Market Power and the Laffer Curve

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Introduction

- Alcoholic beverage sales heavily regulated.
  - Historically, due to concerns about external costs of alcohol consumption (health, social, drunk driving etc.)
  - Typical regulation: uniform excise taxes. Significant source of government income.
  - Our case: The Pennsylvania Liquor Control Board (PLCB), operating a monopoly in the sales of wine & spirits.
    - Applies a single markup to all products, akin to typical excise tax.
    - Recent discussions about pricing rule: "We [the PLCB] ... strive both to increase revenue and maintain fair ... prices for consumers."
    - PLCB contributes ~$600m to PA state treasury annually.
- Tax revenue generation central consideration in setting tax rates / markup policy.

Introduction, cont'd

- Taxed producers are large, multi-product firms.
  - Example – spirits category (our focus) over 2002-2004:
    - 37 distillers but PA market share of top three (Diageo, Bacardi, Beam) is 43%.
    - Unconcentrated overall: HHI of 930.
  - Non-overlapping product portfolios across manufacturers:
    - PA portfolios: from 1 to 63 significant products; avg 8.4 products.
    - Typically clustered within spirits types $\rightarrow$ significantly higher concentration in subpockets of product space.
    - HHI for rums of $\sim$3,000; for brandy and gin of $\sim$2,000.
  - Gross profit margin for publicly traded distillers: 37.8%.
  - Post-sample merger activity subject to regulatory scrutiny and divestiture conditions.
- Taxed firms have market power — Is there a Laffer curve?

Research Questions

- Does the PLCB's chosen tax rate/markup maximize tax revenue under the naïve assumption that distillers do not adjust wholesale price to the agency's choice of tax rate?
- To what extent can upstream repricing undo the tax revenue generation potential at each tax rate?
  - How do firms respond to changes in tax rates?
  - How does increased market power upstream affect this response?
- Who bears the burden of naïve policies that abstracts from upstream responses?
  - Preference heterogeneity for spirits correlates with demographics.
  - Differential concentration by spirit type translates into different tax incidence across demographic groups.

Empirical Approach

- BLP / RCNL demand estimation using detailed data in PA for 2002-2004.
  - Wholesale/retail prices and quantity sold in all stores.
  - 312 horizontally-differentiated products of 34 upstream firms.
  - Consumption linked to demographics.
  - Features of the regulation increase identification.
- Recover upstream marginal cost of each product.
  - We do not impose maximizing behavior on the regulator.
- Compare current tax to counterfactual policies: optimal tax rates under different degrees of regulatory foresight.
  1. *Naïve*: no strategic response by upstream firms to tax rates.
  2. *Response*: firms re-optimize wholesale prices to chosen tax rate.
  3. *Perfect Foresight*: regulator correctly anticipates upstream response (SPNE).

Agenda

- Laffer curve: optimal taxation with a monopoly supplier.
- Institutional details:
  - $PLCB$.
  - Sales data.
  - Pricing rule.
  - Consumers and distillers.
- Model.
- Estimation.
- Optimal tax rates and tax incidence under different conduct foresight environments.
- Summary and Conclusions.

Monopoly

Tax Rate/Revenues Trade-off in Monopoly Model

Consider single product monopolist facing proportional tax rate τ.

- Monopolist chooses pre-tax price p^w, resulting in retail price p^r:

$$p^r = (1+\tau)p^w \,.$$

- Profit maximization $\rightarrow$ set p^w so demand is elastic at implied p^r:

$$\frac{p^w - c}{p^w} = \frac{-D(p^r)}{D'(p^r)(1+\tau)} \cdot \frac{1+\tau}{p^r} = \frac{-1}{\varepsilon(p^r)} \,.$$

Firm Response to Tax Rates

How does the pre-tax price respond to changes in tax rate τ?

- Response elasticity:

$$\eta(\tau) \equiv \frac{dp^w}{d\tau} \cdot \frac{\tau}{p^w} = \frac{-\tau}{1+\tau} \cdot \frac{\left(1 - \frac{1}{\varepsilon(p^r)}\right) - \kappa(p^r)}{2 - \kappa(p^r)},$$

  where $\kappa(p^r)$ curvature of demand.

  - $\kappa(p^r) < 1 \to \eta(\tau) < 0$ [*e.g.* log-concave demand such as Logit].
  - $\kappa(p^r) \in [1, 2) \to \eta(\tau) < 0$ dep on $\kappa(p^r)$ relative to $\varepsilon(p^r) < -1$.
  - Limiting case: isoelastic demand when $\eta(\tau) = 0$.

- Tax rate and pre-tax price strategic substitutes for large class of empirically relevant demand systems. See Fabinger & Weyl (2016).

Tax Rate/Revenue Trade-off

- Government Revenues: $T = \tau \cdot p^w \cdot D\big((1+\tau)p^w\big)$.
- Tax Rate/Revenue Trade-off:

$$\text{sign}\left(\frac{dT}{d\tau}\right) = \text{sign}\left\{1 + \frac{\tau}{1+\tau}\cdot\varepsilon(p^r) + \eta(\tau)\cdot(1+\varepsilon(p^r))\right\}.$$

- Can we get "overpricing" or $dT/d\tau < 0$?
  1. No upstream response ($\eta(\tau) = 0$):

$$\varepsilon(p^r(\tau)) < \varepsilon^\circ(\tau) = -\frac{1+\tau}{\tau}.$$

  2. Upstream response ($\eta(\tau) < 0$ w/ log-concave demand):

$$\varepsilon(p^r) < \varepsilon^\star(\tau,\kappa) = -\frac{2-\kappa(p^r)+\tau}{\tau} < -\frac{1+\tau}{\tau} = \varepsilon^\circ(\tau).$$

Tax Rate/Revenue Trade-off, cont'd

Effect of upstream response on tradeoff between τ and T:

- Revenue maximizing tax rate differs:

$$\tau^{\star}(\varepsilon,\kappa) = -\frac{2-\kappa(p^r)}{1+\varepsilon(p^r)} > -\frac{1}{1+\varepsilon(p^r)}$$
$$= \tilde{\tau}^{\circ}\left(\varepsilon(p^r(\tau^{\star}))\right) \approx \tau^{\circ}\left(\varepsilon(p^r(\tau^{\circ}))\right)$$

- Laffer curve becomes flatter:
  - Strategic price response limits revenue response to changes in τ.
  - Captured by addition of $\eta(\tau) \times (1+\varepsilon(p^r)) > 0$ to $dT/d\tau < 0$.
- Next: empirically evaluate conclusions for less stylized setup
  - Oligopolistic, multi-product, firms.
  - Beyond no-purchase option, account for cross-product substitution.

Data

The PA Alcohol Beverage Industry

- Strictly regulated since Prohibition.
- Alcoholic beverage consumption by segment (volume).
  - Beer (91%)
  - Wine (5%)
  - **Spirits (4%)**
- PLCB tax revenue by segment.
  - Beer (<1%)
  - Wine (36%)
  - **Spirits (63%)**
- Location of sales in PA (bottles).
  - **78% @ state-run stores – "Off-premise"**.
  - 22% @ bars and restaurants – "On-premise".

PLCB and Demographic Data

- Store-level panel data obtained from PLCB for 2002-2004, including daily sales by product, wholesale, and retail prices.
- Retail price fixed during each "pricing period" $\approx$ month.
  $\Rightarrow$ 34 pricing periods; 312 products (3 bottle sizes).
- Identical retail prices across stores at a point-in-time.
  - 456 store markets mid-sample.
  - Variation in product set across stores, though most popular products available in all.
- Connect demographics to closest store.
  - Identifies preference heterogeneity.
  - Also observe exogenous opening/closing of stores.
- Total $\Rightarrow$ 13,090 month-markets for a total of 3,377,659 observations.

Differentiated Products

	Products	Price	Share	% Flavored	% Imported	Proof
By Spirit Type:						
BRANDY	26	13.90	7.26	30.77	26.92	76.15
CORDIALS	62	15.10	13.59	32.26	51.61	55.82
GIN	28	15.59	6.72	3.57	28.57	83.42
RUM	40	14.32	16.31	10.00	17.50	74.03
VODKA	66	13.76	32.10	21.21	40.91	81.60
WHISKEY	90	16.74	24.03	0.00	58.89	80.98
By Price and Size:						
EXPENSIVE	150	19.91	53.00	12.00	64.67	77.82
CHEAP	162	10.50	47.00	17.90	22.84	72.46
375 ML	48	7.15	15.21	8.33	47.92	75.10
750 ML	170	14.49	50.29	21.76	44.71	72.95
1.75 LTR	94	18.83	34.50	6.38	37.23	78.77
ALL PRODUCTS	312	14.87	100.00	16.30	37.40	75.33

- Large set of products with heterogenous characteristics.
- Median store carried 98% of the top 100 best selling products statewide.
- Add `Proof66.com` scores to control for quality.

PLCB Single Markup Pricing Rule

Pricing rule established by State Legislature.

- Use of uniform markups across products:

$$p_j^r = \left[p_j^w \times 1.30 + LTMF_j\right] \times 1.18\,.$$

  - "LTMF" (logistics, transportation and merchandise factor) is a per unit handling fee that varies across bottle sizes.
  - An 18% liquor tax (*i.e.*, 1936 "Johnstown Flood Tax").
- Our focus is on 53.4% markup $\equiv$ *ad valorem* tax.

Changes in Retail Price

- Changes in wholesale price can occur monthly and translate to changes in retail price following the PLCB pricing rule.
  - 85% of price changes, generally a decrease ($\approx$ \$1) in wholesale price.
- Wholesale price changes regulated: limited to four times a year in at most two consecutive months; announced three months in advance.
  - 65.3% of products go on sale at least once per year.
  - Average product goes on sale 2.3 times.
  - Distillers cannot react immediately to unanticipated demand shocks.
- Distillers can change the reference price at four points in the year.
  - 15% of price changes, generally an increase in wholesale price.

Frequency of Sales

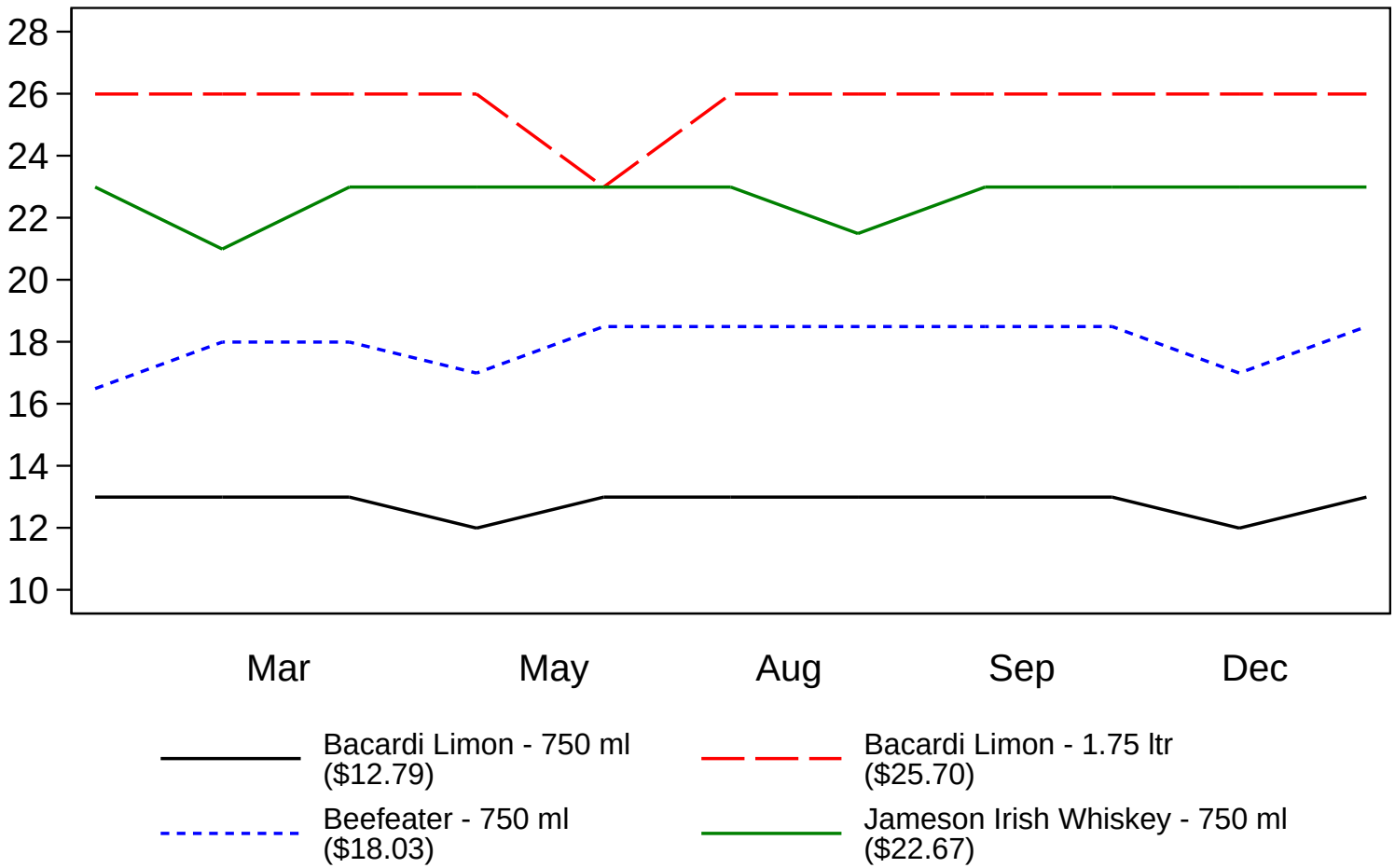
Table: Percent of Products Placed on Sale Over the Year

	Spring	Summer	Fall	Winter	Holiday	Year	Times
By Spirit Type:							
Brandy	30.77	50.00	34.62	26.92	34.62	59.26	2.37
Cordials	40.32	48.39	30.65	45.16	43.55	61.29	2.35
Gin	46.43	39.29	50.00	39.29	39.29	63.64	2.24
Rum	47.50	40.00	50.00	32.50	42.50	57.45	2.12
Vodka	50.00	60.61	57.58	39.39	50.00	76.81	2.24
Whiskey	58.89	51.11	48.89	42.22	53.33	65.71	2.51
By Price and Size:							
Expensive	40.32	48.39	30.65	45.16	43.55	71.66	2.14
Cheap	45.68	41.36	41.98	32.10	37.65	30.91	1.39
375 ml	14.58	18.75	20.83	8.33	6.25	72.28	2.91
750 ml	50.59	53.53	45.88	46.47	51.18	75.44	2.22
1.75 ltr	61.70	59.57	59.57	42.55	58.51	55.23	2.50
All products	48.40	50.00	46.15	39.42	46.47	65.31	2.34

- Sales patterns common across most products (less frequent for 1.75 ltr).
- Seasonality: sales are more common during summer and less over winter.
- Nearly half of products go on sale between Thanksgiving and New Year.

Sales

Figure: Changes in 2003 Retail Price ($)



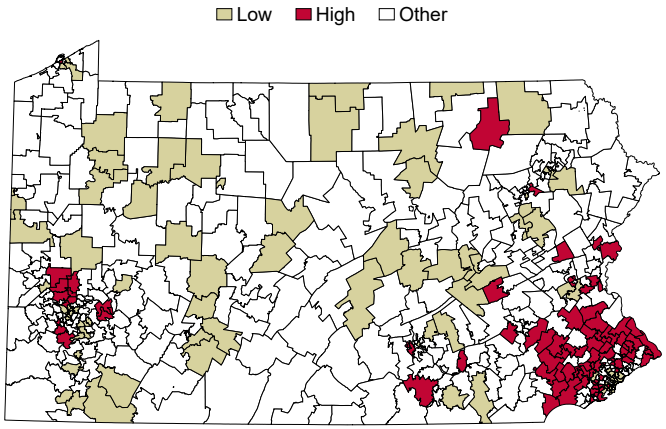
Heterogeneity Among Upstream Distillers

Table: The Upstream Market

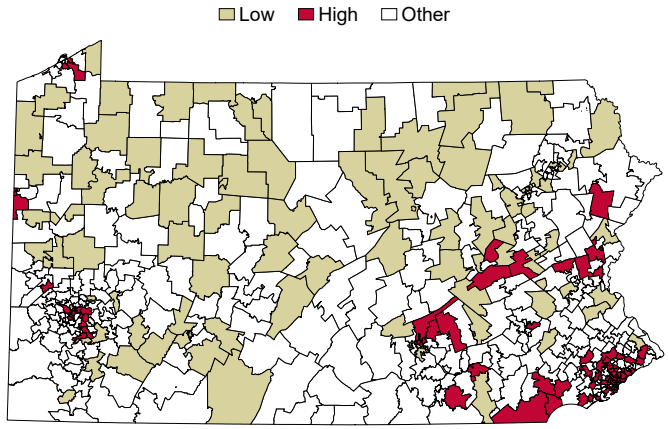
		Share of Spirit Market		Top Selling Product	
Firm	Products	By Revenue	By Quantity	Name	Type
Diageo	63	21.60	24.48	Captain Morgan	Rum
Bacardi	22	8.92	9.79	Bacardi Light Dry	Rum
Beam	32	9.86	9.01	Windsor Canadian	Whiskey
Other Firms (34)	195	59.62	56.72	SKYY (Campari)	Vodka

- Asymmetric industry composition.
- Firms have different product portfolios.
  - Diageo - rums, vodkas, & whiskeys generate 19.6, 31.8, and 24.4% of revenue
  - Bacardi - 70.2% of revenue from rums
  - Beam - 4.1% of revenue from rums

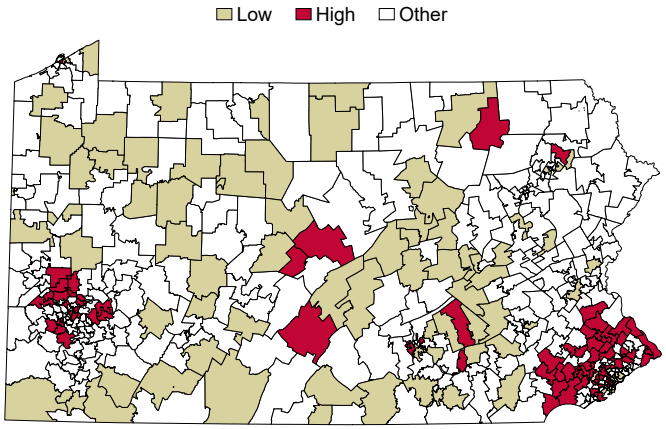
Heterogeneous Demographics Across Local Markets



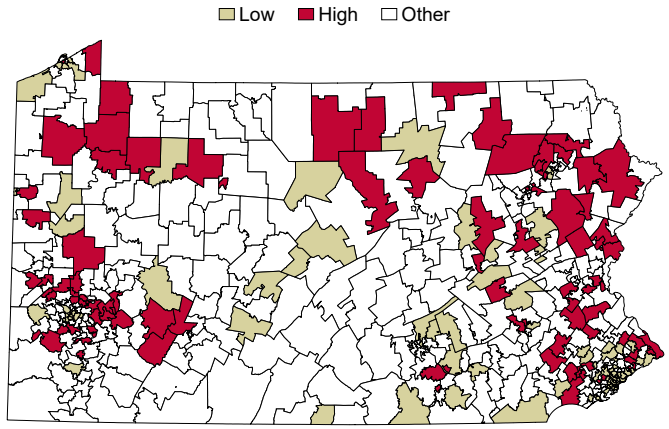
(A) Income



(B) Minority

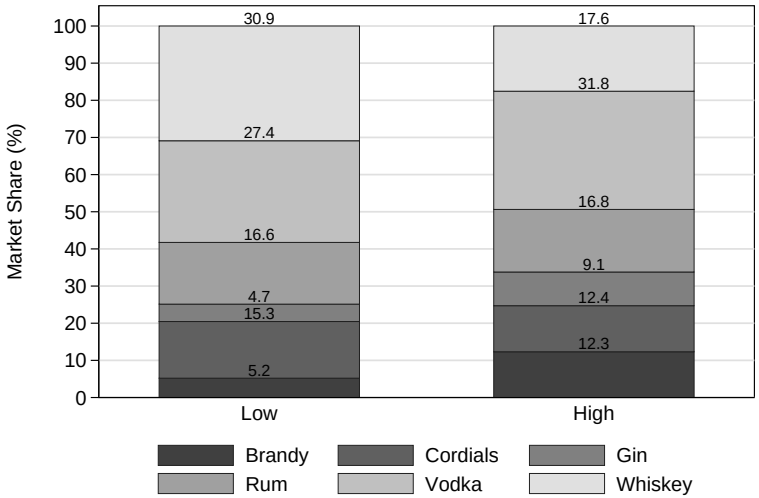


(C) Education

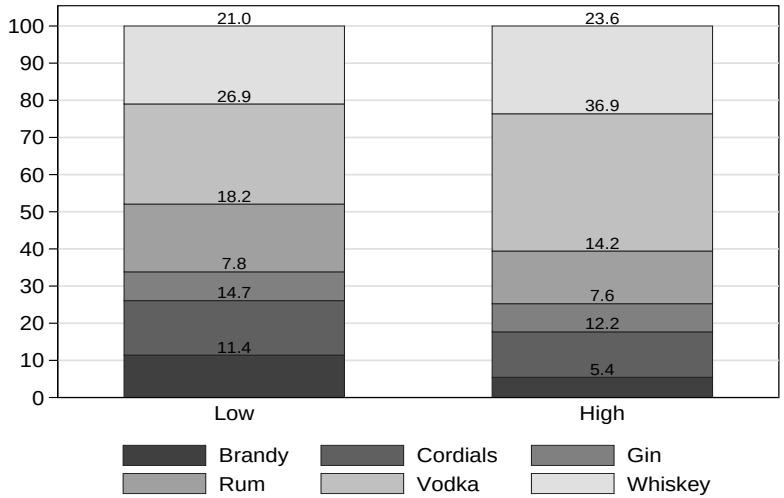


(D) Age

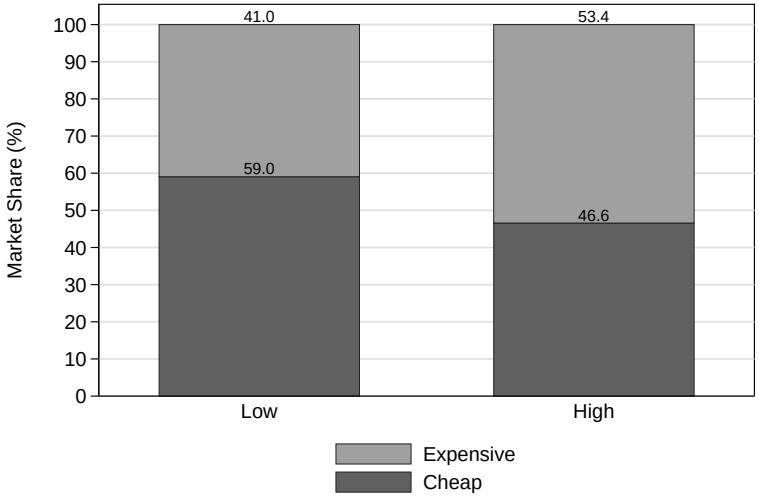
Demographics and Consumption



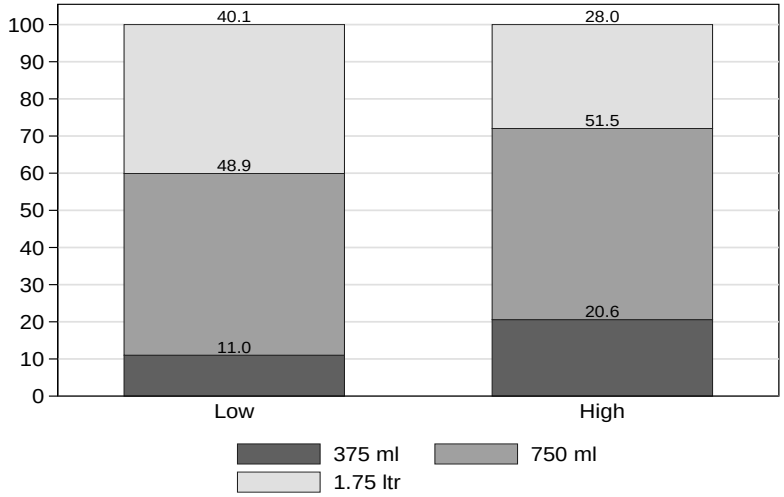
(A) Minority and Spirit Type



(B) Level of Education and Spirit Type



(C) Income and Price



(D) Age and Bottle Size

Model

Model Overview

model details

- Stackelberg SPNE:
  1. $PLCB$ sets the markup policy.
  2. Upstream firms choose wholesale prices $\Rightarrow$ retail prices.
  3. Consumers maximize utility.
- Static BLP discrete choice model of demand $\sim$ Nevo (2001).

  $\rightarrow$ Each period a consumer chooses whether to buy an off-premise bottle at a state-run store or the outside option.
- Consumer product demand allowed to vary systematically with demographics.
- Unique features for identification:
  - Price constant across state in each period.
  - Regulation limits firms' ability to respond to demand shocks.

Potential Market

Defined as total off-premise consumption of alcoholic beverages: spirits (44% ethanol), beer (4% ethanol), and wine (12% ethanol).

$\Rightarrow$ Hold total consumption of alcoholic beverages fixed but policy can change the mix (*i.e.*, ethanol consumption).

- Calculate using market population (over 21) and per capita consumption of alcoholic beverages (ml) from the National Institute on Alcohol Abuse and Alcoholism.
- Outside option (beer, wine) denominated in 750ml bottle-equivalents.

Profits of Upstream Distillers

- F distilleries in the upstream market where each firm $f \in F$ produces a subset J_t^f of the $j = 1, \ldots, J_t$ products which is fixed.
- Firms choose prices to maximize period t profit:

$$\max_{p_t^w} \left[\sum_{j \in J_t^f} (p_{jt}^w - c_{jt}) \times \underbrace{\sum_{l=1}^{L} M_l s_{jlt}(p, x, \xi; \theta)}_{\text{statewide demand for product j in period t}} \right]$$

Distillers' Optimal Prices

- Vector of profit-maximizing wholesale prices solves:

$$p_t^w = c_t + \underbrace{[O_t^w * \Delta_t^w]^{-1} \times s_t(p, x, \xi; \theta)}_{\$ \text{ markup}} .$$

- O_t^w is the ownership matrix for the upstream firms.
- Δ_t^w is a matrix which captures changes in consumer demand due to changes in wholesale price.

$$\Delta_t^w = \Delta_t^d \Delta_t^{p\prime} = \begin{bmatrix} \frac{\partial s_{1t}}{\partial p_{1t}^r} & \cdots & \frac{\partial s_{1t}}{\partial p_{Jt}^r} \\ \vdots & \ddots & \vdots \\ \frac{\partial s_{Jt}}{\partial p_{1t}^r} & \cdots & \frac{\partial s_{Jt}}{\partial p_{Jt}^r} \end{bmatrix} \times \begin{bmatrix} 1.534 & \ldots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \ldots & 1.534 \end{bmatrix}$$

Results

Estimation in Three Steps

▸ estimation details

A. Estimate (Σ, Π) via GMM with product-period and store FEs.

- *Identified by BLP concentration measures interacted with demographics.*

B. Use estimated product-period FEs to identify mean utility price (α) and seasonality coefficients (β) via 2SLS.

- Price instruments = avg price in control states outside NE, input futures (*e.g.*, price of sugar) interacted with spirit type.

- *Identified by consumption variation w/in product in 2003-2004.*

C. Use estimated product FEs from (B) to identify remaining mean utility coefficients (β).

- *Identified by consumption, observable characteristics (e.g., spirit type, proof, flavored, etc.).*

RCNL Estimates

Table: RCNL Demand Estimates

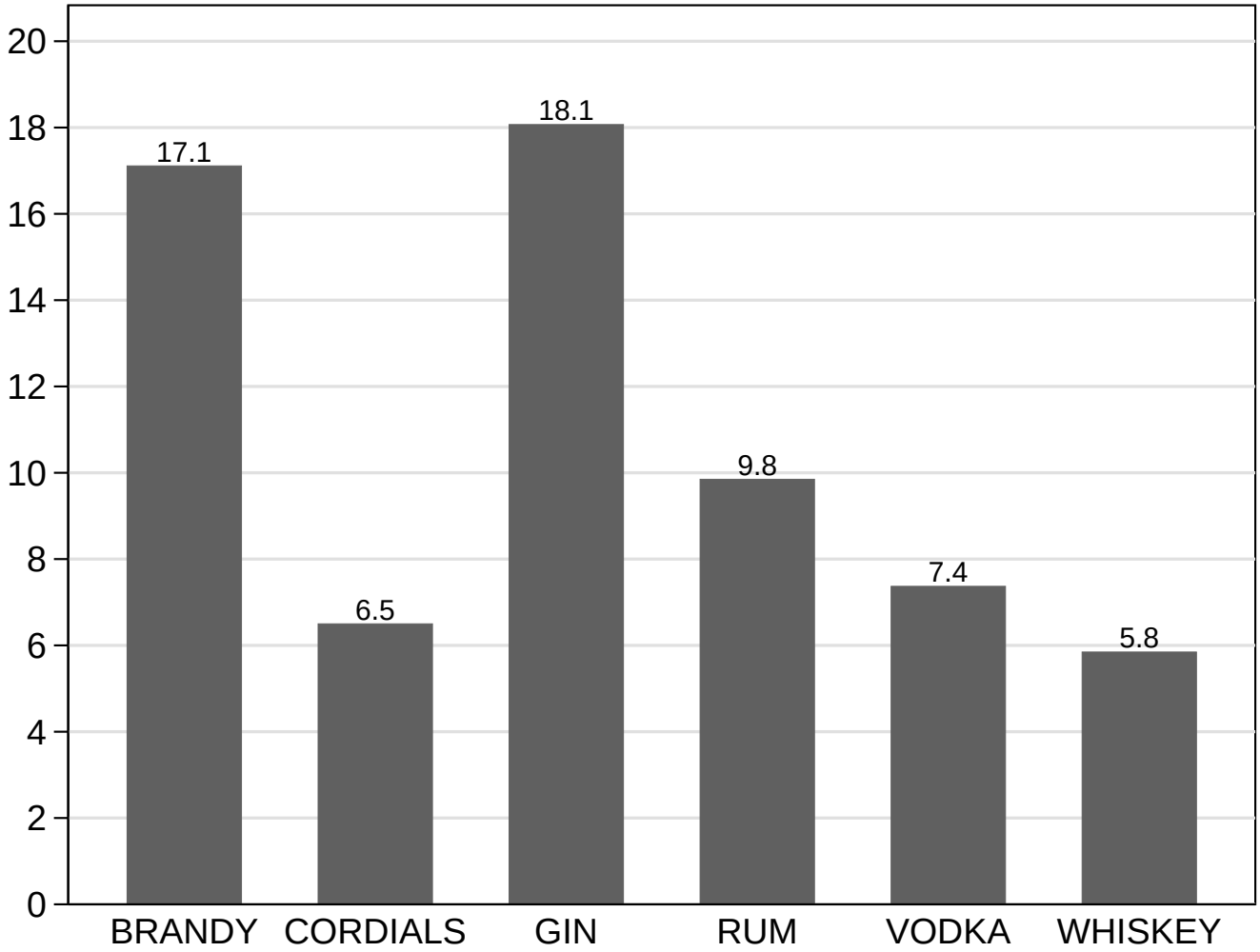
	Mean Utility (β)	Random Coeff. (Σ)	Demographic Interactions (Π)			
			Income	Young	Minority	College
price	-0.3062		0.1151			
	(0.0036)		(0.0036)			
holiday	0.3153					
	(0.0057)					
summer	0.0557					
	(0.0049)					
375 ml	-2.9554					
	(0.5608)					
750 ml	-7.5816	0.5939		22.7684	0.4025	4.9886
	(0.4037)	(0.3061)		(3.2953)	(0.0844)	(0.2976)

- High income consumers are less price sensitive.
- Significant variation in preference for bottle size.

Table: RCNL Demand Estimates

	Mean Utility	Random Coeff.	Demographic Interactions (Π)			
	(β)	(Σ)	Income	Young	Minority	College
Brandy	0.3882			0.8616	1.3978	-0.8738
	(0.6902)			(0.2288)	(0.0231)	(0.0518)
Cordials	0.2977					
	(0.7163)					
Rum	-4.7646			11.5406	-0.1628	0.6795
	(0.8355)			(2.9485)	(0.0146)	(0.0426)
Vodka	-1.9611			4.9747	-0.3713	4.2314
	(0.4835)			(0.6656)	(0.0233)	(0.2701)
Whiskey	0.3875			1.2203	-0.9270	0.9549
	(0.5123)			(0.2059)	(0.0231)	(0.0554)
Flavored	3.7007			-4.9731	-0.5111	-3.2395
	(0.4848)			(0.7219)	(0.0374)	(0.1943)
Imported	1.3598	0.1912				
	(0.3519)	(0.5134)				
Proof	15.1897	1.2575		-26.0064	1.6695	-5.5765
	(1.6844)	(0.2505)		(4.2377)	(0.0913)	(0.4402)
Quality	3.9347					
	(2.1101)					
Nest (ρ)		0.1225				
		(0.0139)				

Closer Substitutes within Spirit Types



Estimated Elasticities, Marginal Costs, Market Power

		$\varepsilon(p^r)$		$\hat{c}$		Lerner	
	Price	Avg	SD	Avg	SD	Avg	SD
By Spirit Type:							
BRANDY	15.41	-3.65	1.49	5.92	4.49	37.56	17.00
CORDIALS	14.57	-3.64	1.22	5.78	3.74	35.26	12.23
GIN	15.15	-3.86	1.54	6.69	5.10	34.86	13.78
RUM	13.15	-3.57	1.08	5.36	2.97	36.66	12.86
VODKA	16.66	-4.05	1.47	7.11	4.77	34.67	18.73
WHISKEY	16.65	-4.07	1.50	7.29	4.95	32.51	12.90
By Price and Size:							
EXPENSIVE	20.37	-4.73	1.37	9.43	4.62	25.94	8.15
CHEAP	11.04	-3.04	0.84	3.79	1.98	42.92	14.75
375 ML	9.16	-2.54	0.83	2.71	2.07	53.54	20.32
750 ML	14.43	-3.76	1.23	5.99	3.57	34.35	11.28
1.75 LTR	21.16	-4.68	1.39	9.34	5.13	26.30	6.80
ALL PRODUCTS	15.63	-3.86	1.41	6.53	4.51	34.66	14.70

- Significant variation in estimated product elasticities.
- Reasonable cost estimates: higher for expensive and aged products.
- Substantial market power but heterogeneous across products.

Heterogenous Price Responsiveness across Demographics

	Income		Young		Minority		College	
	Low	High	Low	High	Low	High	Low	High
Outside Good	-2.98	-2.64	-2.74	-2.83	-3.06	-2.78	-3.07	-2.61
By Spirit Type:								
brandy	-4.01	-3.24	-3.40	-3.86	-3.61	-3.94	-3.87	-3.33
cordials	-4.06	-3.18	-3.43	-3.79	-3.80	-3.85	-4.00	-3.24
gin	-4.19	-3.48	-3.70	-3.94	-4.11	-3.93	-4.18	-3.50
rum	-3.96	-3.12	-3.36	-3.71	-3.72	-3.76	-3.91	-3.18
vodka	-4.42	-3.60	-3.84	-4.18	-4.18	-4.24	-4.38	-3.62
whiskey	-4.43	-3.64	-3.87	-4.21	-4.24	-4.26	-4.42	-3.68
By Price and Size:								
expensive	-5.17	-4.21	-2.85	-3.18	-4.94	-4.93	-5.15	-4.23
cheap	-3.39	-2.64	-4.49	-4.86	-3.18	-3.21	-3.34	-2.70
375 ml	-2.80	-2.22	-2.37	-2.68	-2.58	-2.70	-2.73	-2.29
750 ml	-4.18	-3.29	-3.53	-3.93	-3.89	-4.00	-4.12	-3.35
1.75 ltr	-5.08	-4.21	-4.44	-4.83	-4.84	-4.90	-5.05	-4.25
all products	-4.24	-3.43	-3.66	-4.00	-4.01	-4.05	-4.19	-3.47

- Low income consumer demand is more elastic (-4.24) than high income (-3.43). Similar trends for educational attainment.
- Aggregate off-premise spirit demand elasticity of -2.8.

Upstream Response and Pass-Through

	Wholesale Price Response (η)		Consumer Pass-Through	
	Avg	SD	Avg	SD
By Spirit Type:				
BRANDY	-0.20	0.12	0.41	0.12
CORDIALS	-0.19	0.08	0.42	0.09
GIN	-0.21	0.10	0.42	0.10
RUM	-0.20	0.09	0.40	0.09
VODKA	-0.18	0.12	0.43	0.12
WHISKEY	-0.17	0.09	0.44	0.10
By Price and Size:				
EXPENSIVE	-0.13	0.06	0.49	0.06
CHEAP	-0.24	0.10	0.36	0.09
375 ML	-0.31	0.13	0.30	0.13
750 ML	-0.18	0.07	0.42	0.08
1.75 LTR	-0.13	0.04	0.48	0.06
ALL PRODUCTS	-0.19	0.10	0.42	0.10

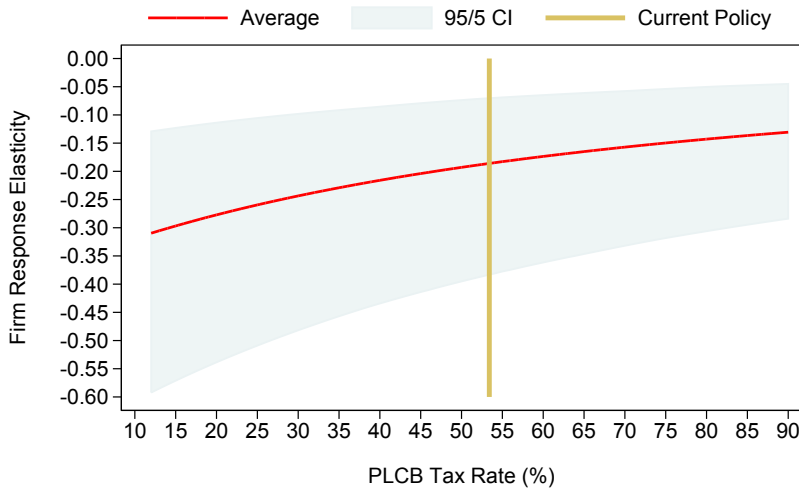
- Distillers pricing and tax rates are strategic substitutes.
- Most of the effect of a tax increase is not passed to consumers.

Maximizing Tax Revenue and Regulatory Foresight

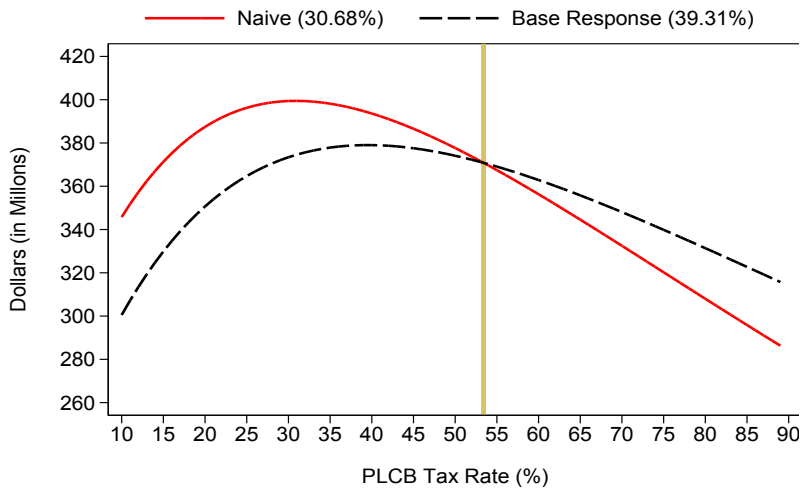
		Response			Stackelberg		
	Naïve	Base	Product	Monopoly	Base	Product	Monopoly
Markup (%)	30.68	30.68	30.68	30.68	39.31	39.18	42.07
Percent Change:							
- Bottles	47.52	34.59	38.05	8.11	19.62	22.89	-6.48
- Distiller Price (p^w)	0.00	3.79	2.80	13.19	2.21	1.31	10.03
- Retail Price (p^r)	-13.36	-10.45	-11.21	-3.22	-6.48	-7.29	1.72
- Distiller Profit	51.33	56.22	55.43	50.57	30.80	30.30	20.37
- Tax Revenue (T)	7.75	1.01	2.78	-14.18	2.23	3.99	-12.40
Elasticities:							
- Spirits (ε)	-2.63	-2.73	-2.72	-2.78	-2.76	-2.75	-2.80
- Upstream Response (η)	0.00	-0.24	-0.23	-0.36	-0.21	-0.21	-0.32

- Overpricing across degrees of foresight.
- Ignoring upstream response misleading. Limits revenue gains to 13% of projected revenue gain.
- Foregone tax revenue increases with upstream market power.

Distiller Response and the Laffer Curve



(A) Upstream Response Elasticity (η)

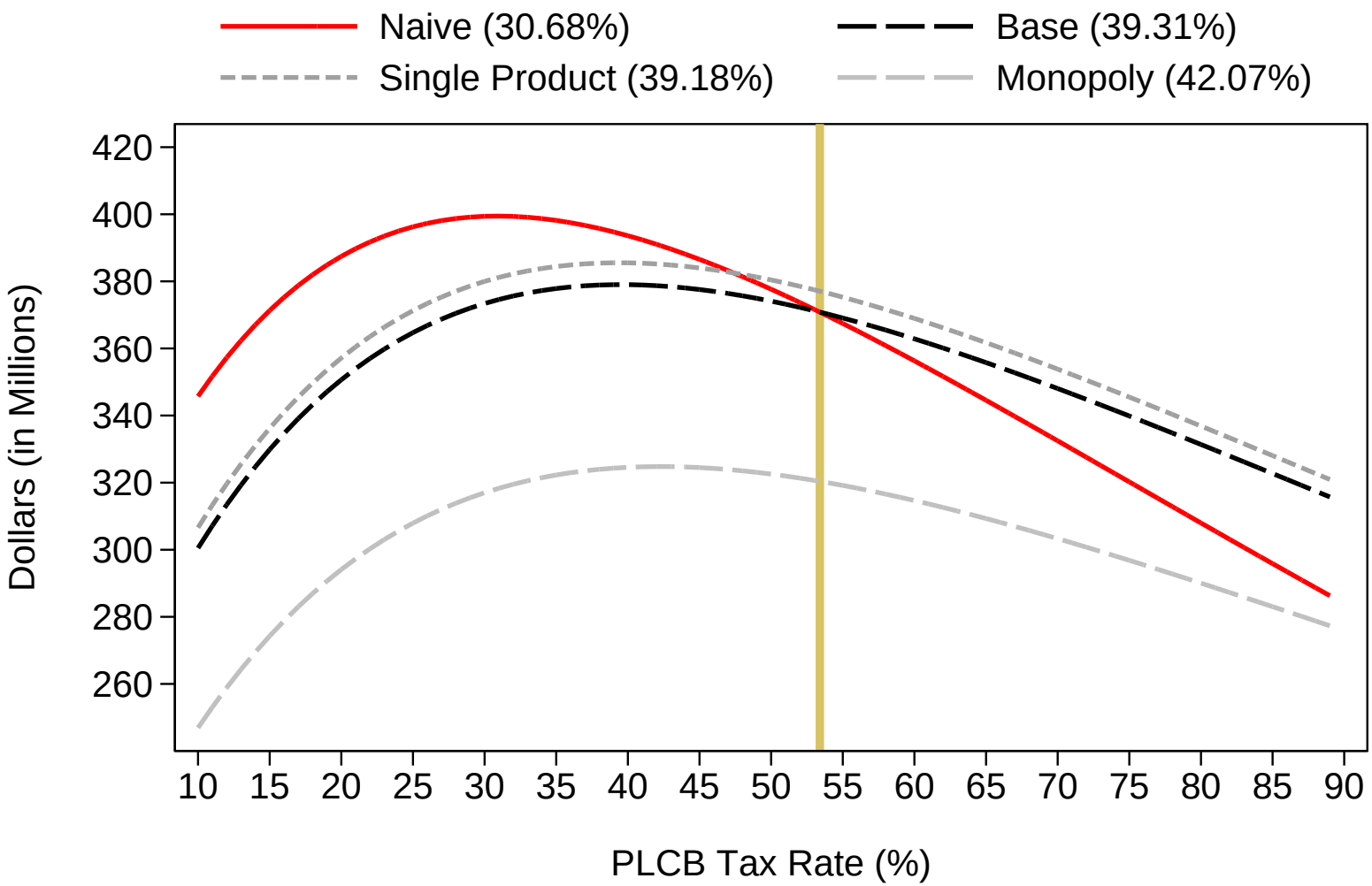


(B) Naïve and Response Laffer Curves

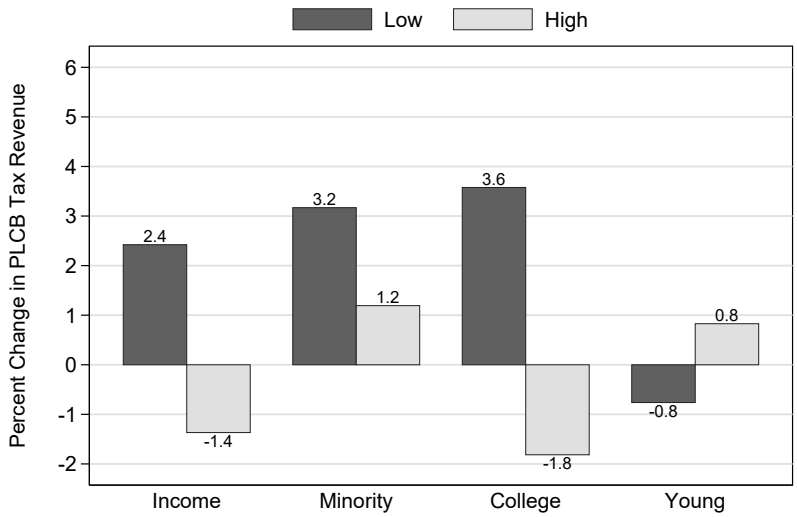
- Significant dispersion in upstream response.
- More muted response (but never zero) at higher tax rates.
- Distiller Response counters tax impact $\rightarrow$ Laffer curve shifts and flattens (as in monopoly model).

Laffer Curve and Upstream Conduct

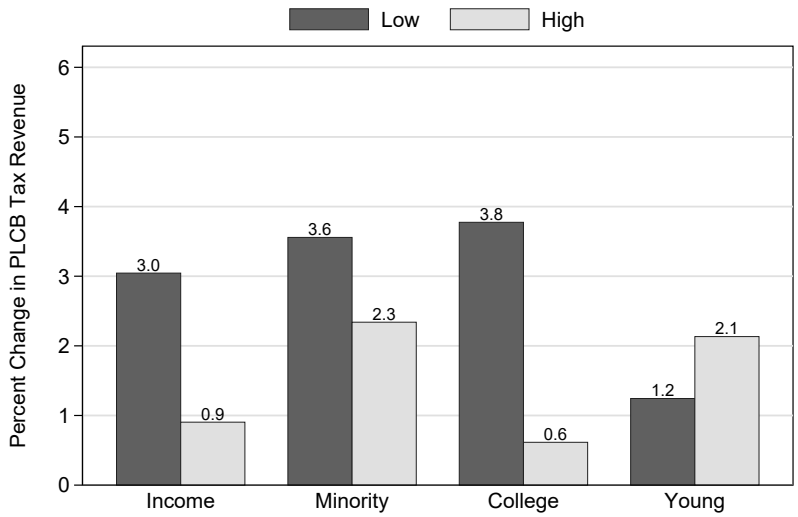
- So far, upstream tax response reflected actual brand portfolios.
- Now consider alternative degrees of upstream concentration.



Naïve Policy & Differential Consumer Burden



(A) Tax Revenue by Demographics, Response Equilibrium



(B) Tax Revenue by Demographics, Stackelberg Equilibrium

- Tax burden of naive policy falls differentially on markets with low-income, minority, poorly educated, and older consumers.
- Naive policy design has both efficiency and equity implications.
- Highlights potential for use of differential tax policy to realize redistributive or regulatory goals. Investigated in companion paper.

Summary

Summary

- We use a unique data set on liquor sales in PA to study interaction between upstream market power and tax policy on tax revenue.
- Upstream responses mitigate effect of tax policy on tax revenue, limiting value of tax rate instrument in affecting revenue.
  - Revenue gains of 7.8% from optimal taxation anticipated by a naive policy maker near eroded by distiller response.
  - Tax rate chosen by informed policy maker results in revenue gains of only 2.2%.
- Naive policies geared at meeting consumption reduction targets similarly vulnerable to undoing by upstream responses.
- Strategic responses affect efficiency & redistribution effects of tax policy $\rightarrow$ significant value to policies such as dynamic scoring.

Appendix

Utility function (I)

- Consumer utility:

$$u_{ijlt} = x_j\beta_i^* + \alpha_i^* p_{jt}^r + [h_t \quad q3_t]\gamma + \xi_{jlt} + \bar{\epsilon}_{ijlt}\,,$$

$$i = 1,\ldots,M_l; \quad j = 1,\ldots,J_{lt}; \quad l = 1,\ldots,L; \quad t = 1,\ldots,T\,.$$

  - x_j: observed product characteristics.
  - p_{jt}: price, *constant for a product across geographic markets*.
  - h_t: seasonality indicator (e.g., holiday).
  - ξ_{jlt}: vector of unobserved (to us) characteristics.
  - $\bar{\epsilon}_{ijlt} = \zeta_{igt} + (1-\rho)\epsilon_{ijlt}$: unobserved preference of consumer i for product j of group g in market l and pricing period t; $\bar{\epsilon}_{ijlt}$ and ϵ_{ijlt} are assumed distributed i.i.d. Type-I extreme value across all available products J_{it}.
  - $\rho \in [0,1]$ is the "nesting parameter." When $\rho \to 1$ products within spirit types are perfect substitutes. When $\rho \to 0$ estimates $\approx$ BLP.

Return to Model

Utility function (II)

- Random coefficients allow for individual heterogenous responses to spirit prices and characteristics:

$$\begin{pmatrix} \alpha_i^* \\ \beta_i^* \end{pmatrix} = \begin{pmatrix} \alpha_i \\ \beta_i \end{pmatrix} + \Pi D_{il} + \Sigma \nu_{il}\,, \quad \nu_{il} \sim N(0, I_{n+1})\,,$$

where:

  - Π is a $(n+1) \times d$ matrix of taste coefficients which vary by demographic.
  - D_{il}: d vector of demographics for consumers i in market l.
  - Σ measures the covariance in unobserved preferences across characteristics.
  - ν_{il}: vector of unobserved idiosyncratic taste components.

Return to Model

Predicted Market Shares (I)

- Because of the extreme value distribution of $\overline{\epsilon}_{it}$, the probability that consumer i purchases product j in market l in period t is:

$$s_{ijlt} = \frac{\exp\left(\frac{\delta_{jlt}+\mu_{ijlt}}{1-\rho}\right)}{\exp\left(\frac{I_{iglt}}{1-\rho}\right)} \times \frac{\exp(I_{iglt})}{\exp(I_{ilt})},$$

where

$$I_{iglt} = (1-\rho)\ln\sum_{m=1}^{J_g}\exp\left(\frac{\delta_{mlt}+\mu_{imlt}}{1-\rho}\right),$$

$$I_{ilt} = \ln\left(1+\sum_{g=1}^{G}\exp(I_{iglt})\right).$$

Return to Model

Predicted Market Shares (II)

- Mean utility:

$$\begin{aligned}\delta_{jlt} &= x_j\beta + \gamma h_t + \alpha p_{jt} + \xi_{jlt}\,, \\ \mu_{ijlt} &= \begin{pmatrix} x_j & p_{jt} \end{pmatrix} \left(\Pi D_{il} + \Sigma \nu_{il}\right)\,.\end{aligned}$$

- The market share in each location integrates out over observable and unobservable consumer attributes:

$$s_{jlt} = \int_{\nu_l}\int_{D_l} s_{ijlt} dP_D(D_i) dP_\nu(\nu_i)\,.$$

◂ Return to Model

Estimation – 1

- We decompose the structural error in product, period, and store fixed effects to account for differences in product quality across products and time as well as unobserved variation of the outside option across markets:

$$\xi_{jlt} = \xi_j + \zeta_l + \Delta\xi_{jt} + \zeta_{jlt} \, .$$

- We then define the structural error ω as product variation within a store, ζ_{jlt}.
- We estimate the random coefficients and demographic interactions, $\theta_1 = \{\Sigma, \Pi\}$, by GMM:

$$\hat{\theta}_1 = \underset{\theta_1}{\text{argmin}} \ \left\{ \omega(\theta_1)' Z W Z' \omega(\theta_1) \right\} \, ,$$

Return to Estimation

Estimation – 1

- To solve for the structural error ω we follow Somaini-Wolak (2015) and use a within transformation of the mean utility δ to remove product-period and store fixed effects.
- Product-pricing fixed effects remove the price variation, and thus price endogeneity is not a concern for the estimation of $\theta_1 = \{\Sigma, \Pi\}$.
- The remaining variation is (largely) due to differences in demographics in the cross-section. Instruments include:
  - Total number of products in the market which share a "cluster" with the product as in Bresnahan, Stern, and Trajtenberg (1997).
  - Average distance in product score space between the product and other products in the same "cluster."
  - Products of these instruments by the percentage of demographic characteristics (to allow for heterogeneous effects of attributes in different markets).

◂ Return to Estimation

Estimation – 2

- Given θ_1^*, we solve for the contribution of price, season, and product characteristics (θ_2) to mean utility.
- Price endogeneity is now a concern — We include the contemporaneous average price from liquor control states outside of the Northeast region as an instrument for price in matrix Z_2.
- Our identifying assumption is that cost shocks are national (since products are often produced in a single facility) but demand shocks are at mostly regional.
- Using the the estimated product-period fixed effects from the GMM estimation, y, the estimates of the slope of demand, seasonal demand shifters, and product fixed effects are then:

$$\hat{\theta}_2 = (\hat{X}_2{}' \hat{X}_2)^{-1} \hat{X}_2{}' y \,,$$

$$\hat{X}_2 = Z_2 (Z_2' Z_2)^{-1} Z_2' X_2$$

Return to Estimation

Estimation – 3

- To recover the contribution of product attributes to the mean utility we compute:

$$\hat{\theta}_3 = (\hat{X_3}'\hat{X_3})^{-1}\hat{X_3}'d_2\,,$$

- d_2 are the estimated product fixed effects from step two.
- X_3 is a matrix of observable product characteristics.

Return to Estimation