The Effects of E-cigarette Taxes on E-cigarette Prices and Consumption: Evidence From Retail Panel Data

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- The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research or the National Institutes of Health.
- Researcher(s) own analyses calculated (or derived) based in part on data from The Nielsen Company (U.S.), LLC and marketing databases provided through the Nielsen Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the Nielsen data are those of the researcher(s) and do not reflect the views of Nielsen. Nielsen is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

Research questions

1. How do e-cigarette taxes affect e-cigarette prices?
   - *Depending on the market structure, how are tax increases passed on to consumers?*
2. How do exogenous changes in e-cigarette prices affect e-cigarette sales?
   - *If prices rise due to tax increases, do e-cigarette sales fall?*
3. How do exogenous changes in e-cigarette prices affect sales of other tobacco products?
   - *Are other tobacco products, particularly (traditional) cigarettes, substitutes for e-cigarettes?*

Closely related literature

- Allcott and Rafkin (2019) use a shift-share strategy to examine how e-cigarette use impacted smoking
  - *With several different model features from ours, they find comparable price pass-through and own-price elasticity of e-cigarettes*
- Saffer et. al (2019) use a synthetic control approach and national survey data to study Minnesota's e-cigarette tax increase in 2013
  - *Find that a higher e-cigarette tax increases adult smoking and reduces smoking cessation*
  - *Making different assumptions than we do (about retailer markups instead of wholesale prices), they arrive at a comparable, if slightly smaller estimate of tax pass-through*

Other related literature

- Some studies consider e-cigarette price - not tax - effects
  - *Huang et. al (2018); Zheng et. al (2017); Stoklosa, Drope, and Chaloupka (2016); Pesko et al. (2016) study effects on e-cigarette sales*
  - *Saffer et al. (2018); Pesko et al. (2018); Cantrell et al. (2019) consider effects on e-cigarette use*
  - *The endogeneity of prices is a potential limitation*
- Others use the extensive margin (presence) of e-cigarette taxes
  - *Outcomes studied include prenatal smoking (Abouk et al. 2019), e-cigarette and traditional cigarette use (Pesko and Warman 2019), current vaping (Pesko, Courtemanche, and Maclean 2019)*
  - *Some advantages of our approach include the use of tax level, a longer time frame, and more policy variation*

Other related literature

- Several papers consider the relationship between e-cigarette use and smoking, more generally
  - *Restrictions on youth access to e-cigarettes lead to more smoking among youth (Friedman 2015, Pesko, Hughes, and Faisal, 2016; Dave, Feng, and Pesko, 2019) and pregnant adolescents (Pesko and Currie, 2019)*
  - *Abouk and Adams (2017) find evidence of complementarity*
  - *Dave et al. (2019) find that e-cigarette advertising helps adult smokers quit smoking*

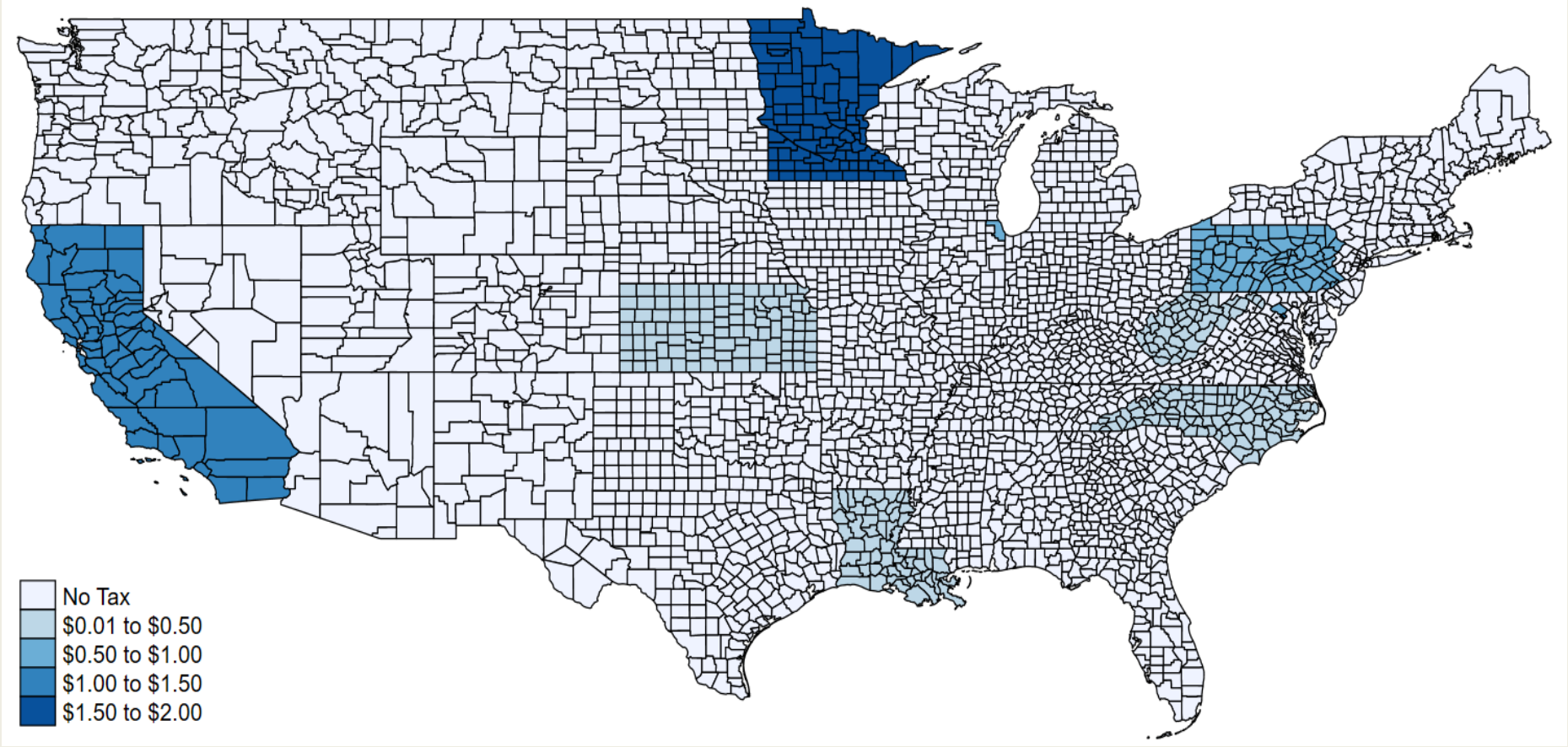
Standardized e-cigarette taxes

- Eight states and three counties/cities adopted e-cigarette taxes during 2011-2017
  - *Some states used ad valorem taxes on wholesalers, others used excise taxes at the point of purchase.*
- We converted ad valorem taxes into excise tax equivalents using DC's tax, which explicitly equalized the e-cigarette ad valorem tax with the cigarette excise tax.
  - *In DC, the 67% ad valorem tax equaled $2.92, implying that each 1 percentage point of ad valorem tax has a value of $0.044. Assuming equal wholesale prices across states, this was applied to convert ad valorem taxes to excise tax equivalent:*

$$ad\ valorem\ rate_{lt} * 0.044 * \frac{sales\ volume\ in\ retail\ units_{lt}}{sales\ volume\ in\ ml\ of\ fluid_{lt}}$$
$$= \frac{tax\ revenue_{lt}}{sales\ volume\ in\ ml\ of\ fluid_{lt}} = tax\ per\ ml\ of\ fluid_{lt}$$

- To address endogeneity concerns, we calculate the retail units to ml fluid ratio using all locations that have not adopted e-cigarette taxes by January 2020

Standardized e-cigarette taxes in 4Q 2017 ($/ml of vaping liquid)



E-cigarette taxes through end of 2017

Locality	Effective date	Unit taxed	Tax amount	Tax value Q4 2017 ($)
State				
California	4/2017, 7/2017	Wholesale price	27.3%, 65.1%	1.272
District of Columbia	10/2015, 10/2016	Wholesale price	67%, 65%	1.272
Kansas	1/2017, 7/2017	Per fluid milliliter	$0.20, $0.05	0.050
Louisiana	7/2015	Per fluid milliliter	$0.05	0.050
Minnesota	8/2010, 7/2013	Wholesale price	35%, 95%	1.849
North Carolina	6/2015	Per fluid milliliter	$0.05	0.050
Pennsylvania	7/2016	Wholesale price	40%	0.775
West Virginia	7/2016	Per fluid milliliter	$0.075	0.075
County/City				
Chicago, Illinois	1/2016	Per unit / per fluid milliliter	$0.80 / $0.55	0.606^
Cook County, Illinois	5/2016	Per fluid milliliter	$0.20	0.606^
Montgomery County, Maryland	8/2015	Wholesale price	30%	0.586

Notes: See text for full details. ^ The Chicago tax is added to the Cook County tax based on the share of the population residing in Chicago, see the appendix for further details. The tax value is inflated to 2017 dollars using the CPI.

Other Tobacco Control Policies

- Cigarette excise taxes measured in real 2017 dollars, from the CDC State System
- California and New Jersey enacted Tobacco 21 laws by the end of 2017
  - *Included as an indicator variable*
- Indoor air laws from the American Non-Smokers' Rights Foundation.
  - *Apply to bars, restaurants and private workplaces.*
  - *Share of the population in each county living with indoor vaping restrictions and indoor smoking restrictions (two separate measures).*

Nielsen Retail Scanner Data

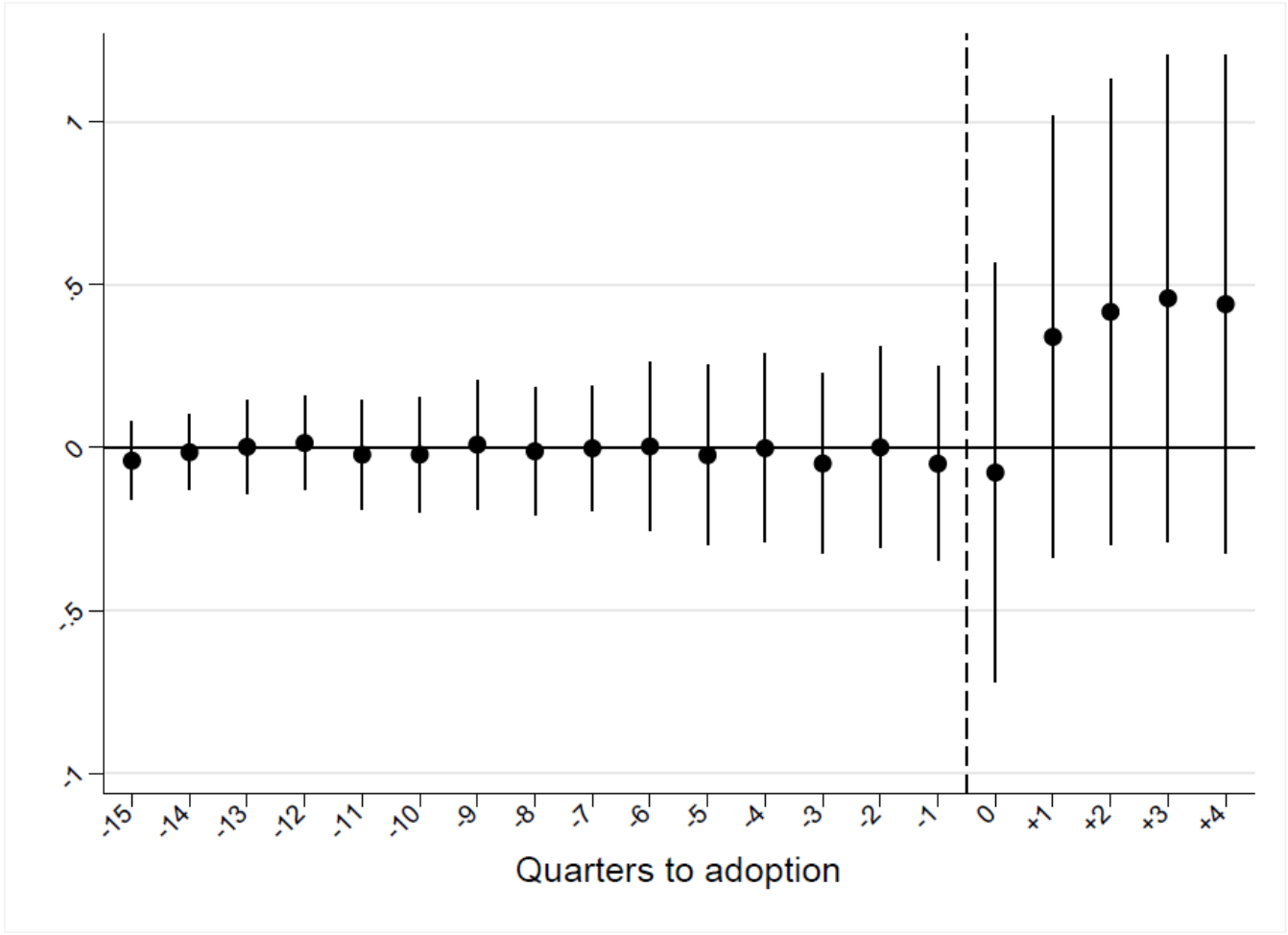
- Merge policies into NRSD from 2011 to 2017, which includes a sample of 30,000 to 35,000 retailers. In 2017, NRSD included:
  - *Between 15% and 26% of all food store, mass merchandiser, dollar store, and club store sales*
  - *Over 50% of drug store sales*
  - *Approximately 2% each of convenience stores and liquor stores*
- NRSD records weekly volume and average price (including all taxes except sales taxes) of each UPC purchased.
- We calculate milliliters of fluid in each e-cigarette UPC using data collected by our team, with a 93.5% match by the value of sales in NRSD (Cotti, Nesson, Tefft 2018)

Price pass-through: Standard two-way fixed effects model (TWFE)

$$Y_{i,l,t} = \beta_0 + \beta_E Etax_{l,t} + \beta_T Ttax_{l,t} + W_{l,t}\beta_W + X_{l,t}\beta_X + \sigma_{l,i} + \tau_q + \varepsilon_{i,l,t}$$

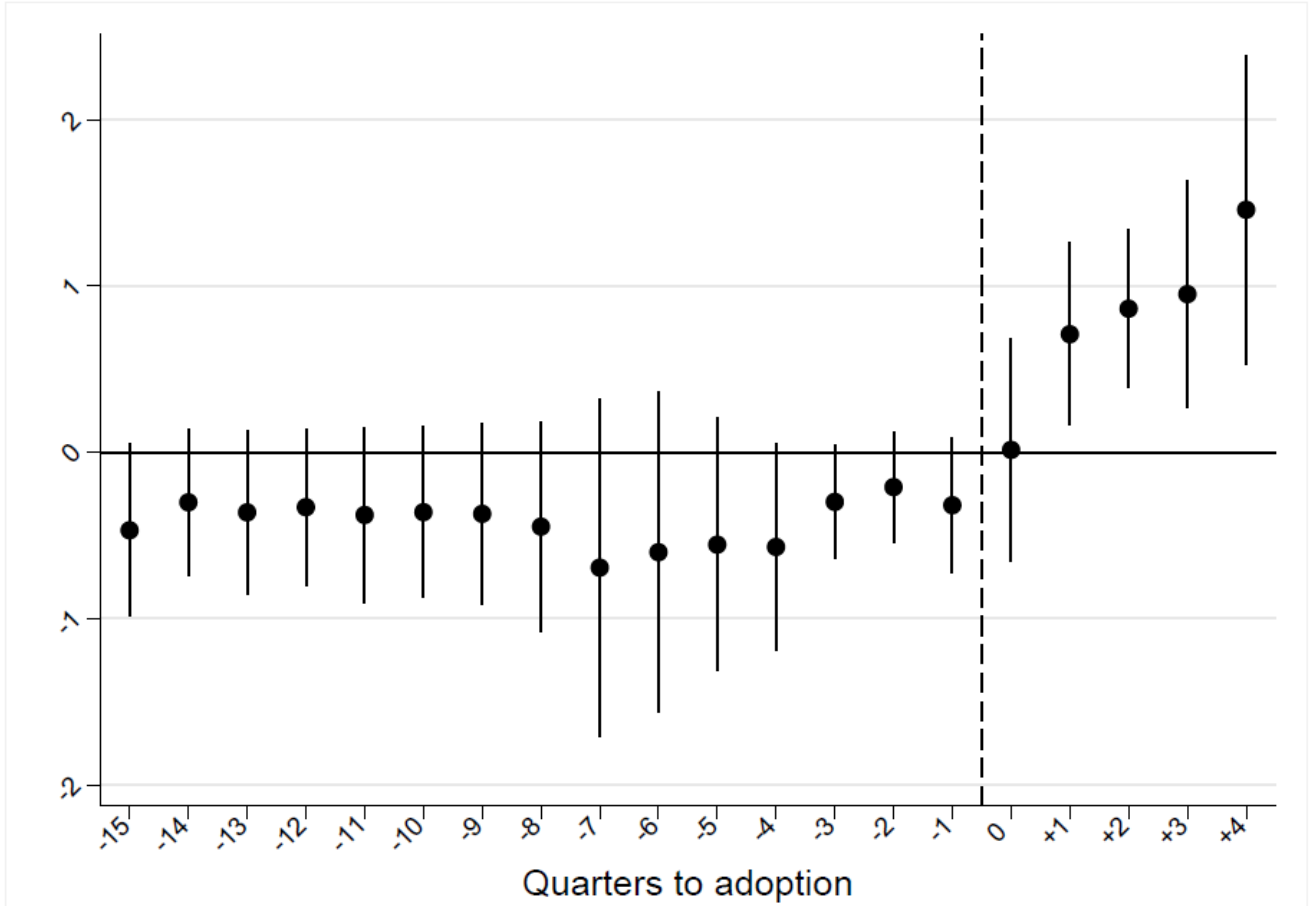
- $Y_{i,l,t}$ is the average price for e-cigarette product i in locality l and quarter t
- E-cigarette taxes are labeled $Etax_{l,t}$
- Cigarette excise taxes are $Ttax_{l,t}$
- Other tobacco control policies (e.g. ISRs and IVRs) are included in vector $W_{l,t}$
- $X_{l,t}$ includes other locality-level characteristics
- $\sigma_{i,l}$ are UPC-by-locality fixed effects
- τ_q are year-by-quarter fixed effects
- We cluster standard errors at the locality level in all specifications
- We also estimate event study versions of this model

Price event study: E-cigarette tax adoption increased e-cigarette prices



Notes: The unit of observation is a UPC-code in a locality (state or county) in a quarter (quarter-by-year). The model estimated by equation (1) except using lag and lead indicators from the first available e-cigarette tax in a given locality. The model is estimated with least squares and controls for time-varying locality characteristics, UPC-by-locality fixed effects, and period (quarter-by-year) fixed effects. Circles reflect the beta coefficient estimate and vertical solid lines reflect 95% confidence intervals. The omitted category is ≥16 quarters prior.

Price event study: Using tax changes instead of dummy for tax events (Cotti, Nesson, and Tefft, 2018)



Notes: The unit of observation is a UPC-code in a locality (state or county) in a quarter (quarter-by-year). The model estimated by equation (1) except using lag and lead changes in the e-cigarette tax amount. The model is estimated with least squares and controls for time-varying locality characteristics, UPC-by-locality fixed effects, and period (quarter-by-year) fixed effects. Circles reflect the beta coefficient estimate and vertical solid lines reflect 95% confidence intervals. The omitted category is the e-cigarette tax change ≥16 quarters prior.

Price model: E-cigarette tax adoption increased e-cigarette prices

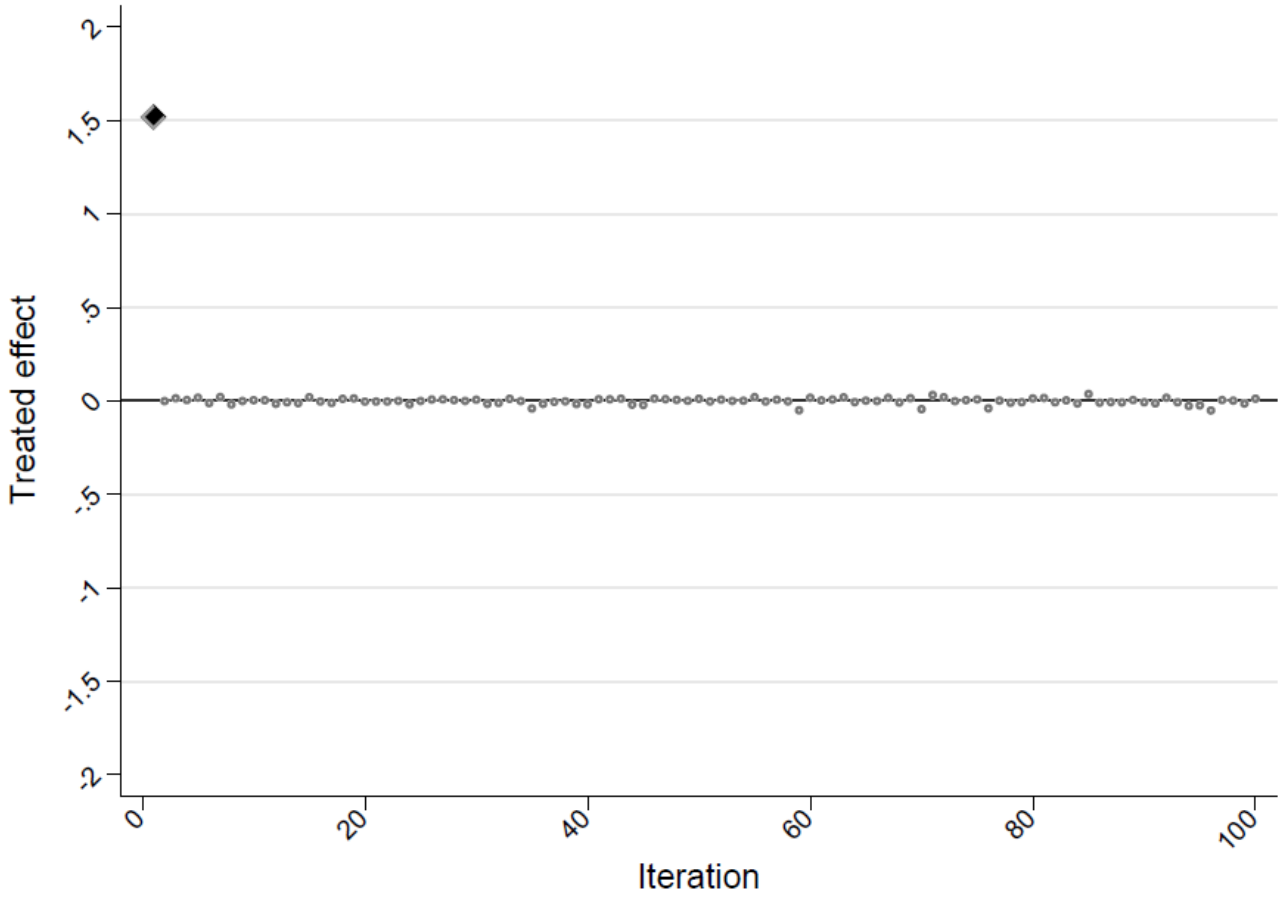
Outcome:	**E-cigarette price ($)**			
Mean: e-cigarette price in e-cigarette tax adopting localities, in the year prior to the tax	3.81	3.81	3.81	3.81
E-cigarette standardized tax ($)	1.314*** [1.103,1.525]	1.573*** [1.158,1.988]	1.568*** [1.206,1.931]	1.554*** [1.322,1.786]
Traditional cigarette tax per pack ($)	--	--	0.025 [-0.142,0.191]	0.052 [-0.196,0.300]
Locality fixed effects	N	Y	Y	n/a
Period (quarter-by-year) fixed effects	N	Y	Y	Y
Time-varying controls	N	N	Y	Y
UPC-by-locality fixed effects	N	N	N	Y
Observations	90730	90730	90730	90730

Notes: The unit of observation is a UPC-code in a locality (state or county) in a quarter (quarter-by-year). All models estimated with least squares. Data are weighted by the share of e-cigarette sales in localities that do not adopt an e-cigarette tax. 95% confidence intervals that account for within-locality clustering are reported in square brackets. ***,**, and * = statistically different from zero at the 1%, 5%, and 10% level.

Price model robustness checks

- Analytical sample changes
  - *Exclude divisions with no adopting localities by 2017 (New England, East South Central, and Mountain)*
  - *Exclude Illinois and Maryland (localities with sub-state taxes)*
  - *Exclude localities for which we transform ad valorem to excise tax*
  - *Enactment period: exclude; separately control for*
  - *Alternative e-cigarette tax construction assumption: use ratio of sales retail units to ml of fluid for all jurisdictions (not only non-adopters by 2020)*
  - *Impute e-cigarette prices, using last available price, when no transactions occurred*
- Modeling assumptions
  - *Exclude time-varying locality-level controls*
  - *Fixed effects: include division-by-quarter fixed effects; include UPC-by-quarter fixed effects*
  - *Interact e-cigarette tax with indicators for excise and ad valorem, and county-level tax*
  - *Lag e-cigarette tax: one quarter; one year*
- Weighting schemes
  - *Regression weights: unweighted; weight by population; weight by quarterly e-cigarette sales in 2013*
  - *Population-weighted e-cigarette tax for Illinois and Maryland (localities with sub-state taxes)*

Price model falsification test



Notes: The unit of observation is a UPC-code in a locality (state or county) in a quarter (quarter-by-year). The model is estimated with least squares and controls for time-varying locality characteristics, UPC-by-locality fixed effects, and period (quarter-by-year) fixed effects. The black diamond is the coefficient estimate from our preferred specification. The small white circles capture coefficient estimates generated in equation (1) after randomly re-shuffling e-cigarette taxes across localities and periods. .

Tobacco product sales: Instrumental variables model

$$Y_{l,t} = \alpha_0 + \alpha_E \widehat{EP}_{l,t} + \alpha_T \widehat{TP}_{l,t} + W_{l,t}\alpha_W + X_{l,t}\alpha_X + \delta_l + \chi_q + \epsilon_{l,t}$$

- We study five categories: e-cigarettes, traditional cigarettes, cigars, chewing tobacco, and loose tobacco
- $Y_{l,t}$ represents the sales of a tobacco product in locality l and time t
- Instead of taxes (as in the RHS of the price equation), we use predicted prices
  - *E-cigarette and cigarette taxes used as instruments in the first-stage prediction models*
  - *Identifying assumption: e-cigarette and cigarette taxes affect demand only through their effects on e-cigarette and cigarette prices*
- Other variables are the same as in the pass-through equation
- Following Harding, Leibtag, and Lovenheim (2012), we use locality fixed effects (dropping UPC) to account for new or discontinued products in response to taxes
- Regressions are weighted using the locality's population
- Cluster standard errors at the locality level

IV sales model: A $1 rise in the e-cigarette price reduces e-cigarette sales by more than a third of the baseline mean.

Outcome:	E-cigarettes	Traditional cigarettes	Cigars	Chewing tobacco	Loose tobacco
Mean: e-cigarette tax adopting localities, in the year prior to the tax	3,590	56,533	4,414	6,218	563
Mean: cigarette tax adopting localities, in the year prior to the first traditional cigarette tax increase	3,162	69,111	3,994	2,741	555
E-cigarette price ($)	-1,255*** [-2,133,-377]	11,489*** [3,322,19,657]	-651 [-2,039,736]	105 [-1,369,1,580]	-194 [-526,137]
Traditional cigarette price ($)	538* [-72,1,149]	-7,057** [-12,622,-1,492]	609 [-362,1,581]	-92 [-981,798]	112 [-74,298]
Observations	1428	1428	1428	1428	1428

Notes: All models estimated with two-stage least squares and control for time-varying area characteristics, area fixed effects, and period (quarter-by-year) fixed effects. 1st stage *F*-statistics are 14.95 for e-cigarette prices and 408.74 for traditional cigarette prices. 95% confidence intervals that account for within-state clustering are reported in square brackets. ***,**, and * = statistically different from zero at the 1%, 5%, and 10% level.

IV sales model: The same $1 e-cigarette price rise increases cigarette pack sales by 20%.

Outcome:	E-cigarettes	Traditional cigarettes	Cigars	Chewing tobacco	Loose tobacco
Mean: e-cigarette tax adopting localities, in the year prior to the tax	3,590	56,533	4,414	6,218	563
Mean: cigarette tax adopting localities, in the year prior to the first traditional cigarette tax increase	3,162	69,111	3,994	2,741	555
E-cigarette price ($)	-1,255*** [-2,133,-377]	11,489*** [3,322,19,657]	-651 [-2,039,736]	105 [-1,369,1,580]	-194 [-526,137]
Traditional cigarette price ($)	538* [-72,1,149]	-7,057** [-12,622,-1,492]	609 [-362,1,581]	-92 [-981,798]	112 [-74,298]
Observations	1428	1428	1428	1428	1428

Notes: All models estimated with two-stage least squares and control for time-varying area characteristics, area fixed effects, and period (quarter-by-year) fixed effects. 1st stage *F*-statistics are 14.95 for e-cigarette prices and 408.74 for traditional cigarette prices. 95% confidence intervals that account for within-state clustering are reported in square brackets. ***,**, and * = statistically different from zero at the 1%, 5%, and 10% level.

IV sales model: A $1 rise in cigarette price reduces cigarette sales by approximately 10%.

Outcome:	E-cigarettes	Traditional cigarettes	Cigars	Chewing tobacco	Loose tobacco
Mean: e-cigarette tax adopting localities, in the year prior to the tax	3,590	56,533	4,414	6,218	563
Mean: cigarette tax adopting localities, in the year prior to the first traditional cigarette tax increase	3,162	69,111	3,994	2,741	555
E-cigarette price ($)	-1,255*** [-2,133,-377]	11,489*** [3,322,19,657]	-651 [-2,039,736]	105 [-1,369,1,580]	-194 [-526,137]
Traditional cigarette price ($)	538* [-72,1,149]	-7,057** [-12,622,-1,492]	609 [-362,1,581]	-92 [-981,798]	112 [-74,298]
Observations	1428	1428	1428	1428	1428

Notes: All models estimated with two-stage least squares and control for time-varying area characteristics, area fixed effects, and period (quarter-by-year) fixed effects. 1st stage *F*-statistics are 14.95 for e-cigarette prices and 408.74 for traditional cigarette prices. 95% confidence intervals that account for within-state clustering are reported in square brackets. ***,**, and * = statistically different from zero at the 1%, 5%, and 10% level.

IV sales model: The same $1 rise in cigarette price increases e-cigarette sales by approximately 17%.

Outcome:	E-cigarettes	Traditional cigarettes	Cigars	Chewing tobacco	Loose tobacco
Mean: e-cigarette tax adopting localities, in the year prior to the tax	3,590	56,533	4,414	6,218	563
Mean: cigarette tax adopting localities, in the year prior to the first traditional cigarette tax increase	3,162	69,111	3,994	2,741	555
E-cigarette price ($)	-1,255*** [-2,133,-377]	11,489*** [3,322,19,657]	-651 [-2,039,736]	105 [-1,369,1,580]	-194 [-526,137]
Traditional cigarette price ($)	538* [-72,1,149]	-7,057** [-12,622,-1,492]	609 [-362,1,581]	-92 [-981,798]	112 [-74,298]
Observations	1428	1428	1428	1428	1428

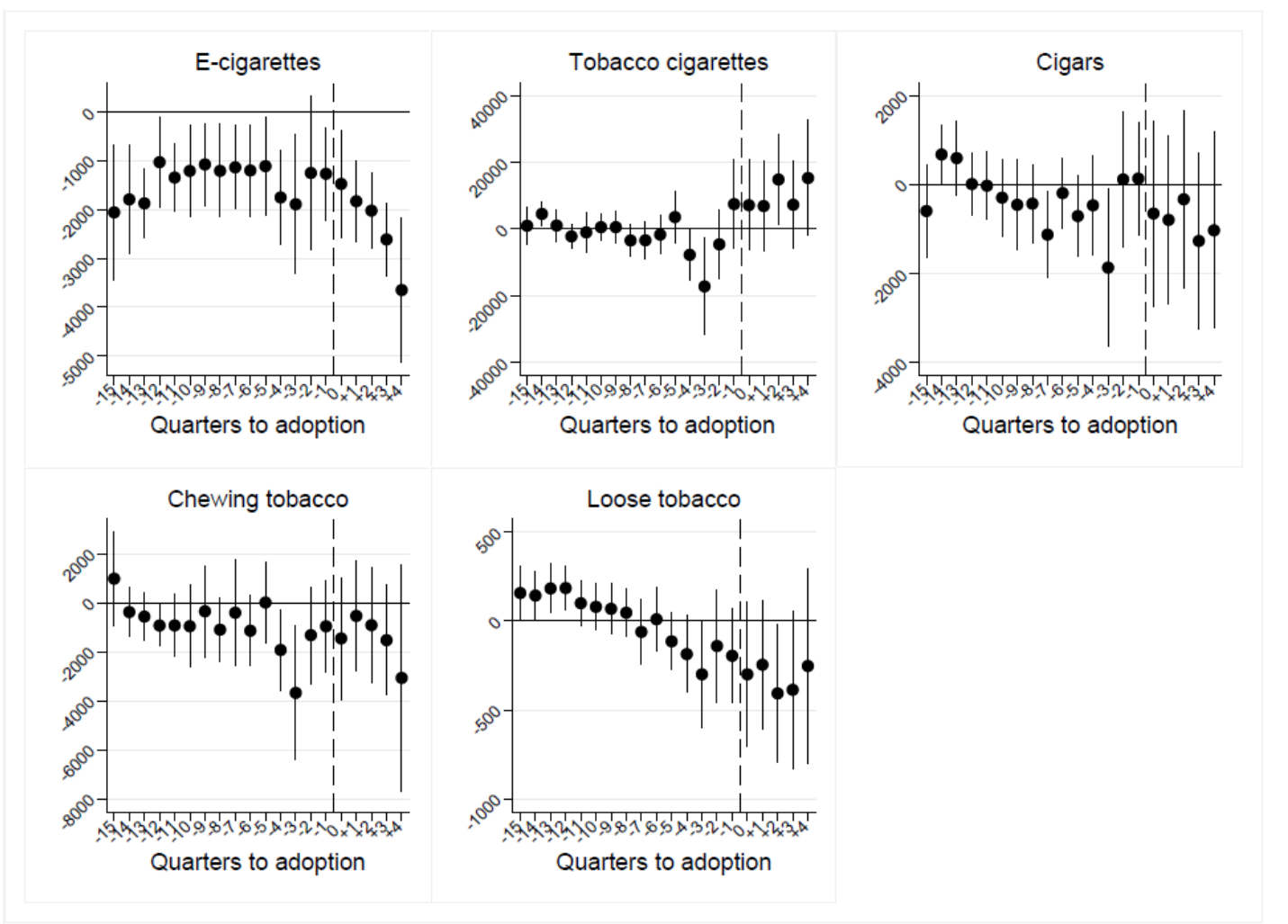
Notes: All models estimated with two-stage least squares and control for time-varying area characteristics, area fixed effects, and period (quarter-by-year) fixed effects. 1st stage *F*-statistics are 14.95 for e-cigarette prices and 408.74 for traditional cigarette prices. 95% confidence intervals that account for within-state clustering are reported in square brackets. ***,**, and * = statistically different from zero at the 1%, 5%, and 10% level.

IV sales model: Neither tax appears to affect sales for cigars, chewing tobacco, or loose tobacco.

Outcome:	E-cigarettes	Traditional cigarettes	Cigars	Chewing tobacco	Loose tobacco
Mean: e-cigarette tax adopting localities, in the year prior to the tax	3,590	56,533	4,414	6,218	563
Mean: cigarette tax adopting localities, in the year prior to the first traditional cigarette tax increase	3,162	69,111	3,994	2,741	555
E-cigarette price ($)	-1,255*** [-2,133,-377]	11,489*** [3,322,19,657]	-651 [-2,039,736]	105 [-1,369,1,580]	-194 [-526,137]
Traditional cigarette price ($)	538* [-72,1,149]	-7,057** [-12,622,-1,492]	609 [-362,1,581]	-92 [-981,798]	112 [-74,298]
Observations	1428	1428	1428	1428	1428

Notes: All models estimated with two-stage least squares and control for time-varying area characteristics, area fixed effects, and period (quarter-by-year) fixed effects. 1st stage *F*-statistics are 14.95 for e-cigarette prices and 408.74 for traditional cigarette prices. 95% confidence intervals that account for within-state clustering are reported in square brackets. ***,**, and * = statistically different from zero at the 1%, 5%, and 10% level.

IV sales model event study (tax changes approach)



Notes: The unit of observation is a UPC-code in a locality (state or county) in a quarter (quarter-by-year). The model estimated by equation (2) except using lag and lead changes in the e-cigarette tax amount. The model is estimated with least squares and controls for time-varying locality characteristics, locality fixed effects, and period (quarter-by-year) fixed effects. Circles reflect the beta coefficient estimate and vertical solid lines reflect 95% confidence intervals. The omitted category is the e-cigarette tax change ≥16 quarters prior.

Tobacco product sales: reduced form TWFE model

$$Y_{l,t} = \gamma_0 + \gamma_E Etax_{l,t} + \gamma_T Ttax_{l,t} + W_{l,t}\gamma_W + X_{l,t}\alpha_X + \delta_l + \tau_q + \mu_{l,t}$$

- Same variables and structure as in the IV TWFE model, except we use taxes on the RHS instead of predicted prices
- Can use this model as a robustness check when calculating elasticities (results are similar)

TWFE reduced form sales model: Substitution patterns are similar to results using the IV sales model.

Outcome:	E-cigarettes	Traditional cigarettes	Cigars	Chewing tobacco	Loose tobacco
Mean: e-cigarette tax adopting localities, in the year prior to the tax	3,590	56,533	4,414	6,218	563
Mean: cigarette tax adopting localities, in the year prior to the first traditional cigarette tax increase	3,162	69,111	3,994	2,741	555
E-cigarette standardized tax ($)	-1,486*** [-2,307,-666]	13,361** [3,324,23,398]	-734 [-2,338,871]	119 [-1,783,2,022]	-227 [-597,144]
Traditional cigarette tax per pack ($)	595** [132,1,058]	-7,724* [-15,568,121]	662 [-406,1,731]	-100 [-1,146,946]	123 [-92,338]
Observations	1428	1428	1428	1428	1428

Notes: The unit of observation is a locality (state or county) in a quarter (quarter-by-year). All models estimated with least squares and control for time-varying locality characteristics, locality fixed effects, and period (quarter-by-year) fixed effects. Data are weighted by the locality population. 95% confidence intervals that account for within-locality clustering are reported in square brackets. ***,**, and * = statistically different from zero at the 1%, 5%, and 10% level.

Summary of pass-through and calculated elasticities (IV model)

- Taxes are over-shifted, with 155% pass-through
- Demand for e-cigarettes is elastic. Elasticity is: -1,255*(4.36/3,590) = -1.5
  - *Effect of $1 e-cigarette price increase on sales, multiplied by the ratio of mean e-cigarette price to sales during year prior to e-cigarette tax adoption*
  - *Similar to a published estimate for Minnesota (Saffer et al. 2019)*
- E-cigarettes and cigarettes are substitutes. Cross-price elasticity is: 538*(5.87/3,162) = 1.0.
  - *Effect of $1 cigarette price increase on e-cigarette sales, multiplied by the ratio of mean cigarette price to e-cigarette sales during year prior to first cigarette tax increase*
  - *Estimates using the e-cigarette instead of cigarette price effect are similar*
- Demand for cigarettes is inelastic. Elasticity is: -7,057*(5.87/69,111) = -0.6
  - *Effect of $1 cigarette price increase on sales, multiplied by the ratio of mean cigarette price to sales during year prior to first cigarette tax increase*
  - *In line with many previous estimates of the price elasticity of demand for traditional cigarettes*

Conclusions

- We estimate a Herfindahl-Hirschman Index for retail sales of e-cigarettes of 0.251, suggesting that the retail-based e-cigarette industry is moderately to highly concentrated industry.
  - *HHI = $\sum s_n^2$, where S_n is the market share for each firm.*
- We estimate an e-cigarette tax-to-price pass through rate of 1.55, consistent with over-shifting (possible in a market that is not perfectly competitive).
  - *A $1 increase in e-cigarette taxes increase e-cigarette prices by $1.55.*
- We use an IV model to estimate an e-cigarette own-price elasticity of -1.5 and cross-price elasticities of approximately 1.0.
  - *A 10% rise in e-cigarette prices reduces e-cigarette sales by 15%.*
- From this, we estimate that for each e-cigarette pod (0.7 ml) no longer purchased due to an e-cigarette tax, the same tax increases cigarettes purchased by 6.4 packs (confidence interval ranges from 1.1 to 11.7 packs).
  - *An e-cigarette typically contains nicotine equivalent to that in 1-2 packs of cigarettes*
- Other evidence suggests that e-cigarettes may be effective in smoking cessation (Hajek et al. 2019), so unintended consequences should be considered when implementing e-cigarette taxes or other restrictions.

Thank you.

Extra slides follow.

Summary statistics: Prices and taxes (merged with Nielsen data 2011-2017)

Sample:	All localities	Localities that adopt a tax by 2017, pre-tax	Localities that do not adopt a tax by 2017
Prices			
E-cigarette ($ per ml)	4.40	4.49	4.34
E-cigarette taxes			
E-cigarette standardized tax ($)	0.044	--	--
Conditional e-cigarette standardized tax ($)	0.68	--	--
Conditional e-cigarette standardized tax ($) - ad valorem	0.17	--	--
Conditional e-cigarette standardized tax ($) - excise	1.06	--	--

Summary statistics: Policies and demographics (merged with Nielsen data 2011-2017)

Policies and Demographics			
Traditional cigarette tax ($)	1.57	1.19	1.60
% covered by indoor vaping ban	0.14	0.086	0.13
% covered by indoor smoking ban	0.81	0.86	0.79
Tobacco 21 law	0.01	0.02	0.00
Beer tax ($)	0.26	0.19	0.28
ACA Medicaid expansion	0.34	0.28	0.33
Unemployment rate	6.00	7.14	5.91
Age	38.4	38.1	38.4
Male	0.49	0.48	0.49
Female	0.51	0.52	0.51
White	0.80	0.76	0.82
African American	0.12	0.16	0.11
Other race	0.08	0.08	0.08
Hispanic	0.11	0.12	0.12
Born outside the U.S.	0.10	0.12	0.10
Less than high school	0.15	0.16	0.15
High school	0.29	0.29	0.29
Some college	0.27	0.25	0.28
College	0.28	0.29	0.28
Population (millions)	6.43	10.2	5.85
Observations	90730	10248	73693

Notes: The unit of observation is a UPC-code in a locality (state or county) in a quarter (quarter-by-year). Data are weighted by the share of e-cigarette sales in localities that do not adopt an e-cigarette tax.