

# Estimating the Cross-Tax Elasticity of Tobacco Demand with respect to Cannabis Taxation in the US: Using Nielsen Retail Scanner Data

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Tobacco Online Policy Seminar Series (TOPS)

December 6, 2024

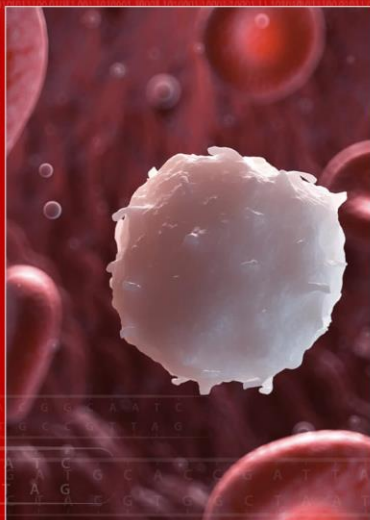
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# Disclaimers

- Funding statement: This project is funded by the National Institutes of Health (NIH)/National Institute on Drug Abuse (NIDA) with grant number R01DA053294 (PI: Ce Shang). The content presented here does not necessarily represent the views of the NIH/NIDA.
- Funding over the Past 10 years (presenter): National Institute on Drug Abuse.
- Researcher(s)' own analyses calculated (or derived) based in part on data from Nielsen Consumer LLC and marketing databases provided through the NielsenIQ Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the NielsenIQ data are those of the researcher(s) and do not reflect the views of NielsenIQ. NielsenIQ is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

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# Background: Considering cannabis in tobacco research

- Legalization of recreational cannabis:
  - As of August 2023, 24 states and the DC legalized recreational cannabis (Hansen et al., 2023)
    - 20 states established retail dispensaries
  - 43% of adults aged 19-30 used in 2021 in the U.S. (Patrick et al., 2022)
  - 27.8% of high schoolers used in the U.S. (Hoots et al., 2023)

“Cannabis flower”



# Cannabis and tobacco taxation share similar frameworks

- Taxation of cannabis (similar to tobacco) has two purposes:
  - Reduce cannabis consumption for public health objectives
  - Fund government functions to provide services to citizens (i.e., tax revenue)
- Similar to e-cigarettes, no federal guidelines in taxing cannabis
  - Significant heterogeneity in state tax laws
- Std. e-cigarette taxes (closed/open) available (Cotti et al., 2024)
- Std. excise cannabis tax measure to evaluate the tax implications on consumption and relevant outcomes (Park et al., 2024)

# Standardized cannabis excise tax measure derived (Park et al., 2024)

International Journal of Drug Policy 134 (2024) 104630

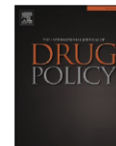


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Research Paper

## Recreational cannabis excise taxation in the USA: Constructing a comparable tax measure for empirical analysis



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### ARTICLE INFO

#### Keywords:

Cannabis legalization  
Adult-use cannabis  
Recreational cannabis  
Excise tax  
Converted cannabis tax  
Tax incidence

### ABSTRACT

**Background:** As of August 2023, 20 states in the US have established recreational cannabis retail markets and impose excise taxes on these products. However, there is significant heterogeneity in the bases (i.e., characteristics that taxes are applied to, such as price, weight, and potency), rates, and collection points (e.g., cultivation vs. wholesale) of excise taxes on recreational cannabis across states.

**Methods:** We constructed a novel cannabis excise tax measure in \$ per flower oz, which is comparable across different tax bases. Specifically, ad valorem excise taxes based on wholesale and retail prices and THC-based taxes were converted to excise taxes (\$) per oz using monthly state-level prices between 2014 and 2023. We also calculated tax incidence (i.e., taxes as a percentage of the retail prices) and analyzed its association with tax bases and converted taxes using ordinary least square (OLS) regressions.

**Results:** The mean and median values of converted excise taxes on recreational cannabis flowers were \$37.93 and \$37.55 per oz, respectively. The tax incidence for recreational cannabis was 18%, lower than the incidence of e-cigarette and cigarette excise taxes. During 2014–2023, real cannabis taxes and prices have decreased significantly over time. In addition, tax bases and converted excise taxes were not associated with tax incidence.

**Conclusion:** As the prices and taxes of recreational cannabis continue to decrease, tax incidence remains low and is not significantly associated with tax bases or rates, posing concerns about whether the current levels of excise taxes are large enough in reducing cannabis use. Future research shall investigate this matter using converted cannabis taxes empirically. In addition, the wide range of tax magnitude and incidence across states suggests that tax avoidance opportunities may exist for recreational cannabis users who live in higher-taxed states to purchase in neighboring states with lower taxes.

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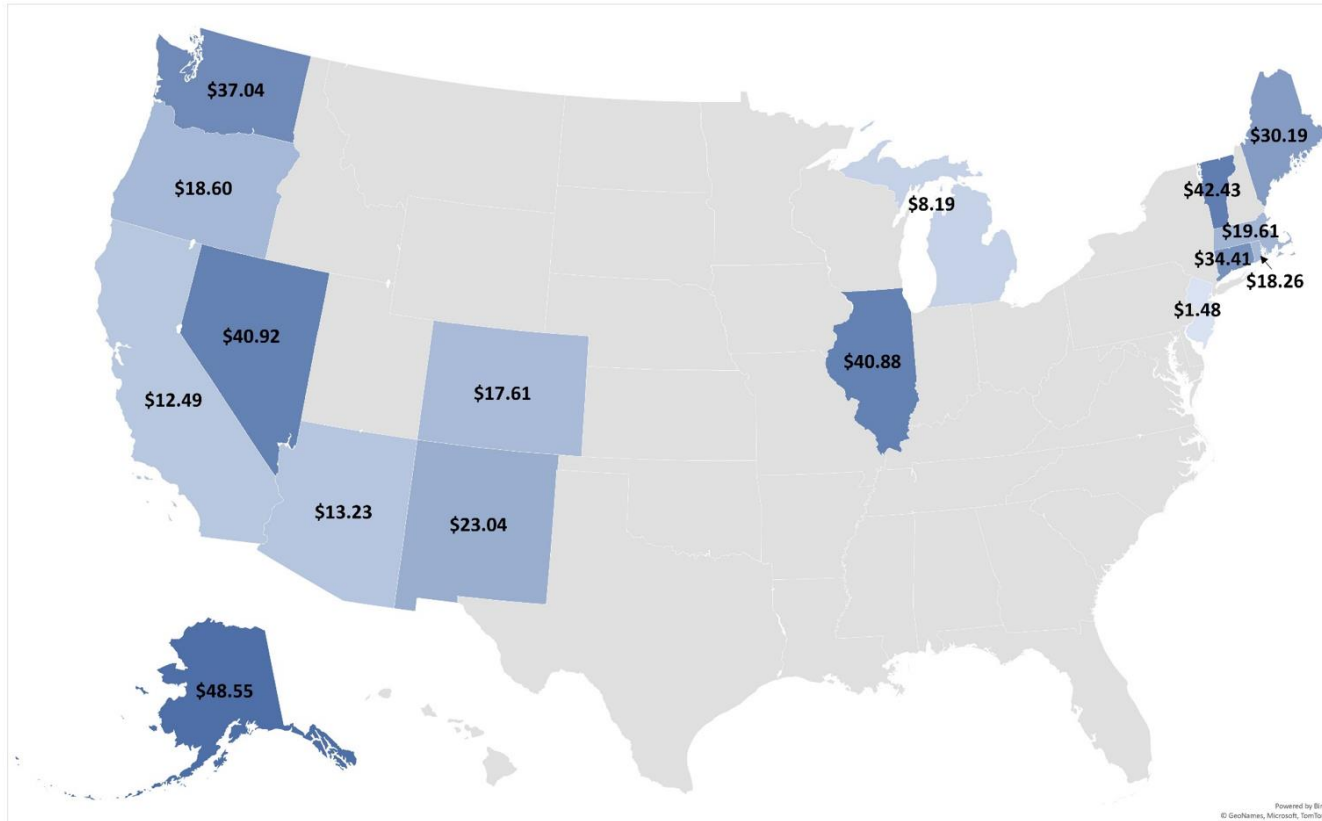
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# Cannabis tax levels per flower oz as of Q1/2023 (Park et al., 2024)

Figure 4. Cannabis Tax Magnitudes across the US States in 2022 dollars, as of Q1/2023



Note: Average values of standardized tax per cannabis flower ounce (in real terms) were used to depict cannabis tax magnitudes in the US as of Q1/2023. US CPI-U for all cities (base year = 2022) was used to adjust nominal values into real terms. Maryland, Missouri, Montana, and New York were legal states with recreational cannabis, but standardization was not available due to the unavailability of prices. Grey-colored states denote states without legal recreational cannabis, including the four states without standardization.



# The relationships among multiple substances

- Mostly studied in a two-product system:
  - Cannabis and cigarettes...
  - Cannabis and alcohol...
  - Cannabis and e-cigarettes...
- No studies investigated a three-product system incorporating taxes and sales of cigarettes, e-cigarettes, and cannabis

# Previous studies on the relationship between cigarettes and e-cigarettes

- Growing evidence on the relationships
  - Cigarettes and e-cigarettes are *substitutes* (Pesko et al., 2020; Friedman and Pesko, 2022; Abouk et al., 2023; Cotti et al., 2022; Deng and Zhang, 2024)
  - Cigarettes and e-cigarettes are *complements* (Diaz et al., 2023; Friedman and Pesko, 2022; Cotti et al., 2016; Dave and Saffer, 2013)
  - Non-significant estimates (*Independence*) (Pesko et al., 2020; Adda and Comaglia, 2013; Deng and Zhang, 2024; Jin et al., 2024)
  - The economic relationship may differ based on the direction of taxes influencing sales
- While the relationship remains empirically debatable (based on tax elasticity), more evidence suggests substitutability.



# Previous studies on the relationship between cannabis and tobacco products

- Lacking evidence of cannabis price/tax impacts on other substances
  - Due to the lack of standardized cannabis tax measure
- Yet, some evidence of how the prices or taxes of other products impact cannabis use:
  - E-cigarette and cannabis are *complements* (Dave et al., 2024)
    - \$1 increase in e-cig tax => 1-2%p (0.8%p) decline in teen (adult) cannabis use
  - Cigarette and cannabis are *independent* (Cooper et al., 2023)
    - Minimal impact of cannabis prices on cigarette consumption
  - Cannabis and alcohol may be *complements or substitutes* (mixed) (Subbaraman, 2016; O'Hara et al., 2016)
    - Depends on environmental factors, motives, and individual characteristics

# Own tax elasticities of tobacco products need updates

- Recently cigarette taxes to be “less” effective in reducing smoking:
  - Backed by Callison and Kaestner (2014); Hansen et al. (2017); Kalousova et al. (2020); Kaneko and Noguchi (2020)
  - Pesko et al. (2020) still argues the effectiveness of price/tax hike policies.
  - More empirical evidence is needed
- All existing studies using std. e-cigarette taxes from Cotti et al. (2023), which did not distinguish close vs. open system e-cigarettes, may have different tax implications in several states.
  - Std. e-cigarette taxes (closed/open) available (Cotti et al., 2024)
- No tax elasticities have been estimated for cannabis

# Summary of evidence gap

- No existing studies have:
  - Jointly studied the own and cross tax (price) elasticities in a three-product system (i.e., cannabis, cigarettes, and e-cigarettes)
  - Used the Seemingly Unrelated Regression (SUR) given correlated errors in each of the substance consumption equation by taxes
  - Evaluated the novel tax measures of cannabis and e-cigarette

# Objective of this study

- **(R-Q) Estimating the own and cross tax elasticities of substance demand in the U.S.**
- What we do in this study:
  - Estimate the own and cross tax impacts in a three-product system
  - Employ the SUR to address correlated error terms in three substance sales equations in response to taxes
  - Evaluate the novel tax measures of cannabis and e-cigarettes (closed/open)

# Data: Outcome variables

- Cannabis sales in ounce, 2014-2022
  - Derived from state-published data on tax revenue and cannabis sales in dollars – *available only when legal sales available*
  - Research team hand collected data, cross-checked, and contacted state officials as necessary
  - ***Sales derived using tax revenue:*** Tax revenue in dollars divided by the std. state-level cannabis tax per flower oz

# Data: Outcome variables (continued)

- Tobacco sales from the NielsenIQ Scanner Data, 2014-2022
  - State-month level collapsed tobacco sales in count
    - ***Cigarette sales sold in sticks***
    - ***E-cigarette sales sold in count (not per ml)***

# Data: Independent variables

- Std. cannabis tax per flower oz, 2014-2022
  - Standardized different types of cannabis taxes into one unified continuous measure (Park et al., 2024) – *available only when legal dispensaries open & conversion made*
  - Based on state-published price data & *CannabisBenchmarks* proprietary wholesale price data
  - ***Taxes based on varying prices:*** Std. cannabis taxes per oz using time-variant prices of cannabis

# Data: Independent variables (continued)

- Other substance taxes per unit, 2014-2022
  - **Cigarette excise tax (\$/pack)**
    - CDC State Tobacco Activities Tracking and Evaluation (STATE) system / Tax Burden on Tobacco
  - **Std. beer excise tax (\$/gallon)**
    - Per gallon of beer with a 5% alcohol concentration and sold off-premises for each state from the Alcohol Policy Information System (APIS)
  - **Std. e-cigarette excise tax (\$/ml)**
    - Specific tax per e-liquid ml (Cotti et al., 2024)
    - 35% markup rate assumed
    - Differentiated by closed form vs. open form e-cigarette products/taxation



# Data: Source

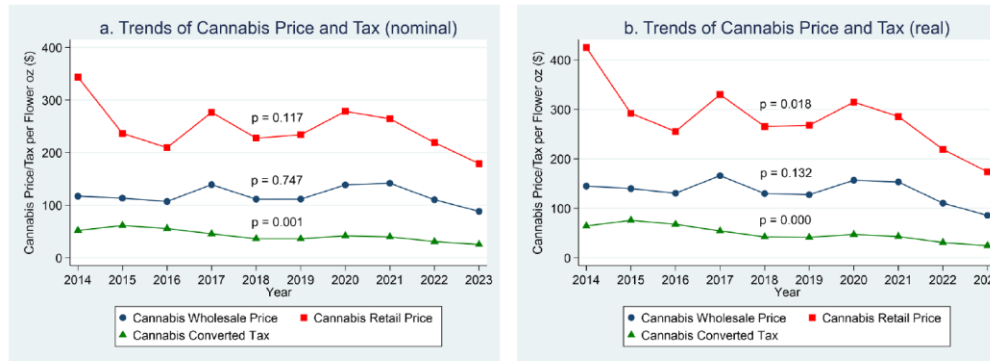
- State-month level dataset that covers (2014-2022):
  - 16 out of 20 U.S. states with retail cannabis dispensaries
  - State-level per capita income and seasonally adjusted unemployment rates (Bureau of Labor Statistics, 2023 & 2024)
  - All tax measures and per capita income were CPI-adjusted using 2022 dollars
  - Final samples vary between 515 and 620 (by varying observations across specifications)
    - Alternative sample included up to 5,340 observations where alternative cannabis tax measure is utilized to generate larger sample that covers all time period of 2014-2022

# Summary statistics

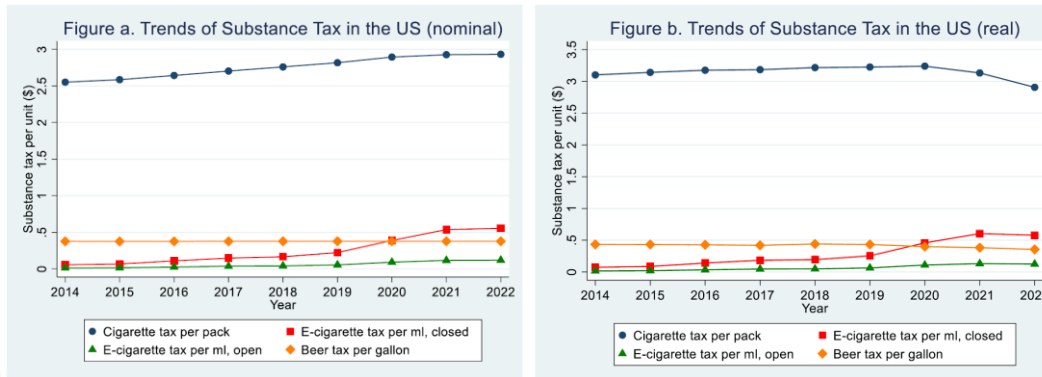
**Table 1. Summary statistics of the analytical sample (N=515)**

Variables	(1)	(2)	(3)	(4)
	Mean	SD	Min	Max
<b>Substance sales variables (in thousand)</b>				
Cannabis sales (in ounce)	562.19	688.95	2.19	4,019.62
Cigarette sales (in sticks sold)	53,838.29	41,438.63	39.16	176,582.25
E-cigarette sales (in count sold)	251.97	263.50	0.00	1,269.89
<b>Substance tax variables</b>				
Cannabis taxes (\$ per ounce)	39.59	15.72	1.08	90.08
Cigarette taxes (\$ per pack)	3.50	0.87	2.09	5.23
E-cigarette taxes, closed (\$ per ml)	0.73	0.89	0.00	2.74
E-cigarette taxes, open (\$ per ml)	0.16	0.20	0.00	0.61
Beer taxes (\$ per gallon)	0.20	0.19	0.08	1.26
<b>State sociodemographic variables</b>				
Unemployment rate (%)	5.22	3.08	2.40	30.60
Per capita income (in thousand \$)	61.66	9.79	45.92	87.44

# Trend of substance tax in the US between 2014 and 2022



**Fig. 2.** Trends of cannabis price and excise tax between 2014 and 2023 in the US (in both nominal and real terms). Note: Data are state-quarter level between Q1/2014 and Q2/2023. Unit is USD per cannabis flower ounce. Whenever necessary, 97% of the retail-wholesale markup rate was used to convert prices. For data, 16 out of 20 states have been included: Maryland, Missouri, Montana, and New York were not included due to the unavailability of prices. US CPI-U for all cities (base year = 2022) was used to adjust nominal values into real terms. P-values for testing the significance of decreasing trends are marked for each line.



Sources: Park et al. (2024) & other tax levels based on our analysis sample.

# Empirical strategy

- OLS regression – TWFE & DID framework:

(1) *Substance sales*<sub>st</sub>

$$= \beta_0 + \beta_1 \text{Cannabis tax}_{st} + \beta_2 \text{Cigarette tax}_{st} + \beta_3 \text{Ecig tax}_{st, \text{closed}} \\ + \beta_4 \text{Ecig tax}_{st, \text{open}} + \beta_5 \text{Beer tax}_{st} + \beta_6 \text{Inc}_{st} + \beta_7 \text{Urate}_{st} + \delta_s + \theta_t + u_{st}$$

- Substance sales for cannabis, cig, and e-cig, respectively
- Tax measures in \$ per unit of cannabis, cig, e-cig, and beer
- Per capita income & unemployment rate controlled
- State & year FEs with state level clustering
- SUR framework to include all three equations considered at once for efficiency

**[Pause for questions]**

# Main results: TWFE estimation of tax elasticities

**Table 2. Tax elasticities of substance demand by different substance taxes between 2014 and 2022**

Variables	(1)	(2)	(3)	(4)	(5)
	Cannabis	Cigarette	Cigarette	E-cigarette	E-cigarette
Cannabis taxes	-1.23* (0.50)	0.11 (0.81)	0.001 (0.01)	0.47† (0.23)	-0.003 (0.02)
Cigarette taxes	-0.36 (0.52)	-0.11 (0.13)	-0.15 (0.30)	-0.03 (0.69)	-0.76 (0.78)
E-cigarette taxes, closed	0.94 (4.51)	0.34 (0.22)	-0.05 (0.04)	2.39 (1.83)	-0.17† (0.09)
E-cigarette taxes, open	-0.92 (4.58)	-0.39 (0.23)	0.01 (0.04)	-2.38 (1.84)	0.09 (0.11)
Beer taxes	-4.45 (2.50)	0.36 (0.23)	-0.95† (0.53)	-0.14 (1.58)	-1.88 (1.86)
Number of states	13	15	51	15	51
Number of observations	525	620	5,340	610	5,294

# Main results: SUR estimation of tax elasticities

**Table 3. Tax elasticities of substance demand by different substance taxes using Seemingly Unrelated Regression (SUR)**

Variables	(1)	(2)	(3)	(4)	(5)
	Cannabis taxes	Cigarette taxes	E-cigarette taxes, closed	E-cigarette taxes, open	Beer taxes
Cannabis sales	<b>-1.22***</b> (0.12)	-0.32 (0.22)	0.84 (2.72)	-0.81 (2.72)	-4.69*** (1.21)
Cigarette sales	0.09* (0.04)	<b>-0.11</b> (0.07)	1.85* (0.87)	-1.90* (0.87)	0.41 (0.39)
E-cigarette sales	0.49** (0.17)	0.26 (0.29)	<b>-4.86</b> (3.63)	<b>5.07</b> (3.63)	-9.06*** (1.61)
Number of states	13	13	13	13	13
Number of observations	515	515	515	515	515

Note: Data are at the state-month levels between 2014 and 2022. Elasticity estimates are reported with bold ones to represent own tax elasticities. Each row represents the sales outcome of each individual regression of the SUR regression. The Breusch-Pagan test of independence rejected the null hypothesis, indicating that the SUR model is preferred to OLS regressions. Standard errors are in parentheses. AIC=1,311.80, BIC=1,808.37. † p<0.1, \* p<0.05, \*\* p<0.01, \*\*\* p<0.001.

# Main results: SUR estimation of tax elasticities with alternative sample

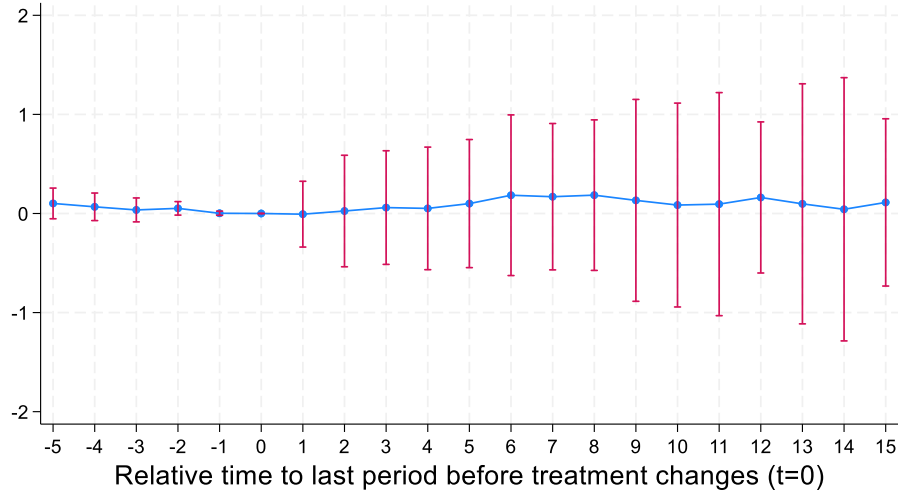
**Table 4. Tax elasticities of substance demand by different substance taxes using Seemingly Unrelated Regression (SUR)**

Variables	(1)	(2)	(3)	(4)	(5)
	Cannabis taxes, alt	Cigarette taxes	E-cigarette taxes, closed	E-cigarette taxes, open	Beer taxes
Cigarette sales	0.001 (0.002)	<b>-0.12*</b> <b>(0.05)</b>	-0.06*** (0.01)	0.01 (0.01)	-0.97*** (0.07)
E-cigarette sales	-0.003 (0.01)	-0.76*** (0.12)	<b>-0.17***</b> <b>(0.02)</b>	<b>0.09***</b> <b>(0.02)</b>	-1.88*** (0.17)
Number of states	51	51	51	51	51
Number of observations	5,294	5,294	5,294	5,294	5,294

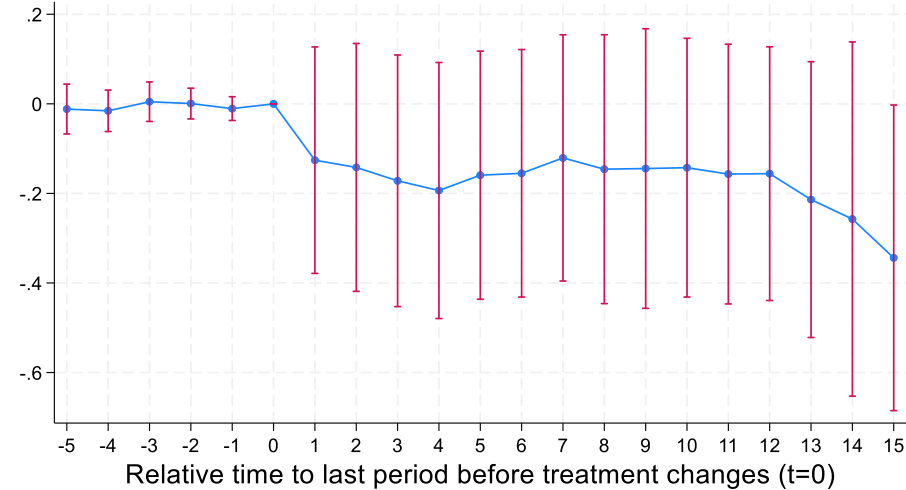
Note: Data are at the state-month levels between 2014 and 2022. Alternative form of cannabis taxes with zero-valued is utilized for larger samples of cigarette and e-cigarette sales analyses. Elasticity estimates are reported with bold ones to represent own tax elasticities. Each row represents the sales outcome of each individual regression of the SUR regression. The Breusch-Pagan test of independence rejected the null hypothesis, indicating that the SUR model is preferred to OLS regressions. Standard errors are in parentheses. AIC=11,853.54, BIC=12,865.99. † p<0.1, \* p<0.05, \*\* p<0.01, \*\*\* p<0.001.

# Consideration of event study using DCDH (2024)

Cigarette sales on cigarette taxes, DCDH (2024)



Cigarette sales on e-cigarette taxes (closed), DCDH (2024)



- Exploratory/suggestive findings at the quarter level in line with TWFE results; rounding of tax variables necessary



# Conclusion

- **(R-Q) Estimation of tax elasticities of tobacco and cannabis sales in the U.S.**
- In summary:
  - [Own tax elasticities]:
    - Cannabis sales to be tax elastic with  $-1.22$  ( $p < 0.001$ )
    - Cig sales to be non-responsive to own tax with  $-0.11$  or inelastic with  $-0.12$  ( $p < 0.05$ )
    - E-cig sales may respond to taxes on different systems differently...
      - $-0.17$  ( $p < 0.001$ ) for std. e-cig taxes based on closed system
      - $0.09$  ( $p < 0.001$ ) for std. e-cig taxes based on open system
      - The Nielsen data capture mostly e-cigarette sales of closed system, and open and closed system e-cigarettes may be substitutes according to a recent VCE study (Ma et al., 2024)

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# Conclusion (continued)

- [Cross-tax elasticities]:
  - Cannabis likely be substitutes to cig (: 0.09,  $p < 0.05$ ) & e-cig (: 0.49,  $p < 0.01$ ), respectively
    - In the direction of cannabis taxes increasing tobacco sales
    - Dave et al. (2024) examined the impact of e-cigarette taxes on cannabis use
  - Mixed results on cig-e-cig relationships; likely complements
    - Adding to the debate of whether they are substitutes
    - A systematic review by Selya (2023) concluded that the evidence on substitutability between cigarettes and e-cigarettes using sales data were inconclusive
  - Beer tends to be economic complements to other substances
    - Consistent with literature showing alcohol is a complement to tobacco products yet can be either a substitute or complement to cannabis (Dee, 1999; Tauchmann et al., 2008; Subbaraman, 2016; O'Hara et al., 2016)

# Future research

- Preliminary findings that need further investigation...
- Future approach includes:
  - E-cigarette sales in e-liquid ml by types of e-cig products
  - Per capita consumption/sales to consider rather than overall
  - Beer/alcohol consumption
  - Coverage of cannabis taxes/sales data for larger sample
  - Price elasticity using instrumental variable
  - Further investigation of event study framework

# Questions?

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