Estimating the Effect of E-cigarette Nicotine Limits on E-cigarette and Cigarette Sales in Canada

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- This paper is not yet published and is subject to change.

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  - EU and UK (2016) - 20mg/ml
  - Canada (2021) - 20mg/ml
  - US: Massachusetts (2019) and Utah (2021) - 35 mg/ml

Motivation

- Currently, there are no economic studies that estimate the impact of limiting nicotine in tobacco products.
- In this paper, we use a difference-in-differences model to study the impact of Canada's nicotine limit of 20 mg/ml in e-cigarettes on sales of e-cigarettes and combustible cigarettes.

Background

- Economic theory is ambiguous about the impact of limiting nicotine in e-cigarettes.
- Lillard (2020) posits that consumers purchase tobacco products because of their underlying demand for nicotine. Consumers purchase different types of tobacco products depending on:
  - the cost of the product.
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- Nicotine limits in e-cigarettes both increase the per unit cost of consuming nicotine from e-cigarettes and decrease the efficiency of nicotine delivery.
- Consumers wishing to keep nicotine consumption constant may either:
  - Increase consumption of e-cigarettes.
  - Substitute to other tobacco products including combustible cigarettes which are a more harmful product (National Academies of Sciences, Engineering, and Medicine, 2018).

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- In other words, the theory posits that limiting nicotine in e-cigarettes should reduce nicotine addiction and lead to reductions in consumption of both e-cigarettes and combustible cigarettes.
- In addition, lower addiction levels could increase quit success rates when people wish to discontinue use of tobacco products.

E-Cigarette 20mg/ml Nicotine Limit Timeline

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- Federal limit - All provinces and territories (July 2021)
- We use a difference-in-differences framework comparing late-adopting provinces (due to the federal limit) to early-adopting provinces.

Data - E-cigarette Sales (Oct. 2020 - Dec. 2022)

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  - Limited to four panels representing five provinces (AB, BC, MB & SK, QC).
  - Outcomes:
    - Average nicotine concentration (mg/ml)
    - Price per mg of nicotine
    - Sales (units/capita)
    - Average fluid volume per unit
    - Price of e-cigarettes
    - Number of unique UPCs

Data - Google Searches (October 2020 - December 2022)

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  - Available at the province by month-year level and includes nine provinces - excludes Prince Edward Island and the territories due to low search volume.

Data - Cigarette Sales (Oct. 2020 - Dec. 2022)

Health Canada's Tobacco Reporting Regulations, Section 13 (Sales)

- Reports shipments of cigarette sticks from cigarette manufacturers to wholesalers and retailers.
- Available at the month-year level for all provinces and territories.

Methodology

- We estimate the following difference-in-differences model:

$$Y_{p,t} = \beta_0 + \beta_1 NicotineLimit_{p,t} + \pi X_{p,t} + \gamma_p + \theta_t + \epsilon_{p,t}$$

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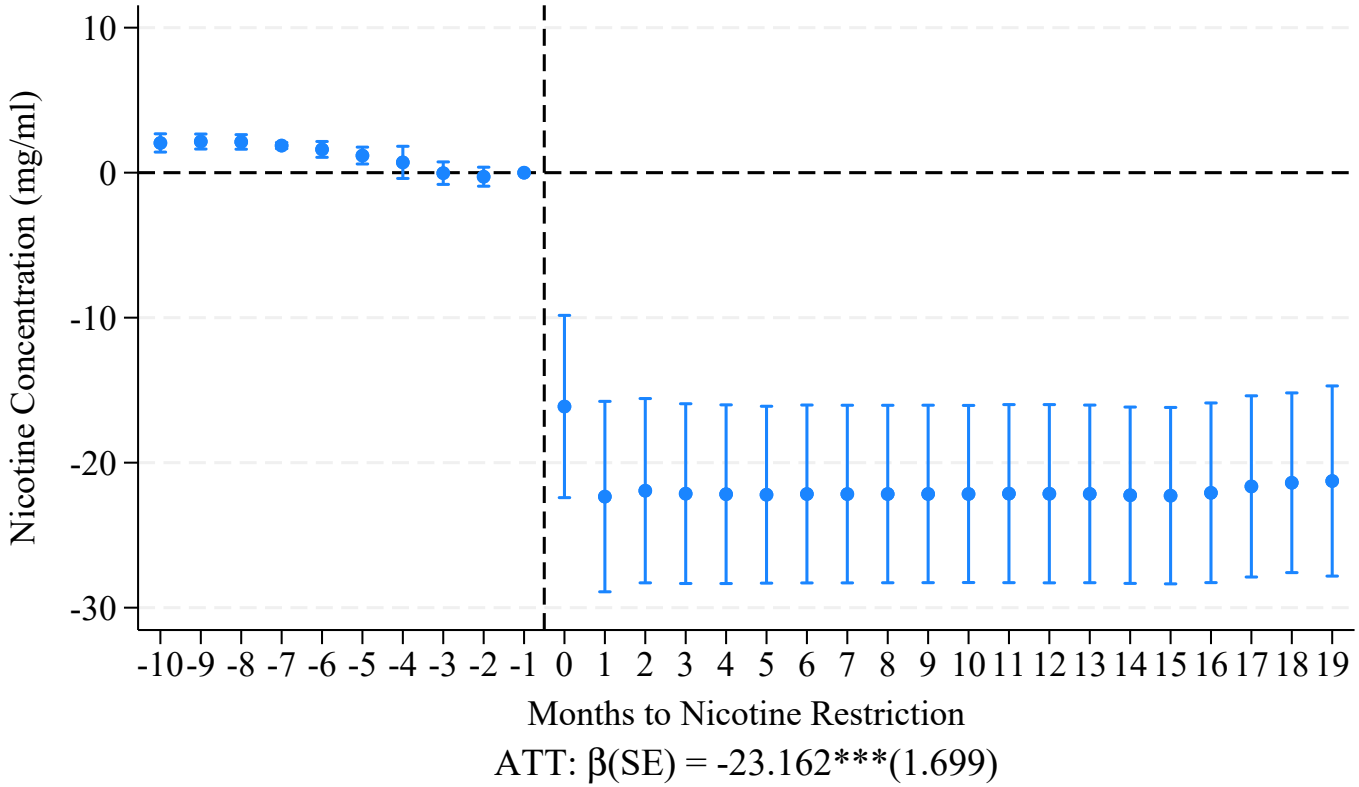
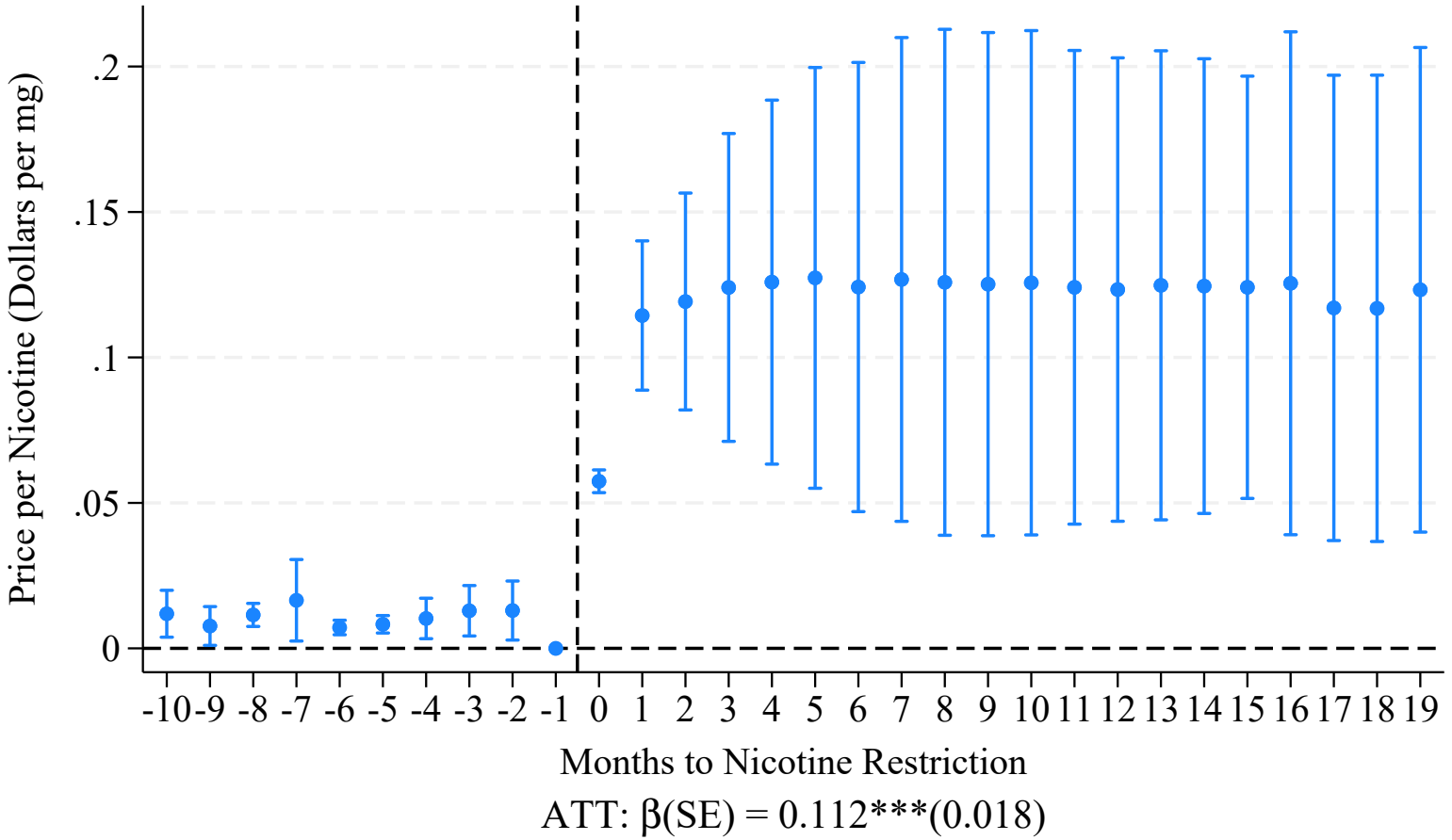
- β_1 has a causal interpretation under the parallel trends assumption.
- Standard errors are clustered at the province level. We supplement inference with wild bootstrap p-values as suggested in (Cameron, Gelbach and Miller, 2008).

Nicotine Concentration (mg/ml) ≈ 55% Reduction



Notes: This figure uses data drawn from NielsenIQ data for gas and convenience stores from October 2020 to December 2022. The event study includes province and year-by-month fixed effects. Covariates include e-cigarette sales tax rates and an indicator variable for e-cigarette flavor bans. Standard errors are clustered at the province level. 95% confidence intervals are shown. * $p<0.10$, ** $p<0.05$, *** $p<0.01$

Price of Nicotine from E-Cigarettes (Dollars/mg) ≈ 128% Increase



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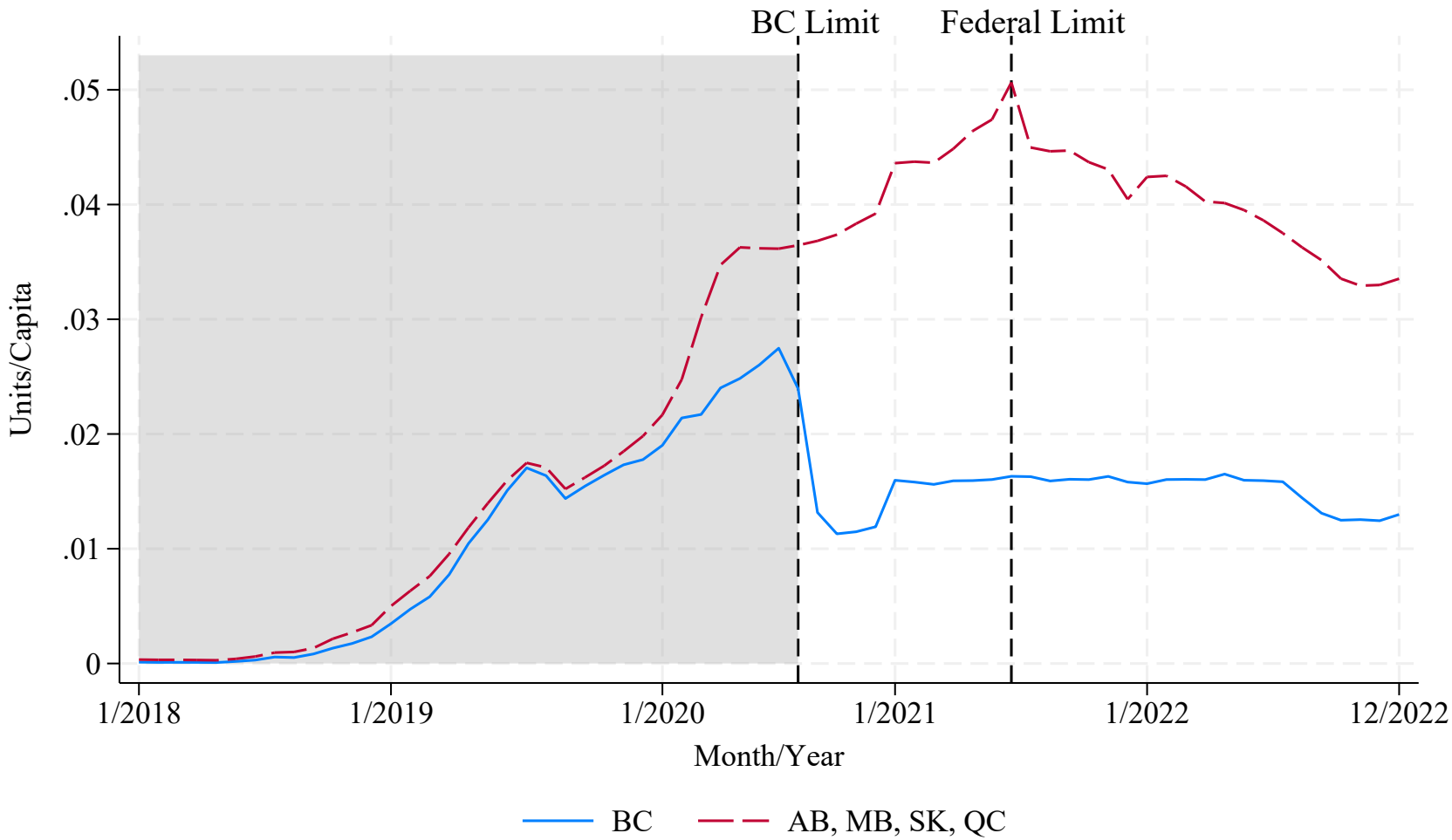
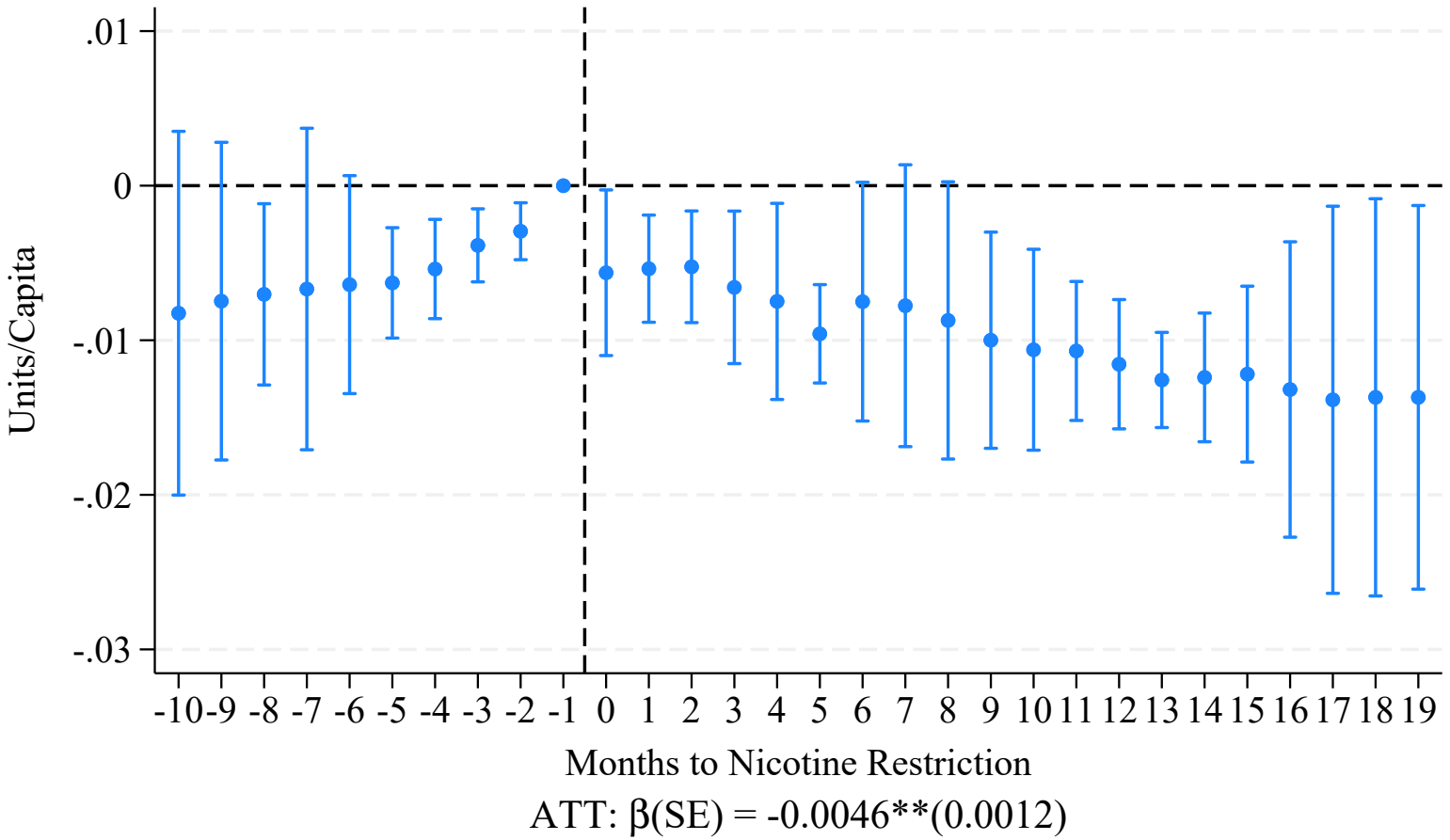
E-Cigarette Sales Trends



This figure shows average trends (weighted by population) in e-cigarette sales per capita in gas and convenience stores across late-adopting provinces (AB, MB, SK, and QC) compared to the early adopter (BC). The shaded region represents data excluded from our analysis. The vertical lines mark the period before nicotine limit in BC was implemented and the period before the federal nicotine limit was implemented.

E-cigarette Sales (Units/Capita) ≈ 10% Reduction



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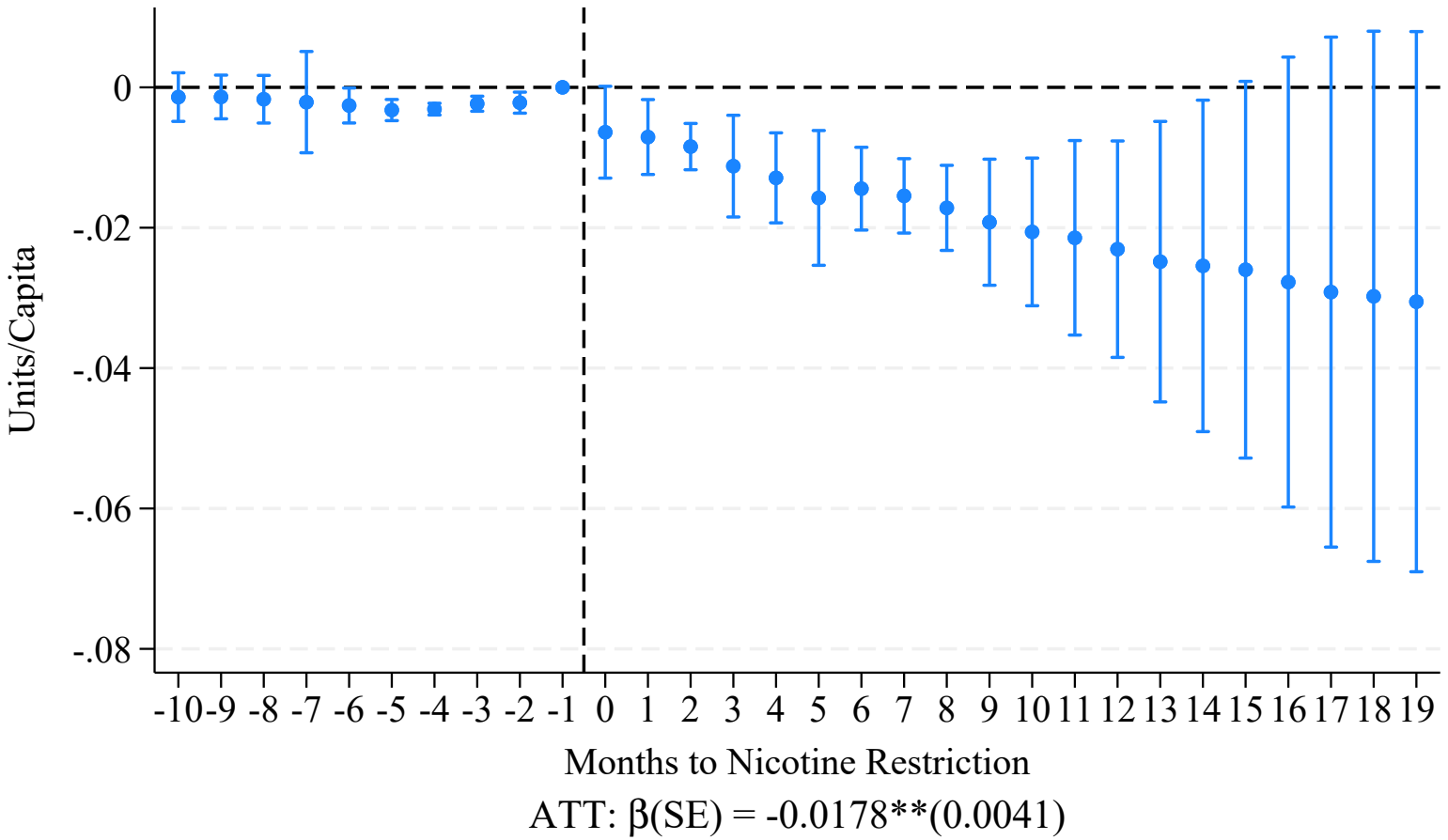
Pre-Trend Extrapolation Procedure

- There are various approaches to correcting bias from non-parallel trends.
- We use a pre-trend extrapolation procedure, as discussed in Bhuller et al. (2013) and Goodman-Bacon (2021).
- This approach assumes that the province-level linear trend from the pre-period would have continued into the post-period and adjusts the dependent variable to reflect deviations from this trend.

E-cigarette Sales ≈ 41% Reduction



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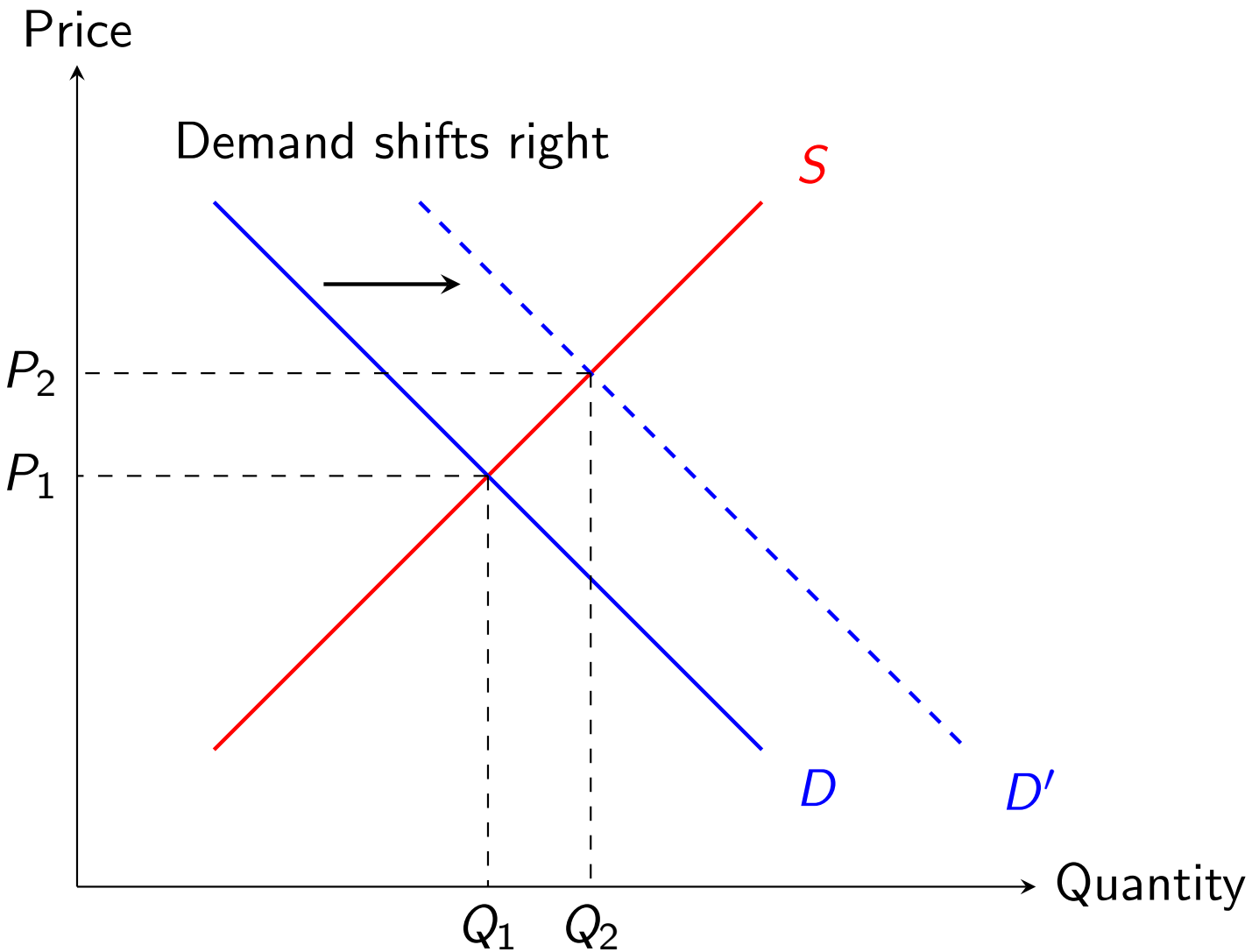
Results - E-cigarettes - Volume per Unit

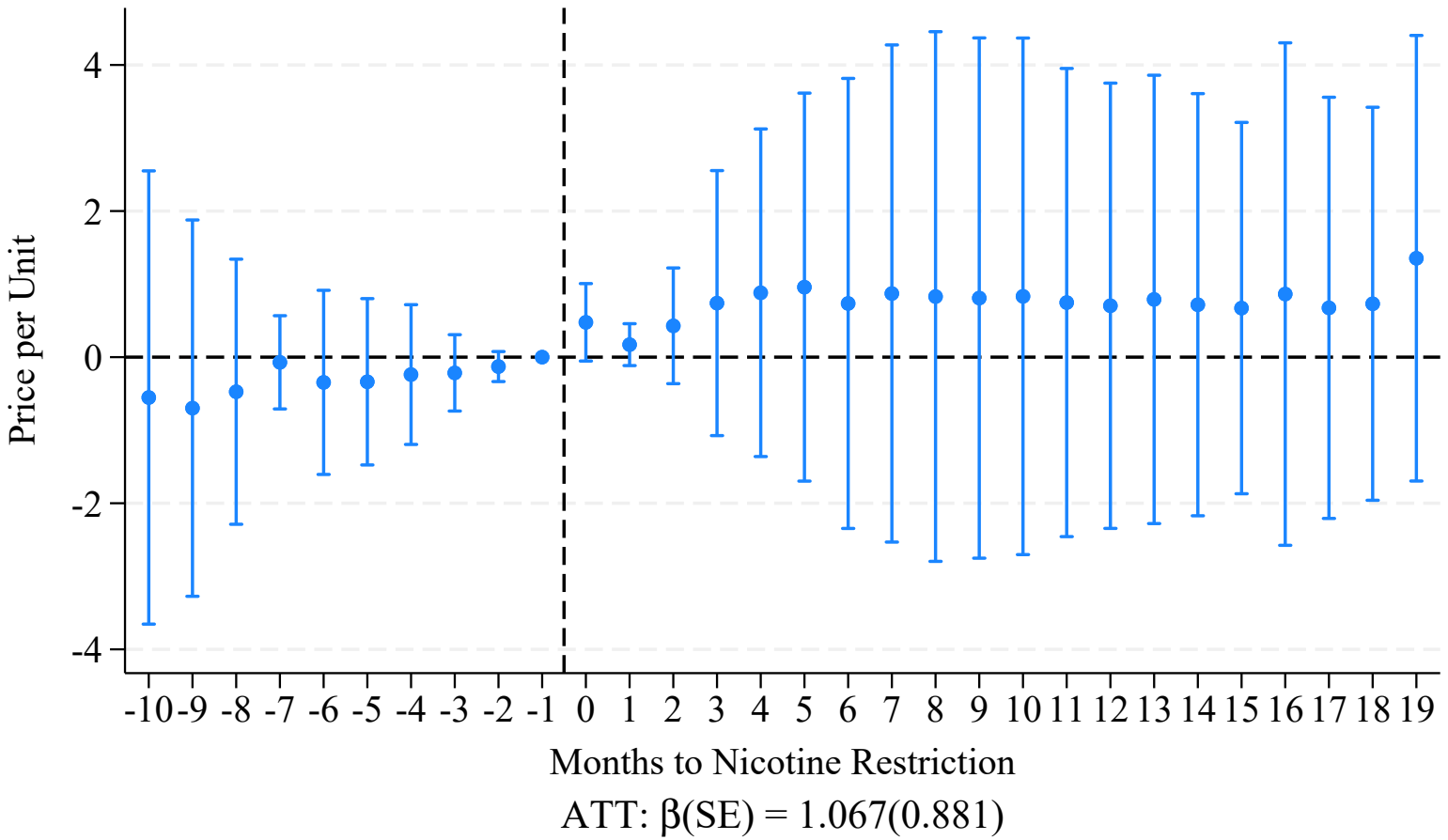
	(1)	(2)	(3)
	Avg. Fluid ML per Unit		
Nicotine Limit	0.102***	-0.005	0.121***
	(0.013)	(0.008)	(0.018)
	[0.004]	[0.530]	[0.000[1]]
	{0.125}	{0.624}	-
Mean[2]	3.621	3.621	3.621
% of Mean	2.82	-0.15	3.35
N	120	120	120
Model	TWFE	Pre-Trend Adjusted TWFE	Synthetic DID
Province FE	Yes	Yes	Yes
Year-by-Month FE	Yes	Yes	Yes
Covariates	Yes	Yes	Yes
Pre-Trend Control	No	Yes	Yes

Notes: Data is drawn from NielsenIQ data for gas and convenience stores from October 2020 to December 2022. Each coefficient is a separate regression. Every regression is weighted by population and includes province and year-by-month fixed effects. Covariates include e-cigarette sales tax rates and an indicator variable for e-cigarette flavor bans. Standard errors are clustered at the province level. Standard errors are in parentheses. P-values are in brackets. Wild bootstrap p-values are in curly brackets. [1] Bootstrapped p-value. [2] Mean for treated units for 9 months of pre-period. * $p<0.10$, ** $p<0.05$, *** $p<0.01$

Impact on Market for Low-Nicotine E-Cigarettes



Price of Low-Nicotine E-Cigarettes ≈ 8% Increase



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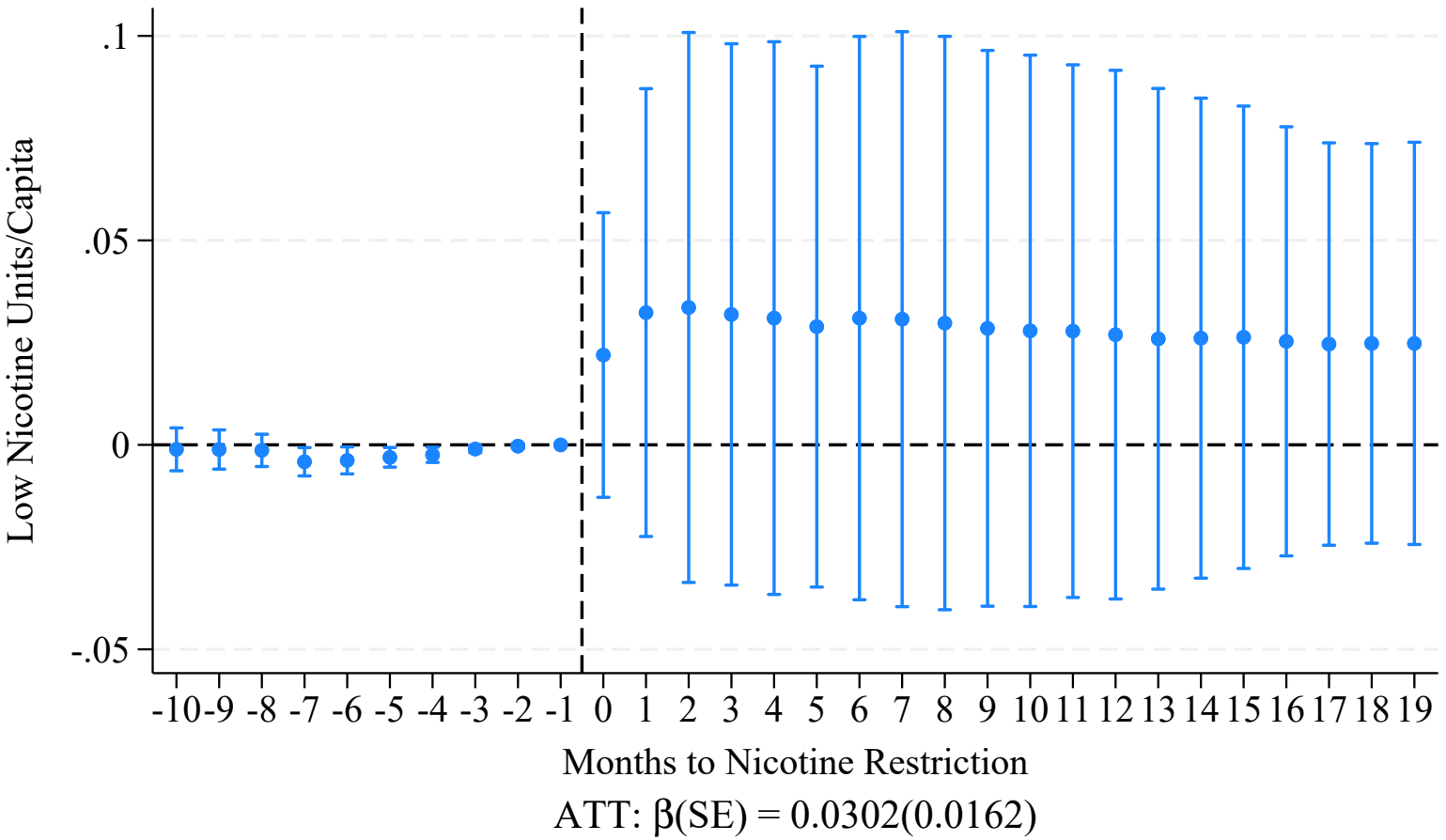
Low Nicotine E-Cigarette Sales ≈ 320% Increase



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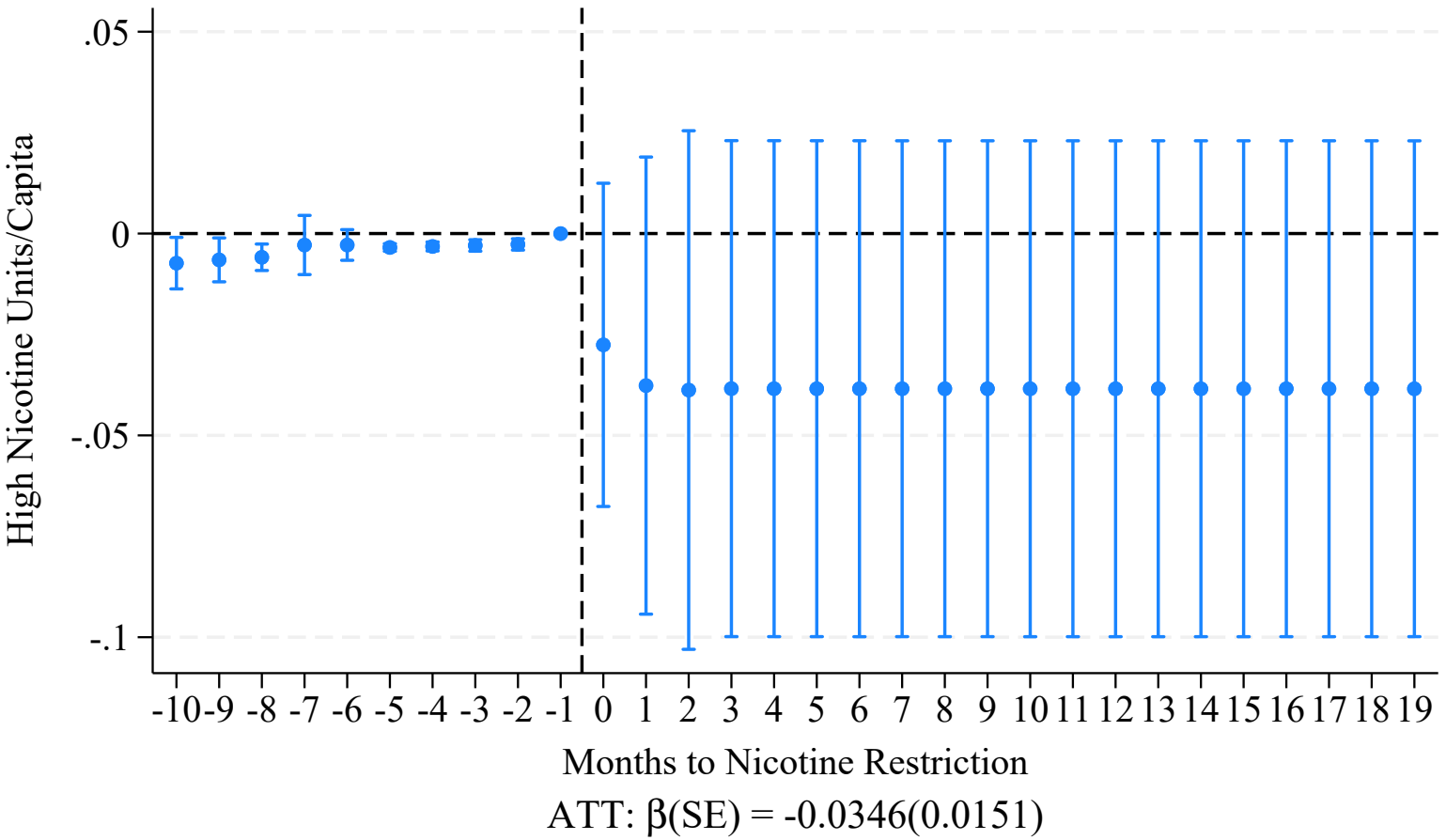
High Nicotine E-Cigarette Sales ≈ 97% Decrease



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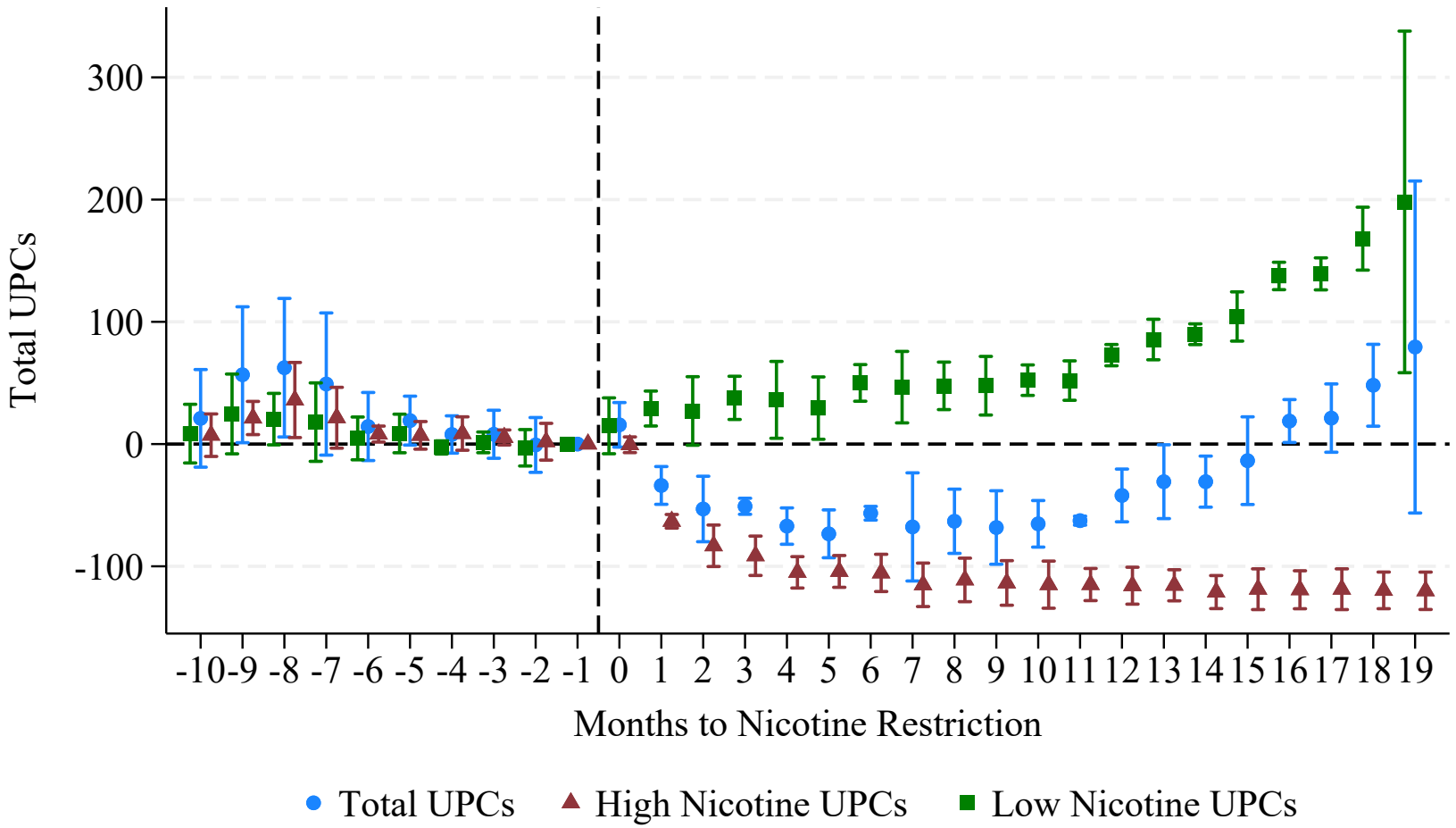
Unique UPCs



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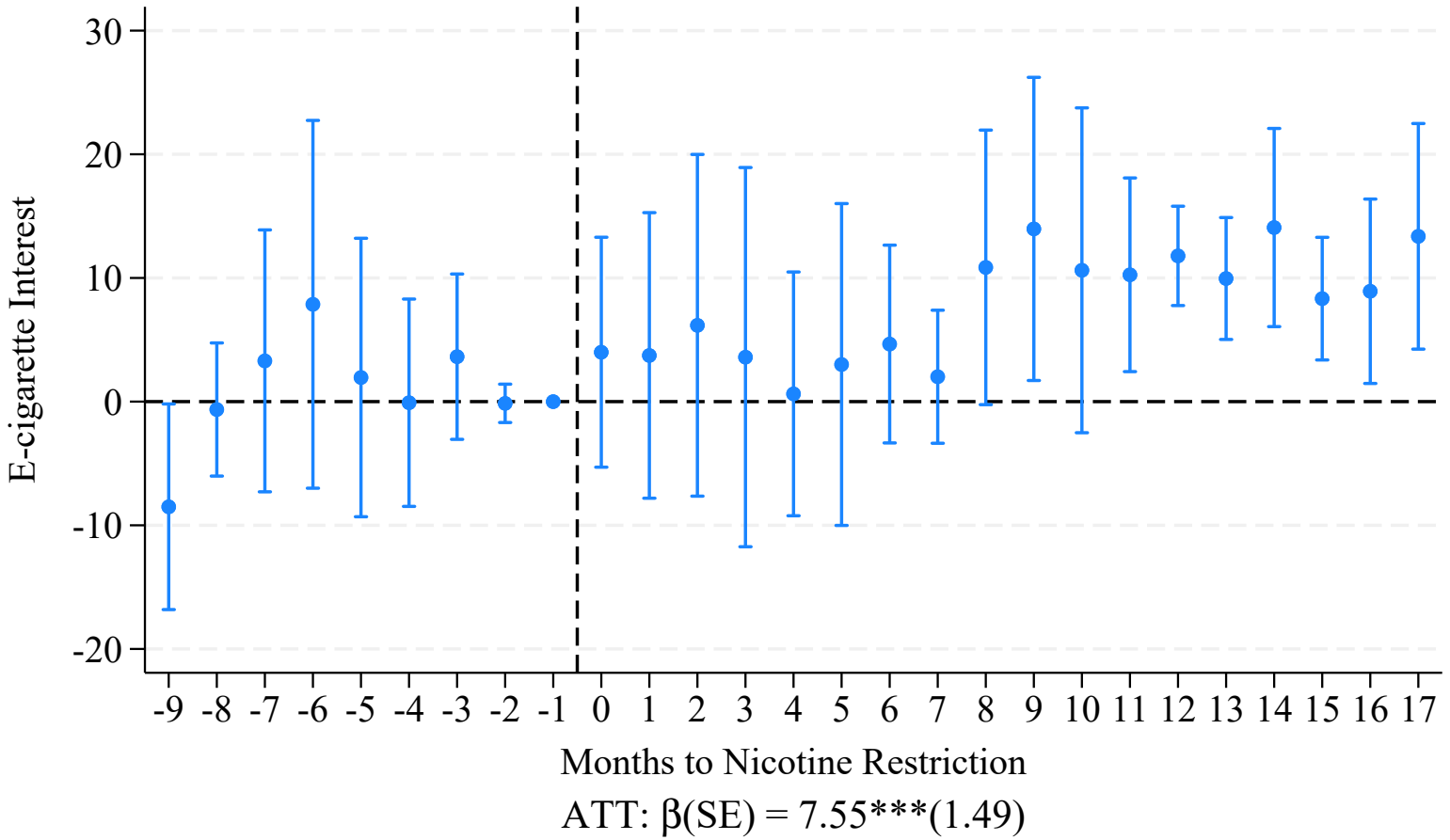
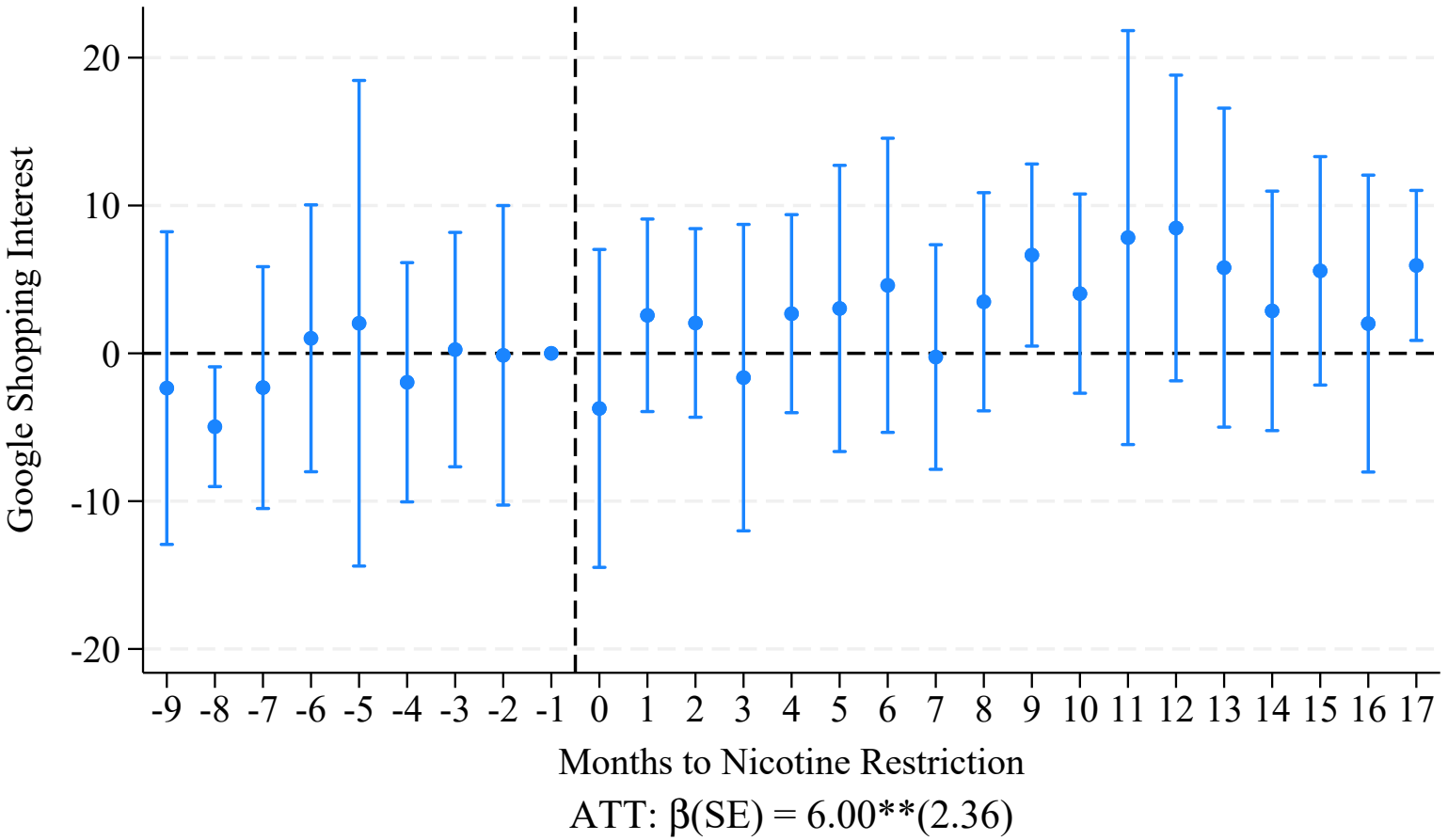
  - Increased the price of consuming nicotine from e-cigarettes by 125%.
  - Increased the number of UPCs for low nicotine e-cigarettes by 125%.
- Next, we will examine our Google Trends analysis, where search trends serve as a proxy for consumer interest and e-cigarette sales in specialty vape shops and online markets.

Google Searches Related to E-cigarettes ≈ 18% Increase



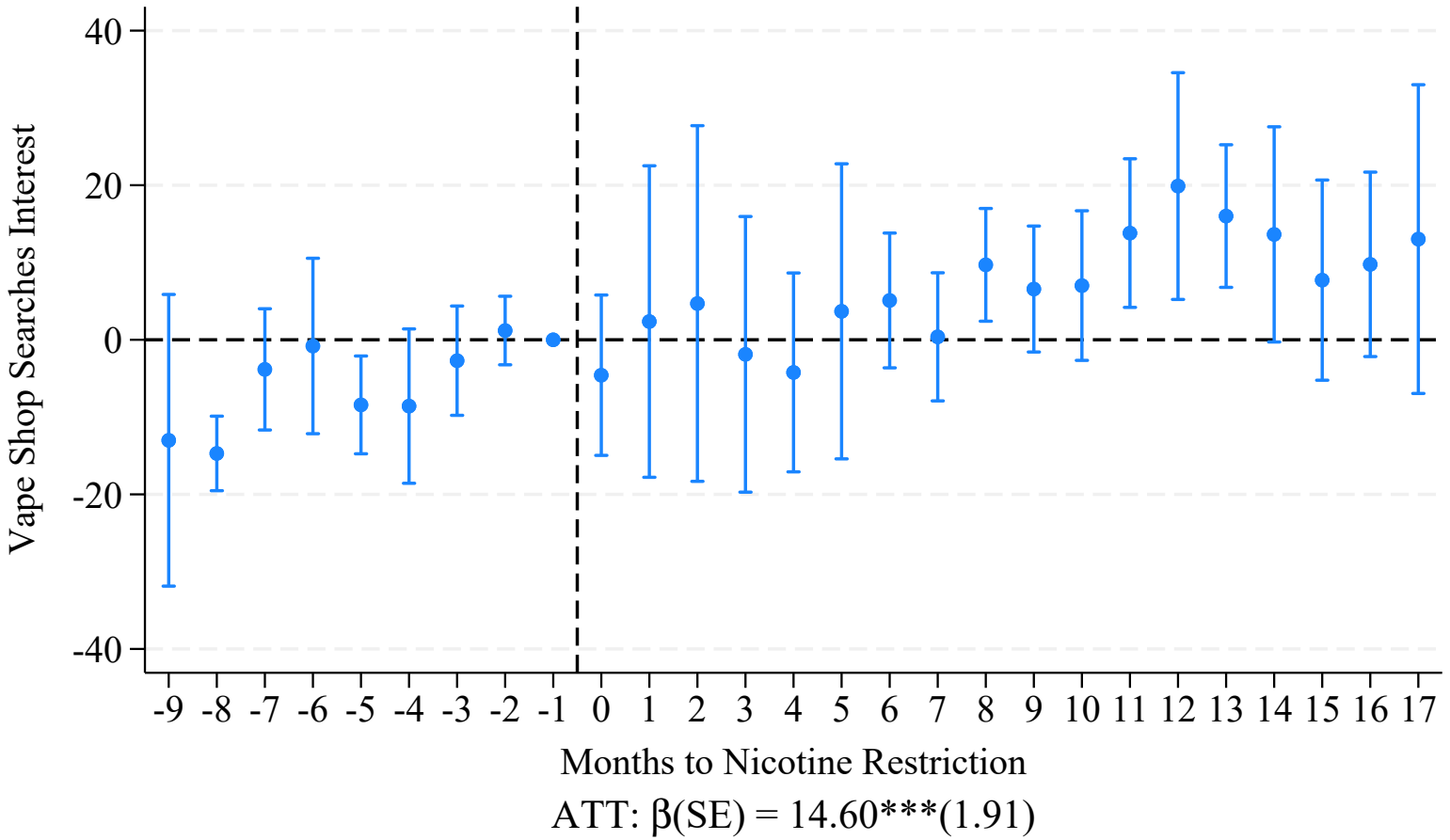
Notes: This figure uses data is drawn from Google Trends from October 2020 to December 2022. The event study is weighted by population and includes province and year-by-month fixed effects. Covariates include cigarette tax rates, e-cigarette sales tax rates, an indicator variable for e-cigarette flavor bans, and an an indicator variable for the Atlantic region during travel restrictions between QC and NB. Standard errors are clustered at the province level. 95% confidence intervals are shown. * $p<0.10$, ** $p<0.05$, *** $p<0.01$

Searches Related to E-cigarettes in Google Shopping ≈ 19% Increase



Notes: This figure uses data is drawn from Google Trends from October 2020 to December 2022. The event study includes province and year-by-month fixed effects. Covariates include cigarette tax rates, e-cigarette sales tax rates, an indicator variable for e-cigarette flavor bans, and an indicator variable for travel restrictions between QC and NB. Standard errors are clustered at the province level. 95% confidence intervals are shown. * $p<0.10$, ** $p<0.05$, *** $p<0.01$

Google Searches Containing "Vape Shop" $\approx$ 34% Increase



Notes: This figure uses data is drawn from Google Trends from October 2020 to December 2022. The event study includes province and year-by-month fixed effects. Covariates include cigarette tax rates, e-cigarette sales tax rates, an indicator variable for e-cigarette flavor bans, and an indicator variable for the Atlantic region during travel restrictions between QC and NB. Standard errors are clustered at the province level. 95% confidence intervals are shown. * $p<0.10$, ** $p<0.05$, *** $p<0.01$

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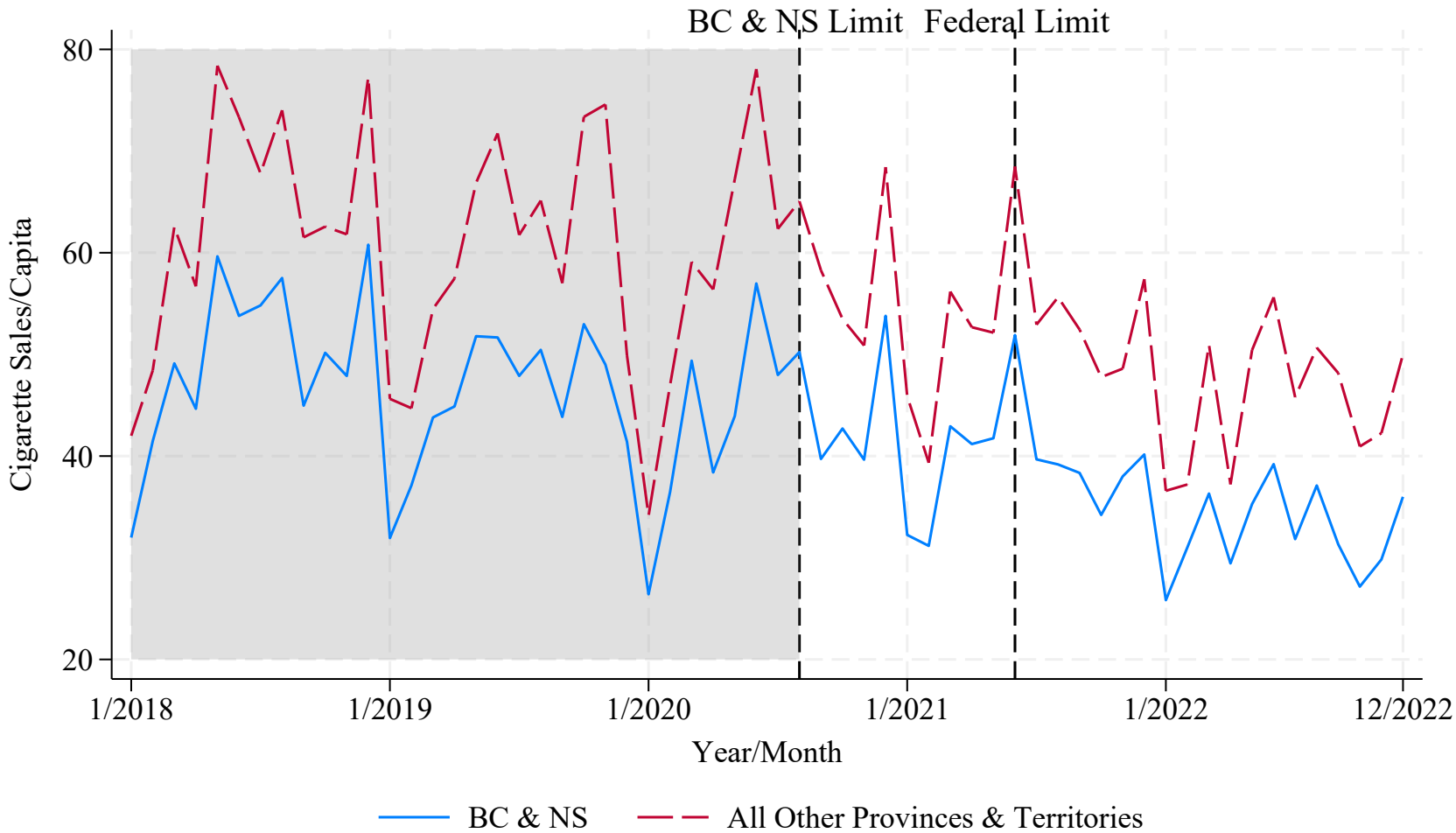
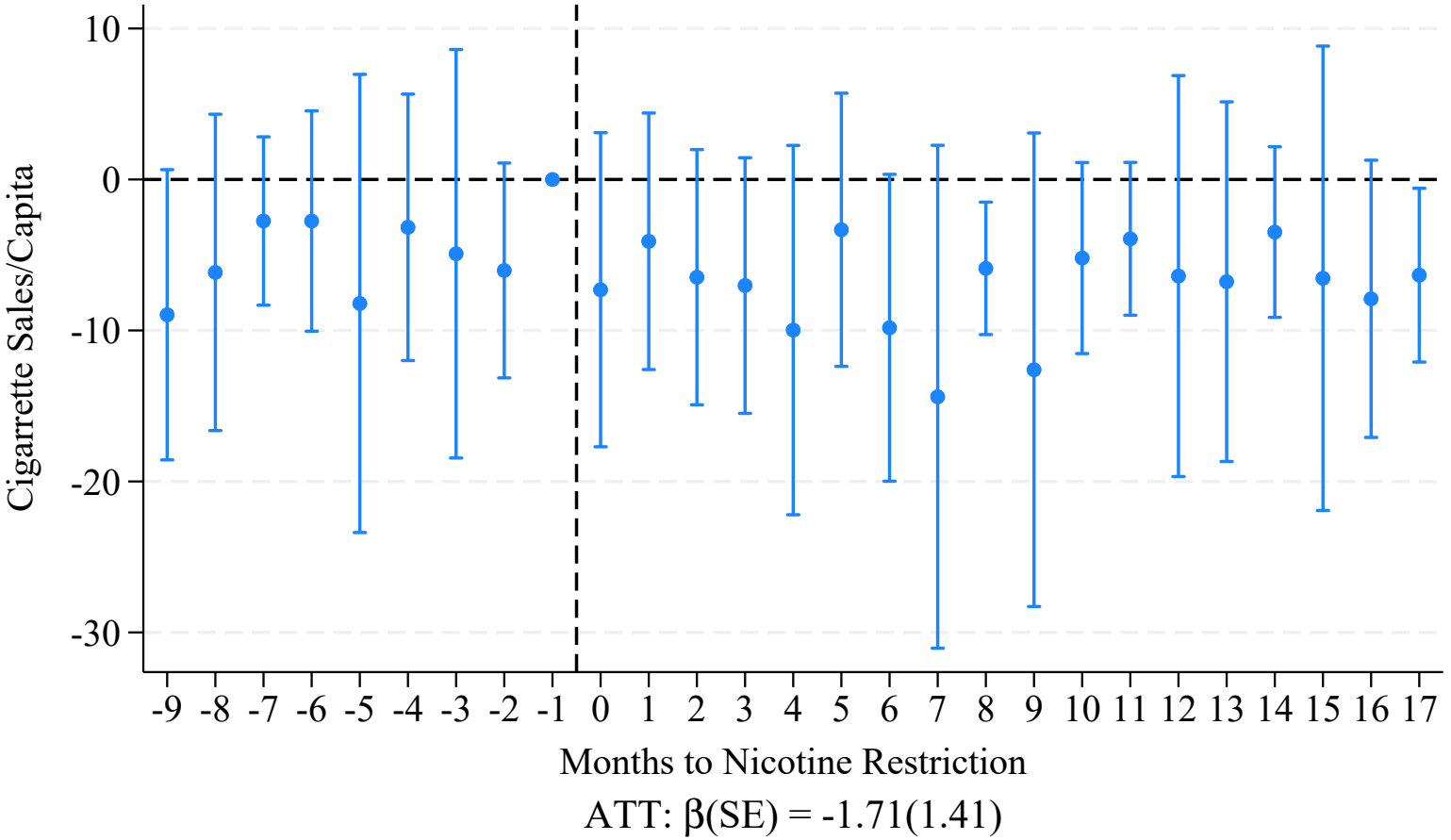
Cigarette Sales Trends



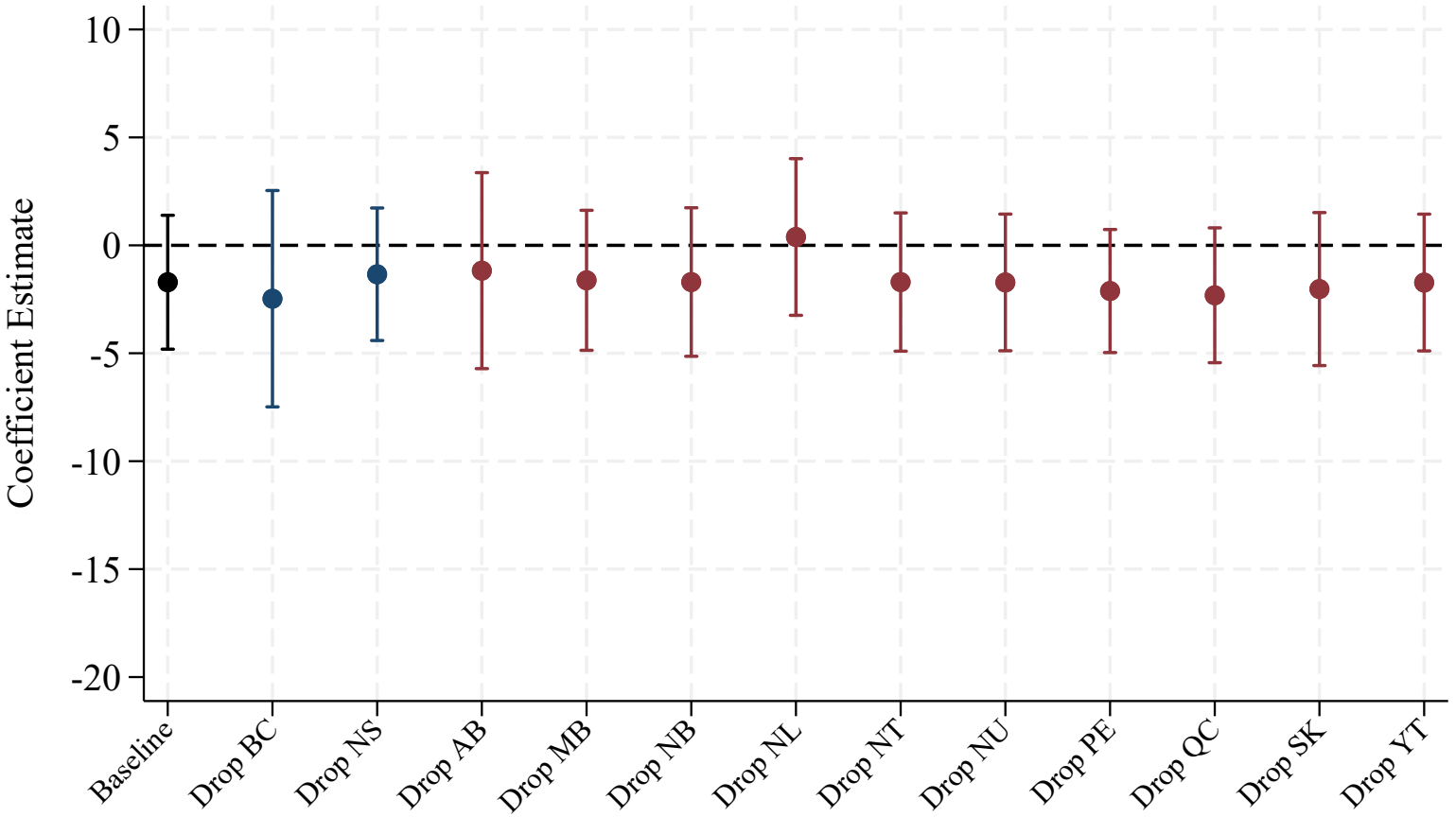
Notes: This figure shows average trends (weighted by population) in cigarette sales per capita across late-adopting provinces and territories (AB, MB, NB, NL, NT, NU, ON, SK, PE, QC, YT) compared to early-adopting provinces (BC and NS). The shaded region represents data excluded from our analysis. The vertical lines mark the period before nicotine limits in BC and NS were implemented and the period before the federal nicotine limit was implemented.

Results - No Effect on Cigarette Sales



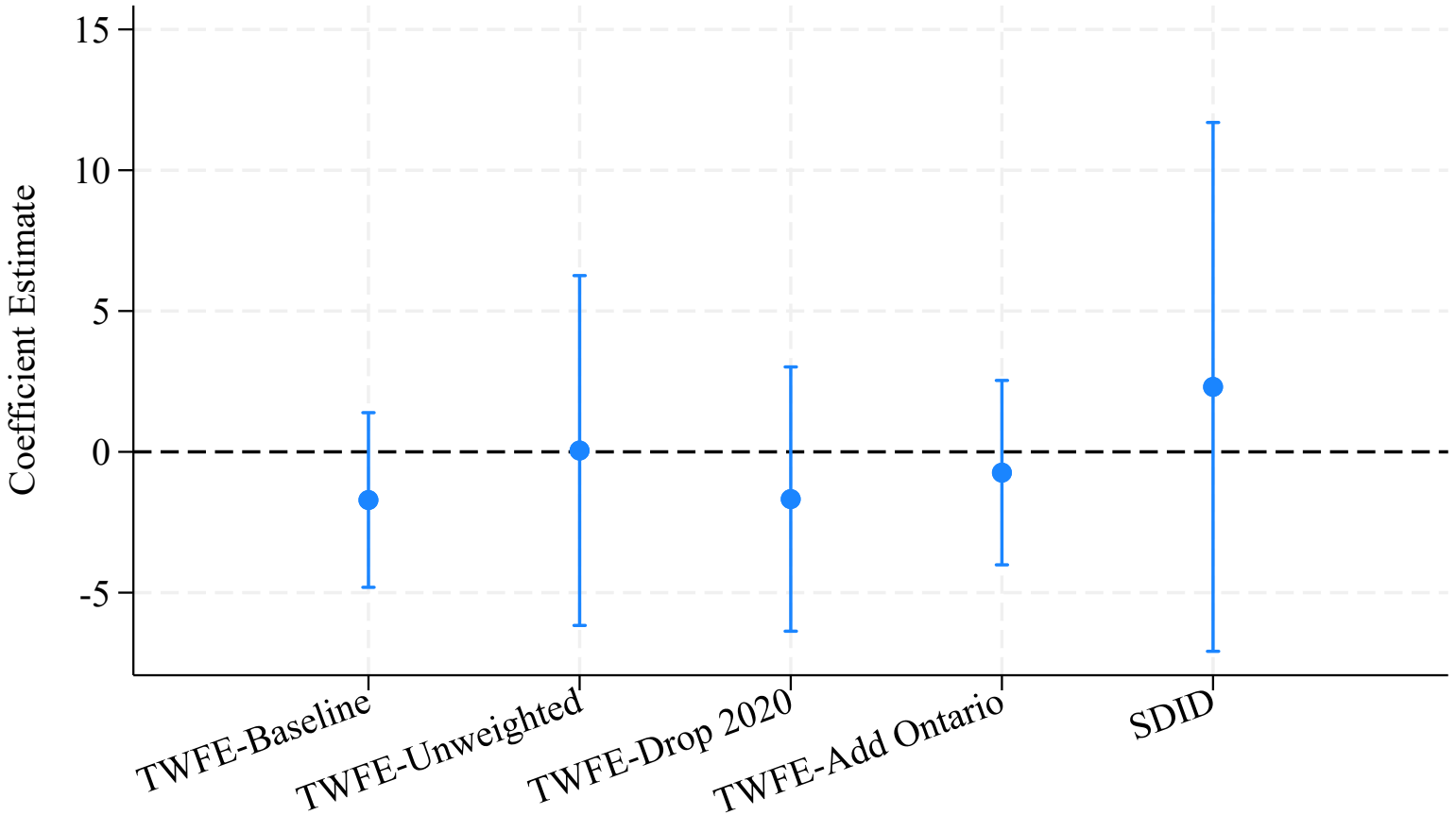
Notes: This figure uses data drawn from shipments of cigarette sticks from cigarette manufacturers to wholesalers and retailers from October 2020 to December 2022 as required by the Tobacco Reporting Regulations. The event study is weighted by population and includes province and year-by-month fixed effects. Covariates include cigarette tax rates, e-cigarette sales tax rates, an indicator variable for e-cigarette flavor bans, and an indicator variable for the Atlantic region during travel restrictions between QC and NB. Standard errors are clustered at the province level. 95% confidence intervals are shown. * $p<0.10$, ** $p<0.05$, *** $p<0.01$

Robustness - Cigarette Analysis - Drop One Province



Notes: This figure uses data drawn from shipments of cigarette sticks from cigarette manufacturers to wholesalers and retailers from October 2020 to December 2022 as required by the Tobacco Reporting Regulations. Each regression is weighted by population and includes province and year-by-month fixed effects. Covariates include cigarette tax rates, e-cigarette sales tax rates, an indicator variable for e-cigarette flavor bans, and an indicator variable for the Atlantic region during travel restrictions between QC and NB. Standard errors are clustered at the province level. 95% confidence intervals are shown.

Robustness of Cigarette Analysis to Alternate Specifications



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Conclusion

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Results - E-cigarette Sales

	(1)	(2)	(3)
	E-Cigarette Sales (Units/Capita)		
Nicotine Limit	-0.005** (0.001) [0.033] {0.375}	-0.018** (0.004) [0.022] {0.125}	-0.004*** (0.001) [0.000[1]] -
Mean[2]	0.044	0.044	0.044
% of Mean	-10.4	-40.2	-9.1
N	120	120	120
Model	TWFE	Pre-Trend Adjusted TWFE	Synthetic DID
Province FE	Yes	Yes	Yes
Year-by-Month FE	Yes	Yes	Yes
Covariates	Yes	Yes	Yes
Pre-Trend Control	No	Yes	Yes

Notes: Data is drawn from NielsenIQ data for gas and convenience stores from October 2020 to December 2022. Each coefficient is a separate regression. Every regression is weighted by population and includes province and year-by-month fixed effects. Covariates include e-cigarette sales tax rates and an indicator variable for e-cigarette flavor bans. Standard errors are clustered at the province level. Standard errors are in parentheses. P-values are in brackets. Wild bootstrap p-values are in curly brackets. [1] Bootstrapped p-value. [2] Mean for treated units for 9 months of pre-period. * $p<0.10$, ** $p<0.05$, *** $p<0.01$

Results - Cigarette Sales

	(1)	(2)	(3)	(4)
	Cigarette Sales/Capita			
Nicotine	2.114	-6.695***	1.100	-1.710
	(6.692)	(1.146)	(1.206)	(1.409)
Limit	[0.758]	[0.000]	[0.381]	[0.250]
	{0.982}	{0.022}	{0.553}	{0.425}
Mean [1]	54.2	54.2	54.2	54.2
% of Mean	3.9	-12.4	2.0	-3.2
N	324	324	324	324
Province/Territory FE	No	Yes	Yes	Yes
Year-by-Month FE	No	No	Yes	Yes
Covariates	No	No	No	Yes

Notes: Data is drawn from shipments of cigarette sticks from cigarette manufacturers to wholesalers and retailers from October 2020 to Dec 2022 as required by the Health Canada's Tobacco Reporting Regulations, Section 13 (Sales). Each coefficient is a separate regression. Each regression is weighted by population. Columns 2-4 include include province/territory fixed effects and columns 3 and 4 include year-by-month fixed effects. Covariates include cigarette tax rates, e-cigarette sales tax rates, an indicator variable for e-cigarette flavor bans, and an indicator variable for the Atlantic region during travel restrictions between QC and NB. Standard errors are clustered at the province level. P-values are in square brackets. Wild bootstrap p-values are in curly brackets. [1] Mean for treated units for 9 months of pre-period. * $p<0.10$, ** $p<0.05$, *** $p<0.01$

Google Trends Results

	(1)	(2)	(3)	(4)
	E-Cigarette Topics in Google Searches	E-Cigarettes Topics in Google Shopping	Search Term Containing "Vape Shop"	First Nations Topics in Google Searches
Nicotine Limit	7.55***	6.00**	14.60***	1.35
	(1.49)	(2.360)	(1.91)	(1.024)
	[0.001]	[0.039]	[0.000]	[0.228]
	{0.015}	{0.078}	{0.000}	{0.219}
Mean [1]	42.1	32.0	42.8	17.4
% of Mean	17.9	18.7	34.1	7.8
N	216	216	216	216
Province FE	Yes	Yes	Yes	Yes
Year-by-Month FE	Yes	Yes	Yes	Yes
Covariates	Yes	Yes	Yes	Yes

Notes: Data is drawn from Google Trends from October 2020 to December 2022. Each coefficient is a separate regression. Every regression includes province and year-by-month fixed effects. Co-variates include cigarette tax rates, e-cigarette sales tax rates, an indicator variable for e-cigarette flavor bans, and an indicator variable for the Atlantic region during travel restrictions between QC and NB. Standard errors are clustered at the province level. Standard errors are in parenthesis. P-values are in square brackets. Wild bootstrap p-values are in curly brackets. [1] Mean for treated units for 9 months of pre-period. * $p<0.10$, ** $p<0.05$, *** $p<0.01$