E-cigarettes and smoking cessation: Evidence from nicotine replacement therapy sales, prescription medications, and quitlines

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Introduction

Smoking cessation attempts are common but largely unsuccessful

- 70% of smokers want to quit
- 55% attempt to quit annually
- Only 7.5% are able to successfully quit in a given year (Babb et al., 2017; US Department of Health and Human Services, 2020)

Nicotine replacement therapies (NRTs) aim to aid cessation attempts

Five NRTs approved by FDA in US: gum, inhalers, lozenges, nasal sprays, patches (FDA, 2017)

- Gum, lozenges, and patches can be purchased over the counter

NRTs increase quit rates by 50% to 60% (Hartmann-Boyce et al., 2018)

But used in less than 1/3 of cessation attempts (Babb et al., 2017; Carabello et al., 2017; Creamer et al., 2019)

Introduction

E-cigarettes have emerged as another possible aid to smoking cessation attempts

- 14% of current smokers who attempted to quit smoking in the past year and 11% of former smokers used e-cigarettes in their quit attempts.
- Recent RCTs suggest that e-cigarettes help some smokers quit (Hajek et al., 2019, 2022).
- But their use for cessation purposes is controversial
  - Supported by the UK's National Health Service, less so by US agencies

Introduction

Are e-cigarettes and NRTs substitutes or complements?

We examine this question in the context of e-cigarette taxes.

- Between 2010 and 2021, 31 states passed legislation requiring a tax on e-cigarettes.
- Concern that these taxes may impede harm reduction efforts
- To understand full effect on harm reduction, need to know whether they influence use of other harm reduction products.
- E-cigarette taxes would increase NRT use if
  - The tax makes vapers try to stop, and they use NRTs to do so
  - The taxes makes smokers who are trying to quit more likely to use NRTs to do so rather than e-cigarettes

Introduction

Previous quasi-experimental work suggests that e-cigarettes & cigarettes are economic substitutes.

- Tax effects: Deng et al (2020); Pesko et al (2020); Saer et al (2020); Abouk et al (2021); Allcott & Rafkin (2021); Cotti et al (2022); Friedman & Pesko (2022); & Pesko & Warman (2020)
  - $1.00 increase in the e-cigarette tax per fluid ml reduces vaping by 0.5 ppts or 15.3% and increases daily smoking by 0.6 ppts or 5.3% (Pesko et al, 2020).

But e-cigarette taxes are not statistically related to use of prescription cessation medications (Maclean et al., 2022).

Introduction

We contribute by providing, to our knowledge, the first investigation of the effect of e-cigarette taxes on sales of over-the-counter NRTs.

- Since e-cigarettes are not prescription medications, they might be more closely related to over-the-counter NRTs.

We also examine effects on quitline calls and Medicaid-financed prescriptions for non-nicotine cessation medications.

We find no clear evidence of effects on any of these outcomes.

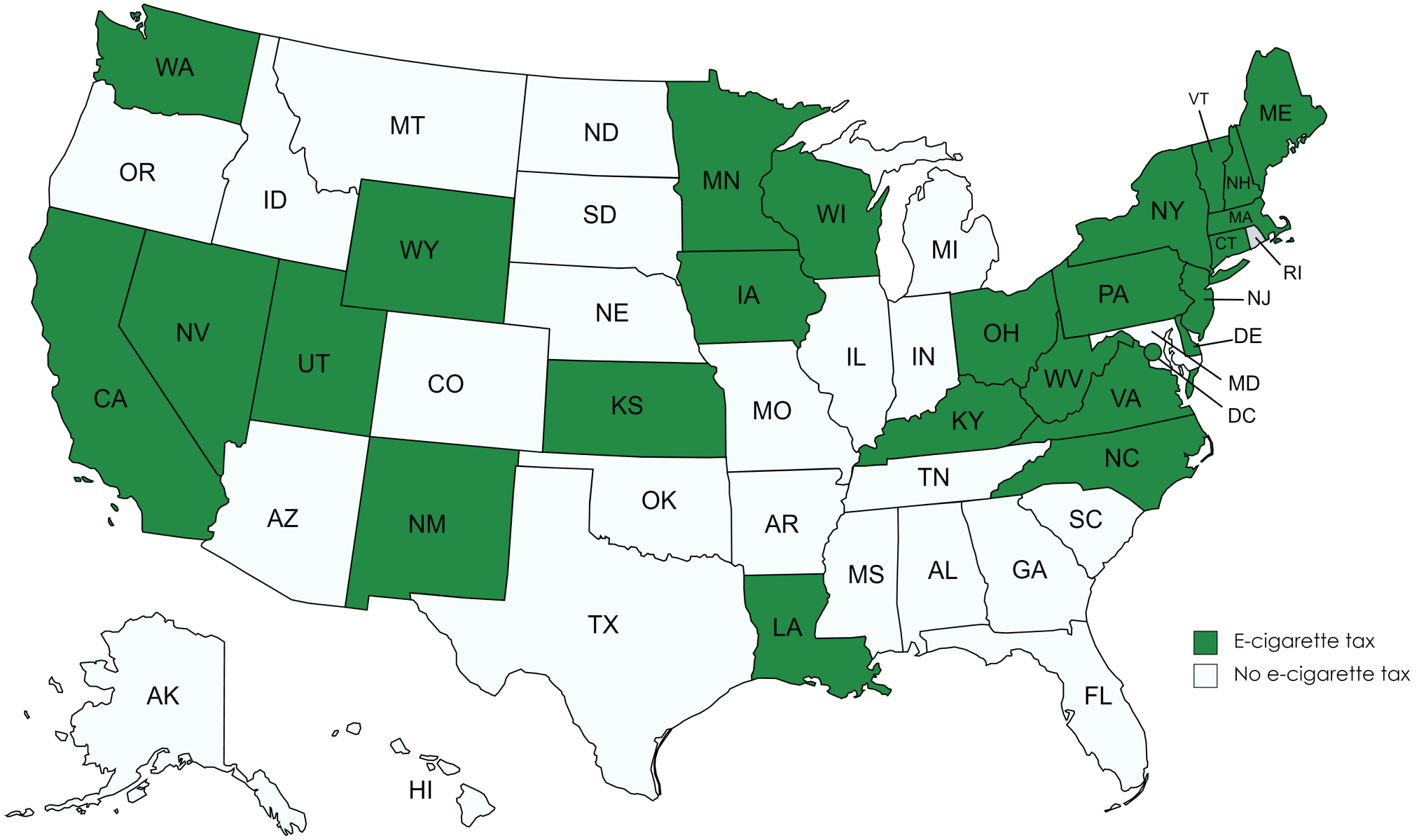
Data

Neilsen Retail Sales Database 2010-2020

- Sample of 30,000 to 36,000 stores prior to 2018; 49,000 since then
  - We only include stores that appear in, and sell at least one NRT product in, each quarter.
- Coverage (as of 2017)
  - 15%-26% of food store, mass merchandiser, dollar store, and club store sales
  - 50% of drug store sales
  - 2% of convenience store and liquor store sales
- We analyze data at the store-by-quarter level
- Outcomes
  - E-cigarette sales (fluid ml sold)
  - Count of total NRTs
  - Count by NRT type (gum, lozenges, patches)

Medicaid-financed non-nicotine cessation medications come from the State Drug Utilization Database

Calls to state quitlines come from the CDC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E-cigarette tax
No e-cigarette tax

Data

Three types of e-cigarette taxes

- Unit tax per ml of liquid volume
- Ad valorem tax as a percent of the wholesale price
- Sales tax as a percent of the pre-tax retail price
- We use Cotti et al.'s (2021) standardized tax measure in $ per ml of fluid nicotine
  - Demand for tobacco products derived from demand for nicotine
  - Assumes 35% retailer markup over wholesale

Data

Other state-level covariates

- County-level Tobacco 21 laws
- Minimum legal sales ages for e-cigarettes and cigarettes
- Indoor smoking and vaping bans
- E-cigarette and cigarette licensure laws
- Cigar and little cigar taxes
- ACA Medicaid expansion
- Whether Medicaid covers different types of NRT products
- Laws that legalize marijuana for medical and recreational use
- Demographics (age, gender, education)

Methods

Two-way fixed effects regressions of the form

$$C_{ijt} = \delta_0 + \delta_1 Etax_{jt} + \delta_2 X_{jt} + \lambda_i + \gamma_t + \mu_{ijt}$$

Where

- i=store, j=tax jurisdiction, t=quarter-year
- C_{ijt}=quarterly store sales
- $Etax_{jt}$=e-cigarette taxes
- X_{jt}=other policies and demographics
- λ_i=store fixed effects
- γ_t=quarter-year fixed effects

Standard errors robust to heteroskedasticity and clustering by tax jurisdiction

Unweighted analyses

Table 2. Effect of e-cigarette taxes on e-cigarette sales per store-quarter using NeilsenIQ retail sales data

Outcome:	E-cigarette sales†	Any NRT sale
E-cigarette tax ($)	-87.6**	0.005
	[-173.2,-2.1]	[-0.018,0.028]
Observations	1032240	1128820
Time period	2011-2020	2010-2020
E-cigarette sales in e-cigarette tax jurisdictions, in the quarter prior to tax adoption	242	0.74
E-cigarette tax ($)	0.13	0.12

Notes: Regression is estimated with OLS and controls for time-varying jurisdiction characteristics (see Table 1), store fixed effects, and period fixed effects. Sample includes stores observed in each quarter-year period 2010-2020. 95% confidence intervals that account for within-jurisdiction clustering reported in square brackets.

***,**, and * = statistically different from zero at the 1%, 5%, and 10% level.

†E-cigarettes sales are not tracked in the NeilsenIQ data prior to 2011.

Table 3. Effect of e-cigarette taxes on NRT sales per store-quarter using NeilsenIQ retail sales data 2010-2020: Alternative sets of control variables and accounting for bias for heterogenous and dynamic treatment effects

Specification:	(1)	(2)	(3)	(4)	(5)
TWFE	-203.6 [-793.4,386.3]	217.6 [-166.0,601.2]	162.9 [-195.8,521.6]	154.4 [-185.7,494.6]	--
DCDH†	--	--	--	--	64.5 [-479.7, 608.7]
Continuous tax	Y	Y	Y	Y	Y
Period fixed effects	Y	Y	Y	Y	Y
Store fixed effects	Y	Y	Y	Y	N
Tobacco control policies	N	Y	Y	Y	Y
Other policies	N	N	Y	Y	Y
Demographics	N	N	N	Y	Y
State fixed effect	N	N	N	N	Y
Observations	617848	617848	617848	617848	2244
Average NRT sales in e-cigarette tax jurisdictions, in the quarter prior to tax adoption	14426	14426	14426	14426	14426
E-cigarette tax ($)	0.13	0.13	0.13	0.13	0.13

Notes: The outcome variable in regressions is the quarterly number of sales per store. All regressions estimated with OLS and control for time-varying jurisdiction characteristics (see Table 1), store fixed effects, and period fixed effects unless otherwise noted. Sample includes stores observed with positive NRT sales in each quarter-year period 2010-2020. ***,**, and * = statistically different from zero at the 1%, 5%, and 10% level.

†DCDH = de Chaisemartin and D'Haultfoeuille (2020) multiperiod model. The e-cigarette tax variable is recast to a categorical variable with the following values: $0.00 to $0.50 = $0.50, $0.51 to $1.00 = $1.00, $1.01 to $1.50 = $1.50; $1.51 to $2.00 = $2.00; and $2.01 and higher = $2.50. Data are aggregated to the jurisdiction-time level and weighted by the jurisdiction population.

Table 5. Heterogeneity in the effect of e-cigarette taxes on NRT sales per store-quarter using NeilsenIQ retail sales data 2010-2020: Alternative sets of control variables

Outcome:	Gum NRT sales	Lozenge NRT sales	Patch NRT sales	Brand NRT sales	Generic NRT sales
E-cigarette tax ($)	94.3	59.8	0.4	19.6	134.8
	[-96.0,284.5]	[-152.8,272.4]	[-13.2,13.9]	[-137.5,176.7]	[-190.3,460.0]
Observations	617848	617848	617848	617848	617848
Average NRT sales in e-cigarette tax jurisdictions, in the quarter prior to tax adoption	9637	4434	355	4767	9658
E-cigarette tax ($)	0.13	0.13	0.13	0.13	0.13

Notes: All regressions estimated with OLS and control for time-varying jurisdiction characteristics (see Table 1), store fixed effects, and period fixed effects. Sample includes stores observed with positive NRT sales in each quarter-year period 2010-2020. 95% confidence intervals that account for within-state clustering reported in square brackets. ***,**, and * = statistically different from zero at the 1%, 5%, and 10% level.

Table 6. Effect of e-cigarette taxes on Medicaid-financed prescriptions for non-nicotine cessation medications per 100,000 state residents using data from the State Drug Utilization Database 2011-2021

Sample:	All states	Medicaid expansion states†	Medicaid non-expansion states†
E-cigarette tax ($)	72.7 [-50.5,196.0]	46.1 [-135.1,227.3]	100.7 [-77.4,278.8]
Observations	2244	1056	1188
Average number of Medicaid-financed prescriptions per 100,000 state residents in e-cigarette tax jurisdictions, in the quarter prior to tax adoption	564	628	418
E-cigarette tax ($)	0.18	0.33	0.05

Notes: All regressions estimated with OLS and control for time-varying state characteristics (see Table 1), state fixed effects, and period fixed effects. Data are weighted by the state population. 95% confidence intervals that account for within-state clustering reported in square brackets.

†Medicaid expansion status is determined as of January 2014, that is states that expanded after that date are not coded as expanding Medicaid.

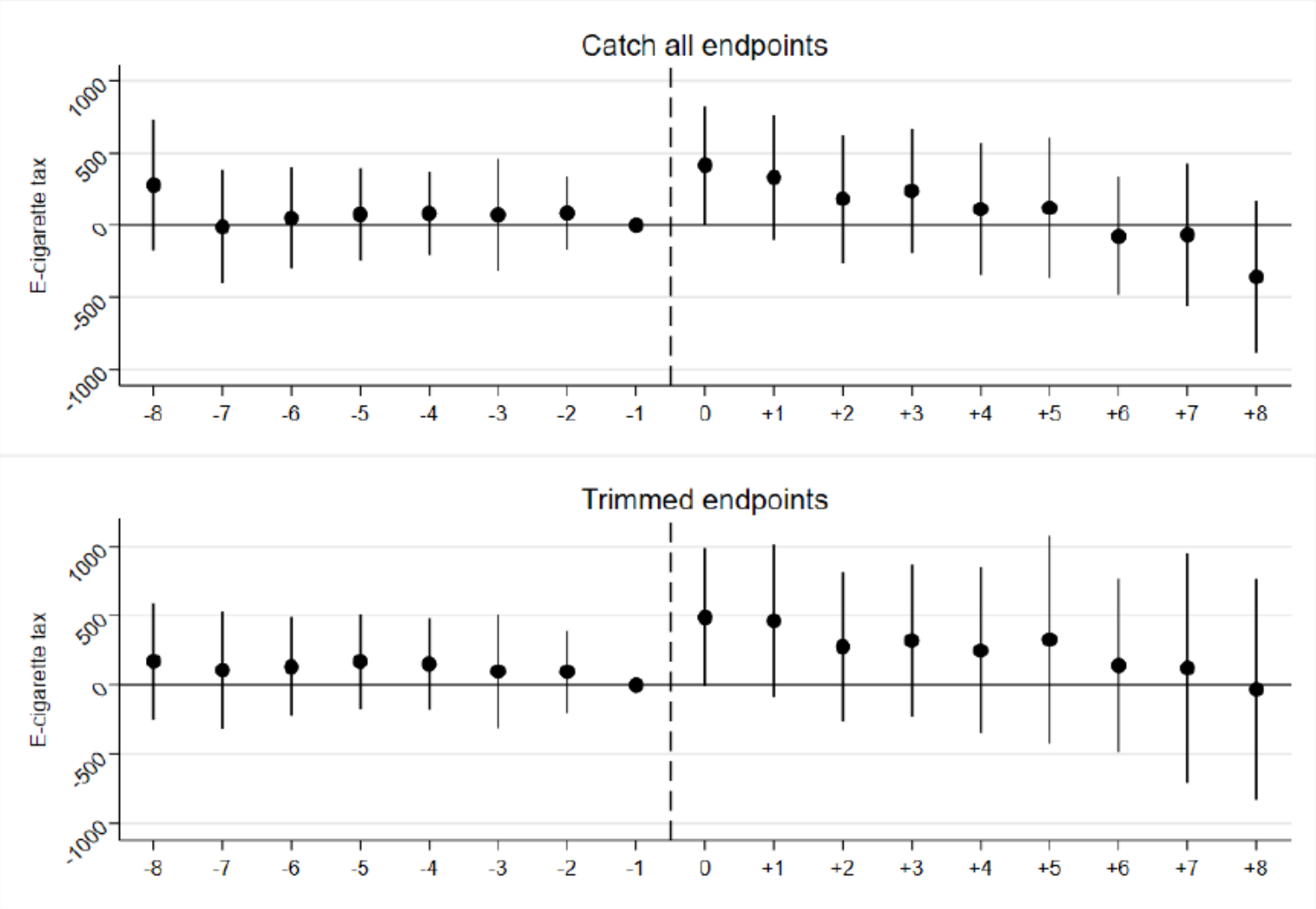
***,**, and * = statistically different from zero at the 1%, 5%, and 10% level.

Table 7. Effect of e-cigarette taxes on calls to state quitlines using data from the Centers for Disease Control and Prevention 2010-2020

Outcome:	Calls to state quitlines per 100,000 state residents
E-cigarette tax ($)	-9.6 [-30.7,11.4]
Observations	2204
Average calls per 100,000 state residents in e-cigarette tax jurisdictions, in the quarter prior to tax adoption	90
E-cigarette tax ($)	0.15

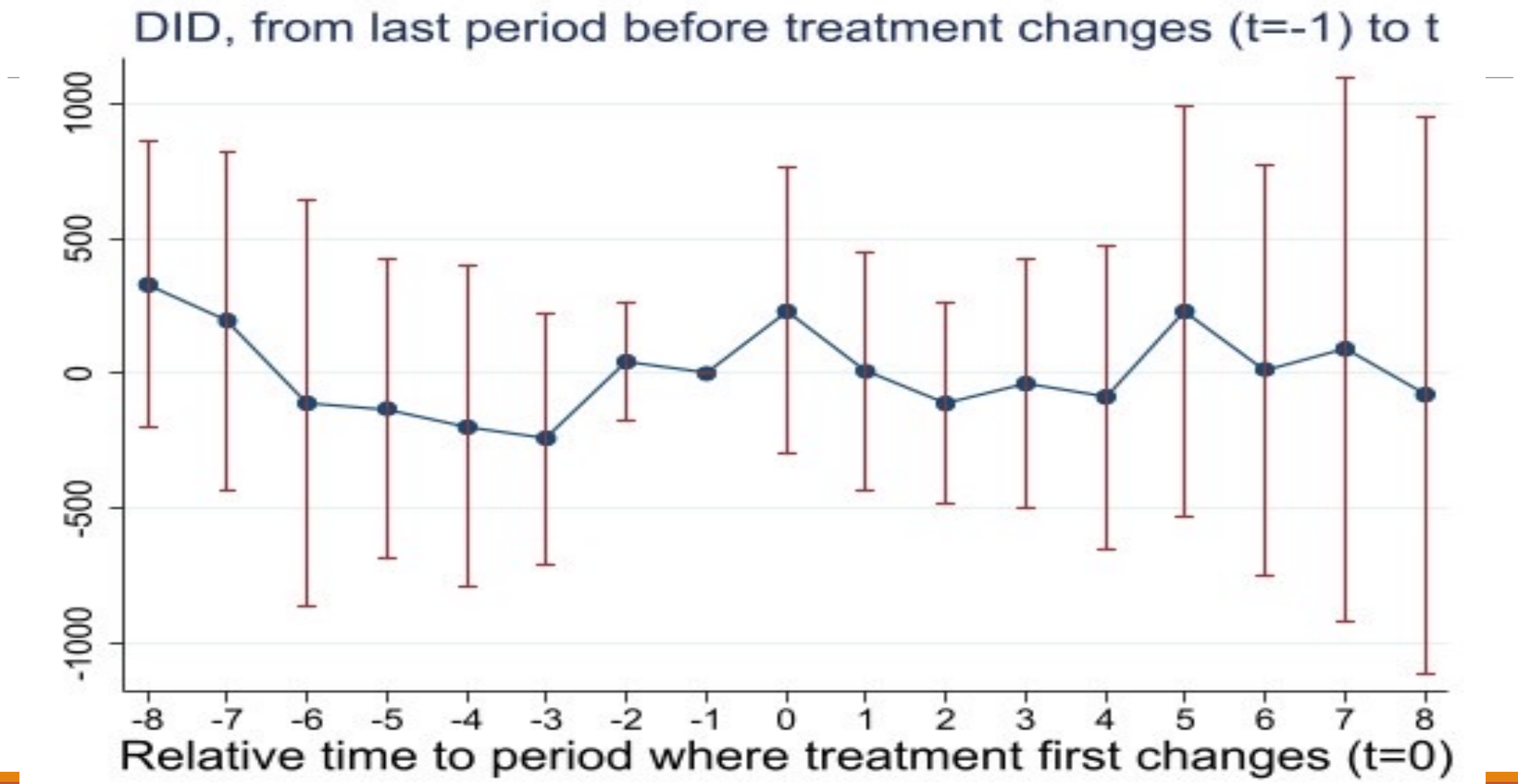
Notes: All regressions estimated with OLS and control for time-varying state characteristics (see Table 1), state fixed effects, and period fixed effects. Data are weighted by the state population and include each state in each quarter-year 2010-2020. 95% confidence intervals that account for within-jurisdiction clustering reported in square brackets. ***,**, and * = statistically different from zero at the 1%, 5%, and 10% level.

Figure 4. Effect of e-cigarette taxes on NRT sales per store-quarter using an event-study: NeilsenIQ retail sales data 2010-2020

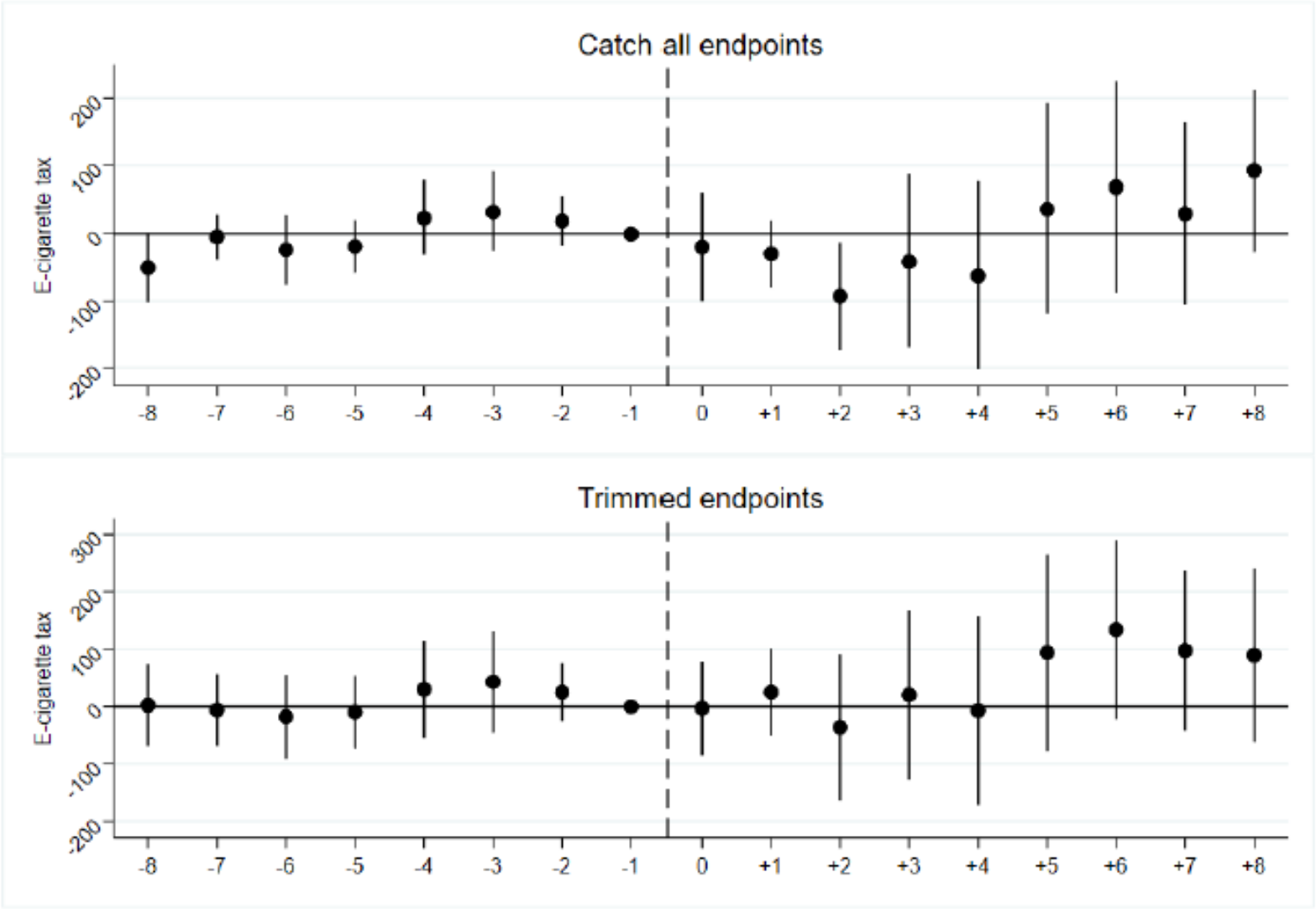


Notes: The outcome variable in regressions is the quarterly number of sales per store. All regressions estimated with OLS and control for time-varying jurisdiction characteristics, store fixed effects, and period fixed effects. Sample includes stores that sell at least one NRT product in each quarter-year period 2010-2020. The omitted period is -1. Circles represent the beta coefficient estimate. Vertical lines indicate 95% confidence intervals that account for within-jurisdiction clustering.

DCDH Event Study



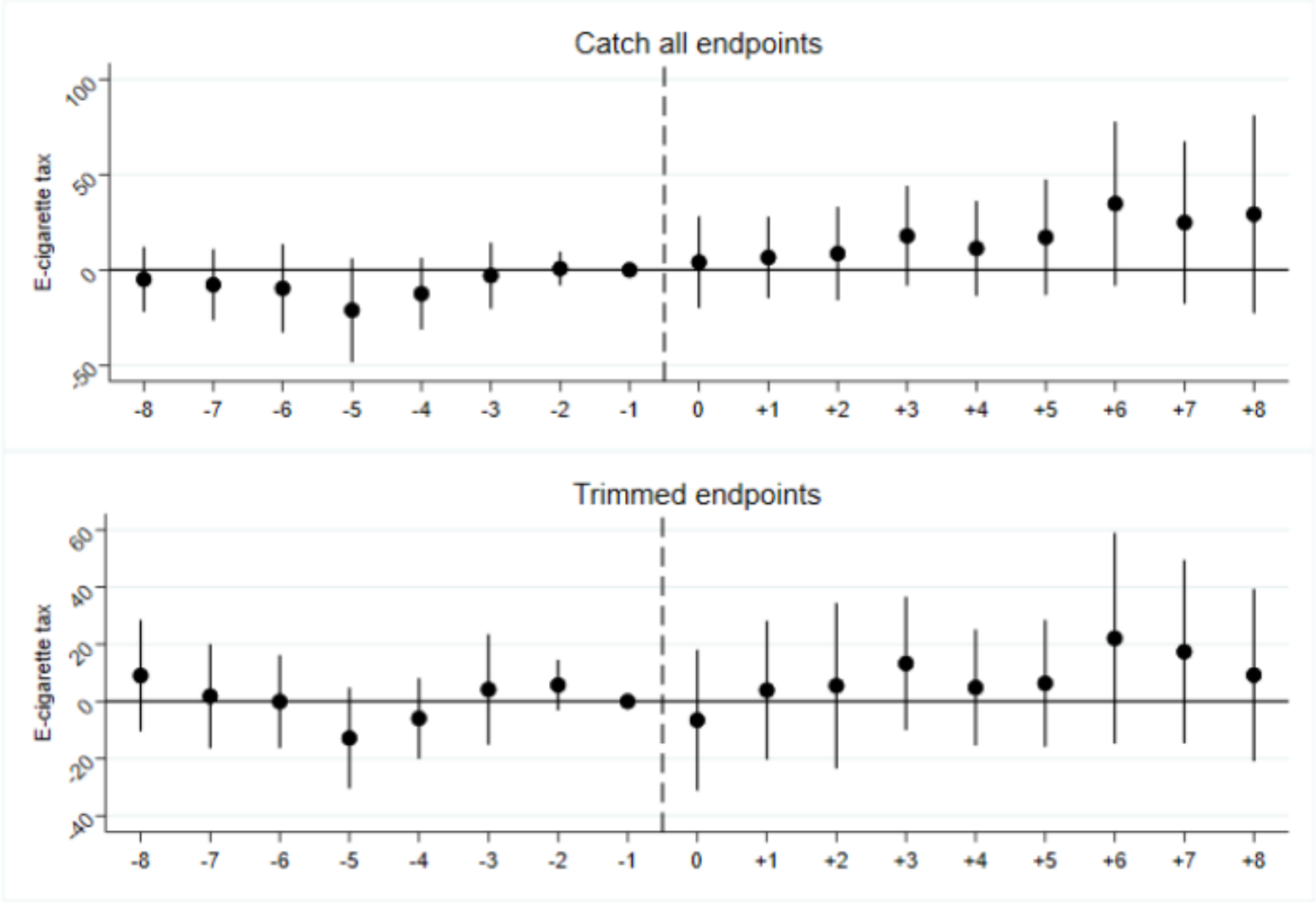
Appendix Figure 2. Effect of e-cigarette taxes on Medicaid-financed prescriptions for non-nicotine cessation medications per 100,000 state residents using an event-study: State Drug Utilization Database 2011-2021



-1 is the omitted category

Notes: The outcome variable in regressions is the number of Medicaid-financed prescriptions for non-nicotine cessation medications per 100,000 state residents. All regressions estimated with OLS and control for time-varying state characteristics (see Table 1), state fixed effects, and period fixed effects. The omitted period is -1. Circles represent the beta coefficient estimate. Vertical lines indicate 95% confidence intervals that account for within-state clustering.

Appendix Figure 4. Effect of e-cigarette taxes on calls to state quitline per 100,000 state residents using an event-study: Centers for Disease Control and Prevention 2010-2020



Notes: The outcome variable in regressions is the number of calls to the state quitlines per 100,000 state residents. Data are weighted by the state population. All regressions estimated with OLS and control for time-varying state characteristics (see Table 1), state fixed effects, and period fixed effects. The omitted period is -1. Circles represent the beta coefficient estimate. Vertical lines indicate 95% confidence intervals that account for within-state clustering.

Robustness Checks

Various sample inclusion criteria

Drop period after law passed but before implemented

Add linear tax-jurisdiction-specific time trend

Add Census Division-by-time fixed effects

Control for distance to a no-e-cigarette-tax city

Weight by 2010 Q1/Q2 sales

Tax jurisdiction rather than store fixed effects

Leave out one treated unit at a time

Conclusion

In our main regressions, we find no statistically significant evidence that e-cigarette taxes affect total over-the-counter NRT sales, any category of NRT sales, Medicaid-financed non-nicotine cessation medications, or quitline calls.

- Point estimates are small … $1 increase in tax per ml => 1.1% increase in NRT sales
- Confidence intervals relatively narrow … can rule out effect bigger than 3.4%

In our event study regressions, we find *some* evidence that e-cigarette taxes lead to a *temporary* increase in NRT sales, consistent with e-cigarettes and NRTs being substitutes.

- But not a robust result … needs further investigation

Paper might benefit from inclusion of survey data

- E.g. Behavioral Risk Factor Surveillance System has information on vaping, smoking, and cessation attempts