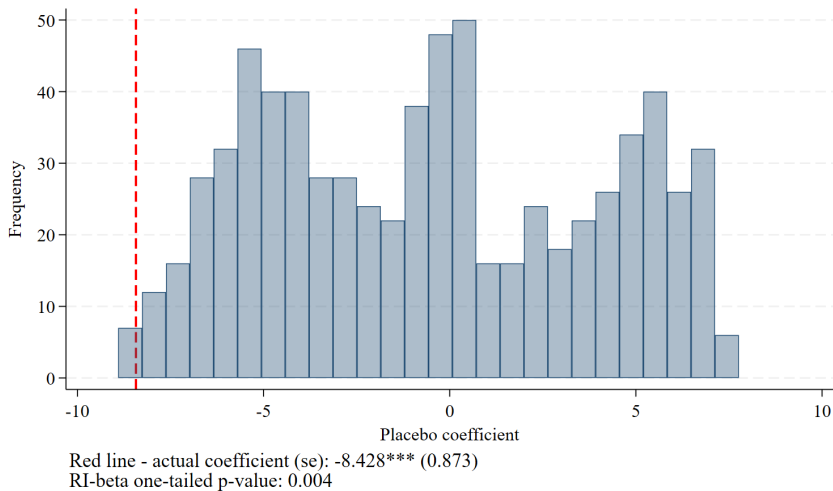
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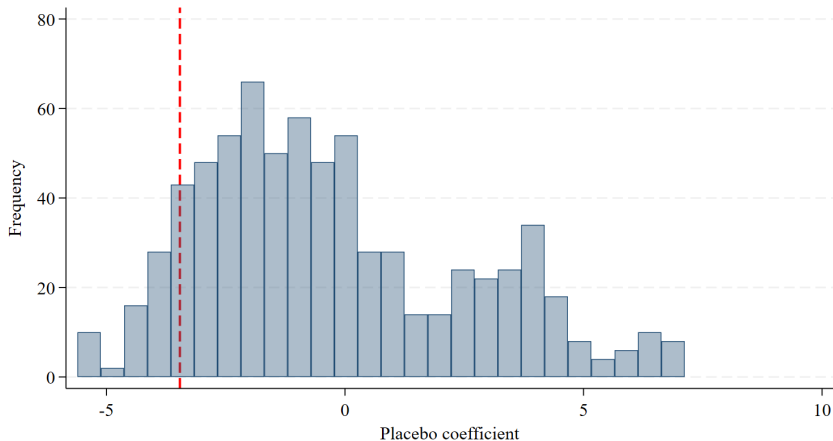
Red line: actual coefficient (se): 0.092\*\* (0.031)

RI-beta one-tailed p-value: 0.035

## Appendix: Randomization Inference - Flavored NVP Sales



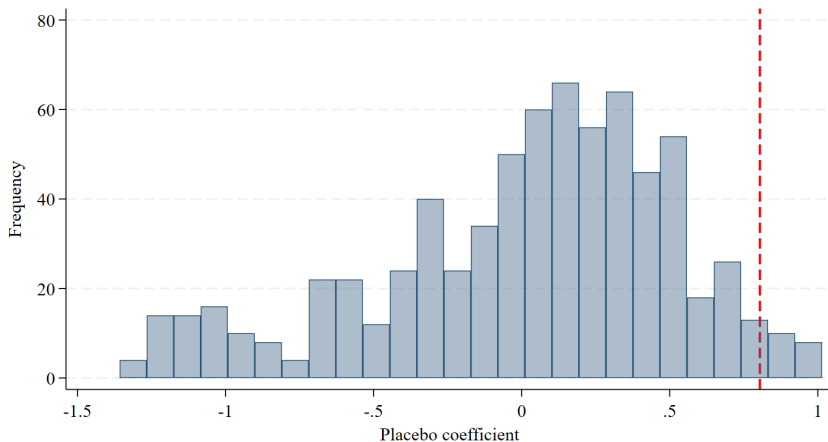
## Appendix: Randomization Inference - Mint NVP Sales



Red line - actual coefficient (se):  $-3.461^* (1.590)$

RI-beta one-tailed p-value: 0.104

# Appendix: Randomization Inference - Tobacco & Unflavored NVP Sales



Red line - actual coefficient (se):  $0.804*(0.367)$

RI-beta one-tailed p-value: 0.029

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