Salience and Taxation: Theory and Evidence

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June 2008

MOTIVATION

- Central assumption in PF: Agents optimize fully with respect to incentives created by tax schedules (Ramsey 1927, Mirrlees 1971, …)

- Tax schedules often complex in theory and practice

- Growing body of evidence suggests that individuals optimize imperfectly when incentives not transparent and feedback limited
  - Financial markets, partitioned prices, etc. (DellaVigna 2007)

→ **Questions**:

(1) Do agents optimize fully with respect to the incentives created by tax policies in practice?

(2) If not, how do welfare consequences of taxation change?

OVERVIEW

- Part 1: Test whether "salience" (visibility of tax-inclusive price) affects behavioral responses to commodity taxation
    - Does effect of a tax on demand depend on whether it is included in **posted** price?
    - Two strategies that provide complementary evidence: experiment in a store and analysis of observational data on alcohol demand

- Part 2: Develop formulas for incidence and efficiency costs of taxation that permit salience effects and other optimization errors
    - Formulas do not require specification of a specific positive theory for why agents fail to optimize with respect to tax policies

    → Simple but robust Harberger-type formulas for welfare analysis

EMPIRICAL FRAMEWORK

- Economy with two goods, *x* and *y*, that are supplied perfectly elastically

- Prices: Normalize price of *y* to 1; let *p* denote posted price of *x*

- Taxes: *y* untaxed, *x* subject to ad-valorem sales tax τ^S (not included in posted price), so tax-inclusive price of *x* is $q = p(1+\tau^S)$.

- If agents optimize fully, demand should only depend on the total tax-inclusive price: $x(p, \tau^S) = x((1+\tau^S)p, 0)$,

- Full optimization implies price elasticity equals gross-of-tax elasticity:

$$\varepsilon_{x,p} \equiv -\frac{\partial \log x}{\partial \log p} = \varepsilon_{x,1+\tau^S} \equiv -\frac{\partial \log x}{\partial \log(1+\tau^S)}$$

ESTIMATING EQUATION

- Hypothesis: agents under-react to tax because it is less salient.

- To test this hypothesis, we log-linearize the demand function and obtain the following estimating equation:

$$\log x(p, \tau^S) = \alpha + \beta \log p + \theta_\tau \beta \log(1 + \tau^S)$$

- θ_τ measures degree to which agents under-react to the tax:

$$\theta_\tau = \frac{\partial \log x}{\partial \log(1+\tau^S)} \Big/ \frac{\partial \log x}{\partial \log p} = \frac{\varepsilon_{x,1+\tau^S}}{\varepsilon_{x,p}}$$

TWO EMPIRICAL STRATEGIES

- Two strategies to estimate θ_τ:

1. Manipulate tax **salience**: make sales tax as visible as pre-tax price

   - Effect of intervention on demand:

$$v = \log x((1+\tau^S)p, 0) - \log x(p, \tau^S)$$

   - Compare to effect of equivalent price increase to estimate θ

$$(1-\theta_\tau) = -v/[\varepsilon_{x,p} \times \log(1+\tau^S)]$$

2. Manipulate **tax rate**: compare $\varepsilon_{x,p}$ with $\varepsilon_{x,1+t}$

$$\theta_\tau = \varepsilon_{x,1+\tau^S} / \varepsilon_{x,p}$$

STRATEGY 1: VARIATION IN TAX SALIENCE

- Experiment manipulating salience of sales tax implemented at a supermarket that belongs to a major grocery chain

  - 30% of products sold in store are subject to sales tax

  - Posted tax-inclusive prices on shelf for subset of products subject to sales tax (7.375% in this city)

- Data: Scanner data on price and weekly quantity sold by product

Orig. Tag

Exp. Tag

TABLE 1

Evaluation of Tags: Classroom Survey

	Mean	Median	SD
Original Price Tags:			
Correct tax-inclusive price w/in \$0.25	0.18	0.00	0.39
Experimental Price Tags:			
Correct tax-inclusive price w/in \$0.25	0.75	1.00	0.43

T-test for equality of means: $p < 0.001$

N=49

Students were asked to choose two items from image.

Asked to report "Total bill due at the register for these two items."

RESEARCH DESIGN

- Quasi-experimental difference-in-differences

- **Treatment** group:

  Products: Cosmetics, Deodorants, and Hair Care Accessories

  Store: One large store in Northern California

  Time period: 3 weeks (February 22, 2006 – March 15, 2006)

- **Control** groups:

  Products: Other prods. in same aisle (toothpaste, skin care, shave)

  Stores: Two nearby stores similar in demographic characteristics

  Time period: Calendar year 2005 and first 6 weeks of 2006

Effect of Posting Tax-Inclusive Prices: Mean Quantity Sold

TREATMENT STORE

Period	Control Categories	Treated Categories	Difference
Baseline	26.48	25.17	-1.31
	(0.22)	(0.37)	(0.43)
Experiment	27.32	23.87	-3.45
	(0.87)	(1.02)	(0.64)
Difference over time	0.84	-1.30	**DD_{TS} = -2.14**
	(0.75)	(0.92)	(0.64)

CONTROL STORES

Period	Control Categories	Treated Categories	Difference
Baseline	30.57	27.94	-2.63
	(0.24)	(0.30)	(0.32)
Experiment	30.76	28.19	-2.57
	(0.72)	(1.06)	(1.09)
Difference over time	0.19	0.25	**DD_{CS} = 0.06**
	(0.64)	(0.92)	(0.90)
		DDD Estimate	***-2.20***
			(0.58)

TABLE 4

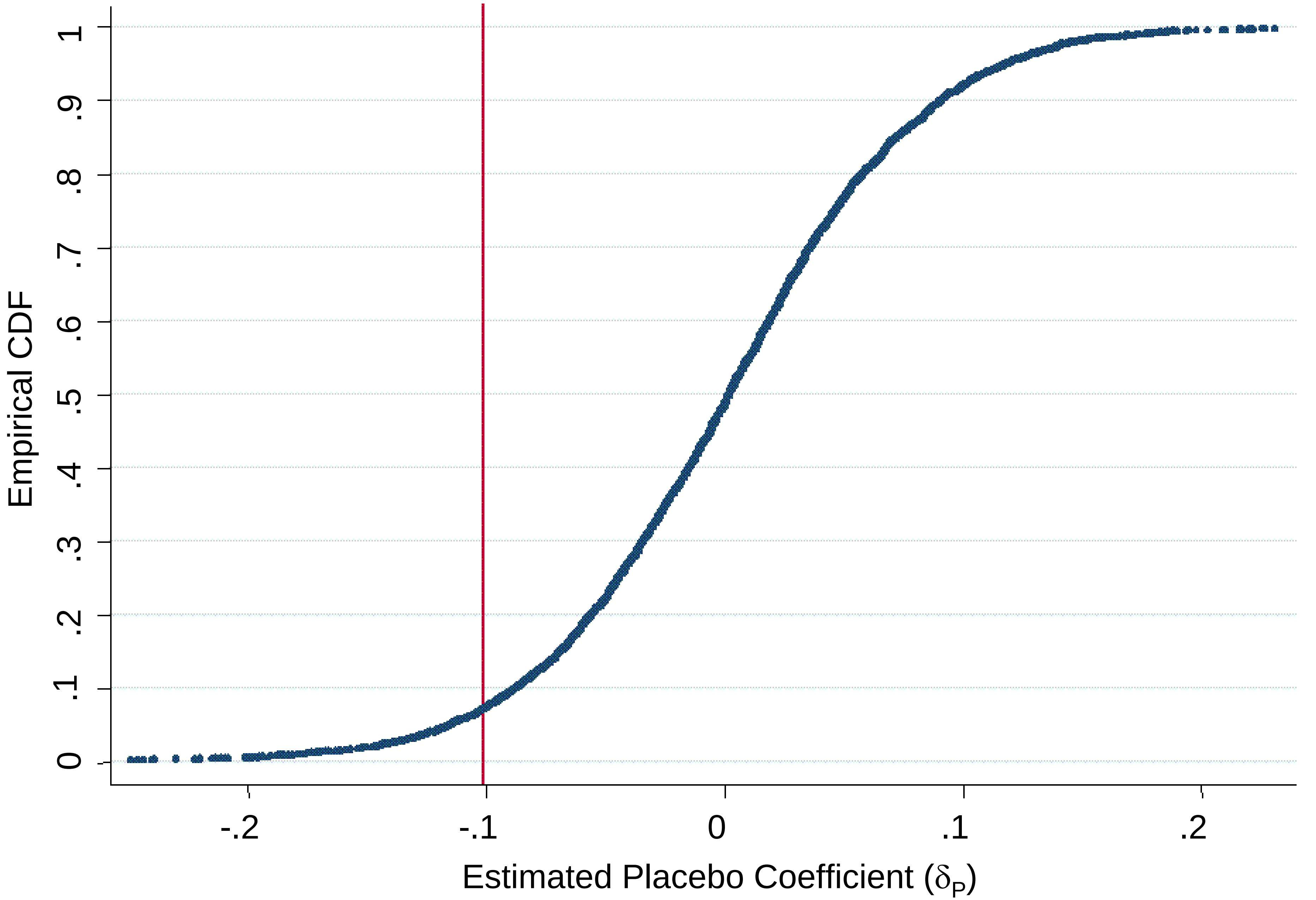
Effect of Intervention: Selected Regression Estimates

	Log Quantity (1)	Revenue (2)	Quantity (3)
Treatment	**-0.10**	**-13.12**	**-2.27**
	(0.03)***	(4.88)	(0.60)***
Log Average Price	-1.59		
	(0.11)***		
Before Treatment			-0.21
			(1.07)
After Treatment			0.20
			(0.78)
N	18,827	19,764	21,060

Note: Estimates imply $\theta_\tau \approx 0.35$

Figure 1

Distribution of Placebo Estimates: Log Quantity



STRATEGY 2: VARIATION IN TAX RATES

- Second method of estimating θ_τ: compare effects of price changes and tax changes

- Focus on **alcohol** consumption because it is subject to two state-level taxes in the U.S.:

  Excise tax (τ^E): included in price

  Sales tax (τ^S): added at register, not shown in posted price

- Exploiting state-level changes in these two taxes, compare elasticities to estimate θ_τ

  - Complements experiment by giving evidence on whether tax salience matters in long run

  - Addresses concern that experiment may have led to a response because of violation of norms or “Hawthorne effect”

RESEARCH DESIGN

- Demand specification for alcohol as a function of tax rates:

$$\log x(\tau^E, \tau^S, \theta_\tau) = \alpha + \beta \log(1 + \tau^E) + \theta_\tau \beta \log(1 + \tau^S)$$

- Estimate β and θ in first-differences using OLS, exploiting state-level changes in sales and excise taxes:

$$\Delta \log x_{jt} = \alpha' + \beta \Delta \log(1 + \tau_{jt}^E) + \theta_\tau \beta \Delta \log(1 + \tau_{jt}^S) + X_{jt}\rho + \varepsilon_{jt}$$

- Complication: Sales tax applies to approximately 40% of consumption (but *not* food).
  - 1% increase in t^S changes relative price of alcohol (*x*) and composite commodity (*y*) by only 0.6%

- Data: aggregate annual beer consumption by state from 1970-2003 based on tax records (NIH)

Figure 2a

Per Capita Beer Consumption and State Beer Excise Taxes

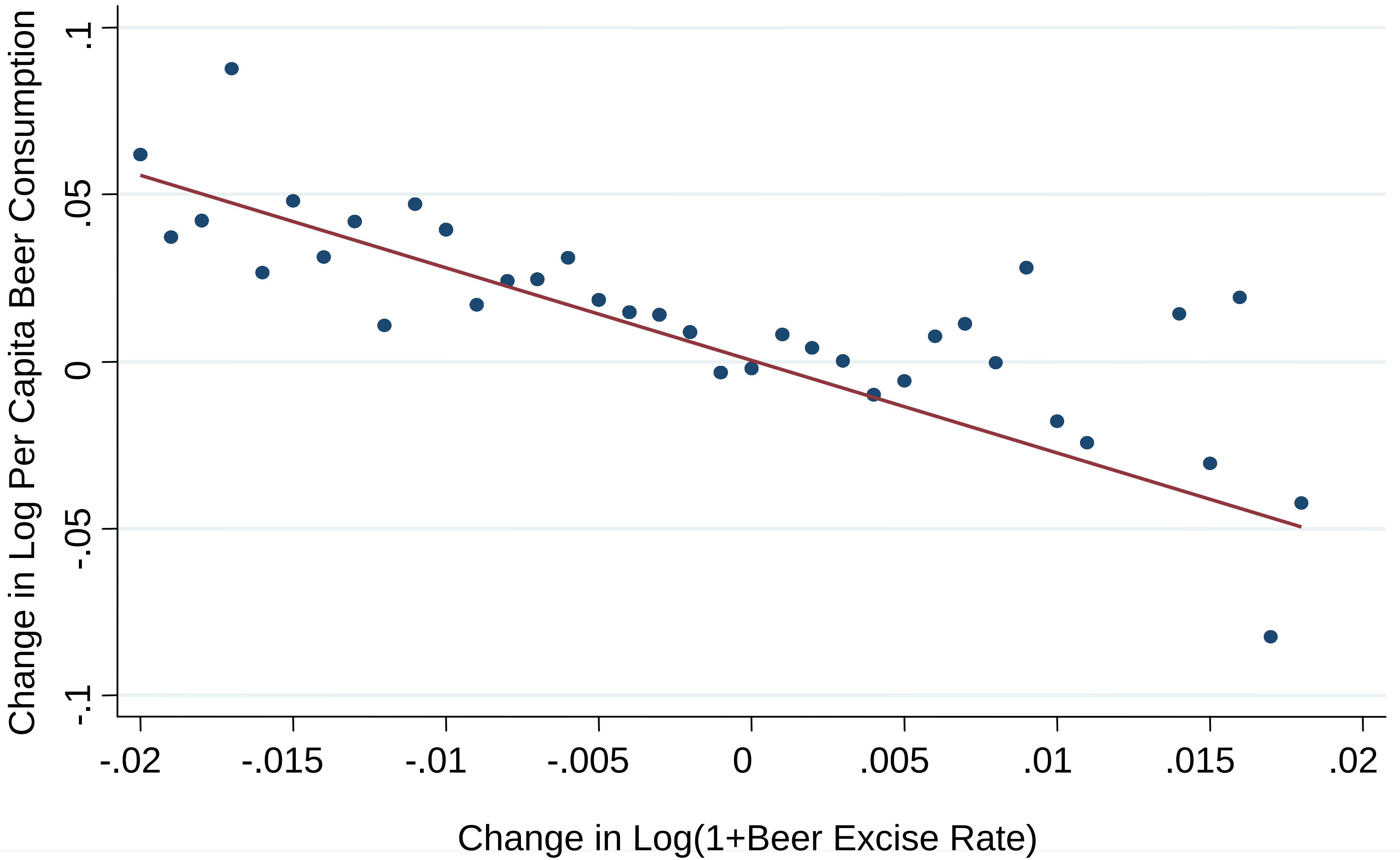
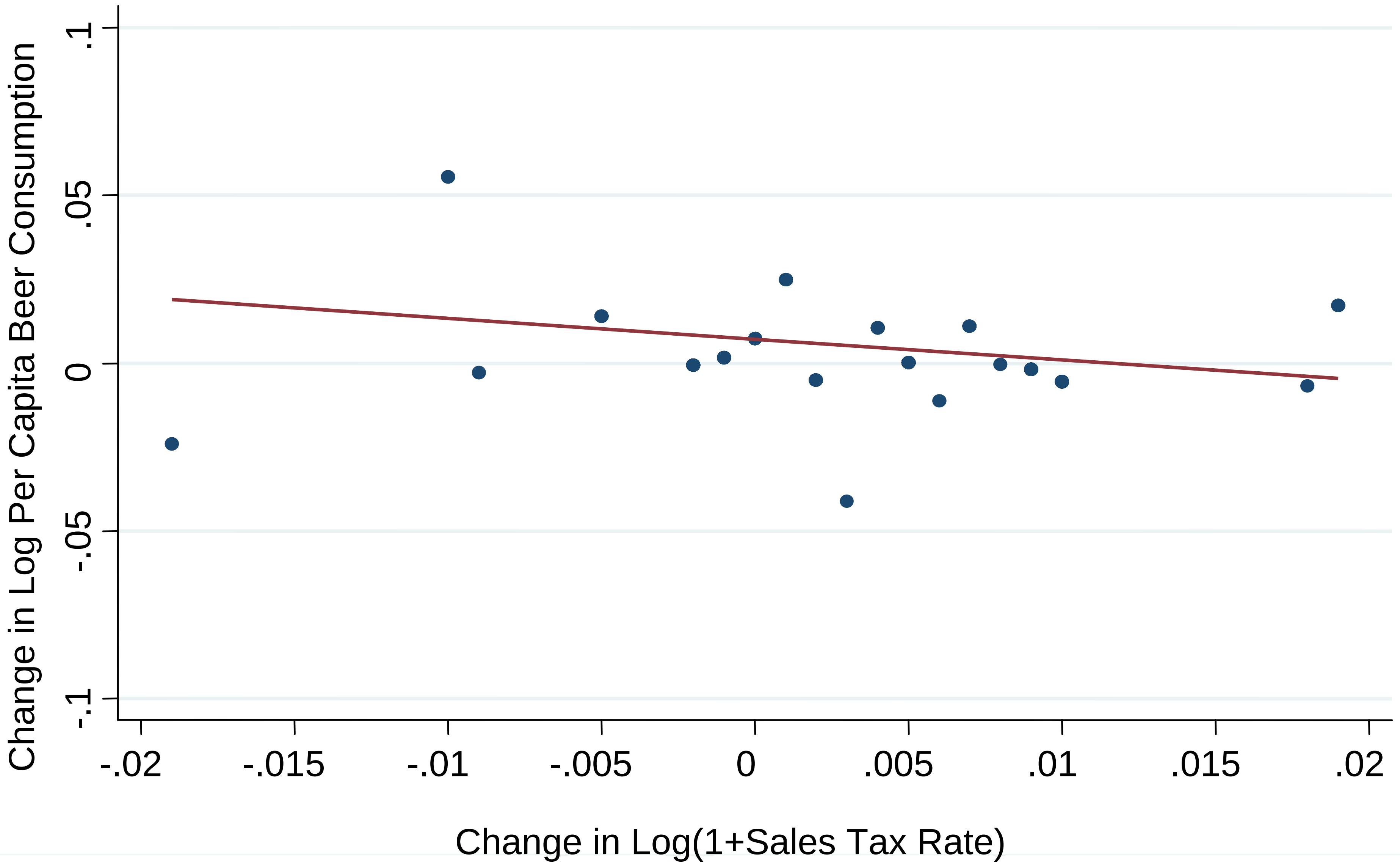


Figure 2b

Per Capita Beer Consumption and State Sales Taxes



Effect of Excise and Sales Taxes on Beer Consumption

Dependent Variable: Change in Log(per capita beer consumption)	Baseline	Bus Cyc, Alc Regs.	3-Year Diffs	Food Exempt
	(1)	(2)	(3)	(4)
ΔLog(1+Excise Tax Rate)	**-0.87**	**-0.89**	**-1.11**	**-0.91**
	(0.17)***	(0.17)***	(0.46)**	(0.22)***
ΔLog(1+Sales Tax Rate)	**-0.20**	**-0.02**	**-0.00**	**-0.14**
	(0.30)	(0.30)	(0.32)	(0.30)
Business Cycle Controls		x	x	x
Alcohol Regulation Controls		x	x	x
Year Fixed Effects	x	x	x	x
F-Test for Equality of Coeffs.	0.05	0.01	0.05	0.04
Sample Size	1,607	1,487	1,389	937

Note: Estimates imply $\theta_\tau \approx 0.06$

WHY DO CONSUMERS UNDER-REACT TO TAXES?

- Two potential explanations of data:

  1. Information: Individuals uninformed about tax rates; tax-inclusive tags provide information, leading to reduced demand

  2. Salience: Individuals do not compute tax-inclusive prices when shopping, focusing instead on salient pre-tax posted price

- Distinguish between these mechanisms using a survey of knowledge about tax rates

Is tax added **at the register** (in addition to the price posted on the shelf) for each of the following items? milk Y N toothpaste Y N magazines Y N soda Y N beer Y N cookies Y N potatoes Y N cigarettes Y N	Have you purchased these items within the last month? milk Y N toothpaste Y N magazines Y N soda Y N beer Y N cookies Y N potatoes Y N cigarettes Y N

What is the sales tax rate in [city]? ____________%

What is the California **state** income tax rate in the highest tax bracket? ______________ %

What percentage of families in the US do you think pay the federal estate tax when someone dies?

< 2% 2-10% 10-25% 25-50% > 50%

POSITIVE THEORIES

- Simple explanation of salience effects: bounded rationality
  - Compute tax-inclusive price if benefit > cost of time/cognition
  - Gains to computing q are small (second-order):
    - With quasilinear utility, initial x = $1,000 and $\varepsilon_{x,p} = 1$, loss from ignoring 10% tax is only $5.
- More sophisticated model: use a heuristic (rounding, different shadow value of money for taxed/untaxed goods)
- Alternative theory: attention triggered by cues
- Our data does not allow us to distinguish between these models, and relevant model/heuristics may differ across environments

→ Important to have a method of welfare analysis that does not rely on a specific model of optimization errors

WELFARE ANALYSIS

- Objective: Simple partial-equilibrium formulas for incidence and efficiency costs that allow for salience effects
  - Focus on commodity taxes, but analysis is easily adapted to income/capital taxes
- Setup: Two goods, *x* and *y*; price of *y* is 1, pretax price of *x* is p.
- Taxes: *y* untaxed. The government levies a **unit** sales tax on *x* at rate t^S, which is not included in the posted price
  - Tax-inclusive price of *x*: $q = p + t^S$
- Assume that govt. does not spend tax revenue on taxed good
- Only deviation from standard Harberger partial-equilibrium analysis: consumers make optimization errors relative to taxes

CONSUMPTION

- Representative consumer has wealth Z and utility u(x) + v(y)

- Let $\{x^*(p,t^S,Z), y^*(p,t^S,Z)\}$ denote bundle chosen by a fully-optimizing agent as a function of pretax price, sales tax, and wealth

- Let $\{x(p,t^S,Z), y(p,t^S,Z)\}$ denote empirically observed demands

- Place no structure on these demand functions except for feasibility:

$$(p+t^S)x(p,t^S,Z)+y(p,t^S,Z) = Z$$

- For unit taxes, define degree of under-reaction to tax as

$$\theta = \frac{\partial x}{\partial t^S} / \frac{\partial x}{\partial p} = \frac{\varepsilon_{x,q|t^S}}{\varepsilon_{x,q|p}}$$

where $\varepsilon_{x,q|t^S} = -\frac{\partial x}{\partial t^S}\frac{q}{x(p,t^S,Z)}$ and $\varepsilon_{x,q|p} = -\frac{\partial x}{\partial p}\frac{q}{x(p+t^E,t^S,Z)}$

- Focus on case where $\theta < 1$, but results apply for any θ

PRODUCTION

- Price-taking firms use *c(S)* units of *y* to produce *S* units of *x*
- All firms optimize perfectly. Supply function S(p) defined by:

$$p = c'(S(p))$$

- Let $\varepsilon_{S,p} = \frac{\partial S}{\partial p} \times \frac{p}{S(p)}$ denote the price elasticity of supply
- Ignore GE effects throughout (market for y unaffected by tax on *x*)

TAX INCIDENCE

- How is tax burden shared between consumers and producers in competitive equilibrium?

- Let $D(p, t^S, Z)$ denote demand curve in incidence analysis

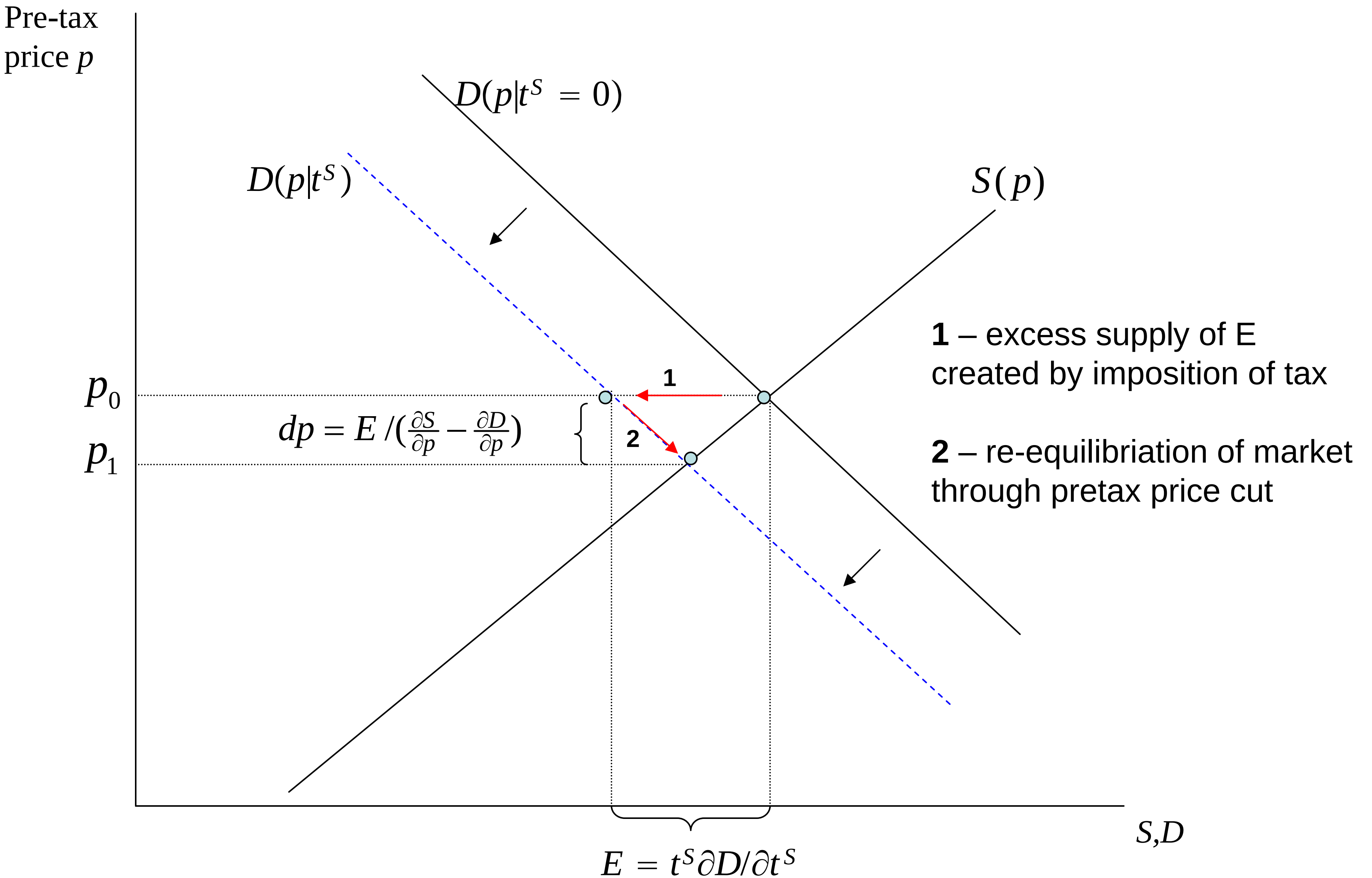
- Let $p = p(t^S)$ denote the equilibrium pretax price that clears the market for good *x* as a function of the tax rate

- Market clearing price *p* satisfies:

$$D(p, t^S, Z) = S(p)$$

- Objective: characterize dp/dt^S and dq/dt^S

Figure 3
Incidence of Taxation



TAX INCIDENCE

Incidence of increasing sales tax rate t^S on producers is

$$\frac{dp}{dt^S} = \frac{\partial D / \partial t^S}{\partial S/\partial p - \partial D/\partial p} = -\frac{\theta\, \varepsilon_{D,q|p}}{\frac{q}{p}\varepsilon_{S,p} + \varepsilon_{D,q|p}}$$

1. Incidence on producers attenuated by θ

2. No tax neutrality: taxes on producers have greater incidence on producers than non-salient taxes levied on consumers

Intuition: Producers need to cut pretax price less when consumers are less responsive to tax

TAX INCIDENCE

Incidence of increasing sales tax rate t^S on producers is

$$\frac{dp}{dt^S} = \frac{\partial D / \partial t^S}{\partial S/\partial p - \partial D/\partial p} = -\frac{\theta \varepsilon_{D,q|p}}{\frac{q}{p}\varepsilon_{S,p} + \varepsilon_{D,q|p}}$$

Increase in θ (attention) not equivalent to increase in $\varepsilon_{D,q|p}$ (elasticity)

Example: Two markets with $\varepsilon_{S,p} = 0.1$, $\varepsilon_{D,q|t} = 0.3$

- Market A: $\varepsilon_{D,q|p} = 0.3$, $\theta = 1$
- Market B: $\varepsilon_{D,q|p} = 1$, $\theta = 0.3$

$[dp/dt^S]^A = -.75$ vs. $[dp/dt^S]^B = -.27$

→ Shortcut of making inferences about incidence from $\varepsilon_{D,Q|t}$ fails

TAX INCIDENCE

Incidence of increasing sales tax rate t^S on producers is

$$\frac{dp}{dt^S} = \frac{\partial D / \partial t^S}{\partial S/\partial p - \partial D/\partial p} = -\frac{\theta\, \varepsilon_{D,q|p}}{\frac{q}{p}\varepsilon_{S,p} + \varepsilon_{D,q|p}}$$

Intuition: price elasticity affects both shift in demand curve and size of price cut needed to re-equilibriate market; tax elasticity only affects shift

Related implication: holding tax elasticity fixed, increase in price elasticity *raises* incidence on consumers

Taxing markets with more elastic demand could lead to greater/lesser incidence on consumers, depending on covariance between tax and price elasticities

EFFICIENCY COST

- Define excess burden using "EV" concept (Mohring 1971)
  - How much extra revenue could be raised by switching to lump sum taxation, keeping agent utility constant?
- Define generalized indirect utility, expenditure, and demand functions with separate posted-price and tax effects
- Excess burden (EB) of introducing a revenue-generating sales tax *t* is:

$$EB(t^S) = Z - e(p, 0, V(p, t^S, Z)) - R(0, t^S, Z)$$

- EB can be interpreted as the total social surplus from the purchases that fail to occur because of the tax.

PREFERENCE RECOVERY

- Efficiency cost of tax depends on: (1) effect of tax on behavior and (2) effect of change in behavior on utility.

- Key challenge: identifying (2) when agents do not optimize perfectly

- We make two assumptions to recover underlying preferences

PREFERENCE RECOVERY ASSUMPTIONS

A1 Taxes affect utility only through their effects on the chosen consumption bundle. Agent's indirect utility given taxes of (t^E, t^S) is

$$V(p+t^E,t^S,Z) = u(x(p+t^E,t^S,Z)) + v(y(p+t^E,t^S,Z))$$

A2 When tax inclusive prices are fully salient, the agent chooses the same allocation as a fully optimizing agent:

$$x(p,0,Z) = x^*(p,0,Z) = \arg\max u(x(p,0,Z)) + v(Z - px(p,0,Z))$$

→ Two steps in efficiency calculation:

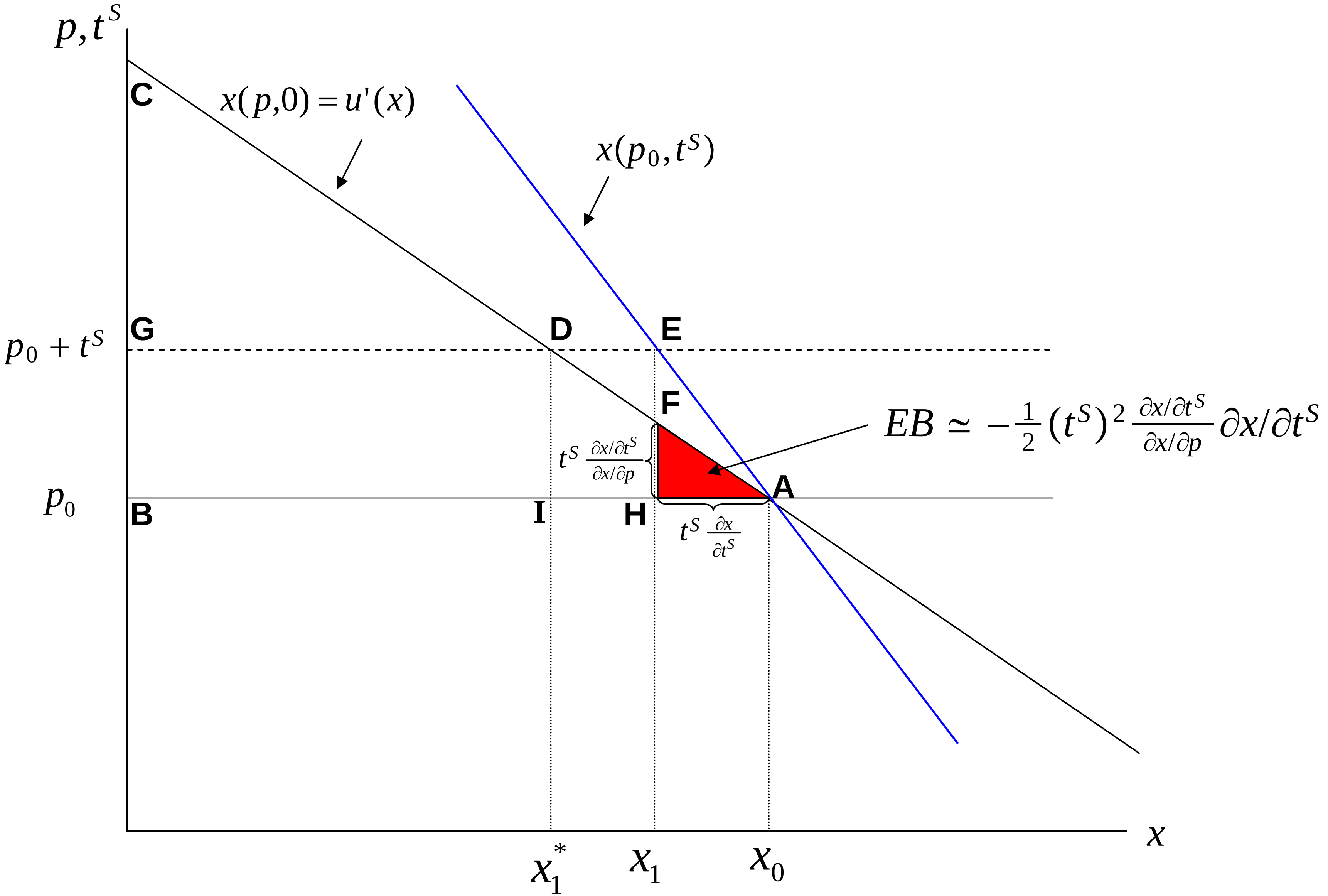
1. Use x(p,0,Z) to recover utility as in standard model

2. Use x(p,t^S,Z) to calculate V(p,t^S,Z)

EFFICIENCY COST

- We derive simple elasticity-based formulas for EB using second-order approximations as in Harberger (1964)
  - Focus here on case with fixed producer price (perfectly elastic supply) and no pre-existing taxes. These are treated in paper.
  - First consider case with no income effects ($v(y) = y$), then turn to general case.
  - In quasilinear case, EB can be illustrated using a simple consumer surplus diagram

Figure 4
Excess Burden with Quasilinear Utility and Fixed Producer Prices



EFFICIENCY COST: QUASILINEAR UTILITY

When utility is quasilinear, excess burden of introducing a small tax t^S is

$$EB \simeq -\frac{1}{2}(t^S)^2 \frac{\partial x/\partial t^S}{\partial x/\partial p} \partial x/\partial t^S = \frac{1}{2}(\theta t^S)^2 \frac{\varepsilon_{x,q|p}}{p+t^S}$$

Inattention reduces excess burden when dx/dZ = 0.

Intuition: tax t^S induces behavioral response equivalent to a fully perceived tax of θt^S.

If $\theta = 0$, tax is equivalent to a lump sum tax and EB = 0 because agent continues to choose first-best allocation.

EFFICIENCY COST WITH INCOME EFFECTS

- Same formula, but all elasticities are now compensated:

$$EB \simeq -\frac{1}{2}(t^S)^2 \frac{\partial x^c/\partial t^S}{\partial x^c/\partial p} \partial x^c/\partial t^S = \frac{1}{2}(\theta^c t^S)^2 \frac{\varepsilon^c_{x,q|p}}{p+t^S}$$

- Compensated price demand: $dx^c/dp = dx/dp + xdx/dZ$
- Compensated tax demand: $dx^c/dt^S = dx/dt^S + xdx/dZ$
  - Compensated tax demand does not necessarily satisfy Slutsky condition $dx^c/dt^S < 0$ b/c it is not generated by utility maximization

EFFICIENCY COST WITH INCOME EFFECTS

$$EB \simeq -\frac{1}{2}(t^S)^2 \frac{\partial x^c/\partial t^S}{\partial x^c/\partial p} \partial x^c/\partial t^S = \frac{1}{2}(\theta^c t^S)^2 \frac{\varepsilon^c_{x,q|p}}{p+t^S}$$

- Important implication of case with income effects (dx/dZ > 0): making a tax less salient can *raise* deadweight loss.

- Tax can generate EB > 0 even if $dx/dt^S = 0$, challenging traditional intuition.

- Example: consumption of food and cars; agent who ignores tax on cars underconsumes food and has lower welfare.

- Intuition: agent does not adjust consumption of *x* despite change in net-of-tax income, leading to a *positive* compensated elasticity.

EFFICIENCY COSTS: EFFECT OF BUDGET ADJUSTMENT

- Inattention need not always lead to $dx/dt^S = 0$. Response depends on how agent meets budget given optimization error.

  - For agents who choose consumption of taxed good (x) first and use remaining funds for y (e.g. credit-constrained), $dx/dt^S = 0$.

  - Agents who smooth intertemporally and make repeated purchases could cut back on consumption of *both* x and y in the long run, leading to first-best allocation with $dx/dt^S = -xdx/dZ$ and EB = 0.

- Budget adjustment process does not affect formula for excess burden

  - Empirically observed price and tax elasticities are "sufficient statistics" for welfare analysis.

CONCLUSIONS AND FUTURE WORK

1. Agents make optimization errors with respect to simple commodity taxes, suggesting that similar errors could arise in many other policies

2. Incidence and efficiency costs of policies can quantified by estimating tax and price elasticities under relatively weak assumptions.

3. Normative Analysis: Tax salience may be a key factor in policy choices

    - Consumption taxation: VAT vs. sales tax
    - Salience of EITC, capital taxes
    - Value of tax simplification

4. Conceptual approach of using a domain where incentives are clear to infer true preferences can be applied in other contexts, e.g. regulation

    - Design consumer protection laws and financial regulation in a less paternalistic manner by studying behavior in domains where incentives are clear.

EFFICIENCY COST OF TAXATION

Proposition 3

Suppose utility is quasilinear (v(y) = y). The excess burden of introducing a small tax t^S in a previously untaxed market is approximately

$$EB(t^S) \simeq -\frac{1}{2}(t^S)^2\theta\frac{dx}{dt^S}$$

$$= \frac{1}{2}(t^S)^2\theta x(p_1, t^S)\frac{\varepsilon^{TOT}_{x,q|t^S}}{p_1 + t^S}.$$

$$\theta = \frac{\partial x/\partial t^S}{\partial x/\partial p} = \frac{\varepsilon_{x,q|t^S}}{\varepsilon_{x,q|p}}.$$

EFFICIENCY COST OF TAXATION

Proposition 4

The excess burden of a small sales tax increase Δt starting from small initial tax rates (t_0^E, t_0^S) is approximately given by the following formulas.

i. *If producer prices are fixed:*

$$EB(\Delta t | t_0^E, t_0^S) \simeq -\frac{1}{2}(\Delta t)^2 \theta^c \frac{\partial x^c}{\partial t^S} - \Delta t \frac{\partial x^c}{\partial t^S}[t_0^E + \theta^c t_0^S]$$

$$= \frac{1}{2}(\Delta t)^2 \theta^c x_0 \frac{\varepsilon_{x,q|t^S}^c}{q_0} + \Delta t x_0 \frac{\varepsilon_{x,q|t^S}^c}{q_0}[t_0^E + \theta^c t_0^S]$$

ii. *If utility is quasilinear (v(y)=y):*

$$EB(\Delta t | t_0^E, t_0^S) \simeq -\frac{1}{2}(\Delta t)^2 \theta \frac{dx}{dt^S} - \Delta t \frac{dx}{dt^S}[t_0^E + \theta t_0^S]$$

$$= \frac{1}{2}(\Delta t)^2 \theta x_0 \frac{\varepsilon_{x,q|t^S}^{TOT}}{q_0} + \Delta t x_0 \frac{\varepsilon_{x,q|t^S}^{TOT}}{q_0}[t_0^E + \theta t_0^S].$$