Econometrica Supplementary Material

SUPPLEMENT TO "MARKET POWER AND THE LAFFER CURVE"

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APPENDIX A: DATA

WE BEGIN WITH A DISCUSSION of how we aggregate the initial daily, store-level *PLCB* data and how we define market areas served by each store. To reduce the size of the estimation sample, we aggregate over days where prices remain unchanged. *PLCB* regulation allows price to change only for two reasons: permanent and temporary wholesale price changes. Both follow set timing requirements. Permanent price changes can take effect on the first day of one of the *PLCB*'s thirteen four-week long accounting period ("reporting periods"). Temporary sales, on the other hand, begin on the last Monday of each month and last for either four or five weeks until the day before the last Monday of the following month; we denote such periods as "pricing periods." Reporting periods and pricing periods thus align, but not perfectly; the vast majority of days in a typical pricing period overlap with an initial reporting period, and the remainder with the next. Since temporary price reductions are more prevalent than permanent ones (84.8% of price changes in the sample are temporary in nature), we use pricing periods as our time interval to avoid having multiple very short periods. This results in 34 pricing periods during which prices remain constant. For permanent price changes in a reporting period that bisects two sales pricing periods, we assume that the price change takes effect in the pricing period that most overlaps with the given reporting period. In aggregating our daily sales data to the level of the sales pricing period, we treat a product as being available in a store if it sold at least once during a given period. The length of the pricing period alleviates concern about distinguishing product availability from lack of sales in the period.

Stores exhibit significant variation in the product composition of purchases. These differences reflect heterogeneity in consumer preferences more than differences in the availability of products across stores: Of the 100 best selling products statewide in 2003, the median store carried 98.0%, while a store at the fifth percentile carried 72.0% of the products. Similarly, of the 1,000 best selling products statewide in 2003, the median store carried 82.03%, while a store at the fifth percentile carried 44.2% of the products. The product availability at designated "premium" stores is somewhat better than the average, with the median premium store carrying all of the top 100 products and 95.1% of the top 1,000 products. A consumer can also request to have any regular product in the *PLCB*'s product catalog shipped to his local store for free, should that store not carry the product.

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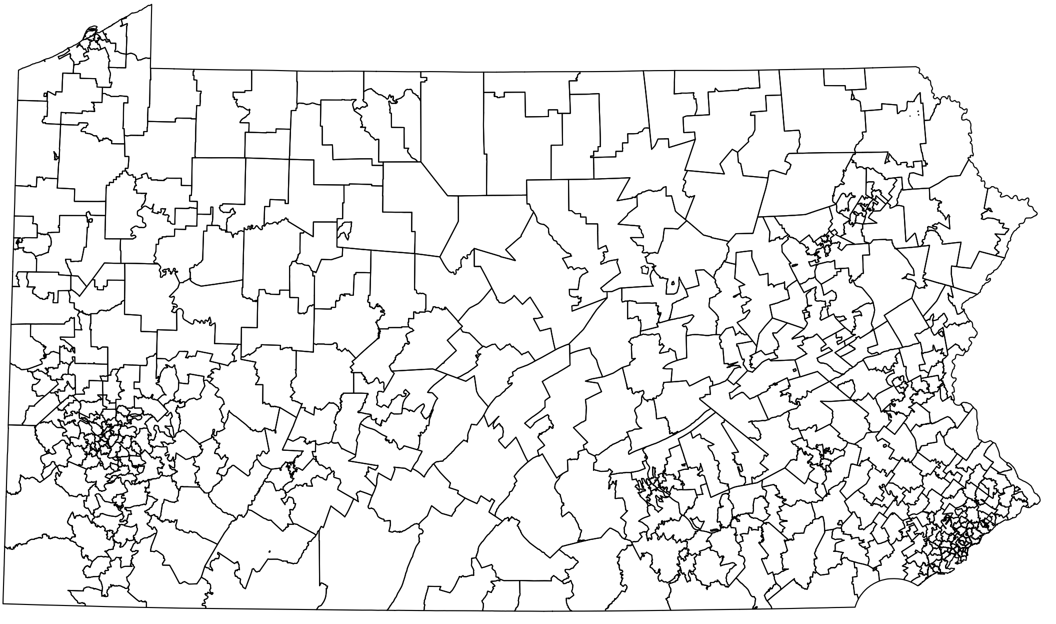


FIGURE A.1.—Pennsylvania markets as of January 2003.

The fact that most stores carry most popular products and can provide access to all products in the catalog easily, together with the absence of price differences across stores, supports an assumption underlying our demand model: Differences in product availability do not drive consumers' store choices to a significant degree and as a result, consumers visit the store closest to them. In making this assumption, which allows us to focus on the consumer's choice between different liquor products available at the chosen store, we follow previous studies using scanner data such as Chintagunta, Dubé, and Singh (2003).

In assigning consumers to stores, we calculate for each of Pennsylvania's 10,351 regular block groups the straight-line distance to each store and assign consumers to the closest open store for each pricing period. In instances where the *PLCB* operates more than one store within a ZIP code, we aggregate sales across stores to the ZIP code level; there are 114 such ZIP codes out of a total of 1,775. Note that these instances include both store relocations, where a store moved from one location in a ZIP code to another during our sample period, but the data contain separate records for the store in the two locations, and instances where the *PLCB* operates two stores simultaneously within a ZIP code.[1] We consider the resulting block group zones as separate markets. Figure A.1 illustrates this aggregation of block groups into markets and shows the markets as of January 2003. We repeat this procedure for each pricing period to account for changes in demographics after store openings and closings. In total, we observe two permanent store closings and 19 permanent store openings over the 3-year period. 125 stores are closed for at least one pricing period; these temporary store closings last on average 2.73 pricing periods. Store closings and openings introduce variation in the demographics of the population served by each store, in addition to cross-sectional variation in demographics, that we exploit to identify heterogeneous tastes for spirits.

[1]We drop wholesale stores, administrative locations, and stores without valid address information, for a total of 13 stores.

We derive consumer demographics for the store's zone by calculating the total population of drinking age and population-weighted average demographics, including the percent of the population that is nonwhite, has at least some college experience, and is between the ages of 21 and 29 years, and the population-weighted income distribution. In the case of income, we obtained detailed information on each block group's discrete income distribution by racial identity of the head of household, with household income divided into one of 16 categories. We aggregate across racial groups and across block groups in a store's market area to derive the income distribution for white households separately from nonwhite households. We construct two income measures. First, we calculate the share of high-income households, defined as households with incomes above $50,000. We use this metric to present differences in consumption patterns across demographic groups (e.g., Figure 1). Second, we fit continuous market-specific distributions to the discrete income distributions conditional on minority status. We employ generalized beta distributions of the second kind to fit the empirical income distributions in each market conditional on racial group (i.e., 456-x-2). McDonald (1984) highlighted that the beta distribution provides a good fit to empirical income data relative to other parametric distributions. We use these distributions to simulate agents in the estimation and when constructing equilibria underlying the Laffer curves in Section 6.

We similarly obtained information on educational attainment by minority status and aggregated across several categories of educational attainment to derive the share of the population above the age of 25 with at least some college education, by minority status and market area. We also obtained the share of young population between the ages of 21 and 29 by market area.

Our price instruments come from two sources. First, the data on retail prices in other liquor control states is from the National Alcohol Beverage Control Association and consists of monthly product-level shelf prices by liquor control state. We assign a month to our Pennsylvania pricing periods to facilitate a match between the two data sets. Second, we obtained historical commodity prices for corn and sugar from Quandl, a data aggregator. The prices are the monthly price of a "continuous contract" for each commodity where a "continuous contract" is defined as a hypothetical chained composite of a variety of futures contracts and is intended to represent the spot market price of the given commodity. We also attained prices for rice, sorghum, wheat, barley, oats, and glass (as a cost input for bottle size) but found these input costs provided little additional explanatory power.

APPENDIX B: ADDITIONAL DESCRIPTIVE STATISTICS

Table B.1 presents the distribution of bottle prices contained in our sample of 312 products. The average price is increasing across bottle sizes both within a category and for the whole sample. Whiskeys tend to be the most expensive products while brandies, rums, and vodkas are less expensive. These statistics mask heterogeneity across products. For instance, vodkas tend to be inexpensive on average, \$13.81 per bottle, but average prices range from the 375 ml Nikolai Vodka at \$3.88 to the 1.75 L Grey Goose at \$48.40. In Table B.2, we present market shares based on quantity (bottles sold), retail revenue, and *PLCB* tax revenue.

TABLE B.1

BOTTLE PRICES BY SPIRIT TYPE AND BOTTLE SIZE[a]

Spirit Type	Average	Median	SD	Max	Min
BRANDY	13.91	11.23	7.00	36.11	5.42
375 ml	9.19	6.01	4.42	15.31	5.42
750 ml	14.47	9.93	7.63	36.11	9.25
1.75 L	18.68	19.25	1.72	22.24	16.70
CORDIALS	14.94	14.99	5.78	38.47	5.99
375 ml	10.41	10.28	3.07	19.24	5.99
750 ml	15.14	15.35	5.04	31.15	5.99
1.75 L	25.92	24.98	6.86	38.47	18.26
GIN	15.63	14.54	7.59	39.50	4.79
375 ml	7.91	6.94	2.51	12.06	4.79
750 ml	13.61	10.60	5.37	22.16	5.99
1.75 L	19.54	17.10	8.24	39.50	11.71
RUM	14.25	13.56	5.30	26.44	5.07
375 ml	6.62	6.43	0.71	7.49	5.07
750 ml	12.57	12.99	2.35	19.57	7.75
1.75 L	19.90	21.16	4.83	26.44	12.99
VODKA	13.81	12.25	7.49	48.40	3.88
375 ml	5.13	4.06	2.38	14.34	3.88
750 ml	15.18	14.82	5.04	26.58	6.17
1.75 L	16.84	12.90	7.53	48.40	10.83
WHISKEY	16.81	15.48	7.59	45.99	5.51
375 ml	8.75	9.63	2.53	15.45	5.51
750 ml	14.98	13.09	6.2	31.84	5.96
1.75 L	20.74	18.34	7.57	45.99	12.97

[a] Statistics weighted by quantity of bottles sold.

TABLE B.2

MARKET SHARE BY TYPE, PRICE, AND SIZE[a]

	Products	Share of Market		
		By Quantity	By Revenue	By Tax Revenue
By Spirit Type:				
BRANDY	26	7.24	6.76	6.77
CORDIALS	62	13.38	13.42	13.24
GIN	28	6.91	7.25	7.23
RUM	40	16.18	15.55	15.64
VODKA	66	31.88	29.55	30.04
WHISKEY	90	24.41	27.47	27.08
By Price and Size:				
EXPENSIVE	150	46.89	62.41	59.94
CHEAP	162	53.11	37.59	40.06
375 ml	48	15.19	7.34	8.14
750 ml	170	50.2	48.82	48.42
1.75 L	94	34.61	43.85	43.43
ALL PRODUCTS	312	100.00	100.00	100.00

[a]"Quantity" market share is based on bottles while "Revenue" and "Tax Revenue" are based on dollars. "Cheap" ("Expensive") products are those products whose mean price is below (above) the mean price of other spirits in the same spirit type and bottle size. "Revenue" is retail price times quantity sold while "Tax Revenue" is defined as retail price minus wholesale price times quantity sold: $(p^r - p^w) \times q$.

APPENDIX C: ROBUSTNESS OF DEMAND ESTIMATES

This Appendix addresses a number of alternative specifications to highlight the robustness of our reported estimates. We show that the inclusion of premium, border stores, or holiday periods are mostly inconsequential. Aggregating sales across local markets leads to less elastic demand estimates, along the lines of other studies using only aggregate sales data. We also show that the inclusion of brand fixed effects helps control for unobservable quality differences across products.

An important robustness check deals with the equilibrium implications of flatter or steeper demand estimates on markups, optimal tax rates, and optimal agents' responses to changes in tax policy. We show that our estimates are broadly consistent with profit maximization in the upstream distiller segment while being on the prohibitive range of the Laffer curves. Thus, the *PLCB* significantly overprices spirits if its goal is only to maximize tax revenues. Finally, we rule out the existence of significant stockpiling that could bias our own-price elasticity estimates upward and our cross-price elasticity estimates downward.

C.1. *Alternative Price Instruments and Samples*

In Table C.1, we display the estimated mean price coefficient under alternative instrumenting strategies. We label our primary specification as IV1.

In Table C.2, we use a simple OLS multinomial logit demand system to highlight the robustness of our demand estimation results to alternative samples. Model (i), the most similar to the full model, employs a similar estimation strategy where we first regress the logged ratio of product to outside share on product-time and store fixed effects and interactions between average demographics and product characteristics (e.g., % minority

TABLE C.1

PRICE ENDOGENEITY[a]

	OLS	IV1	IV2	IV3	IV4
PRICE	−0.2673	−0.3062	−0.3073	−0.3114	−0.3128
	(0.0027)	(0.0036)	(0.0036)	(0.0037)	(0.0037)
First-Stage F-Stat.:	—	1,333.19	1,297.06	1,217.18	1,196.74
Instruments:					
– Input Prices		X	X	X	X
– Alabama		X			
– Iowa		X		X	
– Idaho		X	X	X	X
– Michigan		X			
– Mississippi		X			
– Montana		X		X	X
– North Carolina		X	X		
– Oregon		X	X	X	X
– Utah		X			
– Wyoming		X	X	X	X

[a]All estimates based on 10,532 observations. Specifications include the same covariates as in Table IV. Price instruments based on the average contemporaneous price among alternative sets of control states outside the Northeast and Mid-Atlantic regions. “Input Prices” corresponds to contemporaneous commodity prices for inputs (corn, sugar) interacted with spirit type to further separate cost and demand shocks.

× rum dummy). This model generates product elasticities, both on average and for the spirit category, that are more inelastic than our preferred mixed-logit model. In Models (ii)–(iv), we vary the number of markets to show that including markets with premium and border stores and including the holiday period has little effect on our estimated price coefficient and elasticities.

TABLE C.2

OLS DEMAND ESTIMATES BASED ON DIFFERENT SAMPLES[a]

	(i)	(ii)	(iii)	(iv)
PRICE	−0.2296	−0.2370	−0.2151	−0.2252
	(0.0028)	(0.0028)	(0.0028)	(0.0026)
Product FEs	Y	Y	Y	Y
Premium Stores	Y	N	Y	Y
Border Stores	Y	Y	N	Y
Holiday Period	Y	Y	Y	N
Statistics:				
R^2	0.9416	0.9418	0.9381	0.9582
N	10,532	10,532	10,532	8,670
Elasticities:				
Average	−3.5652	−3.6823	−3.3318	−3.4977
% Inelastic	0.7430	0.7429	0.7563	0.7481
Spirits	−3.2351	−3.3800	−2.9816	−3.1684

[a]The dependent variable for all models is the estimated product-time fixed effects from a first-stage regression of $\log(S_{jmt}) - \log(S_{0mt})$ onto product-time fixed effects and demographic-product interactions. Robust standard errors in parentheses. “% Inelastic” is the percent of products with inelastic demand. “Spirits” is the price elasticity of total *PLCB* off-premise spirit sales.

TABLE C.3

OLS DEMAND ESTIMATES USING AGGREGATE DATA[a]

	(i)	(ii)	(iii)	(iv)
PRICE	−0.1218	−0.0508	−0.0822	−0.0109
	(0.0003)	(0.0003)	(0.0018)	(0.0013)
Brand FEs	Y	N	Y	N
Statistics:				
R^2	0.5052	0.2404	0.8101	0.1473
N	3,377,659	3,377,659	10,532	10,532
Elasticities:				
Average	−1.8910	−0.7885	−1.2764	−0.1686
% Inelastic	13.1151	78.5863	39.6494	100.0000
Spirits	−1.7318	−0.7265	−1.1730	−0.1559

[a]The dependent variable for models (i)–(ii) is $\log(S_{jmt}) - \log(S_{0mt})$ while it is $\log(S_{jt}) - \log(S_{0t})$ for models (iii)–(iv). Robust standard errors in parentheses. "% Inelastic" is the percent of products with inelastic demand. "Spirits" is the price elasticity of total *PLCB* off-premise spirit sales.

C.2. *Aggregation*

In Table C.3, we estimate a simple OLS multinomial logit demand system using various levels of aggregation. In Model (i), we deviate from our multistep approach and estimate a one-step model, regressing the logged ratio of product share to outside share on price, demographic interactions, and fixed effects for brand (different bottle sizes of the same spirit label), bottle size, season, and store. Demand becomes much steeper than under Model (i) in Table C.2. In Model (ii) we replace the brand fixed effects with indicators for spirit type and for imported spirits. Demand becomes even more inelastic due to the coarseness of our observable characteristics that do not capture any quality differences between spirits, for example, two imported rums, that would lead to different market shares and prices. In Models (iii)–(iv), we aggregate consumption to the state-level requiring us to drop the demographic interactions but otherwise using the same controls as in Models (i) and (ii). The inclusion of brand fixed effects is important to absorb differences in unobservable (to the econometrician) characteristics across brands. Table C.3 also shows that aggregation leads to significantly less elastic estimates of product demand and an elasticity of off-premise spirits well within the set of estimates reported in Leung and Phelps (1993). Highlighting the value of our more detailed data, aggregation also increases the prevalence of inelastic product demand—a point which we show below is inconsistent with upstream profit-maximization in our data.

C.3. *Consumer Demand, Product Elasticities, and Upstream Markups*

An advantage of our data and estimation approach is that we can estimate (Σ, Π, ρ) independent of the mean utility parameters, including the mean price coefficient (α). As α modulates the consumer response to changes in prices, it also affects the ability of upstream firms to charge prices that entail significant markups as well as respond to changes in the tax rate. In Table C.4, we vary α exogenously to evaluate the equilibrium implications. This exercise serves two purposes. First, it demonstrates how variation in the price coefficient impacts consumer demand, upstream market power, and ultimately the ability of both consumers and firms to respond to changes in tax policy. Second, it

TABLE C.4

ELASTICITIES, MARGINAL COSTS, AND MARKET POWER UNDER ALTERNATIVE PRICE COEFFICIENTS (α)[a]

	Product Elasticities (ε)			Upstream Firms	
Price Coeff. (α)	Spirits	Average	% Inelastic	Lerner	%MC < 0
−0.38	−3.70	−5.16	0.00	26.56	0.00
−0.36	−3.46	−4.81	0.00	28.35	0.05
−0.34	−3.22	−4.46	0.00	30.41	0.42
−0.32	−2.97	−4.11	0.00	32.79	0.74
−0.30	−2.73	−3.75	0.04	35.58	0.74
−0.28	−2.49	−3.40	0.11	38.91	0.74
−0.26	−2.24	−3.05	0.28	42.94	0.80
−0.24	−2.00	−2.70	0.62	47.95	1.46
−0.22	−1.75	−2.35	1.55	54.35	2.60
−0.20	−1.50	−2.00	4.25	62.92	5.79

[a]Estimated price coefficient under the preferred IV specification is $\hat{\alpha} = -0.3062$. For a given α value, we recover implied upstream marginal costs assuming upstream firm pricing based on observed product ownership. "Spirits" elasticity refers to the elasticity of spirits as a category. We solve for this numerically by increasing the retail price of spirits 1%. "Average" is the average price elasticity across the products. "% Inelastic" is the percent of products with estimated price elasticity less than one. "Lerner" is the average Lerner index defined as $100 \times \frac{p^w - c}{p^w}$. "%MC < 0" is the percent of products with negative estimated marginal cost.

provides supporting evidence that current policy is indeed on the "prohibitive" region of the Laffer curve.

As suspected, alternative values of α rotate consumer demand resulting in significant impacts to the consumer demand elasticities both by product and for spirits as a category. For instance, as we move toward zero from the estimated value of -0.3062, consumers become less sensitive to changes in price leading to a decrease in the average product elasticity and a lower value for the elasticity of spirits as a category. Ultimately, this pivoting leads to greater margins for upstream firms while also enabling the *PLCB* to maximize tax revenue by charging a higher tax rate. The results presented in Table C.4 also indicate the values for spirit demand documented in the meta study by Leung and Phelps (1993) are improbable at least in our context and sample period. To generate category level elasticities similar to the values found by researchers using state or national data, α needs to be around -0.20. At this point, however, 4.25% of products have estimated inelastic demand while 5.79% of the implied upstream marginal costs are negative—both of which are inconsistent with upstream profit-maximization.

C.4. *Consumer Demand and the Prohibitive Region of the Laffer Curve*

Our results indicate that regardless of regulatory foresight, the *PLCB* should choose to decrease the tax rate below current levels to increase tax revenue, leading to a decrease in retail prices. Apart from upstream conduct, this result reflects the demand elasticity we estimate from observed consumer responses. Despite the fact that our demand estimates are robust to various alternative specifications and instrumentation choices, in this section we investigate the sensitivity of this overpricing result to our estimated mean price coefficient, α. In Table C.5, we repeat the analysis from Table C.4 and append statistics on the firm response elasticity as well as the *PLCB*'s optimal ad valorem tax $\tau^\star$ where we assume the *PLCB* operates under naïve beliefs.

Varying the price coefficient from an implied aggregate spirits elasticity of -3.7 to -1.5, we find that the category elasticity would need to rise to at least -2 before the current tax

TABLE C.5

OVERPRICING UNDER ALTERNATIVE PRICE COEFFICIENTS (α)[a]

	Product Elasticities (ε)			Upstream Firms			
Price Coeff. (α)	Spirits	Average	% Inelastic	Response ($\tilde{\varepsilon}$)	Lerner	%MC < 0	PLCB Mup ($\tau^\star$)
Overpricing							
−0.38	−3.70	−5.16	0.00	−0.14	26.56	0.00	20.91
−0.36	−3.46	−4.81	0.00	−0.15	28.35	0.05	23.55
−0.34	−3.22	−4.46	0.00	−0.16	30.41	0.42	26.70
−0.32	−2.97	−4.11	0.00	−0.17	32.79	0.74	30.58
−0.30	−2.73	−3.75	0.04	−0.19	35.58	0.74	35.34
−0.28	−2.49	−3.40	0.11	−0.20	38.91	0.74	41.35
−0.26	−2.24	−3.05	0.28	−0.22	42.94	0.80	49.26
Underpricing							
−0.24	−2.00	−2.70	0.62	−0.24	47.95	1.46	60.10
−0.22	−1.75	−2.35	1.55	−0.26	54.35	2.60	76.72
−0.20	−1.50	−2.00	4.25	N/A	62.92	5.79	108.36

[a]Estimated price coefficient under the preferred IV specification is $\hat{\alpha} = -0.3062$. For a given α value, we recover implied upstream marginal costs assuming upstream firm pricing based on observed product ownership. "Spirits" elasticity refers to the elasticity of spirits as a category. We solve for this numerically by increasing the retail price of spirits 1%. "Average" is the average price elasticity across the products. "% Inelastic" is the percent of products with estimated price elasticity less than one. "Response" is the average firm response elasticity (η) defined as the average percent change in wholesale price given a 1% increase in the tax rate. We solve for this value numerically. When $\alpha = -0.20$ we were unable to find an interior solution to the firms' pricing decision due to the large number of inelastic product demands."Lerner" is the average wholesale Lerner index defined as $\frac{p^w - \hat{c}}{p^w}$. "%MC < 0" is the percent of products with negative estimated wholesale marginal cost. "PLCB Mup" is the tax revenue-maximizing markup under naïve beliefs where a markup less (greater) than 53.4% implies that current *PLCB* policy overprices (underprices) spirits. All upstream distiller statistics assume "Base" conduct.

rate places the *PLCB* on the upward sloping part of the Laffer curve. Such an aggregate elasticity, however, is not consistent with profit maximizing behavior by upstream distillers given their observed prices: For approximately 1% of products, we find that demand is inelastic; 1.5% of marginal costs are negative, and upstream margins are on average 48%. This stands in contrast to industry estimates which place the average wholesale margin earned by distillers at approximately 37%, in line with what we obtain under our demand estimates which entail an average margin of 35%.

When $\alpha = -0.2452$, the current *PLCB* policy maximizes tax revenue assuming the regulator has Naïve beliefs.[2] Since our OLS estimate is $\hat{\alpha} = -0.2673$ and instrumenting for price typically makes demand more elastic (i.e., decreases $\hat{\alpha}$), this supports our finding that current *PLCB* policy operates on the right-hand side of the Laffer curve, overpricing spirits to decrease consumption.

C.5. *Stockpiling*

Hendel and Nevo (2006) showed that static models of demand overstate own-price elasticities when consumers hold inventories and make dynamic purchase decisions. In this study, such a bias would translate into not only poorly estimated consumer demand but also an underestimate of upstream market power including suppliers' ability to respond to changes in *PLCB* policy via η. Such a bias would primarily show up in our estimate of the mean utility price coefficient (α), though in Appendix C.3 above we document

[2]The Stackelberg equilibrium in which current policy also maximizes tax revenue occurs when $\alpha = -0.2687$.

that less elastic estimates of consumer demand are also inconsistent with upstream profit maximization under the observed wholesale prices.

We test for evidence of stockpiling following Pesendorfer (2002) and Hendel and Nevo (2006). The idea is to test whether consumers are increasingly likely to buy a good the more time passes since the last sale. In other words, if consumers can indeed make several purchases at a time when a product is on sale, the likelihood they have to make an additional purchase increases with time since that purchase. In Table C.6, we regress logged quantity sold (bottles) on logged price and the duration since the last temporary sale. In the top panel, we use the product-store-period data in our sample and include fixed effects for product, store, and period heterogeneity. If our data exhibited a pattern of accumulation consistent with an inventory model, the coefficient on duration from the last sale should be positive and significant. We, however, find this coefficient is small, mostly insignificant and often negative. Further, there appears to be little evidence of stockpiling across different product categories. We find similar results when we use the more disaggregated daily sales data (bottom panel). We therefore conclude our data provides no evidence of stockpiling. We do however observe unusual sales patterns in January as quantity sold falls after the holiday season. Such behavior could be due to stockpiling, even though products are less likely to go on sale during the holidays (see Table II), but could also be due to consumers "burning off" their holiday inventory or adopting short-term New Year resolutions. Introducing a January indicator could control for the change in demand caused by the latter two explanations. Being unable to disentangle these explanations, though, we instead chose a conservative approach and dropped all January observations from the estimation.

TABLE C.6

TESTS FOR STOCKPILING: DEMAND AS A FUNCTION OF DURATION FROM PREVIOUS SALE[a]

		Spirit Type						Bottle Size			Price Range	
	ALL	BRANDY	CORDIALS	GIN	RUM	VODKA	WHISKEY	375 ml	750 ml	1.75 L	CHEAP	EXPENSIVE
Period-Level Data												
log(price)	−3.8618	−4.0471	−3.0719	−3.9386	−3.5453	−4.6810	−4.0561	−2.9496	−3.6632	−4.4964	−4.0967	−3.6477
	(0.0496)	(0.1364)	(0.0969)	(0.1287)	(0.1281)	(0.1191)	(0.0798)	(0.1350)	(0.0668)	(0.0661)	(0.0738)	(0.0669)
Duration from previous sale	0.0008	−0.0054	0.0065	0.0021	0.0061	−0.0043	0.0000	0.0103	−0.0040	0.0039	−0.0025	0.0025
	(0.0017)	(0.0051)	(0.0032)	(0.0040)	(0.0040)	(0.0029)	(0.0030)	(0.0044)	(0.0020)	(0.0023)	(0.0026)	(0.0021)
R^2	0.5633	0.4866	0.5380	0.5441	0.6476	0.6966	0.5294	0.5407	0.5413	0.5587	0.5128	0.5724
N	3,376,293	259,472	677,133	288,061	451,472	716,529	983,626	484,761	1,867,437	1,024,095	1,734,593	1,641,700
Daily Data												
log(price)	−1.1657	−1.4532	−0.7594	−1.0414	−0.9622	−1.7140	−1.0972	−0.8615	−1.0786	−1.3500	−1.1905	−1.1498
	(0.0226)	(0.0505)	(0.0532)	(0.0445)	(0.0597)	(0.0484)	(0.0344)	(0.0559)	(0.0346)	(0.0305)	(0.0315)	(0.0322)
Duration from previous sale	0.0000	0.0002	0.0003	0.0003	−0.0004	−0.0001	0.0000	0.0002	−0.0001	0.0000	−0.0001	0.0000
	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
R^2	0.2621	0.2901	0.2052	0.2384	0.2858	0.3344	0.2039	0.3767	0.2194	0.2636	0.276	0.2296
N	31,543,848	2,273,014	4,952,381	2,40,620	4,726,432	8,136,422	9,004,979	4,318,247	16,495,700	1,729,901	16,685,693	14,858,155

[a]The dependent variable in all regressions is the log of quantity purchased (measured in bottles). In the top panel ("Period-Level Data"), an observation is a product-store-period triplet. Duration in the top panels is the number of periods (approx. months) since the last sale. All regressions in the top panel include product, store, and period fixed effects. In the bottom panels ("Daily Data") an observation is a product-store-day triplet and we define duration since the last sale in weeks. All regressions in the bottom panel include product, store, and week fixed effects. Robust standard errors in parentheses.

APPENDIX D: ELASTICITIES

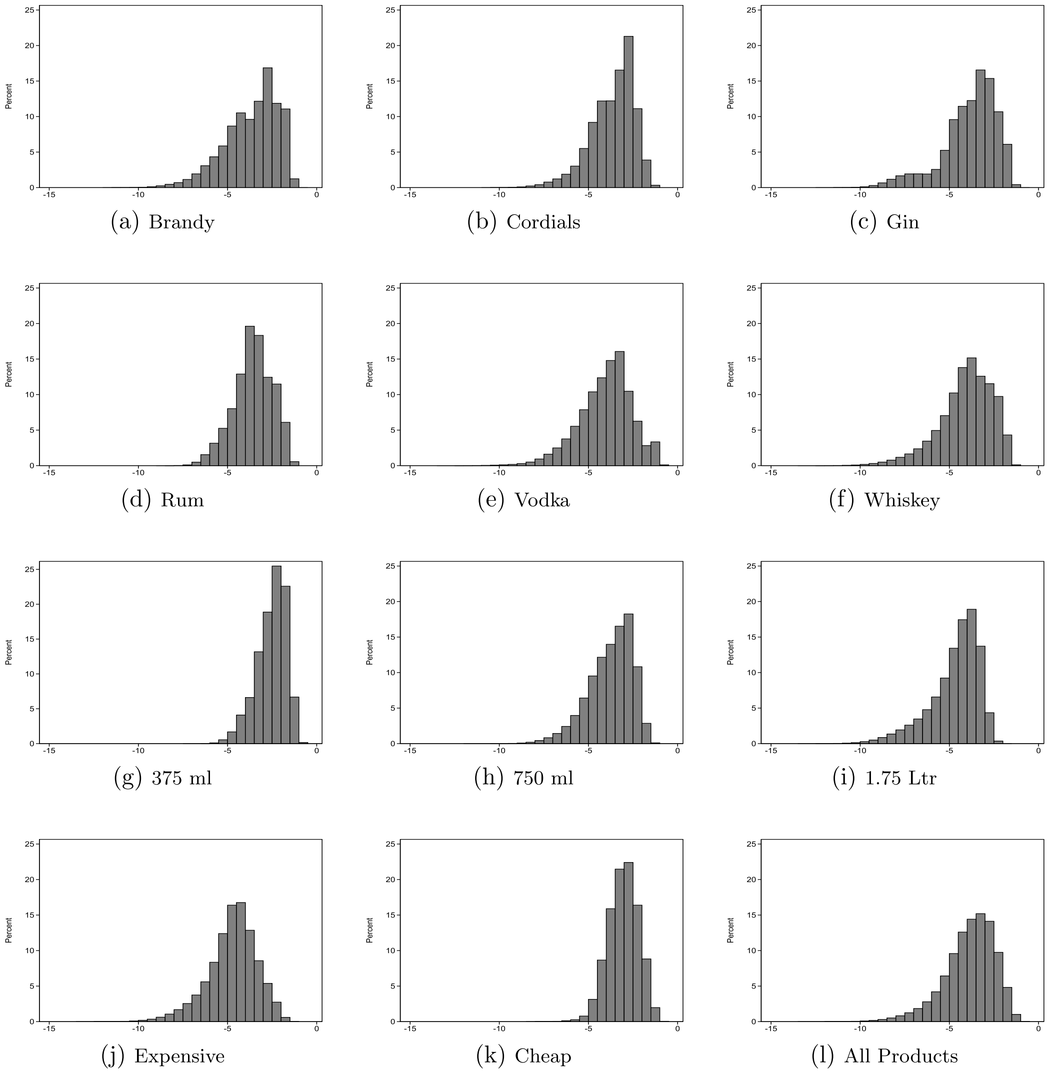


FIGURE D.1.—Distribution of Demand Elasticities.

TABLE D.1

BEST SUBSTITUTES[a]

Product	Owner	Type	Ratio	Closer Substitute: Product	Owner	Type	ϵ_{ij}
HENNESSY V. S. COGNAC—375 ML	MOET HENNESSY	BRANDY	16.87	JACQUIN'S BLACKBERRY FLAV. BRANDY—1.75 LTR	JACQUIN	BRANDY	0.0619
E & J CAL. BRANDY—750 ML	E. AND J. GALLO	BRANDY	15.26	HENNESSY V. S. COGNAC—750 ML	MOET HENNESSY	BRANDY	0.0984
THE CHRISTIAN BROS. CAL. BRANDY—1.75 LTR	HEAVEN HILL	BRANDY	15.76	JACQUIN'S BLACKBERRY FLAV. BRANDY—1.75 LTR	JACQUIN	BRANDY	0.0796
E & J CAL. BRANDY—375 ML	E. AND J. GALLO	BRANDY	27.59	JACQUIN'S BLACKBERRY FLAV. BRANDY—1.75 LTR	JACQUIN	BRANDY	0.0604
HENNESSY V. S. COGNAC—750 ML	MOET HENNESSY	BRANDY	10.38	COURVOISIER V. S. COGNAC—750 ML	ALLIED DOMECQ	BRANDY	0.0637
E & J CAL. BRANDY—1.75 LTR	E. AND J. GALLO	BRANDY	16.04	JACQUIN'S BLACKBERRY FLAV. BRANDY—1.75 LTR	JACQUIN	BRANDY	0.0742
THE CHRISTIAN BROS. CAL. BRANDY—375 ML	HEAVEN HILL	BRANDY	24.19	JACQUIN'S BLACKBERRY FLAV. BRANDY—1.75 LTR	JACQUIN	BRANDY	0.0685
THE CHRISTIAN BROS. CAL. BRANDY—750 ML	HEAVEN HILL	BRANDY	15.57	HENNESSY V. S. COGNAC—750 ML	MOET HENNESSY	BRANDY	0.0900
JACQUIN'S BLACKBERRY FLAV. BRANDY—1.75 LTR	JACQUIN	BRANDY	16.92	THE CHRISTIAN BROS. CAL. BRANDY—1.75 LTR	HEAVEN HILL	BRANDY	0.0512
BAILEYS IRISH CREAM LIQUEUR—375 ML	DIAGEO	CORDIALS	13.80	SOUTHERN COMFORT—76 PROOF—1.75 LTR	BROWN	CORDIALS	0.0616
KAHLUA IMP. COFFEE LIQUEUR—750 ML	ALLIED DOMECQ	CORDIALS	4.35	BAILEYS IRISH CREAM LIQUEUR—750 ML	DIAGEO	CORDIALS	0.0824
SOUTHERN COMFORT—76 PROOF—1.75 LTR	BROWN	CORDIALS	5.25	KAHLUA IMP. COFFEE LIQUEUR—1.75 LTR	ALLIED DOMECQ	CORDIALS	0.0437
KAHLUA IMP. COFFEE LIQUEUR—375 ML	ALLIED DOMECQ	CORDIALS	13.07	SOUTHERN COMFORT—76 PROOF—1.75 LTR	BROWN	CORDIALS	0.0630
SOUTHERN COMFORT—76 PROOF—750 ML	BROWN	CORDIALS	5.00	KAHLUA IMP. COFFEE LIQUEUR—750 ML	ALLIED DOMECQ	CORDIALS	0.0633
DEKUYPER PEACHTREE SCHNAPPS—1.75 LTR	BEAM INC	CORDIALS	9.27	SOUTHERN COMFORT—76 PROOF—1.75 LTR	BROWN	CORDIALS	0.0858
JAGERMEISTER IMP. HERB LIQUEUR—375 ML	MAST-JAGR	CORDIALS	9.89	SOUTHERN COMFORT—76 PROOF—1.75 LTR	BROWN	CORDIALS	0.0691

TABLE D.1
CONTINUED

Product	Owner	Type	Ratio	Closer Substitute: Product	Closer Substitute: Owner	Closer Substitute: Type	ϵ_{ij}
BAILEYS IRISH CREAM LIQUEUR—750 ML	DIAGEO	CORDIALS	4.42	KAHLUA IMP. COFFEE LIQUEUR—750 ML	ALLIED DOMECQ	CORDIALS	0.0973
KAHLUA IMP. COFFEE LIQUEUR—1.75 LTR	ALLIED DOMECQ	CORDIALS	5.19	SOUTHERN COMFORT—76 PROOF—1.75 LTR	BROWN	CORDIALS	0.0871
SEAGRAM'S EXTRA DRY GIN—375 ML	PERNOD RICARD	GIN	32.68	GORDON'S DRY GIN—1.75 LTR	DIAGEO	GIN	0.0798
TANQUERAY IMP. DRY GIN—750 ML	DIAGEO	GIN	15.47	BOMBAY IMP. SAPPHIRE GIN—750 ML	BACARDI	GIN	0.0452
GORDON'S DRY GIN—1.75 LTR	DIAGEO	GIN	18.57	TANQUERAY IMP. DRY GIN—1.75 LTR	DIAGEO	GIN	0.0581
TANQUERAY IMP. DRY GIN—375 ML	DIAGEO	GIN	24.24	GORDON'S DRY GIN—1.75 LTR	DIAGEO	GIN	0.0818
SEAGRAM'S EXTRA DRY GIN—750 ML	PERNOD RICARD	GIN	12.29	TANQUERAY IMP. DRY GIN—750 ML	DIAGEO	GIN	0.0651
BANKER'S CLUB DRY GIN—1.75 LTR	LAIRD	GIN	24.33	GORDON'S DRY GIN—1.75 LTR	DIAGEO	GIN	0.0831
GORDON'S DRY GIN—PET—375 ML	DIAGEO	GIN	28.30	GORDON'S DRY GIN—1.75 LTR	DIAGEO	GIN	0.0859
GORDON'S DRY GIN—750 ML	DIAGEO	GIN	12.41	SEAGRAM'S EXTRA DRY GIN—750 ML	PERNOD RICARD	GIN	0.0675
SEAGRAM'S EXTRA DRY GIN—1.75 LTR	PERNOD RICARD	GIN	19.61	GORDON'S DRY GIN—1.75 LTR	DIAGEO	GIN	0.0812
BACARDI LIGHT-DRY P. R. RUM—375 ML	BACARDI	RUM	21.24	BACARDI LIGHT-DRY P. R. RUM—1.75 LTR	BACARDI	RUM	0.1226
CAPTAIN MORGAN P. R. SPICED RUM—750 ML	DIAGEO	RUM	5.59	BACARDI LIGHT-DRY P. R. RUM—750 ML	BACARDI	RUM	0.0757
BACARDI LIGHT-DRY P. R. RUM—1.75 LTR	BACARDI	RUM	10.15	CAPTAIN MORGAN P. R. SPICED RUM—1.75 LTR	DIAGEO	RUM	0.1360
CAPTAIN MORGAN P. R. SPICED RUM—375 ML	DIAGEO	RUM	22.61	BACARDI LIGHT-DRY P. R. RUM—1.75 LTR	BACARDI	RUM	0.1223
BACARDI LIGHT-DRY P. R. RUM—750 ML	BACARDI	RUM	6.86	CAPTAIN MORGAN P. R. SPICED RUM—750 ML	DIAGEO	RUM	0.1249

TABLE D.1
CONTINUED

Product	Owner	Type	Ratio	Closer Substitute Product	Closer Substitute Owner	Closer Substitute Type	ϵ_{ij}
CAPTAIN MORGAN P. R. SPICED RUM—1.75 LTR	DIAGEO	RUM	9.33	BACARDI LIGHT-DRY P. R. RUM—1.75 LTR	BACARDI	RUM	0.1403
BACARDI LIMON P. R. RUM—375 ML	BACARDI	RUM	23.32	BACARDI LIGHT-DRY P. R. RUM—1.75 LTR	BACARDI	RUM	0.1286
CAPTAIN MORGAN P. R. SPICED RUM PET—750 ML	DIAGEO	RUM	6.40	CAPTAIN MORGAN P. R. SPICED RUM—750 ML	DIAGEO	RUM	0.1316
JACQUIN'S WHITE RUM—1.75 LTR	JACQUIN	RUM	15.33	BACARDI LIGHT-DRY P. R. RUM—1.75 LTR	BACARDI	RUM	0.1391
NIKOLAI VODKA—80 PROOF—375 ML	SAZERAC	VODKA	17.25	JACQUIN'S VODKA ROYALE—80 PROOF—1.75 LTR	JACQUIN	VODKA	0.0559
ABSOLUT IMP. VODKA—80 PROOF—750 ML	V& S SPIRITS	VODKA	4.50	GREY GOOSE IMP. VODKA—750 ML	SIDNEY FRANK	VODKA	0.0882
JACQUIN'S VODKA ROYALE—80 PROOF—1.75 LTR	JACQUIN	VODKA	11.71	NIKOLAI VODKA—80 PROOF—1.75 LTR	SAZERAC	VODKA	0.0391
JACQUIN'S VODKA ROYALE—80 PROOF—375 ML	JACQUIN	VODKA	17.53	JACQUIN'S VODKA ROYALE—80 PROOF—1.75 LTR	JACQUIN	VODKA	0.0564
SMIRNOFF VODKA—80 PF. PORTABLE—750 ML	DIAGEO	VODKA	5.35	ABSOLUT IMP. VODKA—80 PROOF—750 ML	V&S SPIRITS	VODKA	0.1435
NIKOLAI VODKA—80 PROOF—1.75 LTR	SAZERAC	VODKA	11.84	JACQUIN'S VODKA ROYALE—80 PROOF—1.75 LTR	JACQUIN	VODKA	0.0536
SMIRNOFF VODKA—80 PROOF—375 ML	DIAGEO	VODKA	16.10	JACQUIN'S VODKA ROYALE—80 PROOF—1.75 LTR	JACQUIN	VODKA	0.0550
SMIRNOFF VODKA—80 PROOF—750 ML	DIAGEO	VODKA	5.49	ABSOLUT IMP. VODKA—80 PROOF—750 ML	V&S SPIRITS	VODKA	0.1434
BANKER'S CLUB VODKA—1.75 LTR	LAIRD	VODKA	12.73	JACQUIN'S VODKA ROYALE—80 PROOF—1.75 LTR	JACQUIN	VODKA	0.0544

TABLE D.1
CONTINUED

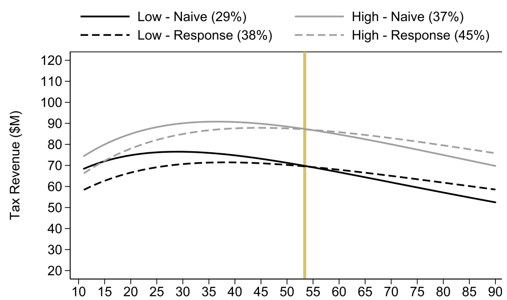
				Closer Substitute			
Product	Owner	Type	Ratio	Product	Owner	Type	ϵ_{ij}
JACK DANIEL'S OLD NO. 7—375 ML	BROWN	WHISKEY	11.33	WINDSOR CANADIAN SUPREME WKY.—1.75 LTR	BEAM INC	WHISKEY	0.0574
JACK DANIEL'S OLD NO. 7—750 ML	BROWN	WHISKEY	3.22	CROWN ROYAL CANADIAN WKY.—750 ML	DIAGEO	WHISKEY	0.0431
WINDSOR CANADIAN SUPREME WKY.—1.75 LTR	BEAM INC	WHISKEY	8.14	JIM BEAM STR. BOURBON WKY.—1.75 LTR	BEAM INC	WHISKEY	0.0495
CROWN ROYAL CANADIAN WKY.—375 ML	DIAGEO	WHISKEY	10.92	WINDSOR CANADIAN SUPREME WKY.—1.75 LTR	BEAM INC	WHISKEY	0.0584
JIM BEAM STR. BOURBON WKY.—750 ML	BEAM INC	WHISKEY	3.80	JACK DANIEL'S OLD NO. 7—750 ML	BROWN	WHISKEY	0.0849
JIM BEAM STR. BOURBON WKY.—1.75 LTR	BEAM INC	WHISKEY	7.40	WINDSOR CANADIAN SUPREME WKY.—1.75 LTR	BEAM INC	WHISKEY	0.0552
WINDSOR CANADIAN SUPREME WKY.—375 ML	BEAM INC	WHISKEY	13.25	WINDSOR CANADIAN SUPREME WKY.—1.75 LTR	BEAM INC	WHISKEY	0.0572
CROWN ROYAL CANADIAN WKY.—750 ML	DIAGEO	WHISKEY	3.40	JACK DANIEL'S OLD NO. 7—750 ML	BROWN	WHISKEY	0.0864
SEAGRAM'S 7 CROWN WKY.—1.75 LTR	DIAGEO	WHISKEY	8.20	WINDSOR CANADIAN SUPREME WKY.—1.75 LTR	BEAM INC	WHISKEY	0.0569

[a]Table presents the three best-selling products by number of bottles for each spirit type, bottle size pair, and the corresponding best substitute based on cross-price elasticity.“Ratio” is the ratio of the average cross-price elasticity between the product and products of its spirit type to the average cross-price elasticity between the product and products outside the its spirit type.

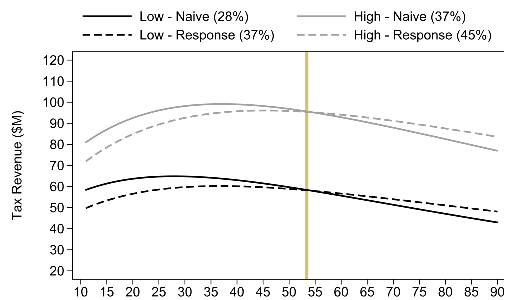
APPENDIX E: DETAILED COUNTERFACTUAL RESULTS

E.1. *Laffer Curves and Demographics*

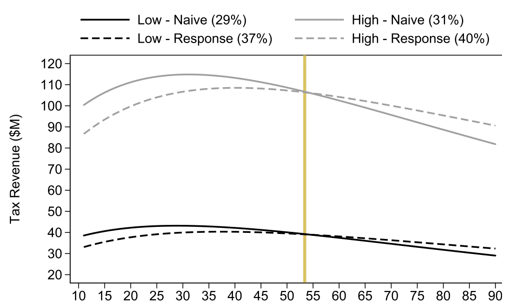
Here, we assess differences in the Laffer curve across different consumer groups. We do so by decomposing the aggregate Naïve and "Base Response" Laffer curves of Figure 3. As in the text, we consider alternative tax rates and, in the case of the "Base" Response equilibrium, wholesale price responses to those tax rates that maximize aggregate distiller profit across all Pennsylvania markets. We then consider purchase behavior under the implied retail prices in the bottom and top quintile of markets for the pertinent demographic attributes. Lastly, we plot in Figure E.1 the tax revenue the *PLCB* would realize from these purchases in the selected bottom and top markets under varying tax rates, and indicate the tax rate that would maximize tax revenue in the select set of markets. Results indicate that the negative trade-off between tax rate τ and tax revenues is a common feature that affects the tax revenue collected from all demographic traits.



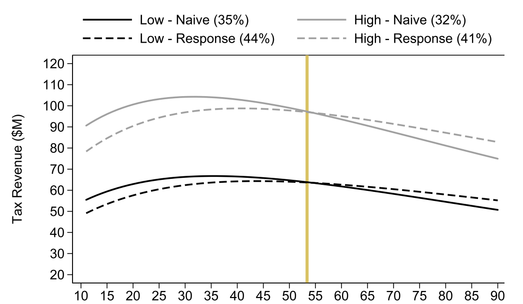
(a) Income



(b) Education



(c) Minority



(d) Young

FIGURE E.1.—Laffer curves across demographic groups. Notes: The x-axis for each graph is the *PLCB* ad valorem tax rate (τ) including the 18% Johnstown Flood tax. The vertical line corresponds to the current policy. Demographic categories are defined in Section 3.4. "High" refers to markets in the top 20% while "Low" refers to markets in the bottom 20% for the corresponding demographic trait. We indicate the tax rate which maximizes tax revenue for each demographic subgroup in parentheses.

TABLE E.1

TAX REVENUE, FIRM CONDUCT, AND REGULATOR FORESIGHT (DETAIL)[a]

	BASE				SINGLE PRODUCT				COLLUSION			
	Bench.	Naïve	Response	Stackelberg	Bench.	Naïve	Response	Stackelberg	Bench.	Naïve	Response	Stackelberg
Markup (%)	53.40	30.68	30.68	39.31	53.40	30.90	30.90	39.18	53.40	29.15	29.15	42.07
Distiller Price ($)	9.08	9.08	9.42	9.28	9.00	9.00	9.33	9.19	9.75	9.00	10.32	9.99
– 375 ml	4.99	4.99	5.32	5.18	4.92	4.92	5.23	5.11	5.47	4.92	5.97	5.68
– 750 ml	8.48	8.48	8.82	8.68	8.40	8.40	8.72	8.59	9.24	9.24	9.84	9.49
– 1.75 L	12.22	12.22	12.58	12.43	12.16	12.16	12.50	12.37	12.83	12.83	13.38	13.06
– BRANDY	8.43	8.43	8.75	8.61	8.35	8.35	8.66	8.53	9.03	8.35	9.56	9.25
– CORDIALS	8.20	8.20	8.54	8.40	8.15	8.15	8.47	8.34	8.90	8.15	9.47	9.14
– GIN	8.79	8.79	9.13	8.99	8.72	8.72	9.04	8.91	9.39	8.72	9.94	9.62
– RUM	7.88	7.88	8.23	8.09	7.76	7.76	8.08	7.95	8.53	7.76	9.11	8.77
– VODKA	9.92	9.92	10.28	10.13	9.83	9.83	10.17	10.03	10.62	9.83	11.21	10.87
– WHISKEY	9.86	9.86	10.21	10.06	9.80	9.80	10.13	10.00	10.55	9.80	11.12	10.79
Distiller Profits ($M)	155.20	234.85	242.45	202.99	154.15	231.56	239.48	202.03	159.12	255.59	258.58	197.43
– DIAGEO	36.10	56.67	58.32	48.22	35.88	55.71	57.65	48.05	37.16	61.89	62.62	46.89
– BACARDI	14.35	22.69	23.38	19.26	14.24	22.29	23.06	19.15	14.71	24.69	24.98	18.62
– BEAM	15.10	21.78	22.45	19.20	15.01	21.51	22.21	19.12	15.48	23.56	23.82	18.78
Retail Price ($)	15.44	13.37	13.82	14.44	15.32	13.30	13.72	14.31	16.47	14.10	14.84	15.70
– 375 ml	8.89	7.76	8.20	8.46	8.79	7.68	8.09	8.35	9.62	8.30	8.95	9.31
– 750 ml	14.43	12.50	12.94	13.51	14.30	12.41	12.83	13.37	15.60	13.36	14.12	14.90
– 1.75 L	20.58	17.80	18.26	19.14	20.49	17.75	18.19	19.04	21.51	18.40	19.11	20.39
– BRANDY	14.40	12.48	12.89	13.46	14.28	12.40	12.80	13.34	15.32	13.13	13.81	14.61
– CORDIALS	13.98	12.12	12.56	13.10	13.90	12.07	12.49	13.01	15.05	12.89	13.63	14.38
– GIN	15.03	13.04	13.48	14.07	14.93	12.97	13.39	13.96	15.96	13.68	14.38	15.22
– RUM	13.61	11.82	12.28	12.79	13.43	11.68	12.10	12.59	14.60	12.54	13.28	13.98
– VODKA	16.77	14.52	14.98	15.66	16.64	14.43	14.86	15.51	17.85	15.28	16.04	17.00
– WHISKEY	16.69	14.45	14.90	15.58	16.60	14.39	14.83	15.48	17.75	15.19	15.92	16.89

TABLE E.1

CONTINUED[a]

	BASE				SINGLE PRODUCT				COLLUSION			
	Bench.	Naïve	Response	Stackelberg	Bench.	Naïve	Response	Stackelberg	Bench.	Naïve	Response	Stackelberg
Consumption (M)												
– LITERS	62.67	96.91	88.53	77.24	64.08	98.32	90.23	79.15	51.69	84.95	73.62	60.60
– BOTTLES	60.31	88.96	81.17	72.14	61.84	90.50	83.00	74.11	49.32	77.17	66.57	56.40
Tax Revenue ($M)	370.84	399.58	374.57	379.12	377.08	405.33	381.40	385.64	320.39	351.63	316.05	324.87
– Percent Change		7.75	1.01	2.23		7.49	1.15	2.27		9.75	−1.36	1.40

[a] Retail price formula is "$p^r = p^w \times$ markup + unit fee" where we adjust both the markup and the unit fees to include the 18% Johnstown Flood tax. "Benchmark" refers to the equilibrium at the *PLCB* markup and fees in the estimated equilibrium after allowing upstream firms to re-optimize given the relevant conduct assumption. "Response" and "Stackelberg" equilibria are defined in the text. "Percent Change" is the percent change in tax revenue collected under each tax rate by the *PLCB* relative to the "Benchmark". In all experiments we use marginal cost estimates based on the observed product portfolio (i.e., "Base") and presented in Table V.

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