Rules of Thumb and Attention Elasticities: Evidence from Under- and Overreaction to Taxes

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Motivation

- consumers react differently to changes in (opaque) taxes than changes in (displayed) prices

- one explanation: costly for consumers to pay attention to taxes
- these models have implications for effects of stakes on attention

- goal of the paper: evaluate predictions of costly attention models for how changing stakes affect (mis)reaction to sales taxes
- key novelty: experimental within-consumer variation in stake sizes

Contribution

1. reduced-form summary of costly attention choice models: consumers act as if they misperceive taxes by a factor called the *revealed valuation weight*

2. derive implications of the models for population and individual comparative statics of revealed valuation weights as stakes change

3. experimentally explore how (population and individual) revealed valuation weights change as stakes change

Related literature

- many papers document under-reaction to sales taxes
  - e.g., Chetty et al. (2009), Goldin and Homonoff (2013); Feldman and Ruffle (2015), Taubinsky and Rees-Jones (2018), Feldman et al. (2018), …

- focus here is on how changes in stakes affect reactions
  - some work on population-level estimates in Taubinsky and Rees-Jones (2018)

Setting

- consumers have quasilinear utility $vx - p$ for an indivisible good, where v is the value, $x \in \{0,1\}$ is the quantity, and p is the price

- true price decomposes as $p = p_s + p_o$, where p_s is the salient component and p_o is the opaque component
  - e.g., p_s is the pre-tax price and p_o is the tax

- opaque component is $p_o = \sigma q_o$, where σ represents the stakes
  - e.g., σ is the expected tax and q_o is the ratio by which taxes deviate
  - e.g., σ is the pre-tax price and q_o is the tax rate

Revealed valuation weight

- in both the Sims (2003) rational inattention model and the Gabaix (2014) attention weight adjustment models, consumers make purchase decisions as if the price is of the form

$$\tilde{p} = p_s + \theta p_o$$

- here, θ is the *revealed valuation weight*, which is endogenous and depends on the stakes and cost of attention

- $\theta = 1$: react to opaque component of prices (e.g., taxes) as if rational
- $\theta < 1$ (resp. $\theta > 1$): under- (resp. over-) reaction to taxes

Comparative statics on increases in σ from “standard stakes” to “high stakes”

1. the average $E[\theta]$ is higher in the high stakes regime

2. consumers with higher θ under standard stakes will also have higher values of θ under high stakes

3. consumers with the highest θ under standard stakes will increase their θ by the smallest amount when put under high stakes

4. consumers whose θ increases the least in response to the change in σ have the highest θ under both standard & high stakes

5. if some consumers have $\theta > 1$ under standard stakes, then some will adjust their θ downward when put under high stakes

Comparison with rules of thumb

- prediction 2: consumers with higher θ under standard stakes will also have higher values of θ under high stakes
- prediction 4: consumers whose θ increases the least in response to the change in σ have the highest θ under both standard & high stakes

both are difficult to reconcile with rules of thumb, which are not likely to generate correlations in misreaction across different stakes

Non-monotonic changes in θ

- prediction 1: the average $E[\theta]$ is higher in the high stakes regime
- prediction 5: if some consumers have $\theta > 1$ under standard stakes, then some will adjust their θ downward when put under high stakes

not consistent with models in which θ has to either increase or decrease with stakes

- e.g., full or no awareness of the opaque price (e.g., Gabaix and Laibson, 2006), costly attention with homogenous prior perceptions

Taking logs

- in the context of taxes, the perceived price is
$$\tilde{p} = p_s + \theta\tau p_s = (1+\theta\tau)p_s$$

- instead, take logs and us first-order approximation
$$\log\tilde{p} = \log(1+\theta\tau) + \log p_s \approx \theta\log(1+\tau) + \log p_s$$

- approximation is valid for small tax rates τ and eases the estimation

Experiment

- 1,846 consumers from ClearVoice research panel (demographically representative of US adult population on age, gender and income)
  - Drawn from population of states with positive sales tax

- Presents consumers with a variety of product purchasing decisions at different prices and different tax rates to elicit willingness to pay under different tax regimes
  - E.g., household cleaning products

- Each decision has a chance of being realized
  - After making decisions, one-third of participants were awarded a $16 budget, and the decision from a randomly selected product-price-tax triple was actually implemented

Experiment

- Each consumer i sees three products (indexed by $j \in \{1,2,3\}$)

- Consumer sees each of those three products in three "stores" (indexed by $k \in \{A, B, C\}$)
  - Store A: zero sales tax
  - Store B: sales tax τ_i of the consumer's state of residence
  - Store C: triple-tax, $3\times\tau_i$

- Each of the nine product-store pairs presents a list of randomly drawn pre-tax prices
  - Consumers indicate whether they would buy the product at each of the prices
  - Not allowed to submit non-monotonic purchasing decisions

- Consumers are told which store they are shopping at before seeing the decision screen

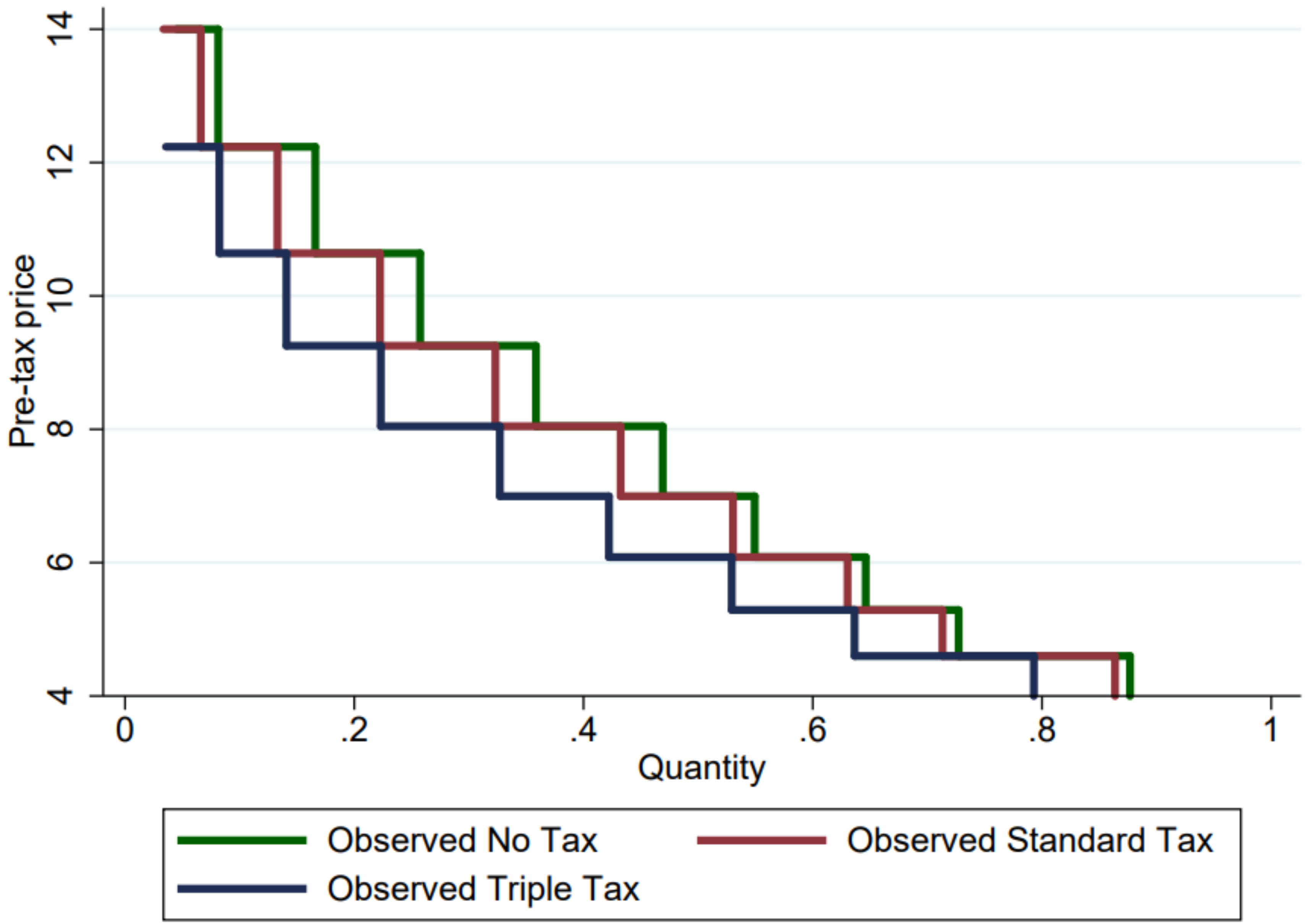
Glad OdorShield Tall Kitchen Drawstring Trash Bags, Fresh Clean, 13 Gallon, 80 Count

Product Description: Glad OdorShield Tall Kitchen Drawstring Trash Bags backed by the power of Febreze are tough, reliable trash bags that neutralize strong and offensive odors for lasting freshness. These durable bags are great for use in the kitchen, home office, garage, and laundry room.

	Yes	No
Would you buy the Glad OdorShield Trash Bags for $8.05?		
Would you buy the Glad OdorShield Trash Bags for $5.29?		
Would you buy the Glad OdorShield Trash Bags for $7.00?		
Would you buy the Glad OdorShield Trash Bags for $4.00?		
Would you buy the Glad OdorShield Trash Bags for $10.64?		
Would you buy the Glad OdorShield Trash Bags for $9.25?		
Would you buy the Glad OdorShield Trash Bags for $12.24?		
Would you buy the Glad OdorShield Trash Bags for $4.60?		
Would you buy the Glad OdorShield Trash Bags for $6.08?		
Would you buy the Glad OdorShield Trash Bags for $14.07?		

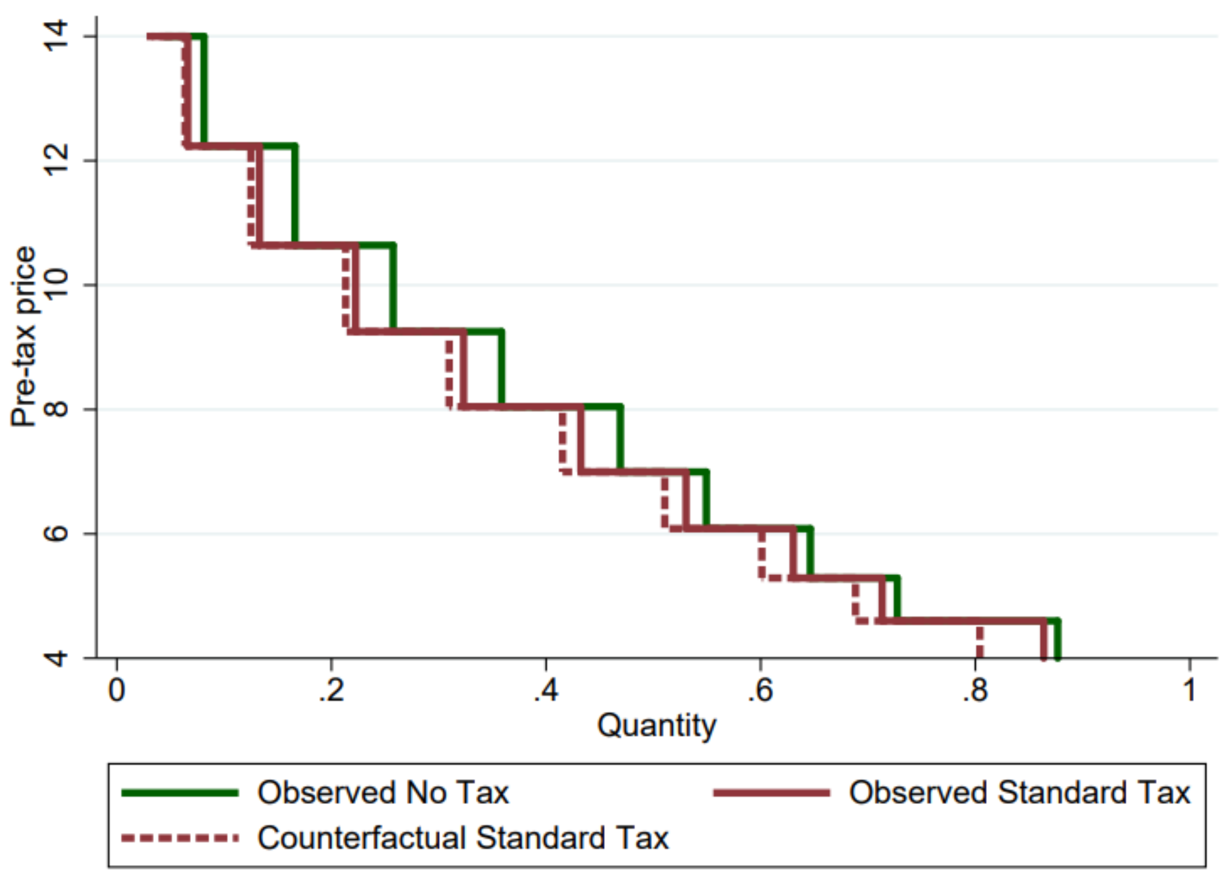
Back Continue

Observed demand

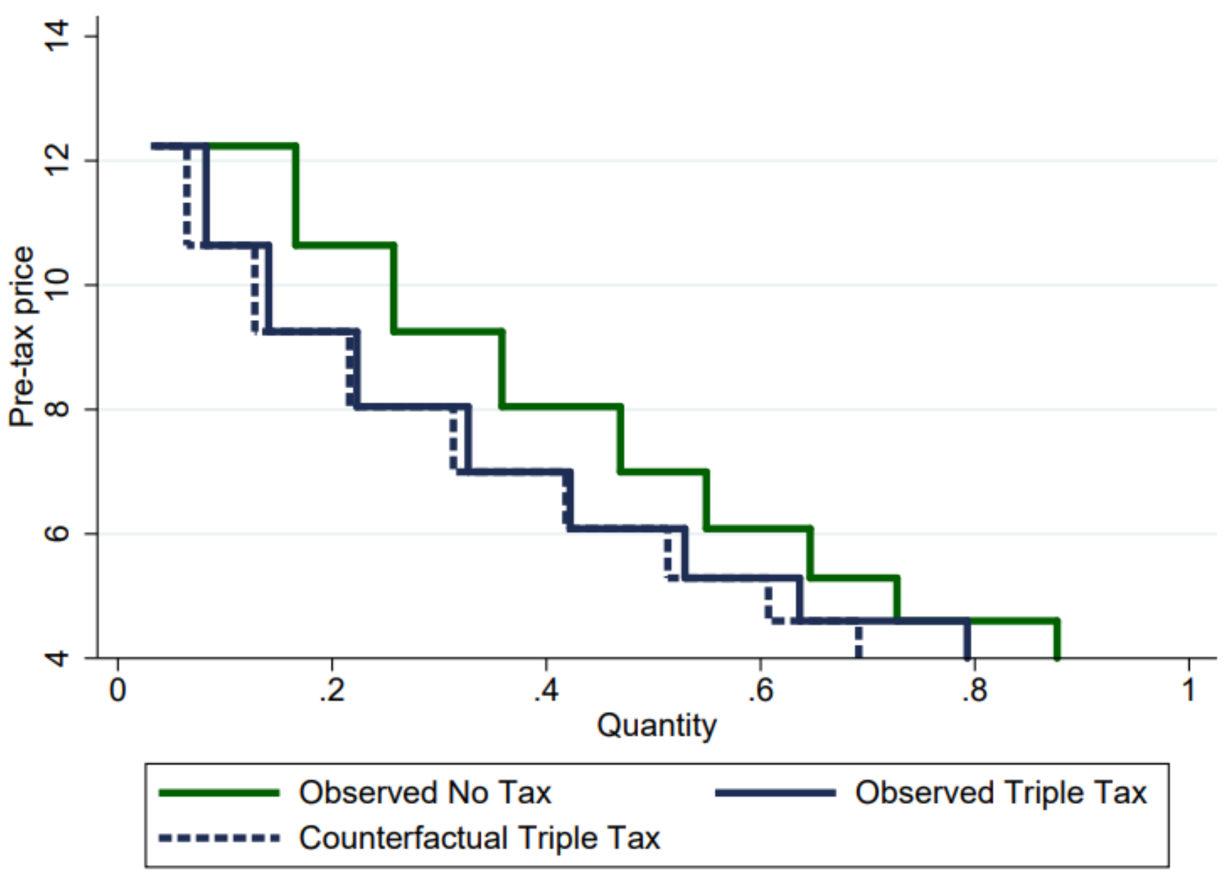


Evidence of underreaction to taxes

(b) Observed vs. counterfactual demand: standard taxes



(c) Observed vs. counterfactual demand: triple taxes



How does average θ respond to stakes?

- **Prediction 1**: $E[\theta]$ is higher under higher stakes

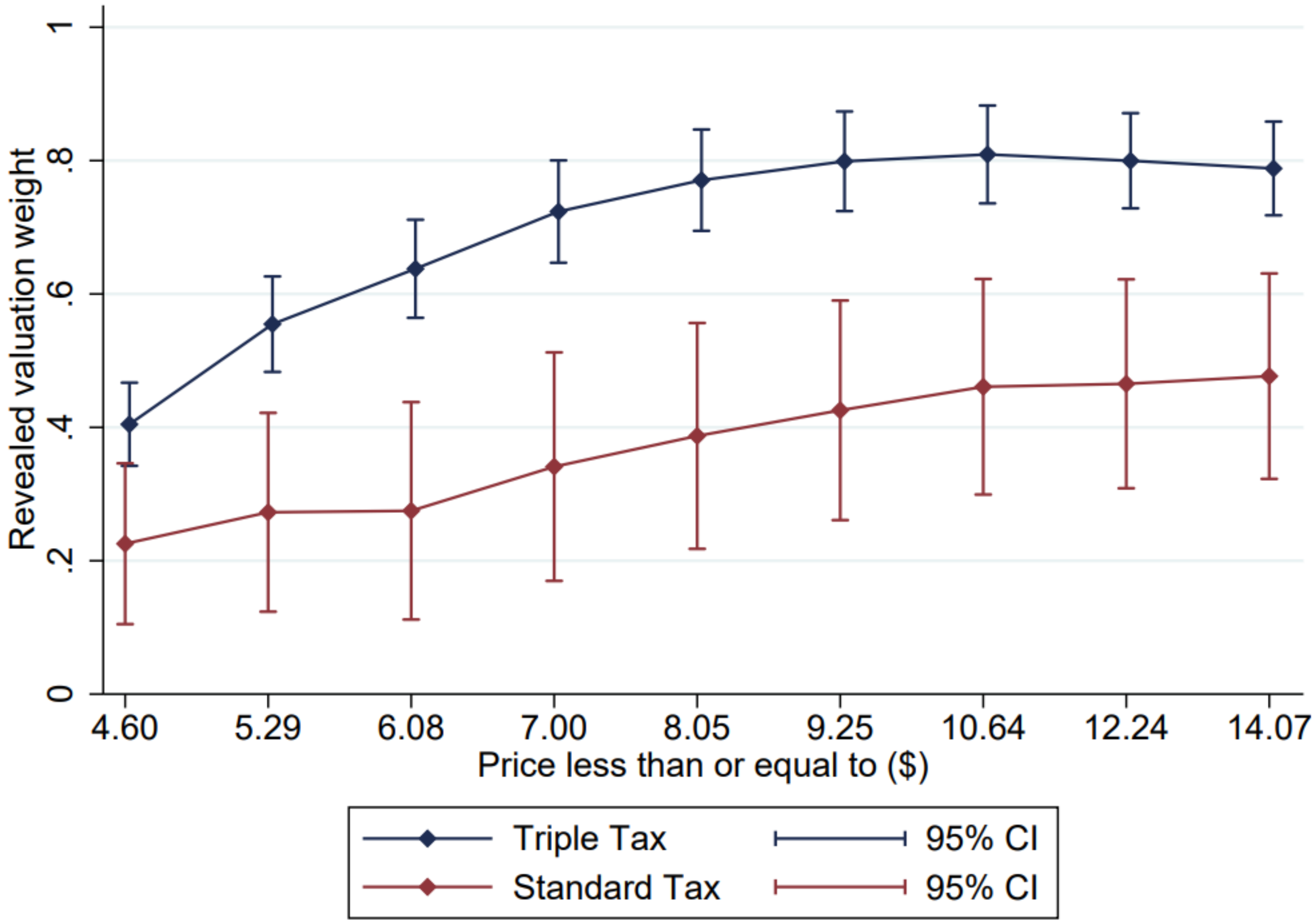
- Probit model to estimate average revealed valuation weight $E[\theta]$

$$1 - Pr(buy_{ijk}|p) = \Phi\left(\frac{\alpha_j + \ln(p) + \bar{\theta}_B \ln(1+\tau_{ik}) \cdot I(k=B) + \bar{\theta}_C \ln(1+\tau_{ik}) \cdot I(k=C)}{\sigma_j}\right) \quad (4)$$

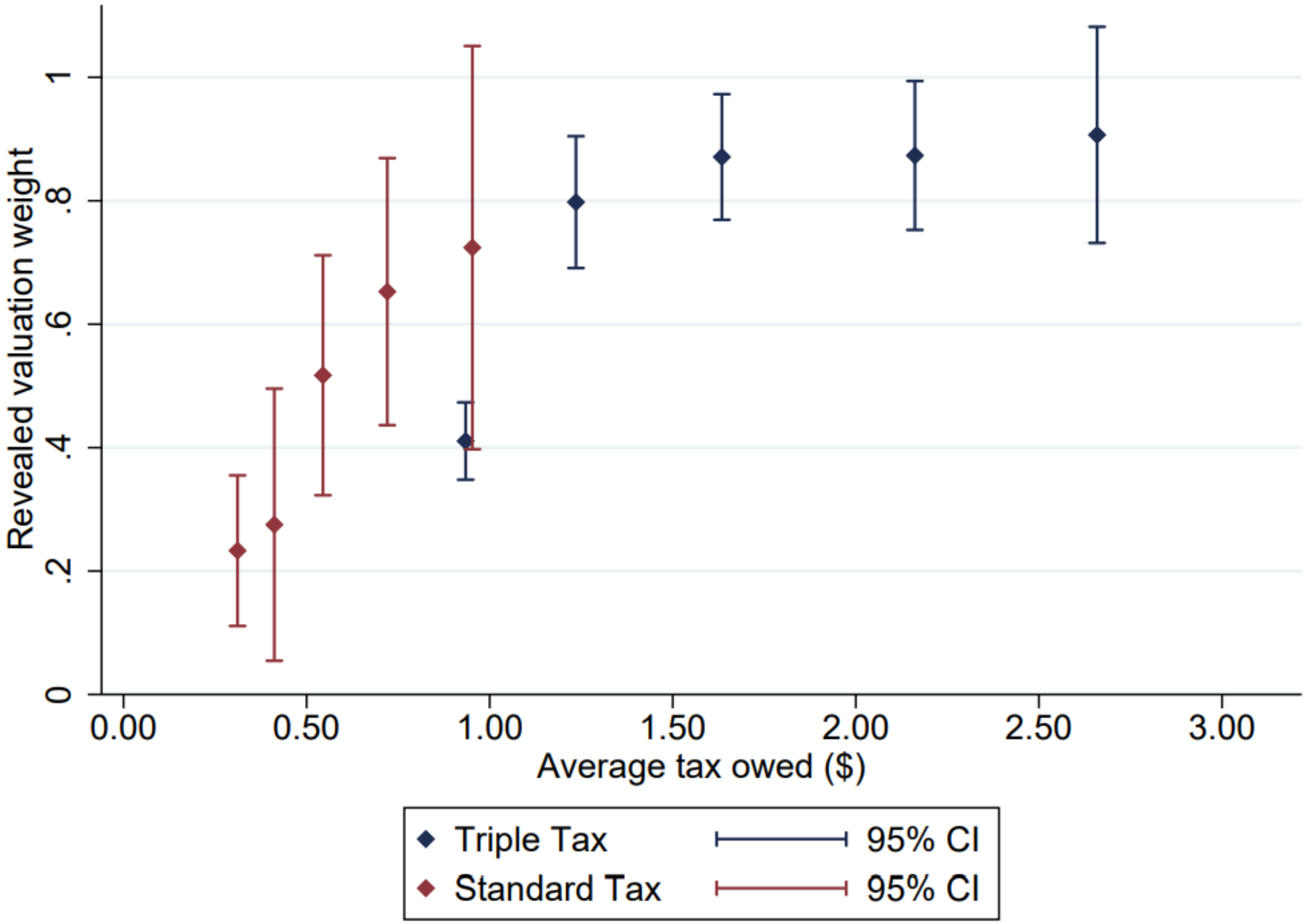
- Coefficients $\bar{\theta}_B$ and $\bar{\theta}_C$ approximate $E[\theta_{ijk}|k = B]$ and $E[\theta_{ijk}|k = C]$, respectively
  - Prediction 1 says that $E\left[\theta_{ijk}\middle|k = B\right] \leq E[\theta_{ijk}|k = C]$

- Authors use (4) to estimate $E[\theta|\text{subsample}]$ for various cuts of the data

Average θ versus Price level, $E[\theta|p < p^\dagger]$



Average θ versus Tax level, $E[\theta|\tau \approx \tau^{\dagger}]$



Mechanism for underreaction

- Incorrect beliefs or Computational ability?

- Try restricting sample to those who:
  - Have precise knowledge of their state's sales tax rate (~70% of participants)
  - Able to precisely compute tax burden (~63% of participants)

- Neither restriction changes results

- Authors: consistent with costly mental effort to compute taxes, rather than incorrect beliefs about taxes or inability to compute tax burden

Individual-level responses to stakes

- Previously, covered relationship between *average* θ and stakes
- Next, examine how *individual-level* revealed valuation weight responds to stakes
- Problem is that individual-level measured weight, $\hat{\theta}_{ijk}$, has a lot of noise
  - Cannot be used to compute properties of the θ distribution
- Solution: group by high and low estimated weight to reduce noise

Individual-level responses to stakes

- The observed individual-level weight is given by $\hat{\theta}_{ijk} = \frac{\ln\left(p^*_{ijA}\right)-\ln\left(p^*_{ijk}\right)}{\ln(1+\tau_{ik})}$
- **Problem: individual-level estimates $\boldsymbol{\hat{\theta}_{ijk}}$ are very noisily measured**
  - E.g., ~33% of individuals are willing to buy at a higher pre-tax price under standard tax regime than under zero tax.
- Use $\hat{\theta}_{i1B}$ (revealed weight for the standard tax regime relative to no tax, for good 1)
  - Divide into two groups: above and below 75th percentile of $\hat{\theta}_{i1B}$ distribution
- Estimate $E[\theta]$ for high and low group, using only goods 2 and 3
  - Uses same probit estimator from before

Estimation procedure

Product 1		Products 2 and 3
High Valuation Wgt $\hat{\theta}_{i1B}$ in top 25%	→	**High Valuation Wgt** $E[\theta_{ijk} \mid k = K, j \neq 1] = ?$
Low Valuation Wgt $\hat{\theta}_{i1B}$ in bottom 75%	→	**Low Valuation Wgt** $E[\theta_{ijk} \mid k = K, j \neq 1] = ?$

Step 1: use product 1 decisions to split the sample into high and low revealed valuation weight groups.

Step 2: calculate $E[\theta_{ijk} \mid k = K, j \neq 1]$ for each store $K \in \{B, C\}$ and each valuation weight group using the other two products.

Testing Predictions 2 and 3

Prediction 2: Consumers with higher θ under standard stakes will also have higher θ under high stakes.

Table 1: Average revealed valuation weights by group

	Standard	Triple	Triple − Standard
(1): High valuation wgt.	1.04	1.20	0.16
	[0.83, 1.26]	[1.10, 1.31]	[-0.02, 0.33]
(2): Low valuation wgt.	0.25	0.64	0.39
	[0.08, 0.42]	[0.57, 0.72]	[0.26, 0.52]
(3): (1) − (2)	0.79	0.56	-0.23
	[0.52, 1.06]	[0.44, 0.68]	[-0.43, -0.03]
(4): Full sample	0.48	0.79	0.31
	[0.32, 0.63]	[0.72, 0.86]	[0.20, 0.42]

Rows (1) and (2) of table 1 present estimates for the high and low valuation weight groups, whose construction is described in Section 5.1. Row (3) presents the difference of the estimates in rows (1) and (2), for each column. Row (4) presents estimates using the full sample. The "Standard" column contains estimates of store B valuation weights in each of the two groups, as well as the differences between these groups. The "Triple" column contains estimates of store C valuation weights in each of the two groups, as well as the differences between these groups. The "Triple-Standard" column presents estimates of $E[\theta_{ijC}] - E[\theta_{ijB}]$ for each of the two groups in rows (1) and (2), and contains the differences in differences in row (3). Bootstrapped confidence intervals from 1000 replications, clustered at the subject level, are reported in brackets.

Testing Predictions 2 and 3

Prediction 3: Consumers with highest θ under standard stakes will increase θ the smallest amount when moving to higher stakes.

Table 1: Average revealed valuation weights by group

	Standard	Triple	Triple − Standard
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	[0.83, 1.26]	[1.10, 1.31]	[-0.02, 0.33]
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Individual-level responses to stakes

- **Prediction 4**: Consumers whose θ *increases the least* when moving to higher stakes have the highest levels of θ under standard and high stakes

- Define "adjustment": $\Delta_{ij} \coloneqq \theta_{ijC} - \theta_{ijB}$

- Empirical strategy is analogous to previous set of results (to deal with individual-level measurement error)

- Individual-level adjustment to high stakes, $\widehat{\Delta}_{ij} \coloneqq \hat{\theta}_{ijC} - \hat{\theta}_{ijB}$
  - Divide consumers into above and below 25th percentile of $\widehat{\Delta}_{ij}$

- For $j' = 1,2,3$
  - Estimate $E\left[\theta_{ij} \middle| j \neq j'\right]$ separately for low- and high-adjustment groups
  - Average across products

Testing Prediction 4

Prediction 4: Consumers whose θ *increases the least* when moving to higher stakes have the highest levels of θ under standard and high stakes

Table 2: Average revealed valuation weights by adjustment group

	Standard	Triple	Triple − Standard
(1): Low Adj.	0.85	0.86	0.01
	[0.64, 1.07]	[0.77, 0.96]	[-0.15, 0.17]
(2): High Adj.	0.34	0.76	0.43
	[0.17, 0.51]	[0.68, 0.84]	[0.30, 0.55]
(3): (1) − (2)	0.52	0.10	-0.42
	[0.28, 0.75]	[-0.01, 0.20]	[-0.60, -0.24]
(4): Full sample	0.48	0.79	0.31
	[0.32, 0.63]	[0.72, 0.86]	[0.20, 0.42]

Rows (1) and (2) of table 2 present estimates for the low and high adjustment groups, whose construction is described in Section 5.2. Row (3) presents the difference of the estimates in rows (1) and (2), for each column. Row (4) presents estimates using the full sample. The "Standard" column contains estimates of store B valuation weights in each of the two groups, as well as the differences between these groups. The "Triple" column contains estimates of store C valuation weights in each of the two groups, as well as the differences between these groups. The "Triple-Standard" column presents estimates of $E[\theta_{ijC}] - E[\theta_{ijB}]$ for each of the two groups in rows (1) and (2), and contains the differences in differences in row (3). Bootstrapped confidence intervals from 1000 replications, clustered at the subject level, are reported in brackets.

Takeaways

- Evidence is broadly consistent with predictions of costly attention models
- Concerns:
  - This is a very low stakes setting (low probability of choices being implemented, as well as low dollar values)
  - Effects of increasing tax level on attention are surprisingly large – could they explain inattention at relatively higher stakes?