Behavioral Public Economics Boot Camp: Optimal Taxation with Behavioral Biases

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Agenda

Framework

1. General setup
2. Example: potato chips and present bias
3. Sufficient statistics approach

Applications

1. Commodity (sin) taxes
    - Empirical applications: soda taxes, lottery tickets
2. Income taxation
    - Empirical application: income taxation with present bias

Selected References

Workhorse Framework

- Farhi and Gabaix (2019 AER): reprises many optimal tax results with behavioral “wedges”
- Commodity taxes with behavioral biases: Allcott and Taubinsky (2015 AER, “Lightbulbs”); Allcott, Lockwood, and Taubinsky (2019 QJE, “Soda Taxes”)
- Sufficient statistics approach: Chetty (2009 Ann. Rev. of Econ.)

Additional Applications / References

- Sin taxes: O’Donoghue Rabin (2006, J. Pub. Econ); Lockwood ⓡ Allcott ⓡ Taubinsky ⓡ Sial (2019 RES, “Lotteries”)
- Income taxation: Gerritsen (2016 J. Pub. Econ.); Lockwood (2020 AEJ:Policy)

General setup

Theoretical framework

Consumers

- Heterogeneous (private) ability and tastes, $\theta \in \mathbb{R}^n_+$, distributed $\mu(\theta)$
- Choose bundle of **c**omposite consumption and good **x** (prices 1 and p), and earnings $\boldsymbol{z}$
- Maximize **decision utility** subject to budget constraint:

$$\max_{c,x,z} U_\theta(c,x,z) \quad \text{s.t.} \quad c + (p+t)x \leq z - T(z)$$

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Utilitarian policymaker

- Chooses **commodity tax** t and **income tax** $T(z)$. Today we'll study both in turn.
- Maximizes total **weighted** **normative utility** (less fiscal **externality**) subject to revenue constraint:

$$\max_{t,T} \int_\Theta [\alpha(\theta) V_\theta(c(\theta), x(\theta), z(\theta))] \, d\mu(\theta)$$

$$\text{s.t.} \quad \int_\Theta [tx(\theta) + T(z(\theta)) - ex(\theta)] \, d\mu(\theta) \geq R$$

- $U \neq V$ if consumers misinformed, inattentive, present biased, etc.

Theoretical framework

Or more generally

- Consumer's choose bundle $\{c(\theta, t, T), x(\theta, t, T), z(\theta, t, T)\}$ according to *some* decision rule.
- Policymaker still solves

$$\max_{t,T} \int_\Theta [\alpha(\theta) V_\theta (c(\theta), x(\theta), z(\theta))] \, d\mu(\theta)$$

$$\text{s.t.} \quad \int_\Theta [tx(\theta) + T(z(\theta)) - ex(\theta)] \, d\mu(\theta) \geq R$$

- This formulation extends to behaviors that don't rationalize *any* utility function. (Farhi and Gabaix, 2019)

Example: potato chips and present bias

A simpler case: quasi-linear framework

Standard Harberger (1964) quasi-linear framework:

- Two goods: x (taxed commodity) and c (numeraire)
- Constant marginal cost, perfect competition
- Government sets per-unit tax t on x, lump sum transfer B. (Abstract from income taxes.)
- Prices $p + t$ and 1

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- Consumer types θ, measure μ_θ, $\sum_\theta \mu_\theta = 1$, exogenous income z_θ
- Demand $x_\theta = x_\theta(p, t)$ and "normative demand" (if maximized V) $x_\theta^V = x_\theta^V(p, t)$
- Aggregate demand: $D(p, t) = \sum_\theta \mu_\theta x_\theta$ and $D^V(p, t) = \sum_\theta \mu_\theta x_\theta^V$

Quasi-linear framework

- Quasi-linear utility:

$$
\begin{aligned}
U_\theta(x,c) &= u_\theta(x) + c \ : \ \text{decision utility (governs choices)} \\
V_\theta(x,c) &= v_\theta(x) + c \ : \ \text{normative utility (what gov't want's to maximize)}
\end{aligned}
$$

- Budget constraint $(p+t)x + c \leq z_\theta + B$
- Assume u, v concave, z_θ "large" ($\implies$ interior solution)

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- Budget constraint $(p + t)x + c \leq z_\theta + B$
- Assume u, v concave, z_θ "large" ($\implies$ interior solution)

- Government maximizes social welfare (aggregate normative utility) subject to actual behavior (decision utility) and budget constraint:

$$
\max_{t,B} W(t, B) = \sum_\theta \mu_\theta V_\theta \left(x_\theta(p, t), c\right) \quad s.t. \ \ B = \sum_\theta \mu_\theta t x_\theta(p, t)
$$

Example: optimal taxation with present bias

- Simplified version of Gruber and Koszegi (2001), O'Donoghue and Rabin (2006)
- x is potato chips. Present enjoyment $\alpha \ln x$. Future health harm hx. No externality ($e = 0$)
- Present-focused consumers with β_θ, δ preferences; $\delta = 1$. They maximize decision utility

$$U(x, c) = \alpha \ln x - \beta_\theta hx + c \;\; s.t. \;\; (p + t)x + c \leq z_\theta + B$$

- Normative utility: $V(x, c) = \alpha \ln x - hx + c \rightarrow$ government prioritizes long-run perspective

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- Substituting in the budget constraint, decision utility is

$$U(x) = \alpha \ln x - \beta_\theta hx - (p + t)x + z_\theta + B$$

- Actual consumption maximizes U, giving demand x_θ that satisfies $dU/dx_\theta = 0$:

$$\alpha/x_\theta = \beta_\theta h + (p + t) \implies x_\theta(p, t) = \frac{\alpha}{\beta_\theta h + p + t}$$

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- First-best consumption maximizes V with $t = 0$, giving demand x_θ^V that satisfies $dV/dx_\theta = 0$

$$\alpha / x_\theta^{FB} = h + p \implies x_\theta^{FB} = \frac{\alpha}{h + p}$$

Deriving the optimal tax

- Social planner uses the long-run criterion.
- Finds optimal t given actual demand $x_\theta = x_\theta(p,t)$ and budget balance $\sum_\theta \mu_\theta t x_\theta = B$

$$\max_{t,B} W(t,B) = \sum_\theta \mu_\theta V(x_\theta) = \sum_\theta \mu_\theta \left(\alpha \ln\left(x_\theta(p,t)\right) - h\left(x_\theta(p,t)\right) - (p+t)\left(x_\theta(p,t)\right) + z_\theta + B\right)$$

$$\begin{aligned}\max_t W(t) &= \sum_\theta \mu(\theta)\left(\alpha \ln x_\theta - (h+p)x_\theta + z_\theta\right)\\ &= \sum_\theta \mu_\theta \left(\alpha \ln\left(\frac{\alpha}{\beta_\theta h + p + t}\right) - (h+p)\left(\frac{\alpha}{\beta_\theta h + p + t}\right) + z_\theta\right)\end{aligned}$$

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- Maximizing $W(t)$ gives

$$\frac{dW(t)}{dt} = \sum_\theta \mu_\theta \left(\frac{h(1 - \beta_\theta) - t}{(\beta_\theta h + p + t)^2}\right) = 0, \implies t^* = \frac{\left(\sum_\theta \frac{\mu_\theta h(1-\beta_\theta)}{(\beta_\theta h+p+t)^2}\right)}{\left(\sum_\theta \frac{\mu_\theta}{(\beta_\theta h+p+t)^2}\right)}$$

Two basic insights from O'Donoghue and Rabin (2006)

$$t^* = \frac{\left(\sum_\theta \frac{\mu_\theta h(1-\beta_\theta)}{(\beta_\theta h+p+t)^2}\right)}{\left(\sum_\theta \frac{\mu_\theta}{(\beta_\theta h+p+t)^2}\right)}$$

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- Homogeneous β: $t^* = h(1-\beta)$.
  - Achieves first-best: $x_\theta(p, t^*) = \frac{\alpha}{\beta h+p+(1-\beta)h} = \frac{\alpha}{h+p} = x_\theta^{FB}$. How to say this in words?

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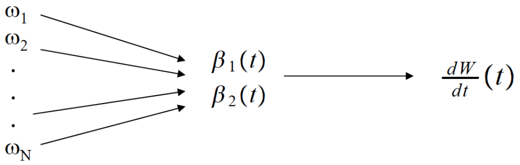
- Answer: they are general!

Sufficient statistics approach

Illustrating sufficient statistics (Chetty 2009)

THE SUFFICIENT STATISTIC APPROACH

Structural Primitives	**Sufficient Statistics**	**Welfare Change**



ω=prefs., constraints	$\beta = f(\omega,t)$ $y = \beta_1 X_1 + \beta_2 X_2 + \varepsilon$	dW/dt used for policy analysis
ω not uniquely identified	β identified using program evaluation	

Benefits and costs of sufficient statistics (Chetty 2009, page 454)

Benefits relative to structural approach

- Can often estimate using reduced form “program evaluation” techniques
  - Simpler to implement empirically
  - More credible and transparent identification
  - Fewer functional form assumptions
- General across models
  - Useful for describing general insights that carry across models
  - Applies immediately to cases with multiple biases, or alternative demand systems

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Costs relative to structural approach

- Need a new formula for each research question (e.g. t^* with vs. without info disclosure)
  - With structural models, sometimes straightforward to just simulate other counterfactuals
- Need sufficient statistics *at optimum*, but often can only estimate *at current equilibrium*
  - Must either assume parameters (e.g. demand slope) are constant or impose other structure

Sufficient statistics approach to behavioral biases

- Define a sufficient statistic for *any* difference between U and V (not just present bias)
- Money-metric "uninternalized cost" of consuming marginal x.
- Uninternalized marginal cost at any x is

$$\gamma_\theta = u'_\theta(x) - v'_\theta(x)$$

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$$\Rightarrow u'_\theta(x_\theta) = p + t$$

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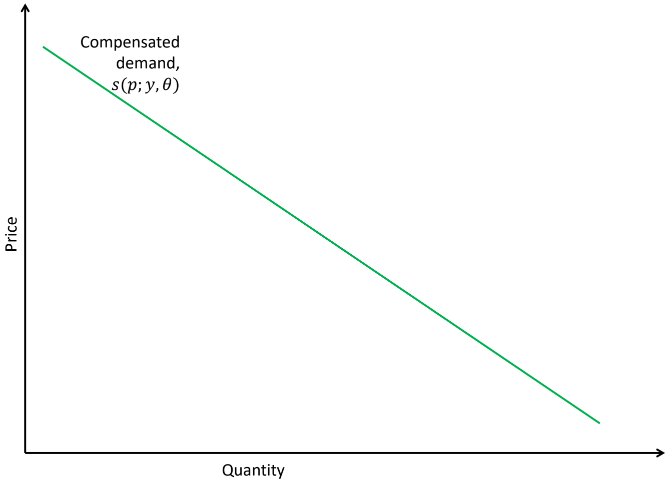
- $\gamma_\theta > 0 \implies$ "over-consume"
- $\gamma_\theta < 0 \implies$ "under-consume"
- $\gamma_\theta = 0 \implies$ consumption maximizes utility (standard model)

Illustrating consumer bias



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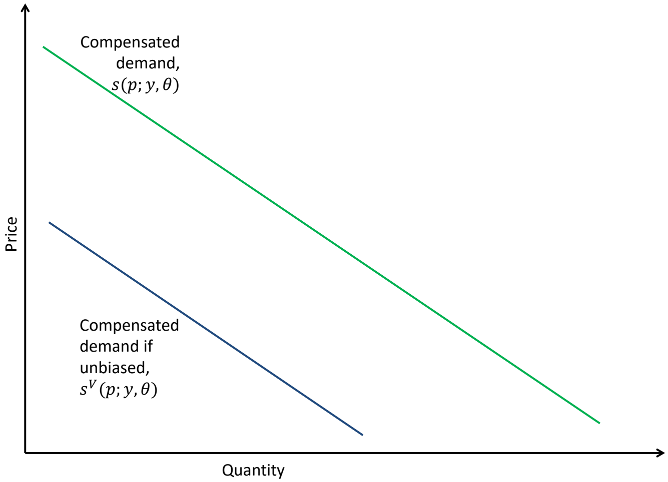

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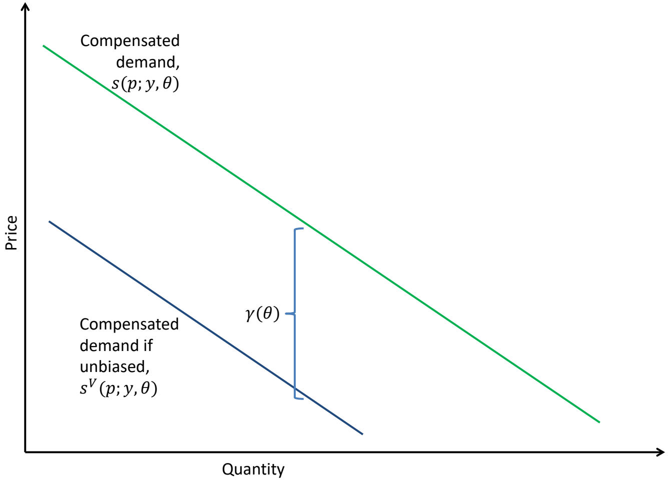

Expressing optimal tax in sufficient statistics

- In potato chips example: policymaker maximizes $W(t, B)$ subject to actual behavior and budget constraint:

$$\max_{t,B} W(t, B) = \sum_{\theta} \mu_\theta V_\theta \left(x_\theta(p, t)\right) \quad s.t. \; B = \sum_{\theta} \mu_\theta t x_\theta$$

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- Substituting budget constraints gives

$$\max_{t} W(t) = \sum_{\theta} \mu_\theta \left(v_\theta(x_\theta) - p x_\theta + z_\theta \right)$$

Expressing optimal tax in sufficient statistics

- Maximizing $W(t)$ gives

$$
\begin{aligned}
\frac{dW(t)}{dt} = 0 &= \sum_\theta \mu_\theta \left(v_\theta'(x_\theta)\frac{dx_\theta}{dt} - p\frac{dx_\theta}{dt} \right) \\
&= \sum_\theta \mu_\theta \left((p + t - \gamma_\theta) - p\right) \frac{dx_\theta}{dt} \\
&= \sum_\theta \mu_\theta \left(t - \gamma_\theta\right) \frac{dx_\theta}{dt} \\
t \sum_\theta \mu_\theta \frac{dx_\theta}{dt} &= \sum_\theta \mu_\theta \gamma_\theta \frac{dx_\theta}{dt} \\
t^* &= \frac{\sum_\theta \mu_\theta \frac{dx_\theta}{dt} \gamma_\theta}{\sum_\theta \mu_\theta \frac{dx_\theta}{dt}} = \bar{\gamma}
\end{aligned}
$$

- $\bar{\gamma} := \frac{\sum_\theta \mu_\theta \frac{dx_\theta}{dt} \gamma_\theta}{\sum_\theta \mu_\theta \frac{dx_\theta}{dt}} =$ average marginal bias. (Like Diamond (1975) for externalities!)

Commodity (sin) taxes with distributional concerns

Recall: theoretical framework

Consumers:

- Heterogeneous (private) ability and tastes, $\theta \in \mathbb{R}^n_+$, distributed $\mu(\theta)$
- Choose bundle of **c**omposite and **s**in good (prices 1 and p), and earnings $\boldsymbol{z}$
- Maximize **decision utility** subject to budget constraint:

$$\max_{c,s,z} U(c, s, z; \theta) \quad \text{s.t.} \quad c + (p + t)s \leq z - T(z)$$

Utilitarian policy maker:

- Chooses sin tax t and income tax $T(z)$
- Maximizes total **weighted normative utility** subject to revenue constraint (including fiscal **externality**):

$$\max_{t,T} \int_\Theta [\alpha(\theta) V(c(\theta), s(\theta), z(\theta); \theta)]\, \mu(\theta)$$

$$\text{s.t.} \quad \int_\Theta [ts(\theta) + T(z(\theta)) - es(\theta)]\, \mu(\theta) \geq R$$

- $U \neq V$ if consumers misinformed, inattentive, present biased, etc.

Two motivations for taxing or subsidizing a good

1. Redistribution

2. Correction

Optimal sin tax

$$t^* = \overbrace{\bar{\gamma}(1+\sigma)+e}^{\text{corrective motive}} - \overbrace{(p+t^*)\,\frac{Cov\left[g(z), s_{pref}(z)\right]}{\bar{s}\bar{\zeta}^c}}^{\text{redistributive motive}}$$

$\bar{\gamma} = \frac{\int_\Theta \gamma(\theta)\left(\frac{ds(\theta)}{dt}\Big|_u\right)\mu(\theta)}{\int_\Theta \left(\frac{ds(\theta)}{dt}\Big|_u\right)\mu(\theta)}$: average marginal bias (same logic as potato chips example above)

$\sigma := Cov_H\left[g(z), \frac{\bar{\gamma}(z)}{\bar{\gamma}}\frac{\bar{\zeta}^c(z)}{\bar{\zeta}^c}\frac{\bar{s}(z)}{\bar{s}}\right]$: bias correction progressivity (new, due to distributional motives)

$g(z) =$ social marginal welfare weight
$s_{pref}(z) := \bar{s}(z) - s_{inc}(z) =$ consumption profile from preference heterogeneity (subtle, see also Ferey Lockwood Taubinsky 2024)

Optimal sin tax

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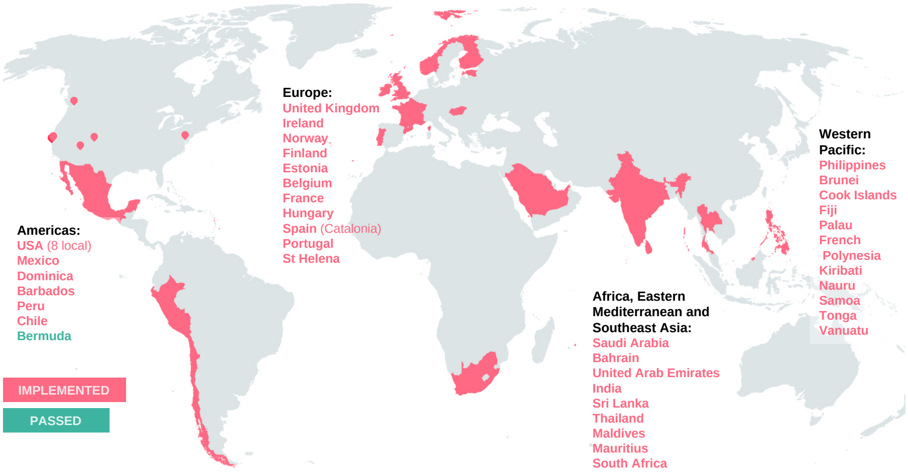
Five sufficient statistics:

1. $\bar{s}(z)$: consumption-income profile
2. ξ: causal income effect
3. $\bar{\zeta}^c, \bar{\zeta}^c(z)$: demand elasticity by income
4. $\bar{\gamma}, \bar{\gamma}(z)$: bias by income
5. e: externality

Empirical application: Sugary drink taxes

Regressive Sin Taxes (Allcott, Lockwood, and Taubinsky 2019)



Corrective motive: offset externalities and “internalities”

[A soda tax] would help prevent obesity, diabetes, and premature deaths—and save more in future health care costs than it would cost to implement.

-Harvard School of Public Health study (2016)

Counterpoint: sin taxes are regressive

A tax on soda and juice drinks would disproportionately increase taxes on low-income families in Philadelphia.

-Bernie Sanders (2016)

Counter-counterpoint: sin taxes reduce regressive harms

If you think a tax on sugary drinks is regressive ... try getting Type 2 diabetes.

-*Forbes* magazine article (Huehnergarth 2016)

Again: optimal sin tax

$$t^* = \overbrace{\bar{\gamma}(1+\sigma) + e}^{\text{corrective motive}} - \overbrace{(p+t^*)\,\frac{Cov\left[g(z), s_{pref}(z)\right]}{\bar{s}\bar{\zeta}^c}}^{\text{redistributive motive}}$$

$\bar{\gamma} = \frac{\int_\Theta \gamma(\theta)\left(\left.\frac{ds(\theta)}{dt}\right|_u\right)\mu(\theta)}{\int_\Theta \left(\left.\frac{ds(\theta)}{dt}\right|_u\right)\mu(\theta)}$: average marginal bias

$\sigma := Cov_H\left[g(z), \frac{\bar{\gamma}(z)}{\bar{\gamma}}\frac{\bar{\zeta}^c(z)}{\bar{\zeta}^c}\frac{\bar{s}(z)}{\bar{s}}\right]$: bias correction progressivity

$g(z) =$ social marginal welfare weight
$s_{pref}(z) := \bar{s}(z) - s_{inc}(z) =$ consumption profile from preference heterogeneity

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Five sufficient statistics:

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2. ξ: causal income effect
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5. e: externality

Data: Neilsen

- RMS (Retail Measurement Services)
  - Price and quantity sold by UPC, store, and week for 2006-2016
  - 35,000 stores covering ~40% of U.S. grocery sales
  - Also merchandising conditions: “feature” and “display”

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- Homescan
  - Grocery purchase scanner data for 2006-2016
  - 61,000 households/year, most households stay multiple years
  - Observe household demographics: income, education, age, household composition, race/ethnicity, etc.
  - Key limitation: do not observe “away from home” consumption

Five sufficient statistics

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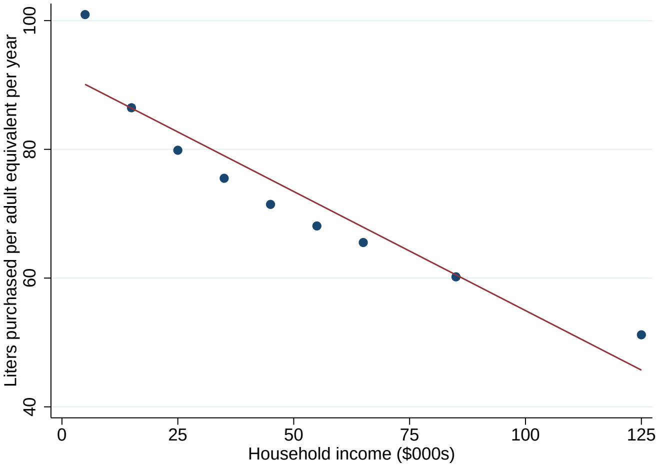
Key statistic: SSB consumption vs. income, $\bar{s}(z)$



- Average Homescan SSB purchases $\approx$ 4.0% of recommended calories

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Empirical strategy: price elasticity and income effects

- Regression equation:

$$\ln s_{it} = -\zeta \ln p_{i,t} + \nu \boldsymbol{f}_i + \xi \ln z_{ct} + \omega_t + \mu_{ic} + \varepsilon_{it}$$

$i =$ households, $c =$ counties, $t =$ quarters

$s_{it} =$ SSB consumption (liters/adult equivalent)

$p_{it} =$ average price paid ($/liter)

$\boldsymbol{f}_{it} =$ share of household i's UPCs that are "featured" or on "display"

$z_{ct} =$ county mean (pre-tax) income

$\omega_t =$ quarter-of-sample indicators

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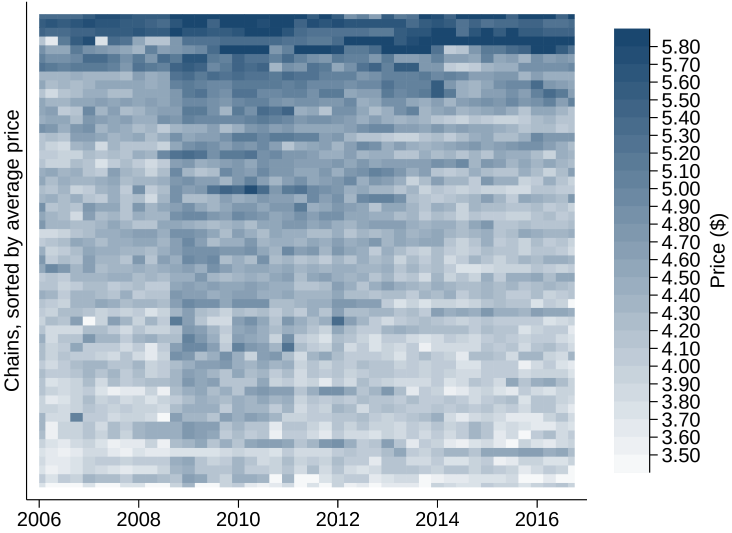
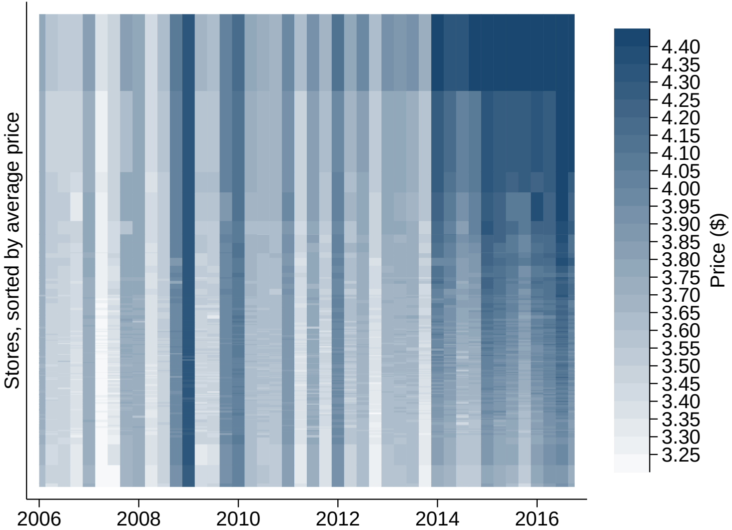
- ξ: income elasticity
- ζ: price elasticity
- Instrument for $\ln p_{it}$ with local price instrument Z_{it}
  - Inspired by DellaVigna and Gentzkow (2017) and Hitsch, Hortacsu & Lin (2017)

Relative prices vary across retail chains



Uniform pricing within retail chains



Local price instrument

1. **Get average leave-out price at chain-county-UPC level**
    - $\ln p_{jkw} =$ average ln(price) for UPC k in store j in week w
    - $\ln p_{kw} =$ national average ln(price)
    - $\ln p_{krt,-c} =$ average of $\ln p_{jkw} - \ln p_{kw}$ at retailer r's stores outside of county c in quarter t
        - Variation generated by retailer r's idiosyncratic pricing decisions
        - Not driven by national prices *or* purely local prices

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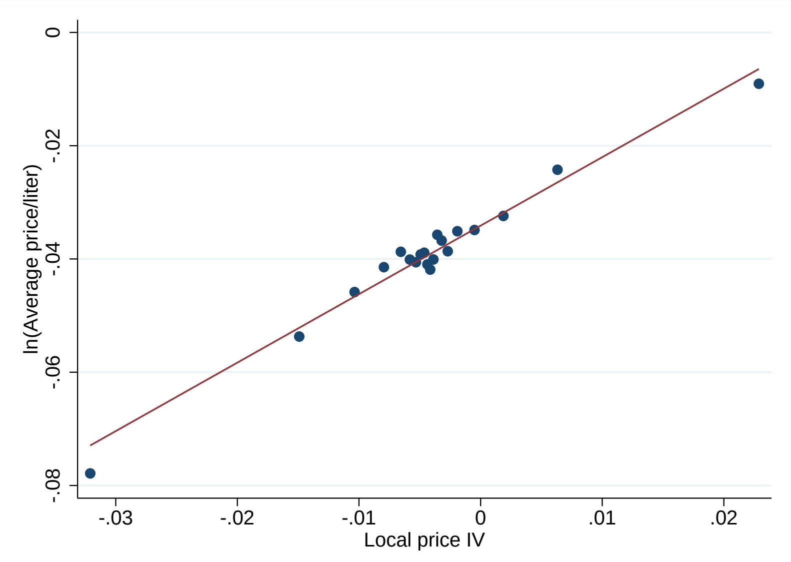
     - Variation generated by retailer r's idiosyncratic pricing decisions
     - Not driven by national prices *or* purely local prices
2. **Fit to each household's specific purchasing patterns**
   - s_{ijkc} = household i's total purchases of UPC k (in liters) at RMS store j while living in county c
   - s_{ic} = household i's total SSB purchases while living in county c
   - $\pi_{ijkc} = s_{ijkc}/s_{ic}$ = share of SSB purchases that are UPC k at store j
   - Household $i's$ predicted local price deviation in quarter t:

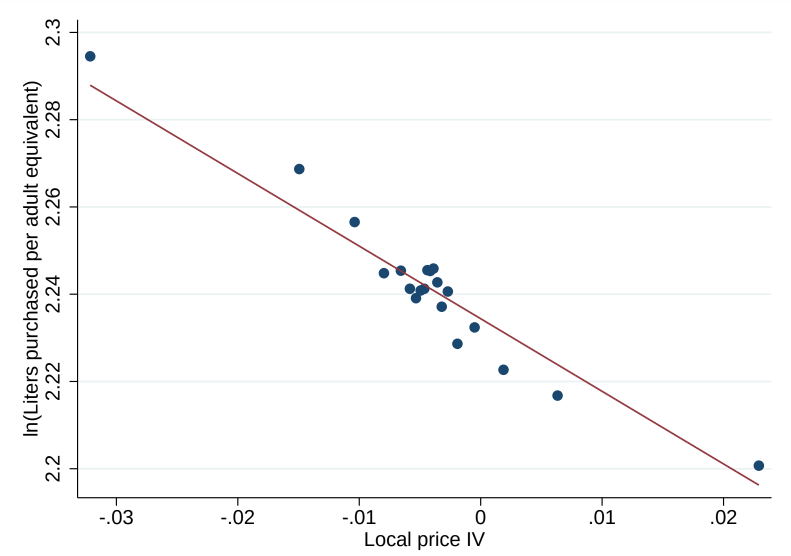
$$Z_{it} = \sum_{k.j \in RMS} \pi_{ijkc} \ln p_{krt,-c}$$

   - Z_{it} is idiosyncratic price variation for the products household i buys.

First stage for contemporaneous prices



Reduced form for contemporaneous prices



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Measuring bias

Alleged biases:

1. Imperfect information
2. Self-control problems

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- See also Bronnenberg *et al.* (2015), Handel and Kolstad (2015)

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Alleged biases:

1. Imperfect information
2. Self-control problems

“Counterfactual normative consumer” strategy:

- See also Bronnenberg *et al.* (2015), Handel and Kolstad (2015)

1. Measure bias proxies using surveys
2. Predict each household’s SSB consumption if they (counterfactually) had the information and self-control of unbiased (normative) consumers
    2.1 Key unconfoundedness assumption
    2.2 And who is “unbiased”
3. Transform quantity effect to money-metric bias using elasticity

PanelViews survey

- October 2017 survey of 24,000 Homescan households

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- Self-control
  - Question: *I drink soda pop or other sugar-sweetened beverages more often than I should*
  - Scaled from 0 (“Definitely”) to 1 (“Not at all”)

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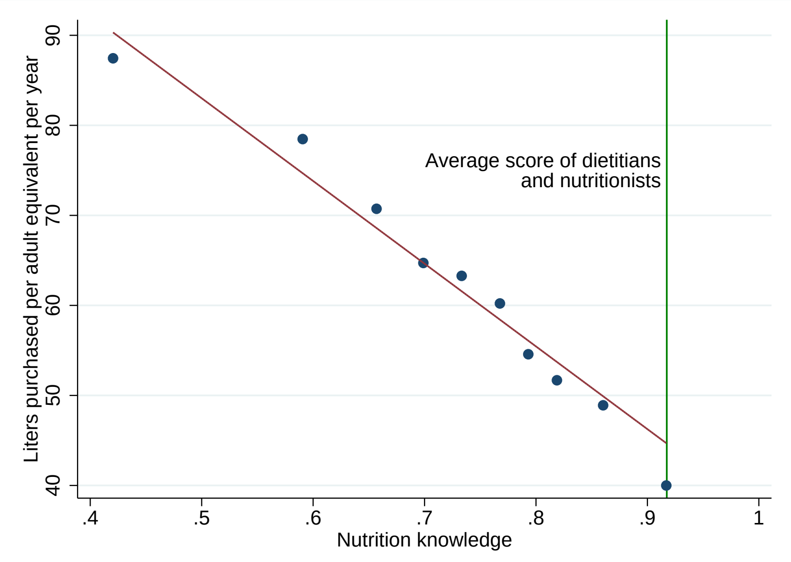
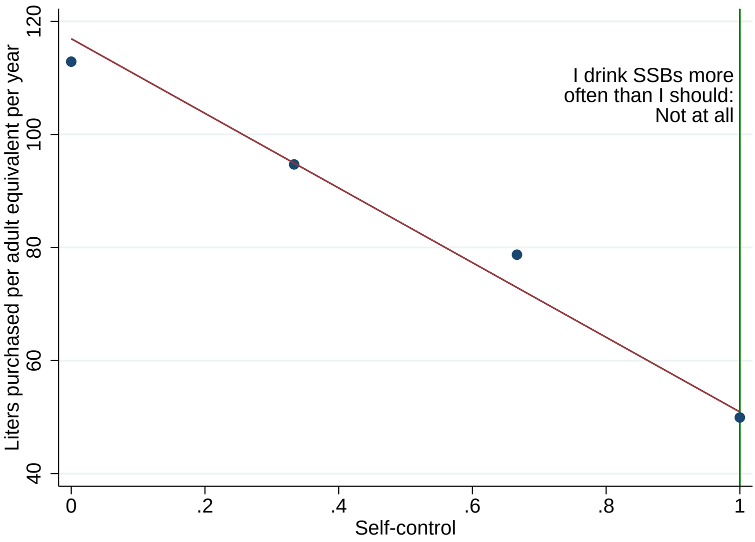
- October 2017 survey of 24,000 Homescan households
- Self-control
  - Question: *I drink soda pop or other sugar-sweetened beverages more often than I should*
  - Scaled from 0 (“Definitely”) to 1 (“Not at all”)
- Nutrition knowledge
  - 28 questions from GNKQ (Kliemann *et al.* 2016)
  - Example 1: *If a person wanted to buy a yogurt at the supermarket, which would have the least sugar/sweetener?*
    - Options: “0% fat cherry yogurt,” “Plain yogurt,” “Creamy fruit yogurt,” “Not sure”
  - Example 2: *Which is the main type of fat present in each of these foods?*
    - Options: “Polyunsaturated fat,” “Monounsaturated fat,” “Saturated fat,” “Cholesterol,” and “Not sure”
    - Olive oil (correct answer: monounsaturated), butter (saturated), sunflower oil (polyunsaturated), and eggs (cholesterol).
  - Scaled to share of questions correct. Average score ≈ 0.65

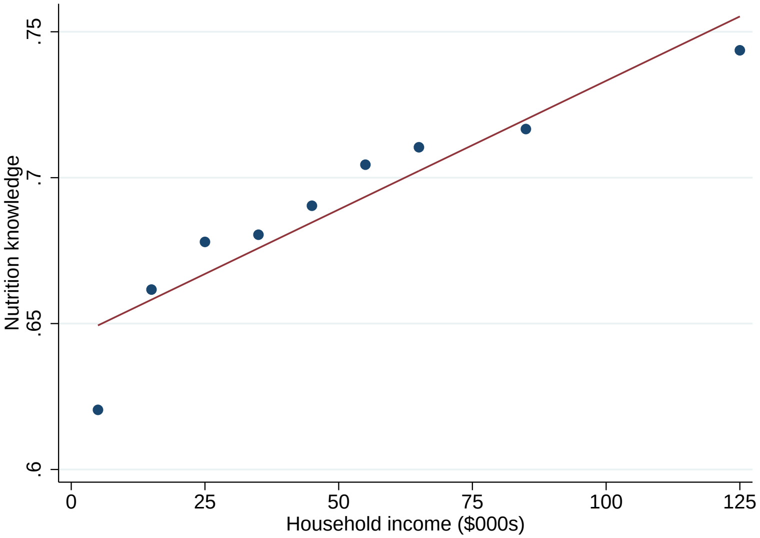
Nutrition knowledge vs. consumption



Self-control vs. consumption



Nutrition knowledge vs. income



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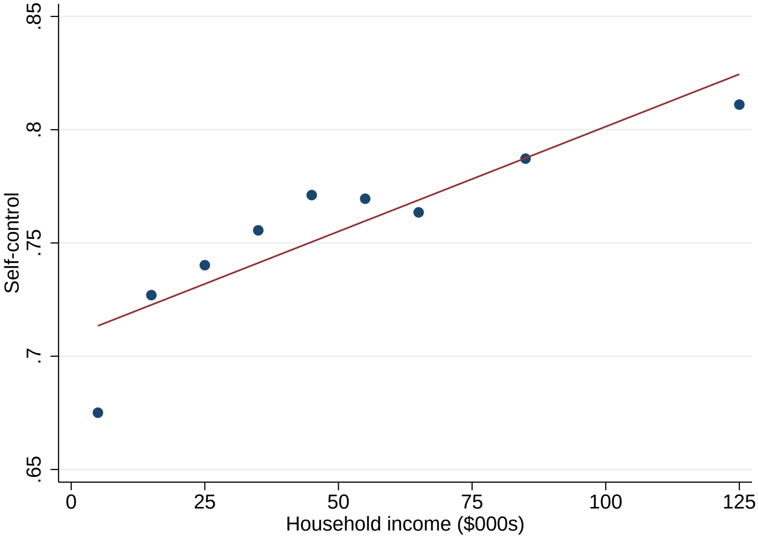


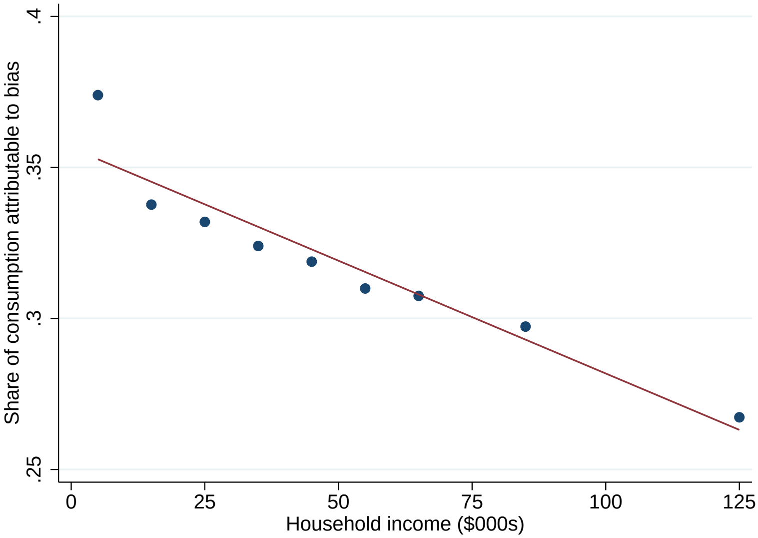
Regressions of SSB purchases on bias proxies

	(1)	(2)	(3)	(4)	(5)	(6)
Nutrition knowledge	-0.854***	-1.187***	-0.939***	-0.851***	-1.030***	-0.659***
	(0.086)	(0.083)	(0.086)	(0.079)	(0.087)	(0.083)
Self-control	-0.825***	-1.163***	-0.775***	-0.865***		-1.408***
	(0.042)	(0.039)	(0.043)	(0.039)		(0.068)
Taste for soda	0.560***		0.547***	0.553***	0.894***	0.390***
	(0.044)		(0.045)	(0.042)	(0.042)	(0.046)
Health importance	-0.258***		-0.121	-0.275***	-0.388***	-0.184**
	(0.075)		(0.075)	(0.072)	(0.076)	(0.072)
ln(Household income)	-0.045**		-0.077***	-0.066***	-0.055***	-0.024
	(0.018)		(0.017)	(0.017)	(0.019)	(0.017)
ln(Years education)	-0.708***		-0.718***	-0.851***	-0.753***	-0.681***
	(0.101)		(0.101)	(0.096)	(0.103)	(0.096)
Other beverage tastes	Yes	No	Yes	Yes	Yes	Yes
Other demographics	Yes	Yes	No	Yes	Yes	Yes
County indicators	Yes	Yes	Yes	No	Yes	Yes
Self-control 2SLS	No	No	No	No	No	Yes
R^2	0.285	0.250	0.272	0.166	0.263	0.285
N	18,568	18,568	18,568	18,568	18,568	18,568

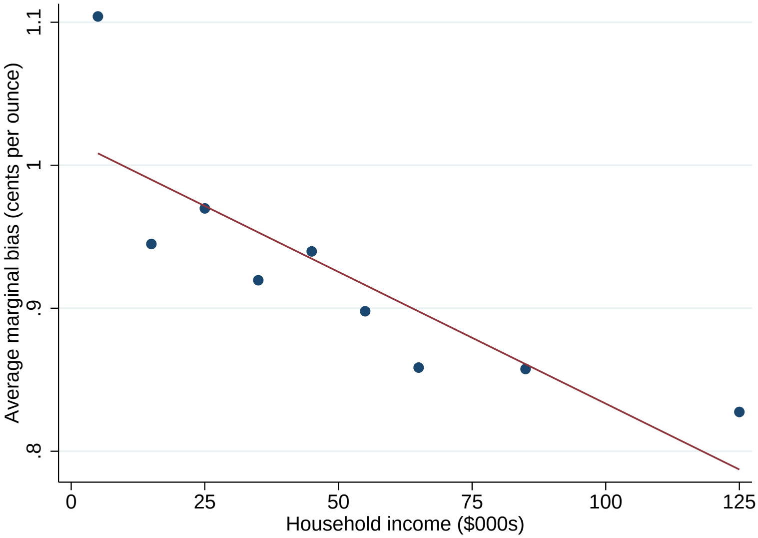
$$\ln(s_i + 1) = \boldsymbol{\tau} \boldsymbol{b}_i + \beta_a \boldsymbol{a}_i + \beta_x \boldsymbol{x}_i + \mu_c + \varepsilon_i$$

$\boldsymbol{b}_i$ = bias proxies, $\boldsymbol{a}_i$ = preferences, $\boldsymbol{x}_i$ = demographics, μ_c = county fixed effects

Share of consumption explained by bias



Average marginal bias by income, $\bar{\gamma}(z)$



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Health system externalities

- 1 cent/oz is total cost to health system (Wang *et al.* 2012)
- ~85% of costs covered by insurance (Yong, Bertko & Kronick 2011; Cawley and Meyerhoefer 2012)
- $\Rightarrow$ $e \approx 0.85$/cents per ounce

Computing optimal t using sufficient statistics formula

Recall:

$$t^* = \overbrace{\bar{\gamma}(1+\sigma)+e}^{\text{corrective motive}} - \overbrace{(p+t^*)\frac{Cov\left[g(z), s_{pref}(z)\right]}{\bar{s}\bar{\zeta}^c}}^{\text{redistributive motive}} \Rightarrow t^* = \frac{\overbrace{\bar{\gamma}(\bar{g}+\sigma)+e}^{\text{corrective motive}} - \overbrace{\frac{p}{\bar{s}\bar{\zeta}^c} Cov\left[\hat{g}(z), s_{pref}(z)\right]}^{\text{redistributive motive}}}{1+\frac{1}{\bar{s}\bar{\zeta}^c} Cov\left[\hat{g}(z), s_{pref}(z)\right]}$$

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Estimates of population parameters:

- $\bar{s} = 46.48$ (ounces per week)
- $\bar{\zeta}^c = 1.39$
- $\bar{\gamma} = 0.93$ (cents per ounce)
- $g(z)$ assuming Pareto weights $\alpha(\theta) = 1/$(status quo after-tax income)
- $\bar{g} = 1$, and $\hat{g}(z) \approx g(z)$
  - Assuming no labor supply income effects, and SSBs are small budget share
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Next: covariances σ and $Cov\left[g(z), s_{pref}(z)\right]$.

Sufficient statistics estimates by income bin

z	f	$\bar{s}(z)$	$\bar{\zeta}^c(z)$	$\xi(z)$	$\bar{\gamma}(z)$	$g(z)$	$T'(z)$	$s_{pref}(z)$
5000	0.11	63.1	1.40	0.33	1.07	2.75	-0.19	0.0
15000	0.16	56.7	1.40	0.31	0.92	1.42	-0.05	-32.9
25000	0.14	53.3	1.39	0.29	0.91	1.03	0.08	-51.1
35000	0.10	47.2	1.39	0.27	0.90	0.82	0.15	-67.5
45000	0.08	44.8	1.38	0.25	0.91	0.69	0.19	-77.6
55000	0.07	42.9	1.38	0.23	0.90	0.60	0.21	-85.5
65000	0.09	39.3	1.37	0.21	0.91	0.53	0.21	-93.8
85000	0.09	35.2	1.36	0.17	0.91	0.43	0.22	-104.8
125000	0.15	30.3	1.34	0.09	0.85	0.31	0.23	-116.8

Letting n index rows,

- $\sigma = \frac{1}{\bar{\gamma}\bar{\zeta}^c\bar{s}} \left(\sum_n f_n(g_n \bar{\gamma}_n \bar{\zeta}_n^c \bar{s}_n) - \sum_n f_n g_n \cdot \sum_n f_n \bar{\gamma}_n \bar{\zeta}_n^c \bar{s}_n \right) = 0.2$
- $Cov\left[g(z), s_{pref}(z)\right] = \sum_n f_n(g_n s_{pref,n}) - \sum_n f_n g_n \cdot \sum_n f_n s_{pref,n} = 24.8$

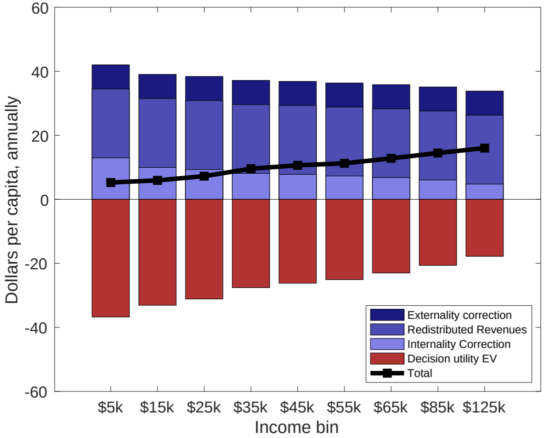
Computing the optimal SSB tax: results

	Existing income tax	Optimal income tax
Baseline	1.42	0.41
Self-reported SSB consumption	2.13	0.96
Pigouvian (no redistributive motive)	1.78	-
Weaker redistributive preferences	1.66	1.35
Stronger redistributive preferences	1.10	-0.64
Redistributive preferences rationalize U.S. income tax	1.73	1.68
Higher demand elasticity ($\zeta^c(\theta) = 2$)	1.57	0.78
Lower demand elasticity ($\zeta^c(\theta) = 1$)	1.23	0.01
Demand elasticity declines faster with income	1.44	0.44
Pure preference heterogeneity	1.44	1.44
Pure income effects	1.49	1.97
Measurement error correction for self control	1.70	0.64
Internality from nutrition knowledge only	1.00	0.08
Self control bias set to 50% of estimated value	1.16	0.20
Self control bias set to 200% of estimated value	1.93	0.82
With substitution: untaxed goods equally harmful	1.48	0.45
With substitution: untaxed goods half as harmful	1.45	0.43
With substitution: untaxed goods doubly harmful	1.53	0.50
With substitution: diet drinks not harmful	1.73	0.66
With substitution: only to diet drinks, equally harmful	1.16	0.20
No internality	0.41	-0.40
No corrective motive	-0.36	-1.01
Optimal local tax, with 25% cross-border shopping	0.97	-
Optimal local tax, with 50% cross-border shopping	0.53	-

Why optimal SSB taxes are lower under optimal income tax than status quo

- Using Pareto weights = 1/income, optimal income taxes higher than status quo
    - $\implies$ fiscal externalities from labor supply distortions larger under optimal income tax
    - $\implies$ t^* lower under optimal income tax

Welfare and equivalent variation



- Optimal tax: 1.42 cents per ounce.
- Net effect on social welfare: \$7.86 per capita, $\approx$ \$2.4 billion across U.S. adult equivalents.

Sugary drink taxes: takeaways

- Exact empirical estimates still uncertain
    - Like estimating the social cost of carbon
- Estimated optimal nationwide tax > 1 cent per ounce rule-of-thumb
- Leakage matters a lot
- Internalities and (fiscal) externalities about the same size
- When judging regressivity, consider internality benefits, not just financial incidence

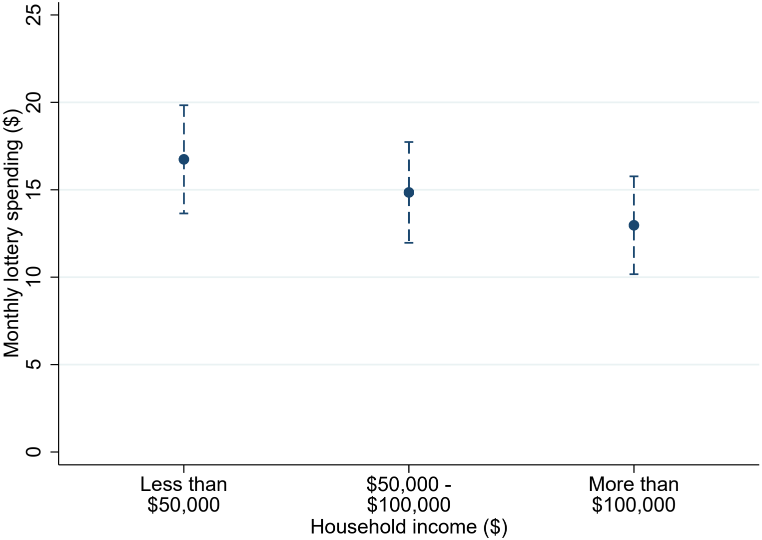
Empirical application: Lottery tickets

Data: new survey of lottery consumption

	Mean	Std. dev.	Min	Max
Household income ($000s)	72.12	53.08	5	250
Years of education	14.32	2.26	4	20
Age	48.82	16.79	18	91
1(Male)	0.50	0.50	0	1
1(White)	0.66	0.47	0	1
1(Black)	0.11	0.31	0	1
1(Hispanic)	0.16	0.36	0	1
Household size	3.04	1.62	1	6
1(Married)	0.53	0.50	0	1
1(Employed)	0.63	0.48	0	1
1(Urban)	0.83	0.37	0	1
1(Attend church)	0.36	0.48	0	1
Political ideology	3.83	1.59	1	7

- 2,879 respondents from AmeriSpeak survey panel, fielded early 2020.
- Resampled in early 2021 to understand test-retest reliability.

Key statistic $s(\theta)$: lottery spending across incomes

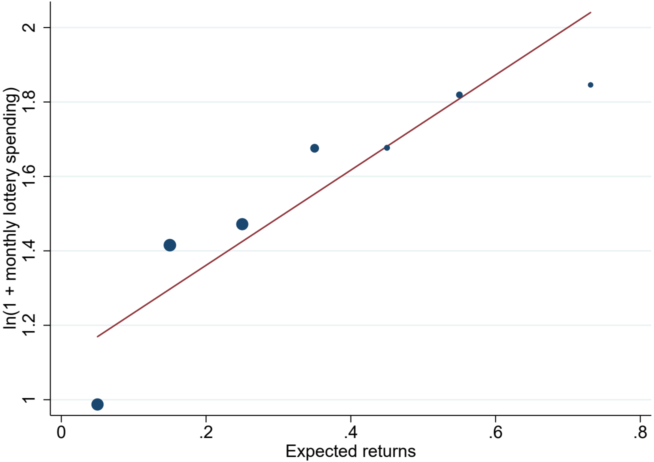


- Spending declines modestly as income rises.
- Heavily skewed: top 10% of spenders account for 56% of spending.
- Consistent with 1998 NORC survey of gambling consumption.
- Two measures of causal income effects, do not explain profile.

Survey questions to assess bias

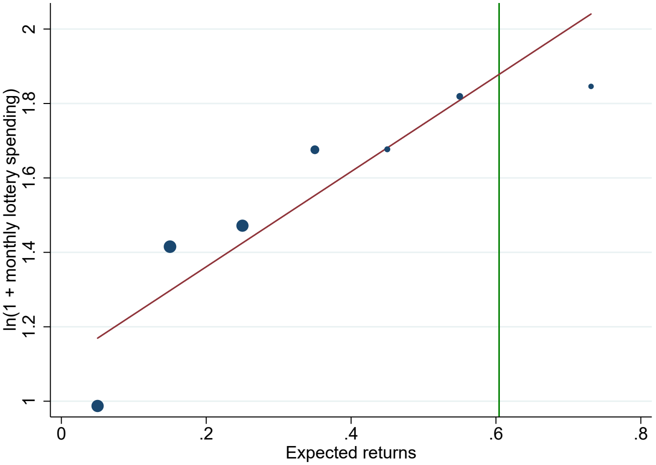
- **Expected returns**: *What percent of the total spending on lottery tickets do you think is given out in prizes?*
- **Self-control**: *Do you feel you should play the lottery less/same/more than you do now?*
- **Financial literacy**: share of correct answers to set of standard financial literacy questions
- **Statistical mistakes**: gambler's fallacy, law of small numbers, expected value calculation
- **Overconfidence**: *"For every $1000 you spend, how much do you think you would win back in prizes, on average?"* vs. *"How much would average player win back?"*
- **Predicted life satisfaction**: *How much do you think $100k more in winnings raised reported well-being?*

Lottery expenditures across perceived returns to lottery



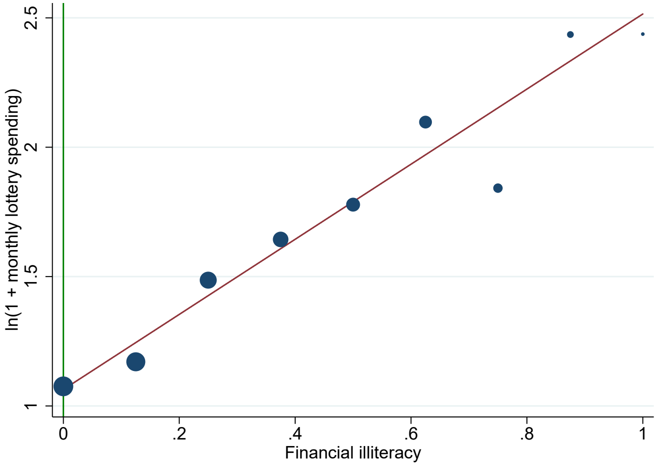
- Plot expenditures across bias proxy.

Lottery expenditures across perceived returns to lottery



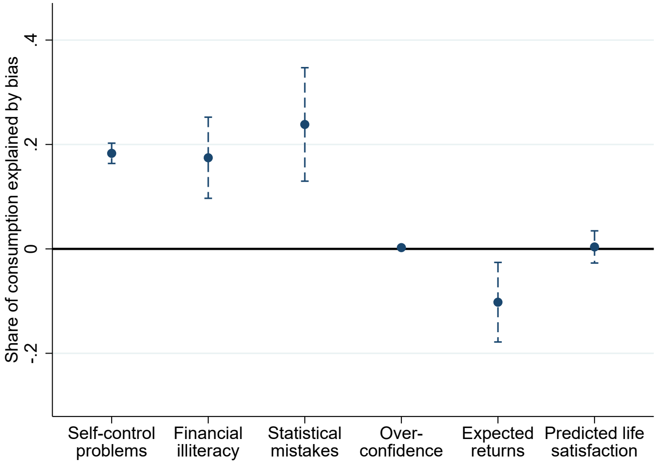
- Plot expenditures across bias proxy.
- Green line indicates “normative” (unbiased) response.
- On average people substantially *underestimate* payout: unlikely source of overconsumption bias. (See also Clotfelter & Cook 1999)

Lottery expenditures by financial illiteracy



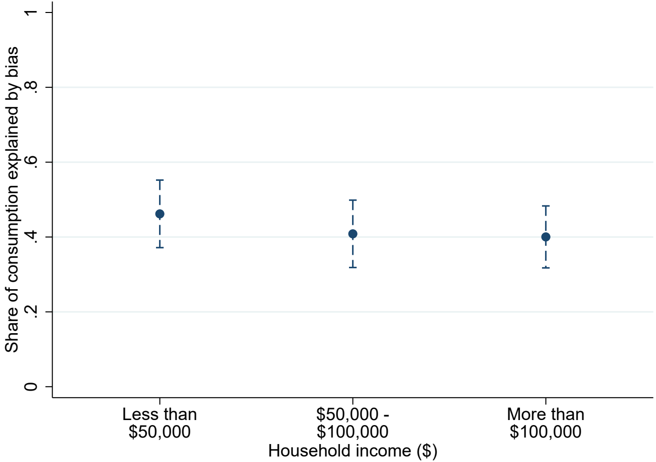
- In contrast, financial illiteracy suggests substantial overconsumption.
- Robust relationship, quantitatively important.
- Substantial heterogeneity in population.

Biases contributing to overconsumption



- Compute counterfactual spending for each consumer if they were unbiased on each dimension, while retaining own demographics, normative preferences.
- Financial illiteracy and statistical mistakes are primary drivers.
- Can use these to predict latent “unbiased consumption” for each consumer. (Caution: causal interpretation!)

Key statistic: quantity effect of bias



- Average person overconsumes lotteries by 43% due to bias.
- Using price elasticity estimate, can convert this *quantity effect* to money-metric bias estimate.

Income taxes

Recall: theoretical framework

Consumers

- Heterogeneous (private) ability and tastes, $\theta \in \mathbb{R}^n_+$, distributed $\mu(\theta)$
- Choose bundle of **c**omposite consumption and good **x** (prices 1 and p), and earnings ***z***
- Maximize **decision utility** subject to budget constraint:

$$\max_{c,s,z} U_\theta(c,x,z) \quad \text{s.t.} \quad c + (p+t)x \le z - T(z)$$

Utilitarian policymaker

- Chooses **commodity tax** t and **income tax** $T(z)$. Today we'll study both in turn.
- Maximizes total **weighted** **normative utility** (less fiscal **externality**) subject to revenue constraint:

$$\max_{t,T} \int_\Theta [\alpha(\theta) V_\theta(c(\theta), x(\theta), z(\theta))]\, d\mu(\theta) \quad \text{s.t.} \quad \int_\Theta [tx(\theta) + T(z(\theta)) - ex(\theta)]\, d\mu(\theta) \ge R$$

- $U \neq V$ if consumers misinformed, inattentive, present biased, etc.

Income taxation: can simplify to just one consumption type

Consumers

- Heterogeneous (private) ability and tastes, $\theta \in \mathbb{R}_+^n$, distributed $\mu(\theta)$
- Choose **c**onsumption and earnings $\boldsymbol{z}$
- Maximize **decision utility** subject to budget constraint:

$$\max_{c,z} U_\theta(c,z) \quad \text{s.t.} \quad c \leq z - T(z)$$

Utilitarian policymaker

- Chooses **income tax** $T(z)$.
- Maximizes total **weighted normative utility** subject to revenue constraint:

$$\max_T \int_\Theta [\alpha(\theta) V_\theta\left(c(\theta), z(\theta)\right)] \, d\mu(\theta) \quad \text{s.t.} \quad \int_\Theta [T(z(\theta))] \, d\mu(\theta) \geq R$$

- $U \neq V$ if consumers misinformed, inattentive, present biased, etc.

Starting point: optimal income tax in sufficient statistics (Saez 2001)

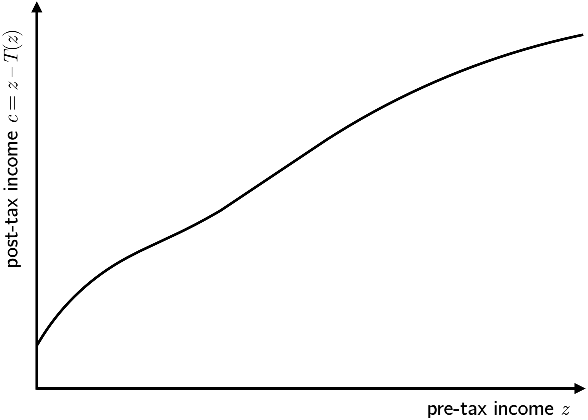
- No bias (for now): $U_\theta \equiv V_\theta$.

- Write optimal income tax $T(z)$ in terms of elasticities (Saez 2001)
    - provides local characterization (first-order condition)

- Positive parameters
    - elasticity of taxable income $\varepsilon(\theta) = \frac{dz(\theta)}{d(1-T')}\frac{1-T'}{z(\theta)}$, assume constant conditional on income: $\bar{\varepsilon}(z)$
    - for simplicity here: no income effects (see paper)
    - income distribution $h(z)$

- Normative parameters
    - "social welfare weights" $g(\theta) = \alpha(\theta)\frac{dV_\theta(c(\theta),z(\theta))}{dc(\theta)}$; often assume depend only on income ($g(z)$)

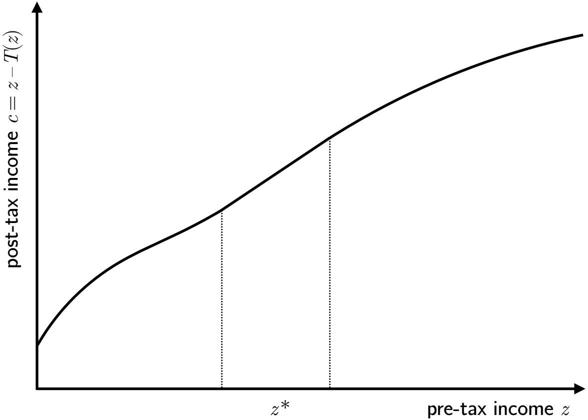
Illustration: optimal income tax in sufficient statistics (Saez 2001)



Heuristic derivation

- Start with candidate optimal $T(z)$ mapping z onto c.

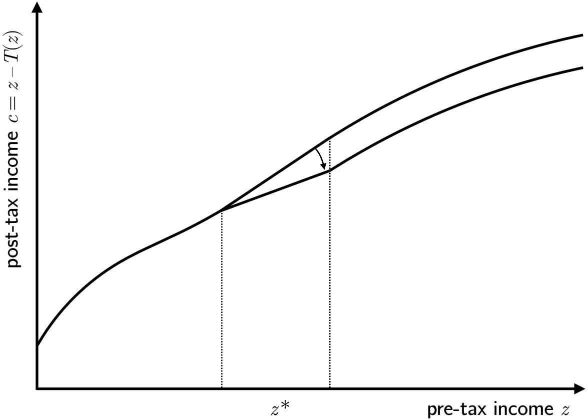
Illustration: optimal income tax in sufficient statistics (Saez 2001)



Heuristic derivation

- Start with candidate optimal $T(z)$ mapping z onto c.
- Slightly raise $T'(z)$ by δt in a narrow bandwidth ϵ around some z^*. Then letting δt and ϵ be "small"...

Illustration: optimal income tax in sufficient statistics (Saez 2001)



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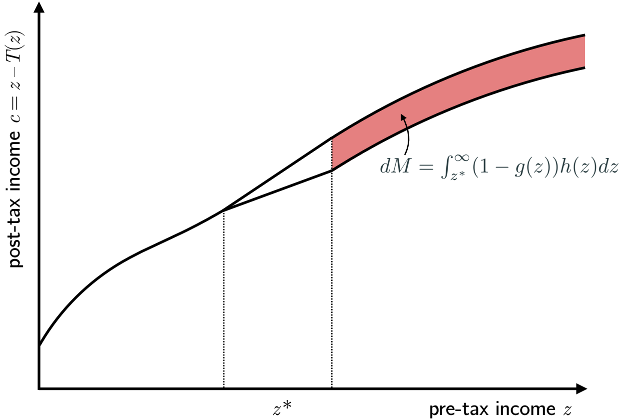
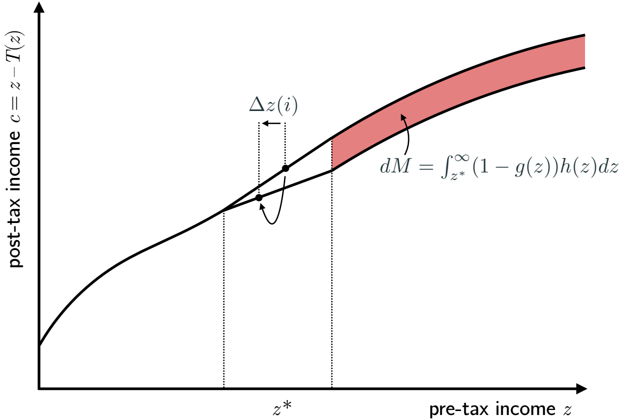


Heuristic derivation

- Start with candidate optimal $T(z)$ mapping z onto c.
- Slightly raise $T'(z)$ by δt in a narrow bandwidth ϵ around some z^*. Then letting δt and ϵ be "small"...
- "Mechanical effect" on welfare is $\approx \delta t \epsilon \times dM$.

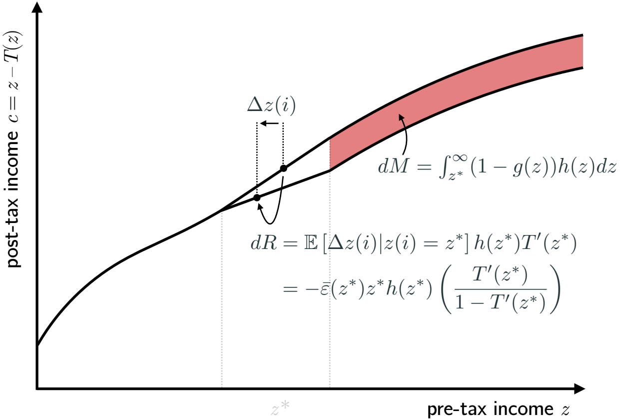
Illustration: optimal income tax in sufficient statistics (Saez 2001)



Heuristic derivation (cont.)

- But this also distorts earnings by $-\Delta z$ in the band around z^*, creating a negative fiscal externality proportional to $T'(z^*)$.

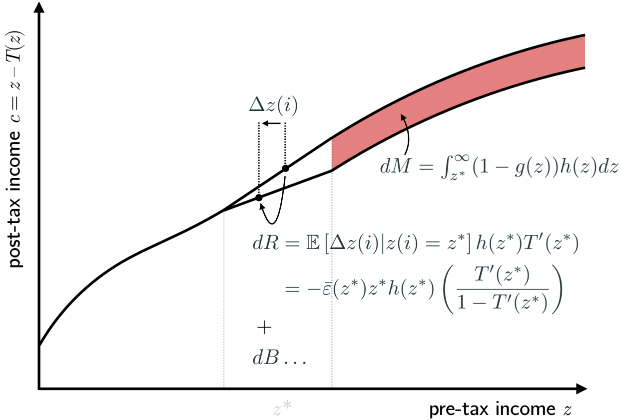
Illustration: optimal income tax in sufficient statistics (Saez 2001)



Heuristic derivation (cont.)

- But this also distorts earnings by $-\Delta z$ in the band around z^*, creating a negative fiscal externality proportional to $T'(z^*)$.
- We can write Δz in terms of ETI $\bar{\varepsilon}(z^*)$.
- "Revenue effect" on welfare is $\approx \delta t \epsilon \times dR$.
- Saez (2001): at optimum $dM + dR = 0$
    - Adjustment Δz has no 1st-order welfare effects (envelope theorem).

Illustration: optimal income tax in sufficient statistics (Saez 2001)



Heuristic derivation (cont.)

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- Saez (2001): at optimum $dM + dR = 0$
  - Adjustment Δz has no 1st-order welfare effects (envelope theorem).
- But if there are behavioral biases...

Now with misoptimization: present bias over labor supply

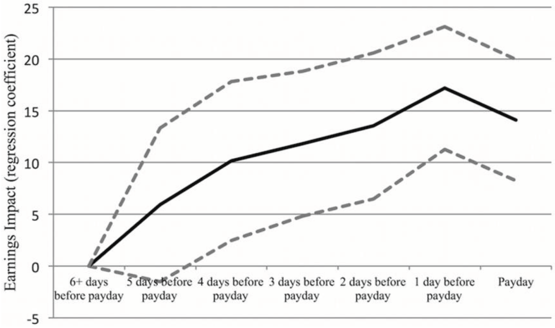
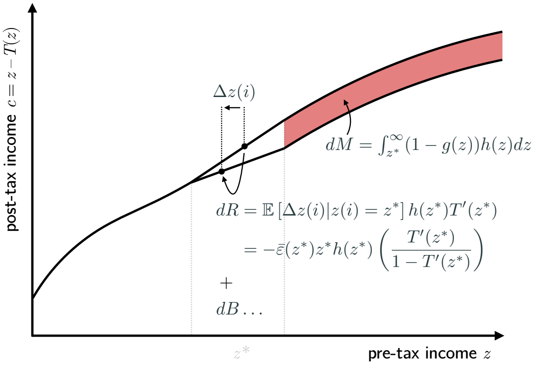


FIG. 3.—Earnings over the pay cycle. This figure graphs the coefficients and 95 percent confidence intervals from a regression of earnings on six binary indicators that capture distance from a worker's next payday (payday, 1 day before payday, 2 days before payday, etc.). The omitted category is 6 or more days before payday. Note that these coefficients correspond to those shown in column 4 of table 2.

- Substantial evidence of present-biased behavior over labor supply choices.
- Simple model: exert labor effort "now" in exchange for compensation (consumption) in the "future".
- Normative utility: $V_\theta(c, z) = -\phi(z/w(\theta)) + u(c)$.
- Decision utility: $U_\theta(c, z) = -\phi(z/w(\theta)) + \beta_\theta u(c)$.
  - $\phi(\cdot)$: disutility of labor effort
  - $w(\theta)$: wage (ability)
  - β_θ: present bias
  - for simplicity, exponential discount factor $\delta = 1$.

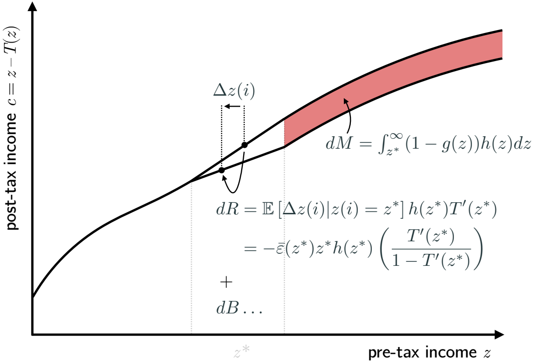
Present bias and labor supply



- dB: 1st-order effect of $\Delta z(\theta)$ on θ's utility:

$$\Delta V_\theta = \Delta z(\theta)\left(\frac{dV_\theta}{dc}(1-T') + \frac{dV_\theta}{dz}\right) \tag{1}$$

Present bias and labor supply



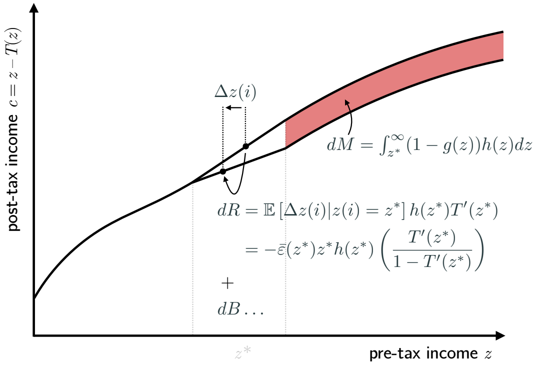
- dB: 1st-order effect of $\Delta z(\theta)$ on θ's utility:

$$\Delta V_\theta = \Delta z(\theta)\left(\frac{dV_\theta}{dc}(1-T') + \frac{dV_\theta}{dz}\right) \qquad (1)$$

- By individual optimization:

$$\frac{dU_\theta}{dc}(1-T') + \frac{dU_\theta}{dz} = 0$$
$$\Rightarrow \beta_\theta \frac{dV_\theta}{dc}(1-T') + \frac{dV_\theta}{dz} = 0$$

Present bias and labor supply



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$$\Delta V_\theta = \Delta z(\theta) \left(\frac{dV_\theta}{dc}(1 - T') + \frac{dV_\theta}{dz} \right) \tag{1}$$

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$$\Rightarrow \beta_\theta \frac{dV_\theta}{dc}(1 - T') + \frac{dV_\theta}{dz} = 0$$

- So eqn (1) can be written

$$\Delta V_\theta = \Delta z(\theta)(1 - \beta_\theta) \underbrace{\frac{dV_\theta}{dc}}_{\propto g(z)} (1 - T')$$

Present bias and labor supply

- Total behavioral effect:

$$\begin{aligned} dB &= \mathbb{E}[\Delta z(\theta)(1-\beta_\theta)|z^*]g(z^*)(1-T')h(z^*) \\ &= \mathbb{E}[\varepsilon(\theta)(1-\beta_\theta)|z^*]g(z^*)z^*h(z^*) \\ &= \bar{\varepsilon}(z^*)(1-\bar{\beta}(z^*))g(z^*)z^*h(z^*) \end{aligned}$$

- Then optimal tax has $dM + dR + dB = 0$, so

$$\frac{T'(z)}{1-T'(z)} = \frac{1}{\bar{\varepsilon}(z)h(z)z}\int_z^\infty (1-g(s))\, h(s)ds - g(z)(1-\bar{\beta}(z))$$

Calibrating present bias across incomes

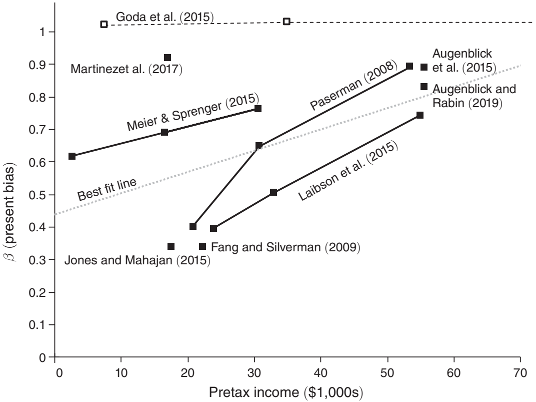
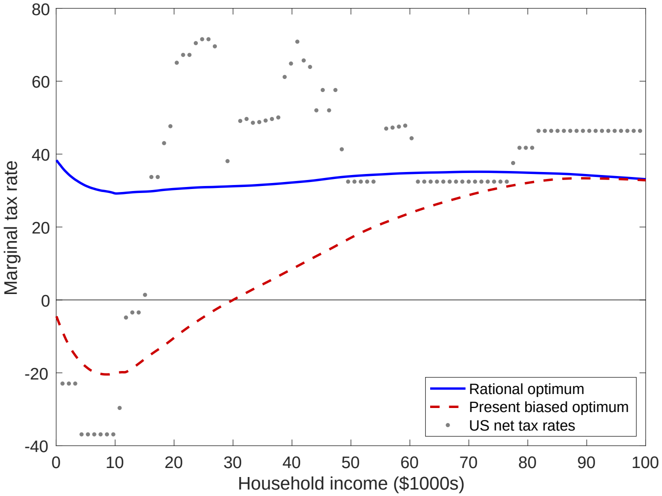


FIGURE 2. ESTIMATED RELATIONSHIP BETWEEN INCOME AND PRESENT-BIAS PARAMETER β

Notes: This figure plots estimates of β across income from several papers. The dotted "best fit line" is used in simulations for the schedule of present bias across the skill distribution. See online Appendix D for details.

- To calibrate, we need an estimated profile of $\beta(z)$ across incomes.
- Combine empirical results from many studies across literature.
- Distinct pattern: smaller β at lower incomes.

Computing optimal tax rates



- Primary effect: lower (even negative!) marginal tax rates at low incomes.
- May play a role in reconciling widespread support for Earned Income Tax Credit with theoretical shortcomings of negative marginal income tax rates.

Conclusion

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- Close (but not exact) analogy between optimal *internality* taxation and optimal *externality* taxation
- Key empirical question: how to measure bias?

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Toolbox of bias identification strategies

Empirical strategy	Example	Naive present focus	Sophisticated present focus	Focusing	Inattention	Biased beliefs
Preference reversals	Sadoff, Samek, and Sprenger (2019)	x	x			
Belief elicitation	Allcott, Kim, Taubinsky, and Zinman (2019)	x				x
Demand for commitment	Schilbach (2019)		x			
Selection into dominated contracts	DellaVigna and Malmendier (2004)	x	x			
Inconsistent discount rates	Kaur, Kremer, and Mullainathan (2015)	x	x			
Information provision	Allcott and Taubinsky (2015)				x	x
Comparing demand responses	Chetty, Looney, and Kroft (2009)	x	x	x	x	x
Counterfactual normative consumer	Allcott, Lockwood, and Taubinsky (2019)	x	x			x