Shopping for Lower Sales Tax Rates

Scott R. Baker Stephanie Johnson Lorenz Kueng

Northwestern University and NBER

January 22, 2018

Research Question

How do households respond to a pre-announced price change induced by a sales tax increase?

- Do households pay attention?
- What adjustment margins do they use?
- How large are the reactions?

Recent research looks at **deviations** from full optimization

- allowing for inattention (eg non-salience, "sparse" information, ...)
- allowing for systematic mistakes (eg optimization fric., biases, ...)

These deviations have profound effects for public economic and macroeconomics.

Research Question

How do households respond to a pre-announced price change induced by a sales tax increase?

- Do households pay attention?
- What adjustment margins do they use?
- How large are the reactions?

Recent research looks at **deviations** from full optimization

- allowing for inattention (eg non-salience, "sparse" information, ...)
- allowing for systematic mistakes (eg optimization fric., biases, ...)

These deviations have profound effects for public economic and macroeconomics.

Public Economics: If consumers do not fully respond to sales tax changes because of non-salience, then

- sales taxes are an efficient form of taxation
- optimal sales tax rates should be higher than under full salience

Macroeconomics: If sales tax changes are not salient, then

- sales tax changes might not be an efficient tool to stimulate economy
  - eg during a crisis when monetary policy is against the Zero Lower Bound (ZLB)

Two Contributions

1. Comprehensive analysis of consumer response to sales taxes

   Why **sales taxes**? Sales taxes are particularly complex in the US

   - taxes not included in most posted prices
   - some goods exempt & exemption rules vary by state
   - fiscal federalism → many tax jurisdictions
     (state, county, local, and special districts)

   ⇒ Powerful setting for detecting deviations from 'optimal' behavior

2. Novel, parsimonious model of shopping behavior

   - Highlights relationship between
     - short-run effects relevant for macroeconomics (stimulus)
     - long-run effects relevant for public econ (optimality, incidence)
   - Use model to evaluate economic magnitude of response with reservation wage

Two Contributions

1. Comprehensive analysis of consumer response to sales taxes

   Why **sales taxes**? Sales taxes are particularly complex in the US

   - taxes not included in most posted prices
   - some goods exempt & exemption rules vary by state
   - fiscal federalism $\rightarrow$ many tax jurisdictions (state, county, local, and special districts)

   $\Rightarrow$ Powerful setting for detecting deviations from 'optimal' behavior

2. Novel, parsimonious model of shopping behavior

   - Highlights relationship between
     - short-run effects relevant for macroeconomics (stimulus)
     - long-run effects relevant for public econ (optimality, incidence)
   - Use model to evaluate economic magnitude of response with reservation wage

Two Contributions

1. Comprehensive analysis of consumer response to sales taxes

   Why **sales taxes**? Sales taxes are particularly complex in the US

   - taxes not included in most posted prices
   - some goods exempt & exemption rules vary by state
   - fiscal federalism $\rightarrow$ many tax jurisdictions
     (state, county, local, and special districts)

   $\Rightarrow$ Powerful setting for detecting deviations from 'optimal' behavior

2. Novel, parsimonious model of shopping behavior

   - Highlights relationship between
     - short-run effects relevant for macroeconomics (stimulus)
     - long-run effects relevant for public econ (optimality, incidence)
   - Use model to evaluate economic magnitude of response with reservation wage

Three Main Findings

1. Consumers respond to sales tax changes using
   - inter-temporal substitution
   - jurisdictional tax arbitrage
   - increased online spending
2. Both **taxable and exempt spending respond**
   - Seemingly irrational behavior is consistent with a rational model with
     - storability of goods (ie **inventory management**)
     - **shopping trip complementarity**
   - We provide evidence of new trips-complementarity mechanism
     - Store traffic: consumers reduce number of store visits
     - Revealed cost approach: infrequent vs. frequent shoppers
     - 'Placebo tests': cases with low trips complementarity

Three Main Findings

1. Consumers respond to sales tax changes using
   - inter-temporal substitution
   - jurisdictional tax arbitrage
   - increased online spending
2. Both **taxable and exempt spending respond**
   - Seemingly irrational behavior is consistent with a rational model with
     - storability of goods (ie **inventory management**)
     - **shopping trip complementarity**
   - We provide evidence of new trips-complementarity mechanism
     - Store traffic: consumers reduce number of store visits
     - Revealed cost approach: infrequent vs. frequent shoppers
     - 'Placebo tests': cases with low trips complementarity

Three Main Findings

1. Consumers respond to sales tax changes using
   - inter-temporal substitution
   - jurisdictional tax arbitrage
   - increased online spending
2. Both **taxable and exempt spending respond**
   - Seemingly irrational behavior is consistent with a rational model with
     - storability of goods (ie **inventory management**)
     - **shopping trip complementarity**
   - We provide evidence of new trips-complementarity mechanism
     - Store traffic: consumers reduce number of store visits
     - Revealed cost approach: infrequent vs. frequent shoppers
     - 'Placebo tests': cases with low trips complementarity

Three Main Findings

3. Sales taxes are both an **efficient tax** *and* an **effective stimulus tool**!
   - **efficient** tax b/c small consumption elasticity
     (not b/c sales tax is not salient)
   - **effective** stimulus tool b/c large spending elasticity

Literature

- Public Finance
  - more US-focused (sales tax), focus on tax (non-)salience
  - recently: implications of non-salience for optimal taxation

    Chetty Looney Kroft (2009), Finkelstein (2009), Cabral Hoxby (2011), Feldman Ruffle (2015), Farhi Gabaix (2016), Agarwal Marwell McGranahan (2017), ...

- Macro
  - focus on estimating EIS (inter-temporal substitution)
  - mostly international studies using one-time VAT change
  - assumes (and relies on) salience of sales taxes/VATs

    Mian Sufi (2012), Cashin (2015), D'Acunto Hoang Weber (2016), Gabaix (2016), ...

- Industrial Organization
  - demand elasticity: typically uses unexpected, temporary sales
  - focus on individual product sales, not store-wide sales
    $\Rightarrow$ assumes that sales has no effect on store traffic

    Hendel Nevo (2006, 2013), Einav Knoepfle Levin Sundaresan (2014), ...

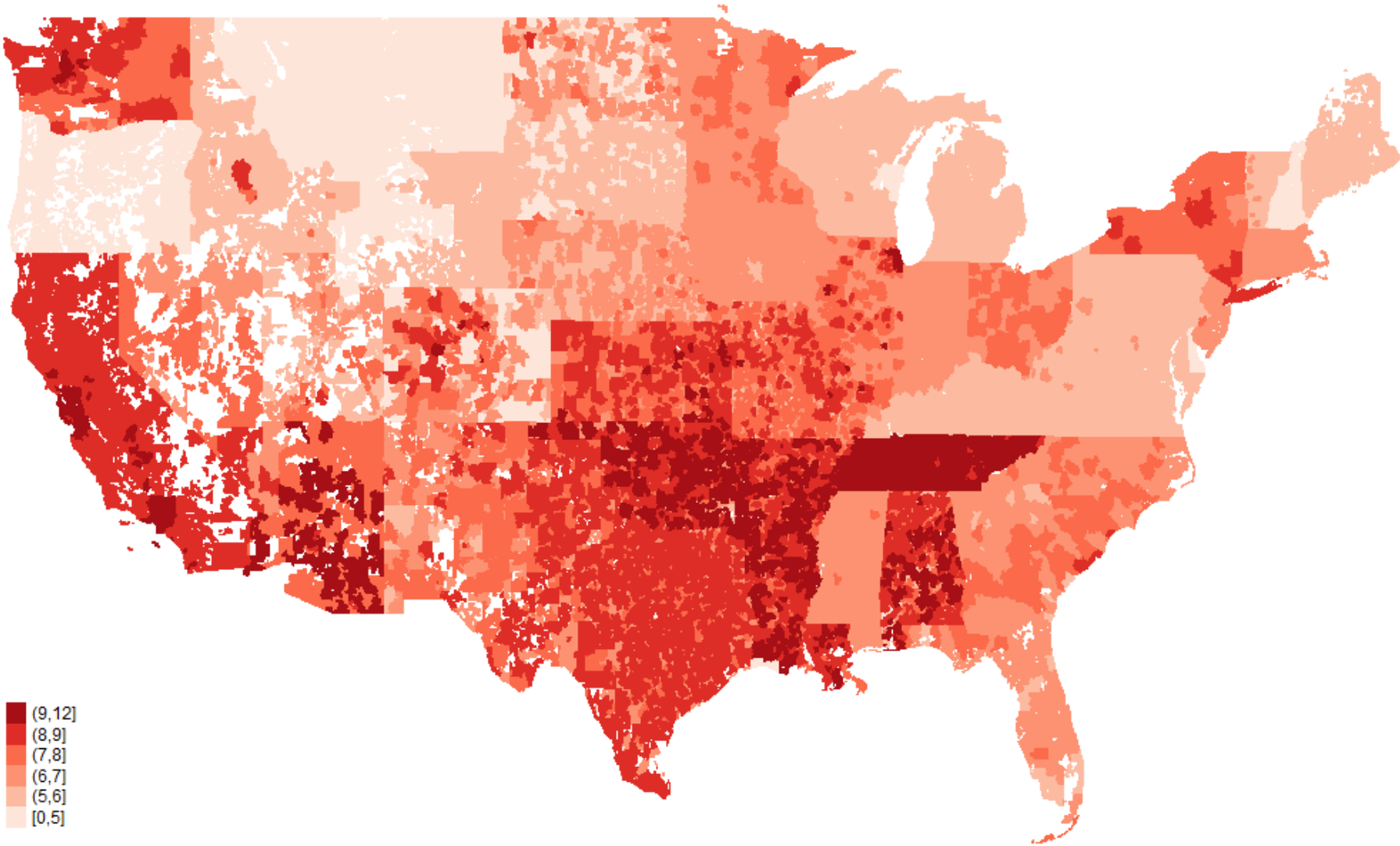
Outline

1. Data
2. Research Design
   - Fiscal lag: newspaper coverage
   - Fiscal foresight: Google searches
3. Spending and Shopping Response
   - Taxable spending
   - Intertemporal substitution
   - Shopping frequency
   - Tax-exempt spending
4. Shopping Model
5. Shopping Complementarity
   - Revealed cost approach: infrequent vs. frequent shoppers
   - Trip complementarity: taxable/exempt mix
   - Online shopping: low complementarity
6. Additional Evidence of Optimizing Behavior
   - Persistent tax incentives prompt long-run responses
     - Cross-border and online shopping
   - Tax salience and announcement effects
     - Newspaper coverage and ballot initiatives

Sales Tax Data

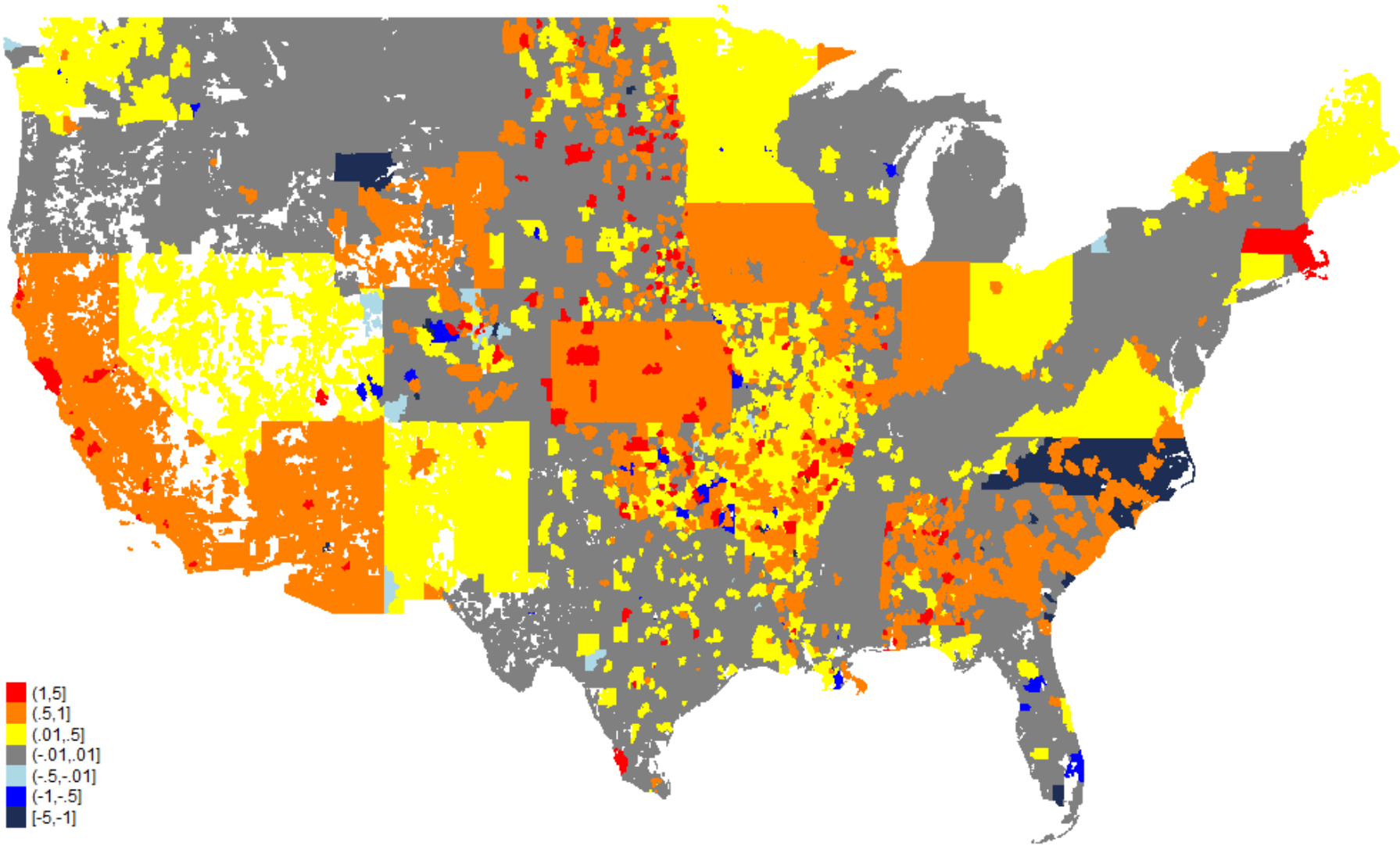
- Zipcode-level sales taxes from Thomson Reuters
  - four layers of tax jurisdictions (state, county, city, special districts)
  - monthly 2008-2015
- State taxes 2003-2016, partially hand collected
- $\approx$ 50 state and over 2,000 distinct local changes
  - $\Delta\tau_{local}$: μ=0.54%, med=0.5%
  - $\Delta\tau_{state}$: μ=0.62%, med=0.5%

Sales Tax Rates (maximum rate 2008-15)



(white ZIP codes have missing sales tax rates or are not covered by Nielsen)

Sales Tax Rate Changes (max. rate change 2008-15)



(white ZIP codes have missing sales tax rates or are not covered by Nielsen)

Spending Data: Nielsen Consumer & Retailer Panels

Nielsen Consumer Panel (NCP)

- 150,000+ HH panel with detailed retail spending micro-data, 2004-2014
- HHs use scanners and diaries to record purchases at UPC level
- Covers groceries, pharmacy items, small home furnishings, electronics, kitchenware, ...

Nielsen Retail Scanner Panel (NRP)

- Store-level sales at UPC level, 2006-2014

All results shown use *pre-tax* prices and spending

- No mechanical effect of sales tax on outcomes

Spending Data: Nielsen Consumer & Retailer Panels

Nielsen Consumer Panel (NCP)

- 150,000+ HH panel with detailed retail spending micro-data, 2004-2014
- HHs use scanners and diaries to record purchases at UPC level
- Covers groceries, pharmacy items, small home furnishings, electronics, kitchenware, ...

Nielsen Retail Scanner Panel (NRP)

- Store-level sales at UPC level, 2006-2014

All results shown use *pre-tax* prices and spending

- No mechanical effect of sales tax on outcomes

Outline

1. Data
2. Research Design
   - Fiscal lag: newspaper coverage
   - Fiscal foresight: Google searches
3. Spending and Shopping Response
   - Taxable spending
   - Intertemporal substitution
   - Shopping frequency
   - Tax-exempt spending
4. Shopping Model
5. Shopping Complementarity
   - Revealed cost approach: infrequent vs. frequent shoppers
   - Trip complementarity: taxable/exempt mix
   - Online shopping: low complementarity
6. Additional Evidence of Optimizing Behavior
   - Persistent tax incentives prompt long-run responses
     - Cross-border and online shopping
   - Tax salience and announcement effects
     - Newspaper coverage and ballot initiatives

Approach

- Use **high frequency** of tax and spending **data** and exploit **fiscal lag**

Important

- These are not shocks (ie tax news/information shocks)
- but predetermined tax *changes*

⇒ Captures **substitution effects**, not income/wealth effects (*if* consumers are forward-looking optimizers)

i.e., transition to a new steady state ('MIT shock')

- Compare HHs in treated with untreated jurisdictions

$$\Delta \ln y_{ht} = \beta \cdot \Delta \ln(1 + \tau_{jt}) + T_t + HH_h + \lambda' z_{ht} + \epsilon_{ht}$$

τ: sales tax rate
h: household
t: month
j: household's tax jurisdiction

SEs clustered at level of tax jurisdiction

Approach

- Use **high frequency** of tax and spending **data** and exploit **fiscal lag**

  Important
  - These are not shocks (ie tax news/information shocks)
  - but predetermined tax *changes*

    ⇒ Captures **substitution effects**, not income/wealth effects (*if* consumers are forward-looking optimizers)

    i.e., transition to a new steady state ('MIT shock')

- Compare HHs in treated with untreated jurisdictions

$$\Delta \ln y_{ht} = \beta \cdot \Delta \ln(1 + \tau_{jt}) + T_t + HH_h + \lambda' z_{ht} + \epsilon_{ht}$$

τ: sales tax rate
h: household
t: month
j: household's tax jurisdiction

SEs clustered at level of tax jurisdiction

Approach

- Use **high frequency** of tax and spending **data** and exploit **fiscal lag**

  Important
  - These are not shocks (ie tax news/information shocks)
  - but predetermined tax *changes*

  ⇒ Captures **substitution effects**, not income/wealth effects (*if* consumers are forward-looking optimizers)

  i.e., transition to a new steady state ('MIT shock')

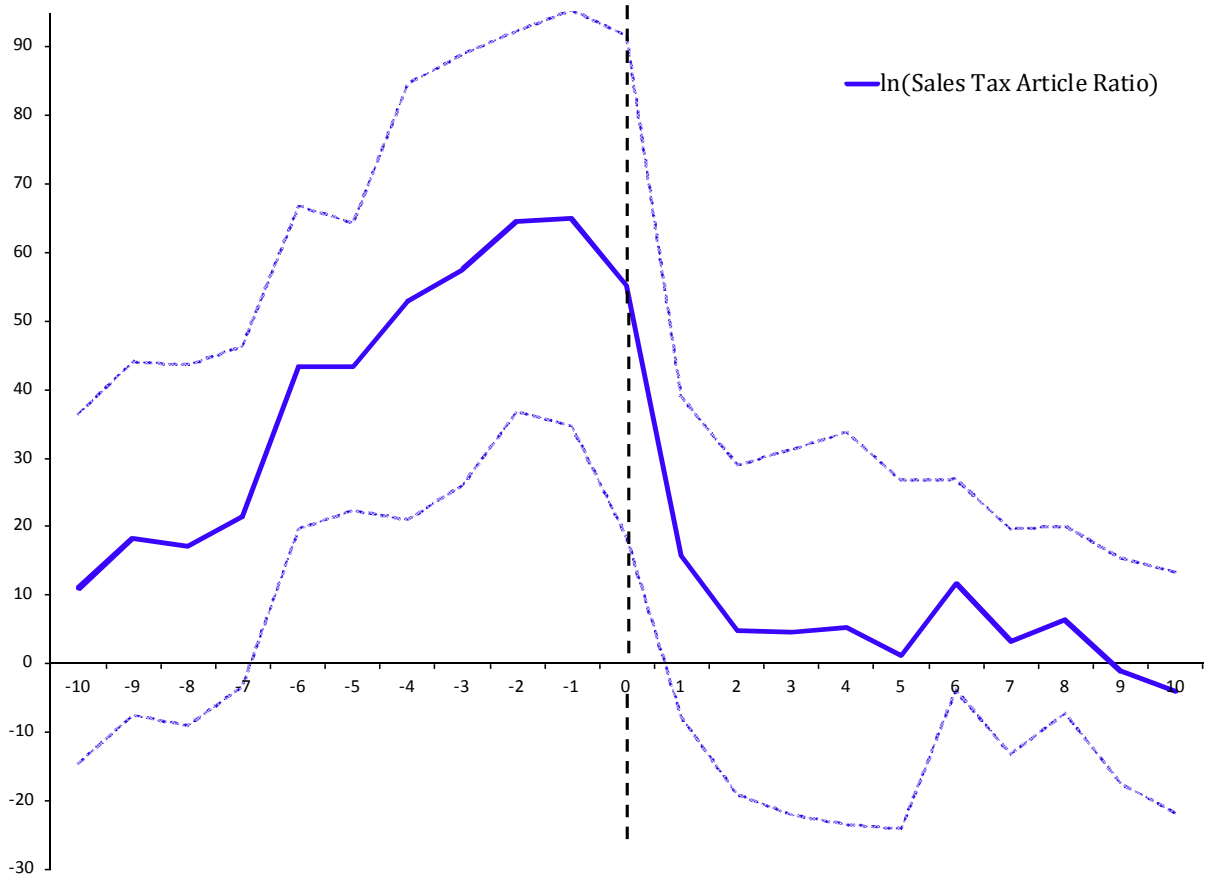
- Compare HHs in treated with untreated jurisdictions

$$\Delta \ln y_{ht} = \beta \cdot \Delta \ln(1 + \tau_{jt}) + T_t + HH_h + \lambda' z_{ht} + \epsilon_{ht}$$

τ: sales tax rate
h: household
t: month
j: household's tax jurisdiction

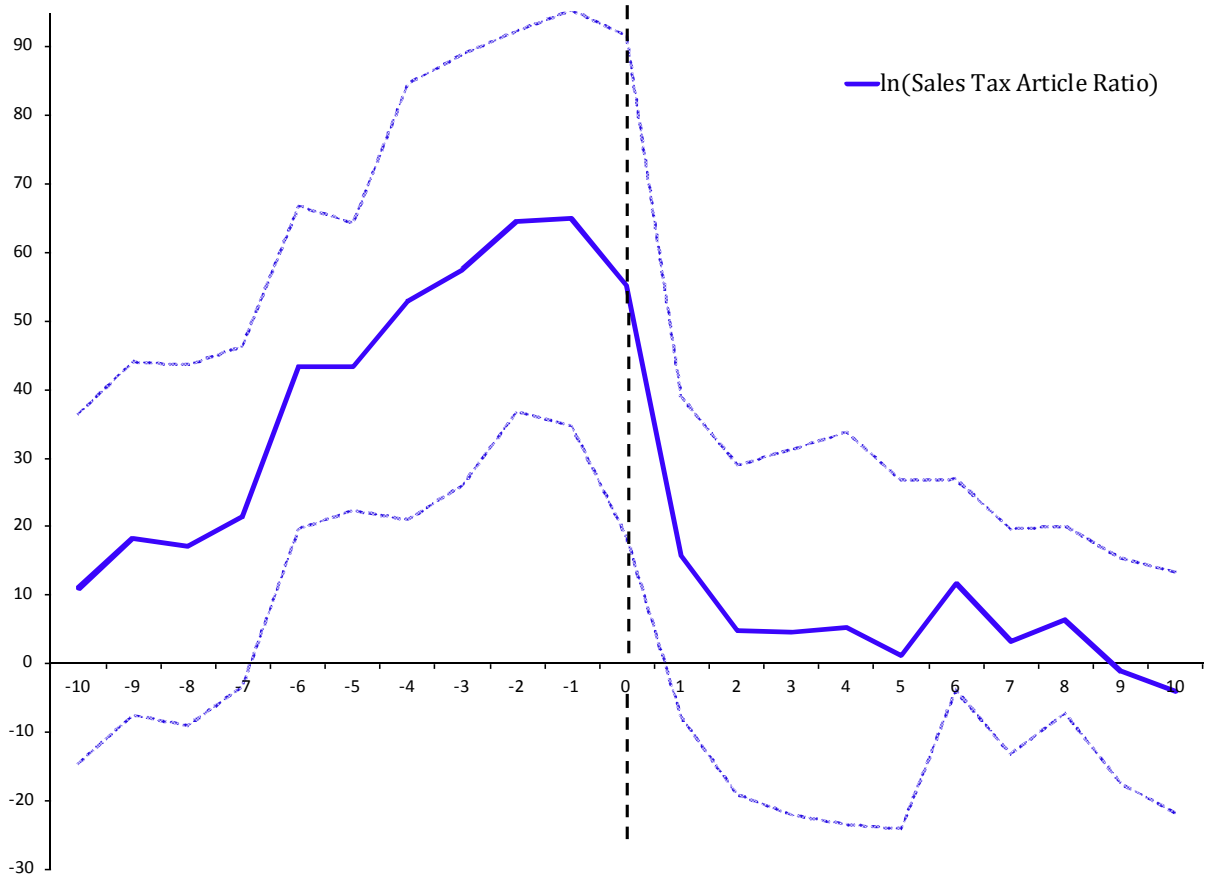
SEs clustered at level of tax jurisdiction

Fiscal Lag: Evidence from # of Newspaper Articles



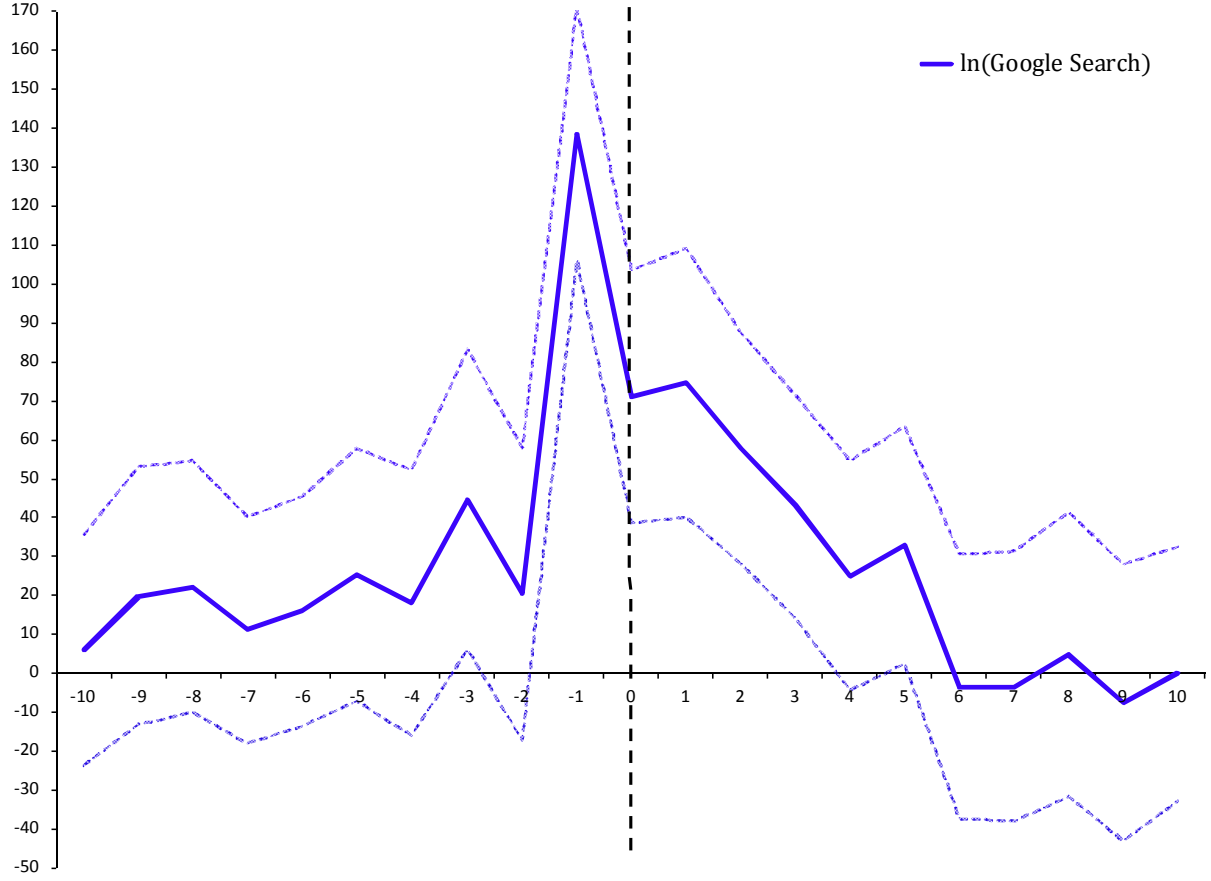
- Announcements/news occur several months in advance
- Hence, at the time of the change this is not a shock (*if salient*)
  - Are HHs aware of these tax changes?

Fiscal Lag: Evidence from # of Newspaper Articles



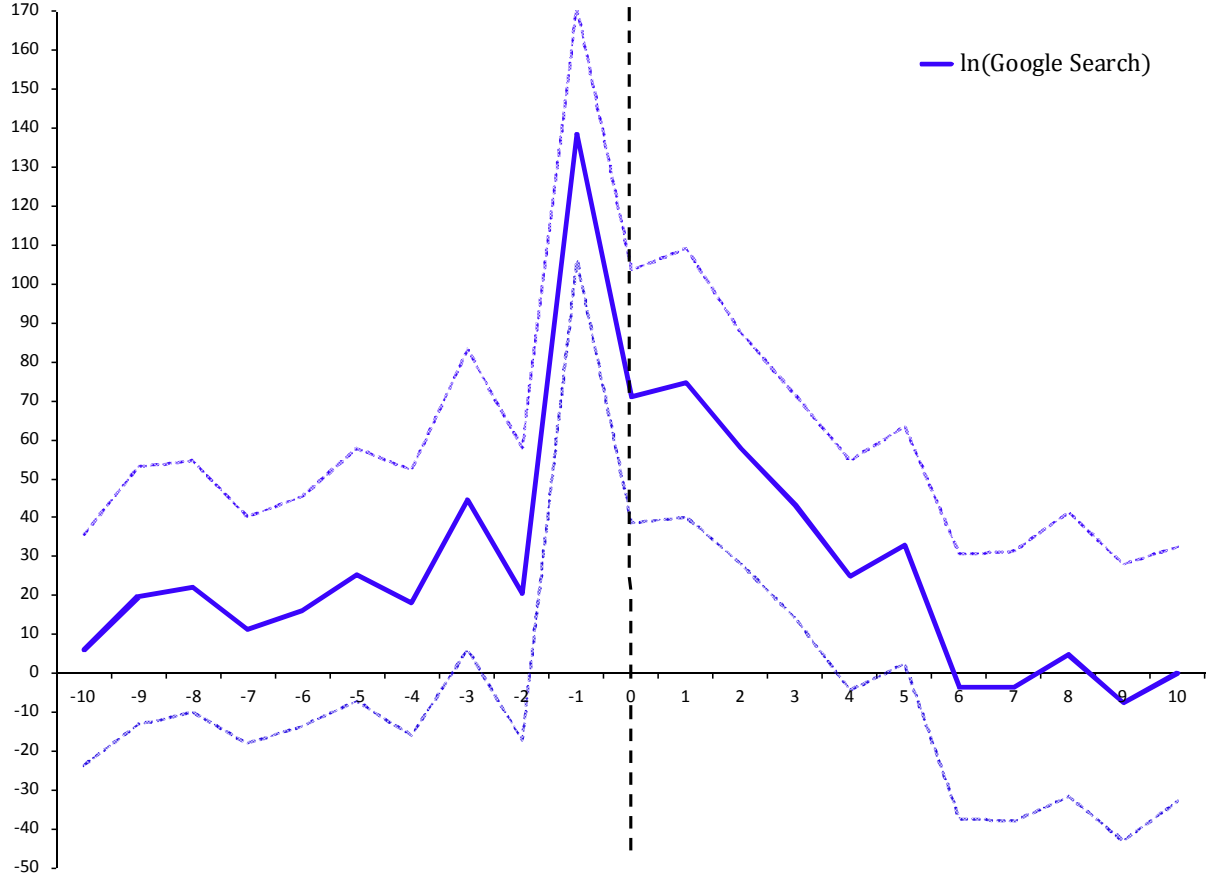
- Announcements/news occur several months in advance
- Hence, at the time of the change this is not a shock (*if salient*)
  - Are HHs aware of these tax changes?

Fiscal Foresight: Evidence from Google Searches



- Users clearly pay attention to upcoming sales tax rate changes
  - Do they also change their spending behavior?

Fiscal Foresight: Evidence from Google Searches



- Users clearly pay attention to upcoming sales tax rate changes
  - Do they also change their spending behavior?

Taxable Spending Response: *Households*

Table 1: Response of Taxable Spending to a Sales Tax Increase

Data source:	Nielsen Consumer Panel (NCP)		
Dependent variable: log change of monthly taxable retail spending	A. Main Analysis		
	Baseline	State tax rate only	Sales tax cuts
	(1)	(2)	(3)
Δln(1 + total sales tax rate)	-2.036***		-1.719*
	(0.648)		(0.965)
Δln(1 + state sales tax rate)		-2.185**	
		(1.031)	
Period FE	Yes	Yes	Yes
Household FE	Yes	Yes	Yes
Household characteristics			
Local unemployment rate			
State-period FE			
Observations	4,137,927	5,928,468	4,114,413
R-squared	0.014	0.013	0.014

- Consumer spending responds to both total- and state-level changes
- Two main concerns
  1. Sensitivity of estimates to local conditions
  2. Representativeness of Nielsen HHs

Taxable Spending Response: *Households*

Table 1: Response of Taxable Spending to a Sales Tax Increase

Data source:	Nielsen Consumer Panel (NCP)						
Dependent variable: log change of monthly taxable retail spending	A. Main Analysis			B. Robustness			
	Baseline	State tax rate only	Sales tax cuts	Household charac.	Business cycle	Drop Great Recession	State-period FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δln(1 + total sales tax rate)	-2.036***		-1.719*	-2.034***	-2.082***	-2.012**	-2.269***
	(0.648)		(0.965)	(0.648)	(0.648)	(0.882)	(0.701)
Δln(1 + state sales tax rate)		-2.185**					
		(1.031)					
Period FE	Yes	Yes	Yes	Yes	Yes	Yes	
Household FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics				Yes	Yes	Yes	Yes
Local unemployment rate					Yes	Yes	Yes
State-period FE							Yes
Observations	4,137,927	5,928,468	4,114,413	4,137,927	4,137,927	3,285,747	4,137,886
R-squared	0.014	0.013	0.014	0.014	0.014	0.015	0.015

- Consumer spending responds to both total- and state-level changes
- Two main concerns
  1. Sensitivity of estimates to local conditions
  2. Representativeness of Nielsen HHs

Taxable Spending Response: *Retailer Sales*

Table 1: Response of Taxable Spending to a Sales Tax Increase

Data source:	Nielsen Retailer Panel (NRP)		
Dependent variables: log change of monthly taxable retail sales	C. Store Sales		
	Baseline	Business cycle	State-period FE
	(10)	(11)	(12)
$\Delta\ln(1 + \text{total sales tax rate})$	-2.814**	-2.794**	-3.265**
	(1.368)	(1.368)	(1.440)
Period FE	Yes	Yes	
Store FE	Yes	Yes	Yes
Local unemployment rate		Yes	Yes
State-period FE			Yes
Observations	2,461,491	2,461,491	2,461,491
R-squared	0.140	0.140	0.150

- Consumer spending responds to both total- and state-level changes
- Two main concerns
  1. Sensitivity of estimates to local conditions
  2. Representativeness of Nielsen HHs

Quantity Response Similar as Spending

- Spending response **not** driven by substitution to **lower quality**

	A. Quantity Response	
Dependent variable:	Δln(taxable)	Δln(taxable)
	(1)	(3)
Δln(1 + total sales tax rate)	-2.330***	
	(0.479)	
Δln(1 + state sales tax rate)		-2.245**
		(0.908)
Period FE	Yes	Yes
Household FE	Yes	Yes
Product FE		
ZIP3 FE		
Observations	4,140,969	5,928,529
R-squared	0.014	0.013

What is driving these large responses? Two main candidates:

- **Passive behavior**: Inattention and delayed income effects
- **Active behavior**: Attention and substitution effects

Quantity Response Similar as Spending

- Spending response **not** driven by substitution to **lower quality**

	A. Quantity Response	
Dependent variable:	Δln(taxable)	Δln(taxable)
	(1)	(3)
Δln(1 + total sales tax rate)	-2.330***	
	(0.479)	
Δln(1 + state sales tax rate)		-2.245**
		(0.908)
Period FE	Yes	Yes
Household FE	Yes	Yes
Product FE		
ZIP3 FE		
Observations	4,140,969	5,928,529
R-squared	0.014	0.013

What is driving these large responses? Two main candidates:

- **Passive behavior**: Inattention and delayed income effects
- **Active behavior**: Attention and substitution effects

Substitution Margins

The main margins of adjustment are

1. inter-temporal substitution
2. online shopping
3. cross-border shopping
4. consumption substitution to exempt goods

We first focus on intertemporal substitution ...

- available to all consumers
- hence, direct test of forward-looking, attentive behavior

... before analyzing online and cross-border shopping

- incentives change only after sales tax change
- cross-border shopping very costly for most consumers (at state or ZIP-3 level)

Substitution Margins

The main margins of adjustment are

1. inter-temporal substitution
2. online shopping
3. cross-border shopping
4. consumption substitution to exempt goods

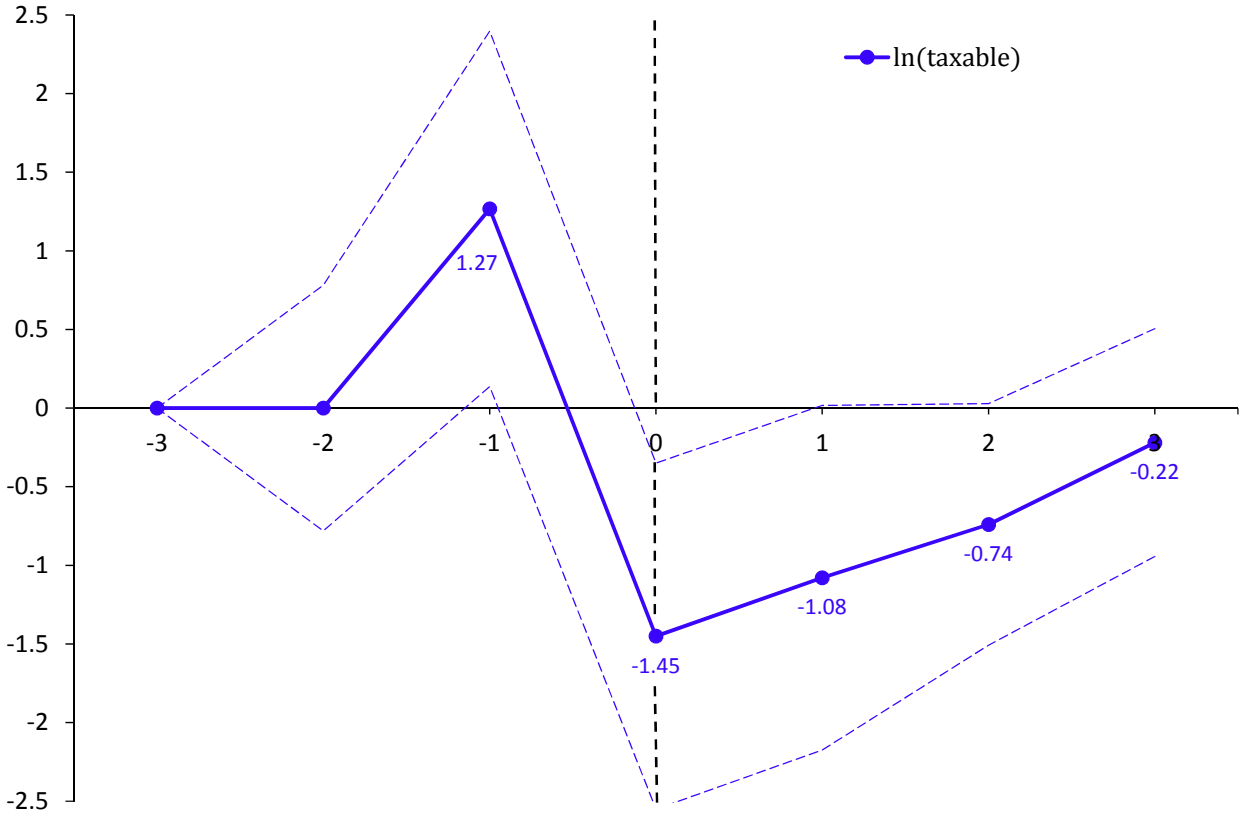
We first focus on intertemporal substitution ...

- available to all consumers
- hence, direct test of forward-looking, attentive behavior

... before analyzing online and cross-border shopping

- incentives change only after sales tax change
- cross-border shopping very costly for most consumers (at state or ZIP-3 level)

Intertemporal Substitution



- Only effect in the short run
  - characteristic of **inventory demand**
  - suggests substitution of spending, not consumption

$\Rightarrow$ inspect inventory demand: storability and shopping frequency

Table 2: Storability and Intertemporal Substitution

	C. Poduct Groups by Purchase Frequency	
	Non-storability: avg. # of purchases/month	
	(6)	(7)
Δln(1 + sales tax rate)	CARBONATED BEVERAGES	1.942
	CANDY	1.700
Δln(1 + sales tax rate) × Storability	PAPER PRODUCTS	1.615
- Quartile 2	PET FOOD	1.382
	ICE CREAM, NOVELTIES	0.967
- Quartile 3	SOFT DRINKS, NON-CARB.	0.906
	DETERGENTS	0.726
- Quartile 4	WRAPPING MATERIALS	0.612
	STATIONERY, SCHOOL SUP.	0.604
Δln(1 + sales tax rate), lead		
	...	...
Δln(1 + sales tax rate) × Storability, lead		
- Quartile 2	FRAGRANCES - WOMEN	0.081
	PHOTOGRAPHIC SUPPLIES	0.076
- Quartile 3	MEN'S TOILETRIES	0.075
	CANNING, FREEZING SUP.	0.069
- Quartile 4	TOYS & SPORTING GOODS	0.065
	GRT CARDS/PARTY NEEDS	0.049
	SEWING NOTIONS	0.044
Period FE	SEASONAL	0.042
Product FE	SHOE CARE	0.041
State FE		
Observations	Sample mean (weighted)	0.846
R-squared	Sample standard deviation	0.602

Table 2: Storability and Intertemporal Substitution

Dependent variable: monthly taxable retail spending by product group and state	B. Response by Storability	C. Poduct Groups by Purchase Frequency	
	Quartiles	Non-storability: avg. # of purchases/month	
	(5)	(6)	(7)
Δln(1 + sales tax rate)	-1.476	CARBONATED BEVERAGES	1.942
	(1.324)	CANDY	1.700
Δln(1 + sales tax rate) × Storability		PAPER PRODUCTS	1.615
- Quartile 2	1.652*	PET FOOD	1.382
	(0.916)	ICE CREAM, NOVELTIES	0.967
- Quartile 3	-5.543*	SOFT DRINKS, NON-CARB.	0.906
	(2.911)	DETERGENTS	0.726
- Quartile 4	-12.678**	WRAPPING MATERIALS	0.612
	(6.272)	STATIONERY, SCHOOL SUP.	0.604
Δln(1 + sales tax rate), lead	0.015		
	(0.658)	...	...
Δln(1 + sales tax rate) × Storability, lead			
- Quartile 2	-0.300	FRAGRANCES - WOMEN	0.081
	(0.489)	PHOTOGRAPHIC SUPPLIES	0.076
- Quartile 3	1.951*	MEN'S TOILETRIES	0.075
	(1.127)	CANNING, FREEZING SUP.	0.069
- Quartile 4	14.910*	TOYS & SPORTING GOODS	0.065
	(8.885)	GRT CARDS/PARTY NEEDS	0.049
		SEWING NOTIONS	0.044
Period FE	Yes	SEASONAL	0.042
Product FE	Yes	SHOE CARE	0.041
State FE	Yes		
Observations	307,520	Sample mean (weighted)	0.846
R-squared	0.064	Sample standard deviation	0.602

Table 2: Storability and Intertemporal Substitution

Dependent variable: monthly taxable retail spending by product group and state	B. Response by Storability	C. Poduct Groups by Purchase Frequency	
	Quartiles	Non-storability: avg. # of purchases/month	
	(5)	(6)	(7)
Δln(1 + sales tax rate)	-1.476	CARBONATED BEVERAGES	1.942
	(1.324)	CANDY	1.700
Δln(1 + sales tax rate) × Storability		PAPER PRODUCTS	1.615
- Quartile 2	1.652*	PET FOOD	1.382
	(0.916)	ICE CREAM, NOVELTIES	0.967
- Quartile 3	-5.543*	SOFT DRINKS, NON-CARB.	0.906
	(2.911)	DETERGENTS	0.726
- Quartile 4	-12.678**	WRAPPING MATERIALS	0.612
	(6.272)	STATIONERY, SCHOOL SUP.	0.604
Δln(1 + sales tax rate), lead	0.015		
	(0.658)	...	...
Δln(1 + sales tax rate) × Storability, lead			
- Quartile 2	-0.300	FRAGRANCES - WOMEN	0.081
	(0.489)	PHOTOGRAPHIC SUPPLIES	0.076
- Quartile 3	1.951*	MEN'S TOILETRIES	0.075
	(1.127)	CANNING, FREEZING SUP.	0.069
- Quartile 4	14.910*	TOYS & SPORTING GOODS	0.065
	(8.885)	GRT CARDS/PARTY NEEDS	0.049
		SEWING NOTIONS	0.044
Period FE	Yes	SEASONAL	0.042
Product FE	Yes	SHOE CARE	0.041
State FE	Yes		
Observations	307,520	Sample mean (weighted)	0.846
R-squared	0.064	Sample standard deviation	0.602

Shopping Behavior and Intertemporal Substitution

Prediction: If intertemporal substitution of *consumption* is low, then increase in inventory should decrease shopping frequency.

Shopping Behavior and Intertemporal Substitution

Prediction: If intertemporal substitution of *consumption* is low, then increase in inventory should decrease shopping frequency.

Table 1: Response of Shopping Frequency to a Sales Tax Increase

Data source:	Nielsen Consumer Panel (NCP)		
Dependent variable: log change of the number of monthly store visits	D. Shopping Frequency (Log # of Trips)		
	Baseline	Household charac.	Business cycle
	(13)	(14)	(15)
$\Delta \ln(1 + \text{total sales tax rate})$	-1.479***	-1.479***	-1.455***
	(0.449)	(0.449)	(0.449)
Period FE	Yes	Yes	Yes
Household FE	Yes	Yes	Yes
Household characteristics		Yes	Yes
Local unemployment rate			Yes
Observations	4,137,927	4,137,927	4,137,927
R-squared	0.020	0.020	0.020

Shopping fixed costs have implication for exempt goods

- If most stores sell both exempt and taxable products, then HHs can save on future trips by also stocking up on exempt goods.

$\Rightarrow$ tax-exempt products are not a valid control!

Shopping fixed costs have implication for exempt goods

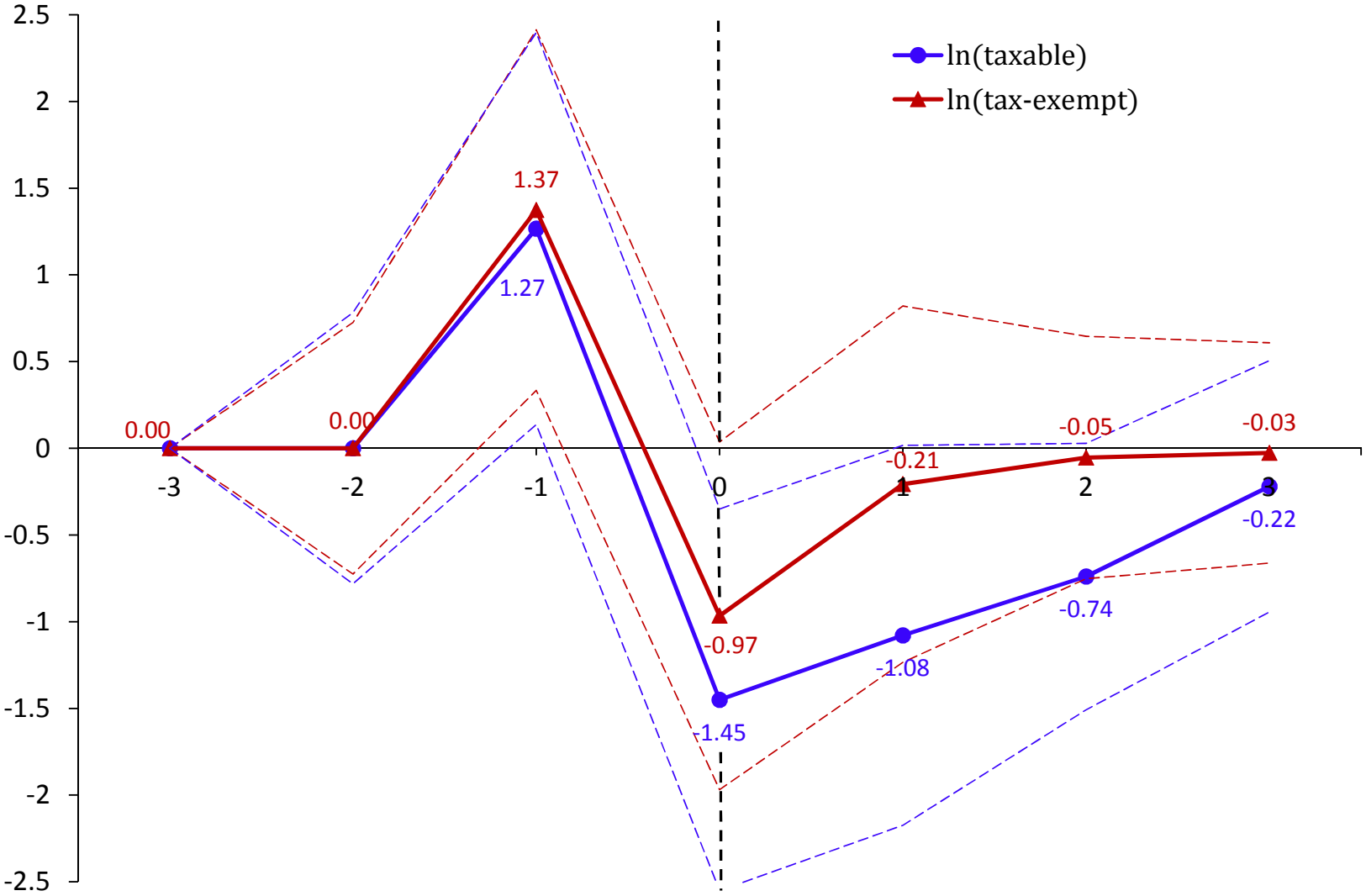
- If most stores sell both exempt and taxable products, then HHs can save on future trips by also stocking up on exempt goods.

⇒ tax-exempt products are not a valid control!

Table 3: Tax-Exempt Spending Response to a Sales Tax Increase

Data source:	Nielsen Consumer Panel (NCP)				
Dependent variable: log change of monthly exempt retail spending	A. Main Analysis		B. Robustness		
	Baseline	State tax rate only	Household charac.	Business cycle	State-period FE
	(1)	(2)	(3)	(4)	(5)
Δln(1 + total sales tax rate)	-1.395***		-1.393***	-1.329***	-1.215**
	(0.513)		(0.513)	(0.513)	(0.557)
Δln(1 + state sales tax rate)		-1.618**			
		(0.656)			
Period FE	Yes	Yes	Yes	Yes	
Household FE	Yes	Yes	Yes	Yes	Yes
Household characteristics			Yes	Yes	Yes
Local unemployment rate				Yes	Yes
State-period FE					Yes
Observations	4,095,406	5,865,177	4,095,406	4,095,406	4,095,406
R-squared	0.015	0.014	0.015	0.015	0.016

Shopping Complementarity



- Dynamics of exempt spending similar to taxable
- Consistent with shopping complementarity due to fixed costs

Outline

1. Data
2. Research Design
   - Fiscal lag: newspaper coverage
   - Fiscal foresight: Google searches
3. Spending and Shopping Response
   - Taxable spending
   - Intertemporal substitution
   - Shopping frequency
   - Tax-exempt spending
4. Shopping Model
5. Shopping Complementarity
   - Revealed cost approach: infrequent vs. frequent shoppers
   - Trip complementarity: taxable/exempt mix
   - Online shopping: low complementarity
6. Additional Evidence of Optimizing Behavior
   - Persistent tax incentives prompt long-run responses
     - Cross-border and online shopping
   - Tax salience and announcement effects
     - Newspaper coverage and ballot initiatives

Cons-Savings Model with Inventories and Shopping

Goal:

- Specify a parsimonious model with rational consumers that matches observed spending responses
- Use model to assess quantitatively economic magnitude of observed response using implicit reservation wage

Problem:

- Standard inventory models (eg Baumol-Tobin) cannot easily deal with non-stationary problem due to anticipated price change

Solution: "Friedman meets Baumol-Tobin"

- We derive a model of dynamic demand with multiple goods, fixed costs and inventory management ($\Rightarrow$ consumption $\neq$ spending)

Cons-Savings Model with Inventories and Shopping

Goal:

- Specify a parsimonious model with rational consumers that matches observed spending responses
- Use model to assess quantitatively economic magnitude of observed response using implicit reservation wage

Problem:

- Standard inventory models (eg Baumol-Tobin) cannot easily deal with non-stationary problem due to anticipated price change

Solution: "Friedman meets Baumol-Tobin"

- We derive a model of dynamic demand with multiple goods, fixed costs and inventory management ($\Rightarrow$ consumption $\neq$ spending)

Cons-Savings Model with Inventories and Shopping

Ingredients:

1. continuous time with transaction fixed costs κ per shopping trip $\Rightarrow$ endogenous shopping intervals Δt_n ("trips response")
2. consumption of taxable and tax-exempt goods (c_τ, c_e)
3. investment in risk-free asset a or in inventory of storable goods (s_τ, s_e) with common depreciation rate δ
4. perfect foresight: consumers know of upcoming permanent sales tax increase at future date t_τ
   - no "announcement" (wealth) effect
   - "MIT shock"

Notation:

- $C(t) = [c_\tau(t)^{1-1/\eta} + c_e(t)^{1-1/\eta}]^{\frac{\eta}{\eta-1}}$: **composite consumption**
- $u(t) = C(t)^{1-1/\sigma}$ with utility $\int e^{-\rho t} u(t) dt$
- $\mathbf{S_{t_n}}$: Beginning-of-period **inventory** to support $C(t)$ during Δt_n
  - $K_{t_n} = \kappa + P_{t_n}(\tau) \cdot S_{t_n}$: total costs per transaction
  - inventory depreciates at constant rate, $\dot{S}(t) = -\delta S(t) - C(t)$

Cons-Savings Model with Inventories and Shopping

Ingredients:

1. continuous time with transaction fixed costs κ per shopping trip $\Rightarrow$ endogenous shopping intervals Δt_n ("trips response")
2. consumption of taxable and tax-exempt goods (c_τ, c_e)
3. investment in risk-free asset a or in inventory of storable goods (s_τ, s_e) with common depreciation rate δ
4. perfect foresight: consumers know of upcoming permanent sales tax increase at future date t_τ
   - no "announcement" (wealth) effect
   - "MIT shock"

Notation:

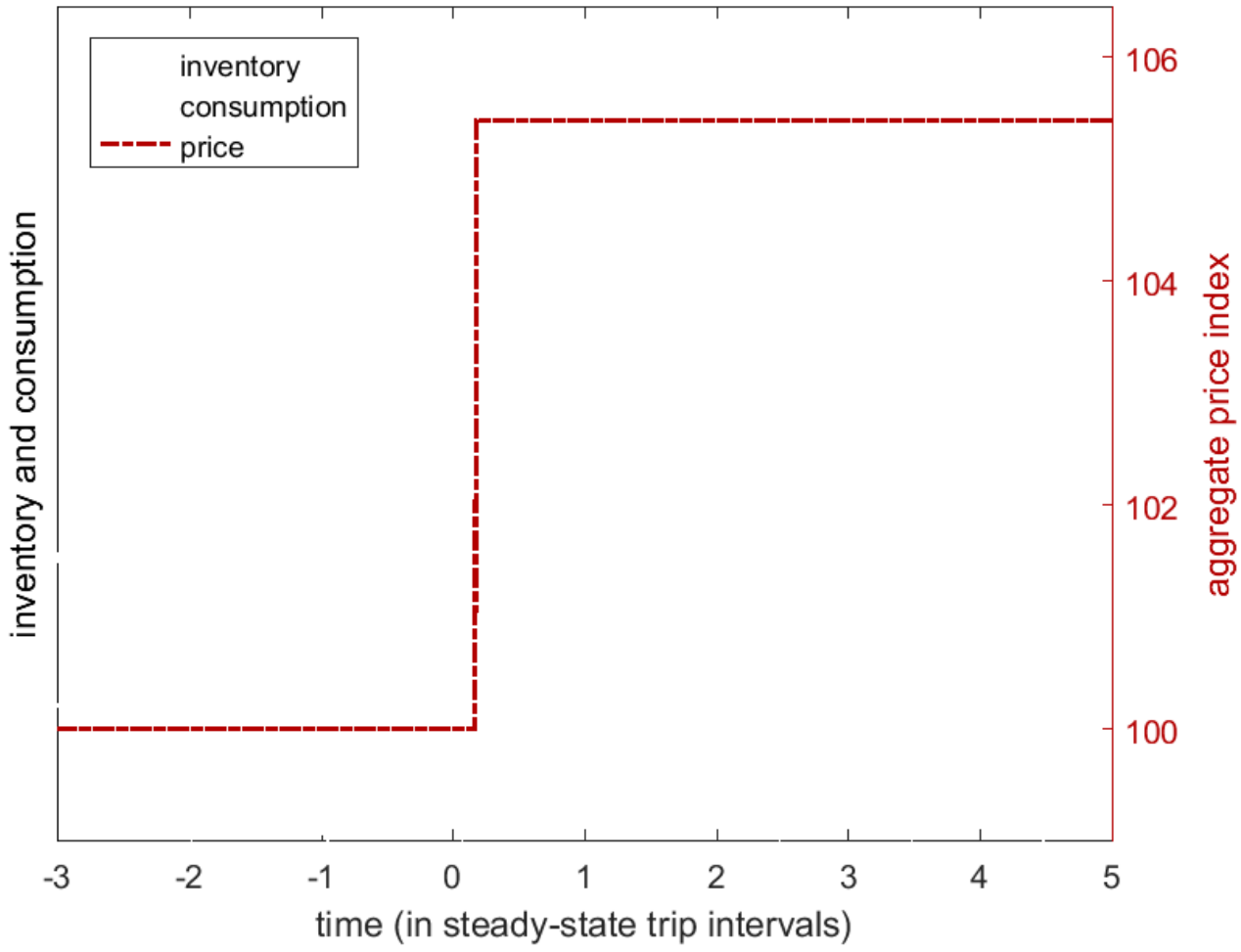
- $C(t) = [c_\tau(t)^{1-1/\eta} + c_e(t)^{1-1/\eta}]^{\frac{\eta}{\eta-1}}$: **composite consumption**
- $u(t) = C(t)^{1-1/\sigma}$ with utility $\int e^{-\rho t} u(t) dt$
- $\mathbf{S_{t_n}}$: Beginning-of-period **inventory** to support $C(t)$ during Δt_n
  - $K_{t_n} = \kappa + P_{t_n}(\tau) \cdot S_{t_n}$: total costs per transaction
  - inventory depreciates at constant rate, $\dot{S}(t) = -\delta S(t) - C(t)$

Model transition dynamics has 3 stages

1. **pre-periods**: shopping trips under the old lower tax rate
2. **interim** period: last shopping trip before tax increase
3. **final** stationary steady state

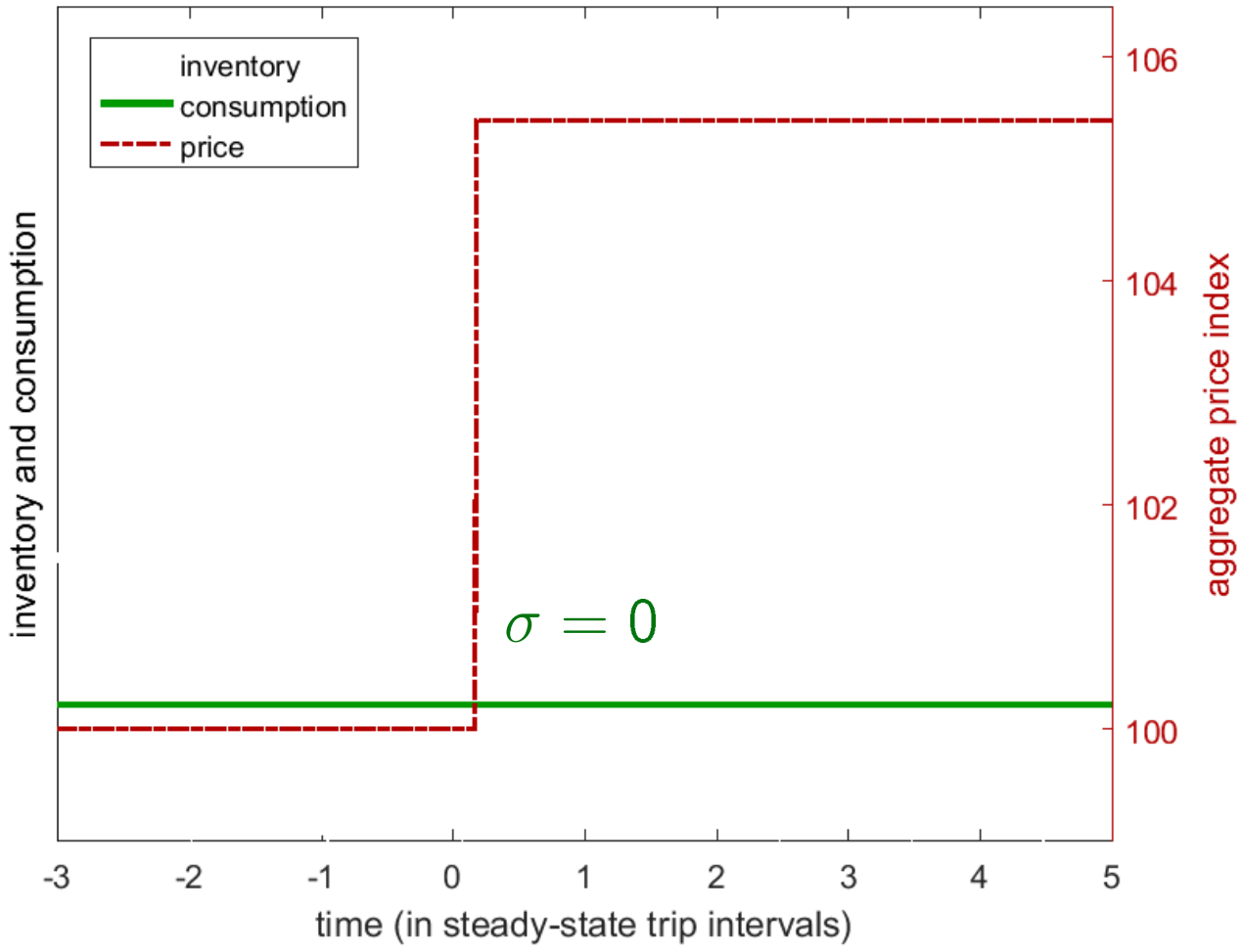
Model transition dynamics has 3 stages

1. **pre-periods**: shopping trips under the old lower tax rate
2. **interim** period: last shopping trip before tax increase
3. **final** stationary steady state



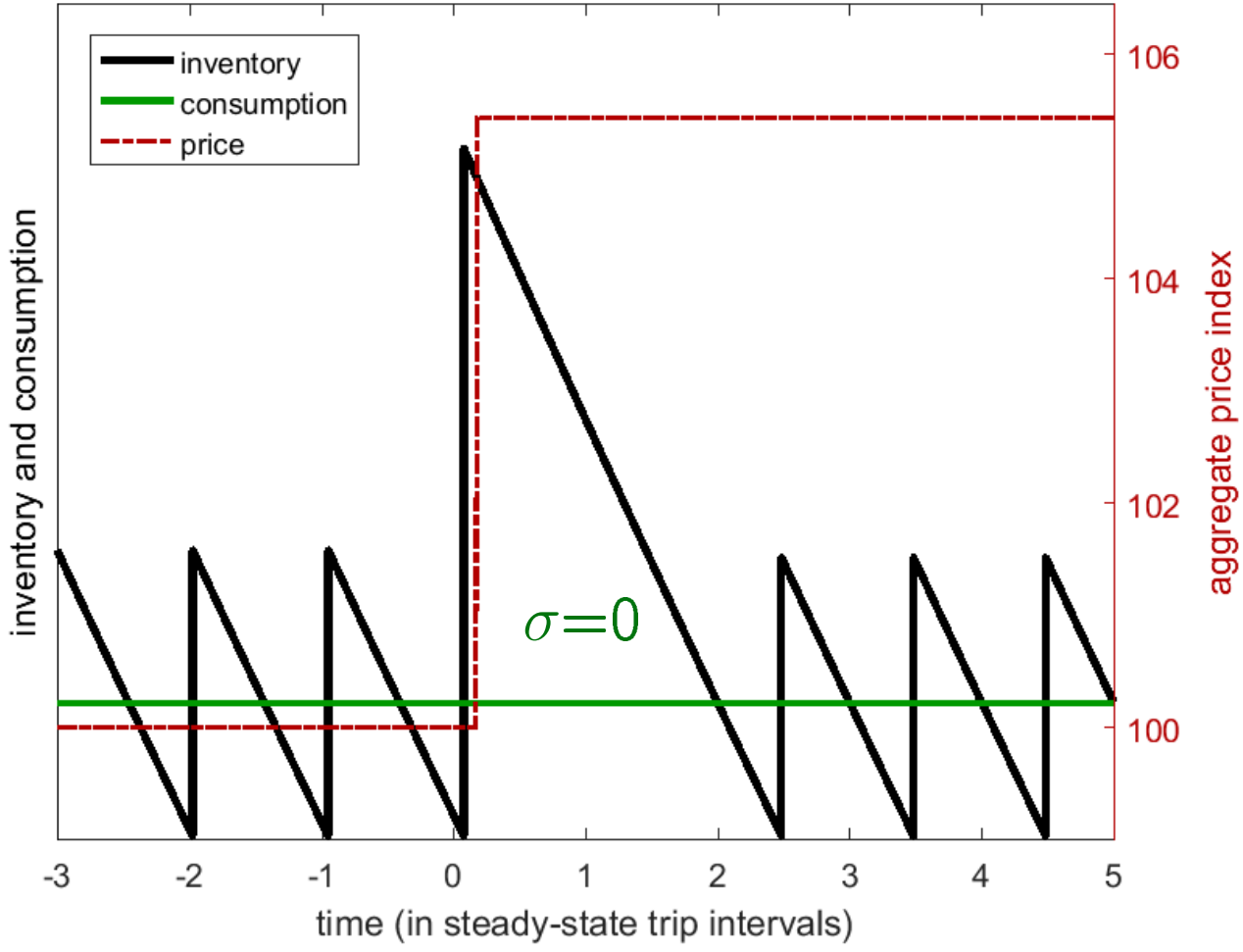
Model transition dynamics has 3 stages

1. **pre-periods**: shopping trips under the old lower tax rate
2. **interim** period: last shopping trip before tax increase
3. **final** stationary steady state



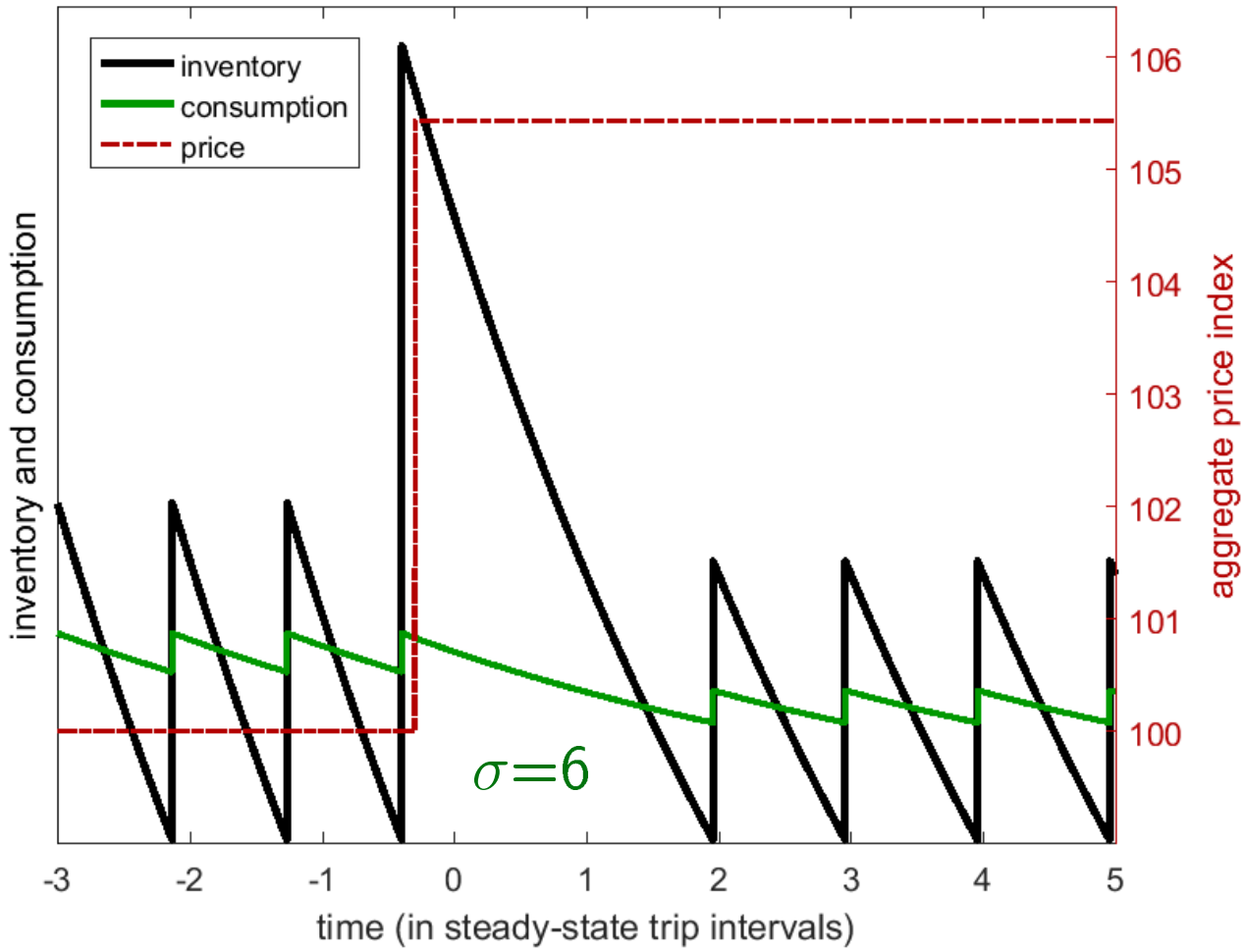
Model transition dynamics has 3 stages

1. **pre-periods**: shopping trips under the old lower tax rate
2. **interim** period: last shopping trip before tax increase
3. **final** stationary steady state



Model transition dynamics has 3 stages

1. **pre-periods**: shopping trips under the old lower tax rate
2. **interim** period: last shopping trip before tax increase
3. **final** stationary steady state



Tax Elasticities: Consumption, Shopping & Spending

- consumption elasticities (unobserved): $\varepsilon_{c_i} \equiv \frac{d \ln(c_i(t_{ss})/c_i(t_{ss-1}))}{d \ln(1+\tau_{t_{ss}})}$

$$\varepsilon_{c_i} = -(\sigma - \eta) B_\tau - \eta \cdot 1_{\{i=\tau\}}$$

with taxable expenditure share $B_\tau = p_{\tau,t_{ss}} s_{\tau,t_{ss}} / (P_{t_{ss}} S_{t_{ss}})$ and Hicksian demand $c_{it} = b_i \cdot (p_{it}/P_t)^{-\eta} C_t = b_i p_{it}^{-\eta} P_t^{-(\sigma-\eta)} \cdot e^{\sigma(r-\rho)\Delta t} C_{t-1} / P_{t-1}^{-\sigma}$

- shopping trip elasticity (observed): $\varepsilon_{\Delta t_{ss-1}} \equiv \frac{d \ln(\Delta t_{ss}/\Delta t_{ss-1})}{d \ln(1+\tau_{t_{ss}})}$

$$\varepsilon_{\Delta t_{ss-1}} = -\frac{B_\tau}{(\delta + r)\Delta t_{ss}}$$

- spending elasticities (observed): $\varepsilon_{s_{i,t_{n-1}}} \equiv \frac{d \ln(\Delta t_n/\Delta t_{n-1})}{d \ln(1+\tau_{t_n})}$

$$\varepsilon_{s_{i,t_{ss-1}}} \approx \varepsilon_{c_i} + \varepsilon_{\Delta t_{ss-1}}$$

$$\varepsilon_{s_{i,\infty}} \approx \varepsilon_{c_i}$$

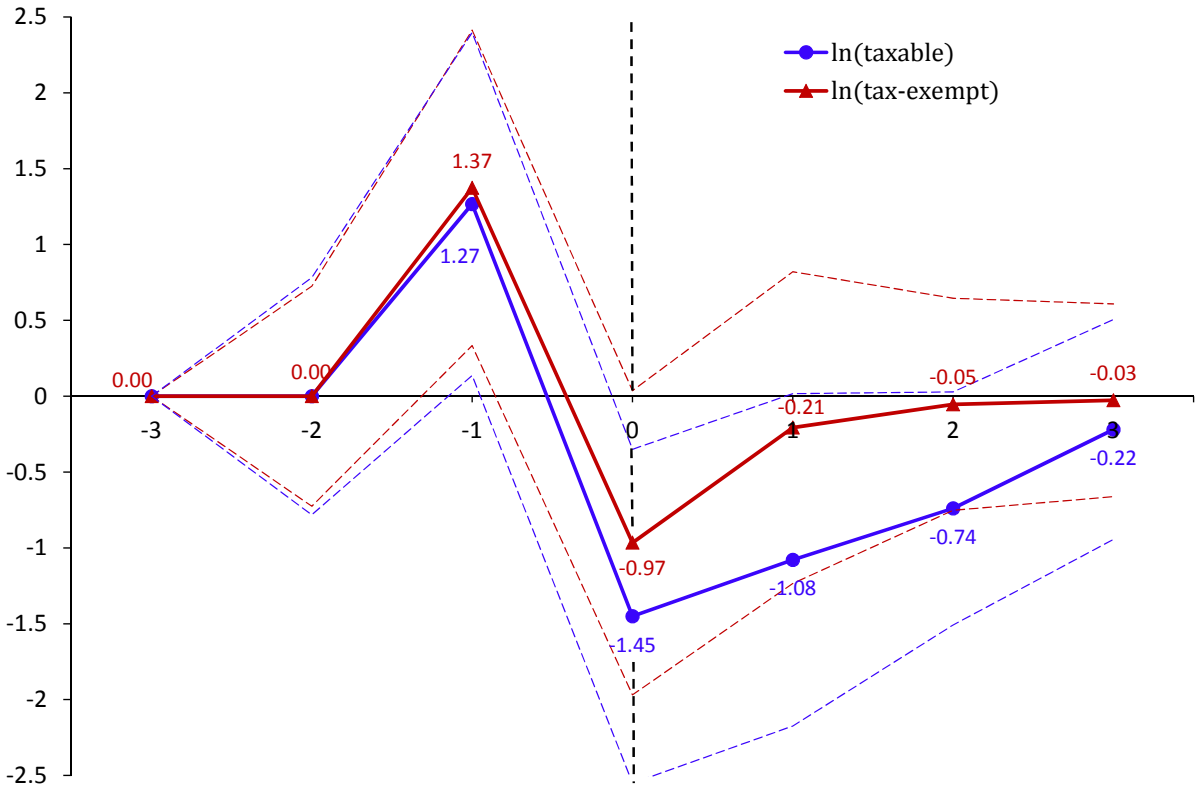
back to calibration

Calibration

- We derive analytic expression of all tax elasticities: tax elasticities

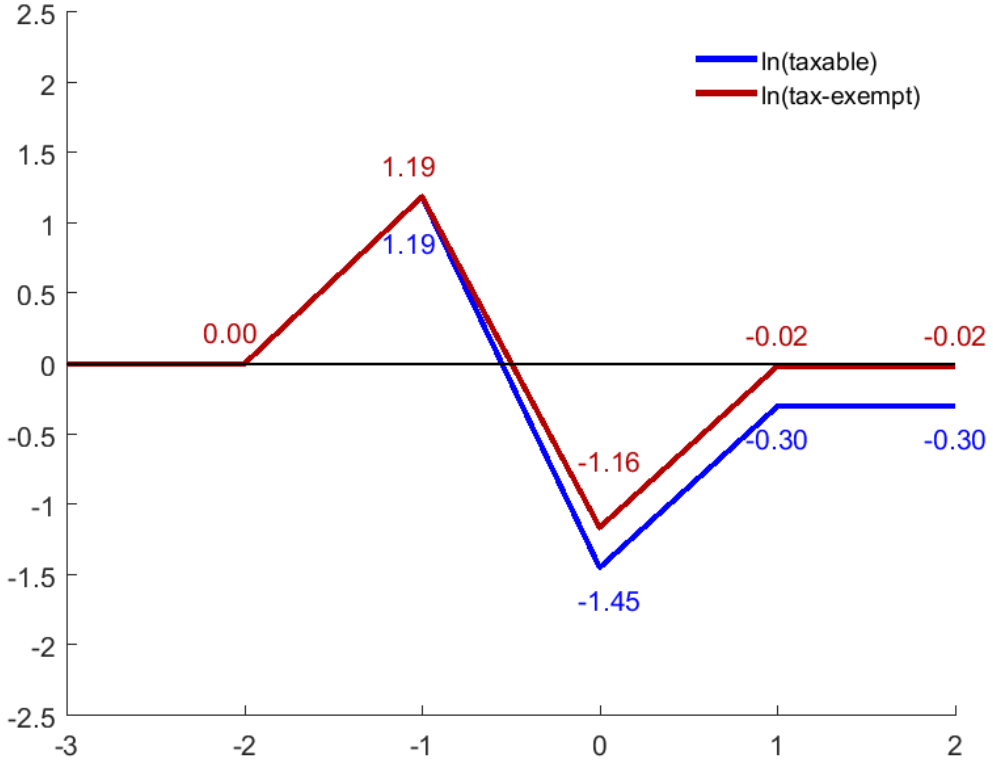
Calibration

- We derive analytic expression of all tax elasticities: tax elasticities



- Long-run (non)response of exempt spending implies $\eta \approx \sigma$
- Small difference in long-run responses implies both elasticities are small: $\eta = \sigma = 0.3$
- Fixed cost $\kappa = \$5.2$ calibrated to match taxable response of -1.45% in month 0
- All other parameters are set to match steady state values (e.g., δ, r, ...)

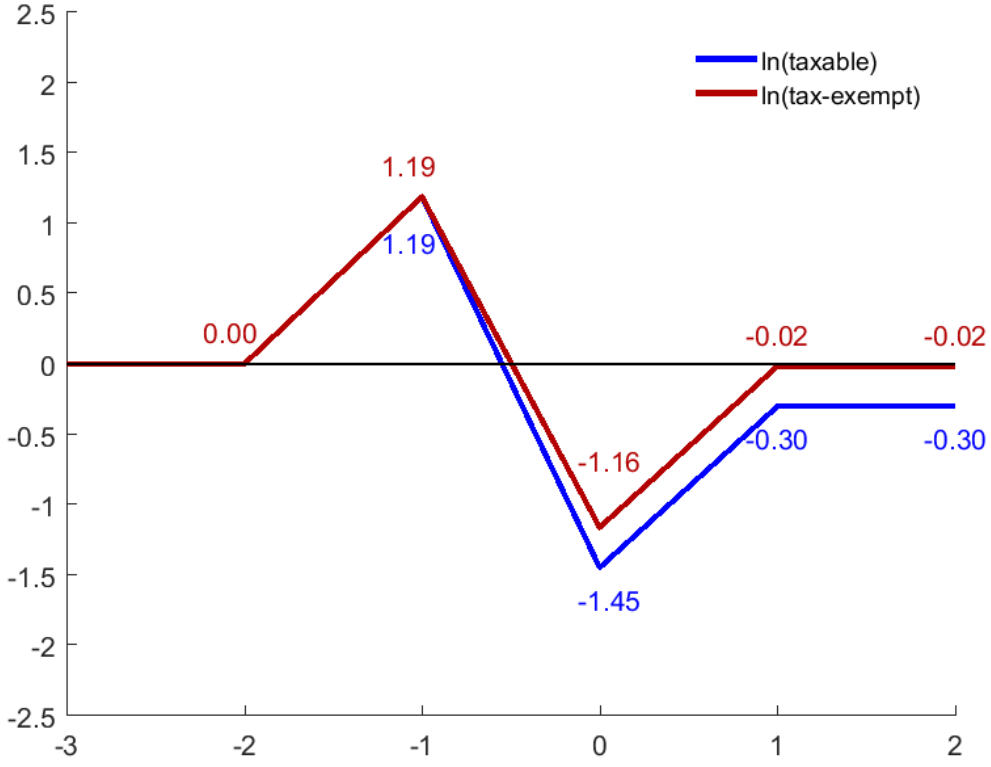
Calibration



- Evaluation of economic magnitude of $\kappa = \$5.2$
  - 6 minutes per day spent on grocery shopping (ATUS)
  - (median) average # of 6 (4) days between two grocery trips (Nielsen CP)
  - additional travel time per grocery trip of 15 minutes

$\Rightarrow$ implies post-tax reservation wage of \$7–10

Calibration



- Evaluation of economic magnitude of $\kappa = \$5.2$
  - 6 minutes per day spent on grocery shopping (ATUS)
  - (median) average # of 6 (4) days between two grocery trips (Nielsen CP)
  - additional travel time per grocery trip of 15 minutes

$\Rightarrow$ implies post-tax reservation wage of \$7–10

Outline

1. Data
2. Research Design
   - Fiscal lag: newspaper coverage
   - Fiscal foresight: Google searches
3. Spending and Shopping Response
   - Taxable spending
   - Intertemporal substitution
   - Shopping frequency
   - Tax-exempt spending
4. Shopping Model
5. Shopping Complementarity
   - Revealed cost approach: infrequent vs. frequent shoppers
   - Trip complementarity: taxable/exempt mix
   - Online shopping: low complementarity
6. Additional Evidence of Optimizing Behavior
   - Persistent tax incentives prompt long-run responses
     - Cross-border and online shopping
   - Tax salience and announcement effects
     - Newspaper coverage and ballot initiatives

Shopping Complementarity: Additional Evidence

Table 4: Evidence of Shopping Complementarity

	A. Revealed Cost Approach			
	frequent shoppers		infrequent shoppers	
Dependent variable:	Δln(exempt)	Δln(taxable)	Δln(exempt)	Δln(taxable)
	(1)	(2)	(3)	(4)
Δln(1 + sales tax rate)				
Period FE				
Household FE				
Observations				
R-squared				

Shopping Complementarity: Additional Evidence

Table 4: Evidence of Shopping Complementarity

	A. Revealed Cost Approach			
	frequent shoppers		infrequent shoppers	
Dependent variable:	Δln(exempt)	Δln(taxable)	Δln(exempt)	Δln(taxable)
	(1)	(2)	(3)	(4)
Δln(1 + sales tax rate)	-0.010	-2.202**		
	(0.756)	(0.910)		
Period FE	Yes	Yes		
Household FE	Yes	Yes		
Observations	1,086,921	1,091,667		
R-squared	0.016	0.017		

Shopping Complementarity: Additional Evidence

Table 4: Evidence of Shopping Complementarity

	A. Revealed Cost Approach			
	frequent shoppers		infrequent shoppers	
Dependent variable:	Δln(exempt)	Δln(taxable)	Δln(exempt)	Δln(taxable)
	(1)	(2)	(3)	(4)
Δln(1 + sales tax rate)	-0.010	-2.202**	-2.236*	-2.406*
	(0.756)	(0.910)	(1.191)	(1.451)
Period FE	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes
Observations	1,086,921	1,091,667	934,657	951,890
R-squared	0.016	0.017	0.022	0.020

Similar evidence for online purchases and exempt/taxable mix

Shopping Complementarity: Additional Evidence

Table 4: Evidence of Shopping Complementarity

	B. Trip Complementarity		C. Online Purchases
	combined trips	separate trips	
Dependent variable:	Δln(exempt)	Δln(exempt)	
	(5)	(6)	
Δln(1 + sales tax rate)	-2.109**	-0.813	
	(0.828)	(1.16)	
Period FE	Yes	Yes	
Household FE	Yes	Yes	
Observations	1,049,599	895,365	
R-squared	0.017	0.018	

$\text{Trip Complementarity}_i = 1 - \frac{\sum_j |T_{ij} - 0.5| \times 2}{\sum_j 1}$; 1 if trips 50/50 taxable/exempt, 0 if 100/0

Shopping Complementarity: Additional Evidence

Table 4: Evidence of Shopping Complementarity

	B. Trip Complementarity		C. Online Purchases	
	combined trips	separate trips		
Dependent variable:	Δln(exempt)	Δln(exempt)	Δln(exempt)	Δln(taxable)
	(5)	(6)	(7)	(8)
Δln(1 + sales tax rate)	-2.109**	-0.813	0.145	1.592**
	(0.828)	(1.16)	(0.464)	(0.709)
Period FE	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes
Observations	1,049,599	895,365	6,868,924	6,868,924
R-squared	0.017	0.018	0.004	0.005

Less shopping complementarity with online purchases → exempt goods respond less

Outline

1. Data
2. Research Design
   - Fiscal lag: newspaper coverage
   - Fiscal foresight: Google searches
3. Spending and Shopping Response
   - Taxable spending
   - Intertemporal substitution
   - Shopping frequency
   - Tax-exempt spending
4. Shopping Model
5. Shopping Complementarity
   - Revealed cost approach: infrequent vs. frequent shoppers
   - Trip complementarity: taxable/exempt mix
   - Online shopping: low complementarity
6. Additional Evidence of Optimizing Behavior
   - Persistent tax incentives prompt long-run responses
     - Cross-border and online shopping
   - Tax salience and announcement effects
     - Newspaper coverage and ballot initiatives

Tax Avoidance Channels in Short- and Long-Run

- Cross-border shopping
  - Households who can shop in neighboring ZIP-3 increasingly do so
  - Elasticity of approximately 0.5 for those who do 20% of shopping cross-border
    - Magnitude similar to Davis Knoepfle TengSun Yannelis (2015) who utilize aggregate geographic data

- Online Shopping
  - Households substitute more to online shopping
  - Elasticity of **positive** 1.6
    - Magnitude similar to Baugh Ben-David Park (2017) when looking at sales on Amazon

Tax Avoidance Channels in Short- and Long-Run

- Cross-border shopping
  - Households who can shop in neighboring ZIP-3 increasingly do so
  - Elasticity of approximately 0.5 for those who do 20% of shopping cross-border
    - Magnitude similar to Davis Knoepfle TengSun Yannelis (2015) who utilize aggregate geographic data
- Online Shopping
  - Households substitute more to online shopping
  - Elasticity of **positive** 1.6
    - Magnitude similar to Baugh Ben-David Park (2017) when looking at sales on Amazon

Long-Run Tax Incentives: Cross-Border Shopping

Table 5: Persistent Tax Incentives

	A. Fraction Spent in Alternative Tax Jurisdiction		
Dependent variable: Δln(frac. spent in alt. ZIP3)	short-run response (1m)		long-run (12m)
	(1)	(2)	(5)
Δln(1 + total sales tax rate)	-0.075	-0.182***	-0.674***
	(0.072)	(0.056)	(0.093)
Δln(1 + total sales tax rate) × avg. fraction in alt. ZIP3		1.497	5.484***
		(0.951)	(1.507)
Period FE	Yes	Yes	Yes
Household FE	Yes	Yes	Yes
Observations	4,231,065	4,231,065	2,510,373
R-squared	0.005	0.005	0.119
Average of interaction variable		0.079	0.079

Long-Run Tax Incentives: Online Shopping

Table 5: Persistent Tax Incentives

	B. Online Spending	
Dependent variable: Δln(online spending)	short-run	long-run
	(7)	(8)
Δln(1 + state sales tax rate)	1.703**	1.591**
	(0.824)	(0.791)
Period FE	Yes	Yes
Household FE	Yes	Yes
Observations	6,868,924	3,010,794
R-squared	0.005	0.044

Outline

1. Data
2. Research Design
   - Fiscal lag: newspaper coverage
   - Fiscal foresight: Google searches
3. Spending and Shopping Response
   - Taxable spending
   - Intertemporal substitution
   - Shopping frequency
   - Tax-exempt spending
4. Shopping Model
5. Shopping Complementarity
   - Revealed cost approach: infrequent vs. frequent shoppers
   - Trip complementarity: taxable/exempt mix
   - Online shopping: low complementarity
6. Additional Evidence of Optimizing Behavior
   - Persistent tax incentives prompt long-run responses
     - Cross-border and online shopping
   - Tax salience and announcement effects
     - Newspaper coverage and ballot initiatives

Salience Effects: Newspaper Coverage

Table 6: Salience and Announcement Effects

	A. Salience Effects					
	newspaper coverage			ballot-induced tax changes		
Dependent variable:	Δln(total)	Δln(taxable)	Δln(exempt)	Δln(total)	Δln(taxable)	Δln(exempt)
	(1)	(2)	(3)	(4)	(5)	(6)
Δln(1 + sales tax rate)	-1.738***	-2.124**	-1.572**	-1.526**	-2.238*	-1.310**
	(0.581)	(1.053)	(0.603)	(0.687)	(1.179)	(0.591)
Δln(1 + sales tax rate)	**-0.361*** **	-0.336	-0.439**			
× Score(newspaper coverage)	(0.110)	(0.257)	(0.166)			
Δln(1 + sales tax rate)				-4.195***	-4.765**	-5.043***
× I(state ballot proposition)				(1.050)	(2.038)	(0.889)
Score(newspaper coverage	-0.001	-0.001*	0.001			
of state sales tax changes)	(0.001)	(0.001)	(0.001)			
I(date ballot proposition failed)				0.022***	0.030***	0.022***
				(0.005)	(0.009)	(0.005)
Period FE	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,822,806	5,777,878	5,865,177	5,865,949	5,928,421	5,777,966
R-squared	0.016	0.015	0.014	0.014	0.012	0.013

Salience Effects: Ballot Initiatives

Table 6: Salience and Announcement Effects

	A. Salience Effects					
	newspaper coverage			ballot-induced tax changes		
Dependent variable:	Δln(total)	Δln(taxable)	Δln(exempt)	Δln(total)	Δln(taxable)	Δln(exempt)
	(1)	(2)	(3)	(4)	(5)	(6)
Δln(1 + sales tax rate)	-1.738***	-2.124**	-1.572**	-1.526**	-2.238*	-1.310**
	(0.581)	(1.053)	(0.603)	(0.687)	(1.179)	(0.591)
Δln(1 + sales tax rate)	-0.361***	-0.336	-0.439**			
× Score(newspaper coverage)	(0.110)	(0.257)	(0.166)			
Δln(1 + sales tax rate)				**-4.195*** **	-4.765**	-5.043***
× I(state ballot proposition)				(1.050)	(2.038)	(0.889)
Score(newspaper coverage	-0.001	-0.001*	0.001			
of state sales tax changes)	(0.001)	(0.001)	(0.001)			
I(date ballot proposition failed)				0.022***	0.030***	0.022***
				(0.005)	(0.009)	(0.005)
Period FE	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,822,806	5,777,878	5,865,177	5,865,949	5,928,421	5,777,966
R-squared	0.016	0.015	0.014	0.014	0.012	0.013

Announcement Effects

Table 6: Salience and Announcement Effects

	B. Announcement Effects	
Dependent variable:	Δln(total)	Δln(total)
	(7)	(8)
I(date tax rate change proposed)	-0.529	-1.706
	(0.330)	(1.444)
I(date tax rate change proposed) × I(ballot proposition failed)		1.434
		(1.493)
I(ballot proposition failed)		-0.002
		(0.006)
Period FE	Yes	Yes
Household FE	Yes	Yes
Observations	5,860,476	5,860,476
R-squared	0.014	0.014

Announcement Effects

Table 6: Salience and Announcement Effects

	B. Announcement Effects	
Dependent variable:	Δln(total)	Δln(total)
	(7)	(8)
I(date tax rate change proposed)	-0.529	-1.706
	(0.330)	(1.444)
I(date tax rate change proposed) × I(ballot proposition failed)		1.434
		(1.493)
I(ballot proposition failed)		-0.002
		(0.006)
Period FE	Yes	Yes
Household FE	Yes	Yes
Observations	5,860,476	5,860,476
R-squared	0.014	0.014

Conclusion

1. Consumers respond to sales tax changes along several dimensions

2. Two realistic extensions of **standard model can explain most of observed behavior**
   - **storability** of most goods (for inter-temporal substitution)
   - **shopping trip complementarities** (for tax-exempt response)

3. Sales taxes are both an **efficient tax** *and* an **effective stimulus tool**!
   - **efficient** tax b/c small consumption elasticity (not b/c sales tax is not salient)
   - **effective** stimulus tool b/c large spending elasticity

Conclusion

1. Consumers respond to sales tax changes along several dimensions

2. Two realistic extensions of **standard model can explain most of observed behavior**
   - **storability** of most goods (for inter-temporal substitution)
   - **shopping trip complementarities** (for tax-exempt response)

3. Sales taxes are both an **efficient tax** *and* an **effective stimulus tool**!
   - **efficient** tax b/c small consumption elasticity
     (not b/c sales tax is not salient)
   - **effective** stimulus tool b/c large spending elasticity

Conclusion

4. In presence of shopping trip complementarity or non-salience, **exempt goods are not a valid control**
   - highlights that diff-in-diff is not model free
   - failure is not due to general equilibrium effects, but holds in partial equilibrium using within-household spending variation
   - also affects other pricing questions (eg. cross-selling, sales promotions and store traffic)

THANK YOU!

Conclusion

4. In presence of shopping trip complementarity or non-salience, **exempt goods are not a valid control**
   - highlights that diff-in-diff is not model free
   - failure is not due to general equilibrium effects, but holds in partial equilibrium using within-household spending variation
   - also affects other pricing questions
     (eg. cross-selling, sales promotions and store traffic)

THANK YOU!

Appendix

Model Solution & Tax Elasticities

Model: "Nested" Dynamic Program

Bellman equation of outer nest ("between periods")

$$V(w_{t_n}) = \max_{C_{t_n}, \Delta t_n} \Big\{ U(C_{t_n}, \Delta t_n) + e^{-\rho \Delta t_n} V(w_{t_{n+1}}) \qquad (1)$$

$$s.t. \;\; w_{t_{n+1}} = e^{r \Delta t_n} \big(w_{t_n} - K_{t_n} \big) \;\; \Big\} \qquad (2)$$

Value function of inner nest ("within period")

$$U(C_{t_n}, \Delta t_n) = \max_{C(t)} \Big\{ \int_{x=0}^{\Delta t_n} e^{-\rho x} u\big(C(t_n + x)\big) dx : \qquad (3)$$

$$s.t. \int_{x=0}^{\Delta t_n} e^{\delta x} C(t_n + x) dx = S_{t_n} \Big\} \qquad (4)$$

Solution: Envelope theorem (5) and consumption FOC (6)

$$\text{Inter-temporal: } \overbrace{V'_{t_n}}^{\partial\text{benefit}} - \overbrace{e^{-\rho\Delta t_n} V'_{t_{n+1}}}^{\partial\text{cost in } t_n\text{-utils}} \times \overbrace{e^{r\Delta t_n}}^{\text{gross return}} = 0 \qquad (5)$$

$$\text{Intra-temporal: } \partial_C U'_{t_n} = \partial_C K'_{t_n} \cdot V'_{t_n} \qquad (6)$$

$$= \underbrace{P_{t_n} f(\Delta t_n; \phi)}_{\text{effective price}} \cdot V'_{t_n}$$

with $f(\Delta t_n; \phi) = \int_0^{\Delta t_n} e^{\phi x} dx$ and $\phi = \delta - \sigma(\delta + \rho)$

leads to familiar Euler eqn for consumption & spending growth:

$$\frac{C(t_{n+1})}{C(t_n)} = e^{\sigma(r-\rho)\Delta t_n} \left(\frac{P_{t_{n+1}}}{P_{t_n}} \right)^{-\sigma}$$

$$\frac{S_{t_{n+1}}}{S_{t_n}} = \frac{C(t_{n+1})}{C(t_n)} \frac{f(\Delta t_{n+1}; \phi)}{f(\Delta t_n; \phi)}$$

Solution: FOC for endogenous shopping interval is less familiar

$$\underbrace{\partial_{\Delta t} U'_{t_n} - \partial_{\Delta t} K'_{t_n} \cdot V'_{t_n}}_{\text{Net MU}_{t_n} \text{ from} \uparrow \Delta t_n} = e^{-\rho \Delta t_n} \underbrace{\left[\rho V_{t_{n+1}} - r w_{t_{n+1}} \cdot V'_{t_{n+1}}\right]}_{\text{Net MC}_{t_{n+1}} \text{ from} \uparrow \Delta t_n}$$

LHS: Net marginal utility from extending shopping interval

- $\partial_{\Delta t} U'_{t_n}$: additional utility during extended interval
- $\partial_{\Delta t} K'_{t_n}$: cost of additional necessary inventory

RHS: Net marginal cost from extending shopping interval

- $\rho V_{t_{n+1}}$: marginal cost of delaying the continuation value
- $r w_{t_{n+1}}$: additional interest earned during extended interval

Steady state is given by two non-linear equations

$$(1-\sigma)\frac{\kappa}{P_{t_{ss}}S_{t_{ss}}} = e^{\phi\Delta t_{ss}}\frac{f(\Delta t_{ss};r)}{f(\Delta t_{ss};\phi)} - 1$$

$$P_{t_{ss}}S_{t_{ss}} + \kappa = (1-e^{-r\Delta t_{ss}})w_{t_{ss}}$$

The familiar Baumol-Tobin square-root solution is only a very special case

- *if* $\sigma = 0$ (no intertemporal substitution) and
- *if* we take a 2^{nd}-order approximation around $\Delta t_{ss} = 0$:

$$\Delta t_{ss} \approx \sqrt{\frac{\kappa}{\frac{\delta+r}{2}P_{t_{ss}}C_{t_{ss}}}}$$

Tax Elasticities: Consumption, Shopping & Spending

- consumption elasticities (unobserved): $\varepsilon_{c_i} \equiv \frac{d \ln(c_i(t_{ss})/c_i(t_{ss-1}))}{d \ln(1+\tau_{t_{ss}})}$

$$\varepsilon_{c_i} = -(\sigma - \eta) B_\tau - \eta \cdot 1_{\{i=\tau\}}$$

with taxable expenditure share $B_\tau = p_{\tau,t_{ss}} s_{\tau,t_{ss}} / (P_{t_{ss}} S_{t_{ss}})$ and Hicksian demand $c_{it} = b_i \cdot (p_{it}/P_t)^{-\eta} C_t = b_i p_{it}^{-\eta} P_t^{-(\sigma-\eta)} \cdot e^{\sigma(r-\rho)\Delta t} C_{t-1} / P_{t-1}^{-\sigma}$

- shopping trip elasticity (observed): $\varepsilon_{\Delta t_{ss-1}} \equiv \frac{d \ln(\Delta t_{ss}/\Delta t_{ss-1})}{d \ln(1+\tau_{t_{ss}})}$

$$\varepsilon_{\Delta t_{ss-1}} = -\frac{B_\tau}{(\delta + r)\Delta t_{ss}}$$

- spending elasticities (observed): $\varepsilon_{s_{i,t_{n-1}}} \equiv \frac{d \ln(\Delta t_n/\Delta t_{n-1})}{d \ln(1+\tau_{t_n})}$

$$\varepsilon_{s_{i,t_{ss-1}}} \approx \varepsilon_{c_i} + \varepsilon_{\Delta t_{ss-1}}$$

$$\varepsilon_{s_{i,\infty}} \approx \varepsilon_{c_i}$$

back to calibration

Retail Price Response

Moderate *Decline* in Pre-Tax Prices

Table A.1: Quantity and Price Response

	B. Price Response			
Dependent variable:	Δln(retail price)		Δln(wholesale price)	
	(5)	(6)	(7)	(8)
Δln(1 + total sales tax rate)	-0.215***		-0.008*	
	(0.036)		(0.004)	
Δln(1 + state sales tax rate)		-0.171**		-0.007
		(0.069)		(0.015)
Period FE	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes
ZIP3 FE	Yes	Yes	Yes	Yes
Observations	4,333,000	5,862,621	4,333,000	5,862,621
R-squared	0.011	0.010	0.189	0.177

- Price *decline* drives spending *up*; ie without price decline, we might see even larger spending elasticities