Appendix A: Data and Empirical Methods

Grocery Experiment. The store changes product prices on Wednesday nights and leaves the prices fixed (with rare exceptions) for the following week, termed a "promotional week." To synchronize our intervention with this pricing cycle, a team of researchers and research assistants printed tags every Wednesday night and attached them to each of the 750 products. The tags were changed between 11 pm and 2 am, which are low-traffic times at the store. The tags were printed using a template and card stock supplied by the store (often used for sales or other additional information on a product) in order to match the color scheme and layout familiar to customers. The two control stores were chosen by a minimum-distance criterion based on the characteristics listed in Appendix Table 1.

The raw scanner data provided by the grocery chain contains information on weekly revenue and quantity sold for each product (UPC id) that was sold among the 108 categories listed in Appendix Table 2 in the three stores from 2005 week 1 to 2006 week 15. The original dataset contains 331,508 product-week-store observations. The quantity and revenue variables are measured net of returns (i.e., returns count as negative sales). We exclude 1,756 observations where the weekly quantity or revenue was zero or negative, which are cases where as many or more items were returned than purchased in that week. Including these observations does not affect the results. Finally, we aggregate to the category-week-store level by summing quantity and revenue across products, setting the sum to zero if no products were sold in a given category-week-store.

The average price for each category of goods is defined as $P_{ct} = \Sigma_{i \in c}(p_{it}\bar{q}_i)/\Sigma_{i \in c}\bar{q}_i$ where c indexes the category, t time, and i products, p_{it} is the price of good i at time t, and $\bar{q}_i$ is the average quantity sold of good i. This "category price" is effectively a price index for a fixed basket of products where each product's weight in the basket is determined by its average weekly sales over the period before and during the experiment. Since the scanner data reports only items that have sold each week, we impute prices for unsold items when constructing P_{ct}. In particular, we use the price in the last observed transaction for unsold products; if no previous price is available, we use the next available price. Alternative imputation methods – such as using the closest observed price, or an average of previous and subsequent prices – give similar results. Varying the imputation technique has little impact on the estimates in Tables 4 and 5 because items requiring imputation have low sales volume, and therefore receive little weight in the category-level price variable.

Grocery Store Survey. We surveyed 91 customers entering the treatment store in August 2006 about their knowledge of sales taxes. Survey respondents were offered candy bars and sodas to spend a few minutes filling out the survey displayed in Appendix Exhibit 2. After collecting basic demographic information, the survey asked individuals to report whether each of eight goods were subject to sales tax or not. Many individuals remarked while filling out the survey that they did not think about taxes while shopping, and therefore were hesitant to report which goods were taxed. These individuals were asked to mark their best guess to avoid nonresponse bias. To assess whether knowledge of taxes is correlated with experience, we also asked whether individuals had purchased each of these goods recently. Finally, we asked questions about tax rates and bases – the sales tax rate in the city where the store is located, the state income tax rate, and the tax base for the federal estate tax.

Alcohol Analysis. Data on aggregate annual beer, wine, spirits, and ethanol consumption by state are available from the NIAAA (2006) from 1970-2003. These data contain information on total gallons of beer sold by wholesalers because this measure determines tax liabilities. See Thomas M. Nephew et al. (2004) and Nekisha E. Lakins et al. (2004) for details on data construction.

State excise tax rates on beer are primarily obtained from the Brewer's Almanac (various years), published annually by the Beer Institute. These rates were verified and corrected using the Tax Foundation's State Tax Collections and Rates (various years) and the State Tax Handbook. Our measure of the excise rate includes taxes that are statutorily 'local' excise taxes – which are sometime excluded from state statistics available in the Brewer's Almanac – that are applied state-wide. Specifically, in Alabama, Georgia, and Louisiana all counties or localities levy an excise tax in addition to the state excise tax.

Excise taxes on alcohol frequently differ by product, packaging, and whether sold for on- or off-premise consumption. In states where rates differ, our measure corresponds to the excise tax on packaged 12oz. beer, sold for off-premise consumption, with an alcohol content of 3.2 percent or more. Excise rates on other beer products are highly correlated with this measure across states, and the timing of tax changes for different categories of alcoholic beverages within a state are virtually identical. Per-gallon taxes are converted to per-case rates by multiplying by 2.25, the number of gallons in 24 12oz. cans or bottles. The excise tax rate is converted into an ad valorem rate by dividing the real CPI-adjusted beer excise tax per case in year 2000 dollars by the average cost of a case of beer in the United States in 2000, as measured by the Beer Institute. Since Alaska has a higher price level than the continental United States, we follow Census Bureau practice and adjust its price level up by 25 percent when calculating the percentage excise tax rate. None of our results are affected by this adjustment, or by excluding Alaska entirely. For a subset of years (1982-2000) and states, we have actual beer price data from the ACCRA cost of living index survey, which samples the price of a six pack of beer (Budweiser, Schlitz, or Miller Lite) in large cities. We define the ACCRA price variable as the annual average of all prices in each state.

State sales taxes are obtained primarily from the World Tax Database (2006) at the University of Michigan. These data were verified and corrected using state Department of Revenue websites and the State Tax Handbook. Four states (KS, VT, DC, MN) apply a higher sales tax rate to alcohol than other products. In those states we include the alcohol rate rather than the general sales rate when they differ. We supplement the data on state-level sales taxes with data on average local sales tax rates, which are imputed from data on local revenues from the Census Bureau's Survey of State and Local Government Finances and a tax base defined as state revenues divided by the state rate.

Since our estimation strategy relies on the timing and magnitude of the tax changes, we evaluate the precision of the data by regressing the change in the log of state tax revenues on the change in the log of the sales tax rate, controlling for state income. In the full sample, the coefficient estimate on the sales tax rate is 0.76 (s.e. 0.03). A state-by-state analysis of changes in rates and changes in revenues also yields similarly high correlations, with the exception of West Virginia. In WV, the correlation between sales tax rates and revenues is near zero and statistically insignificant, perhaps because the tax base is often changed at the same time as the rate. Since this problem could artificially attenuate the sales tax elasticity, we exclude West Virginia from our analysis.

Appendix B: Proof of Proposition 2

We derive an expression for $EB(t^S)$ using Taylor expansions that ignore third and higher-order terms, i.e. terms proportional to $(t^S)^n$ for $n \geq 3$. Let $V^*(p, t^S, Z)$ denote the utility attained by a fully optimizing agent who consumes the optimal bundle $(x^*(p, t^S, Z), y^*(p, t^S, Z))$. Let $R^*(p, t^S, Z) = t^S x^*(p, t^S, Z)$ denote tax revenue obtained from a fully optimizing agent.

The agent's loss from failing to optimize relative to the tax is

$$G(t^S) = e(p, 0, V^*(p, t^S)) - e(p, 0, V(p, t^S))$$

The gain in revenue due to the agent's underreaction to the tax is

$$\Delta R(t^S) = R(p, t^S, Z) - R^*(p, t^S, Z)$$

Recall that excess burden in the full optimization case is

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

Combining these three equations, we can rewrite the formula for excess burden in (**??**) as

$$EB(t^S) = EB^* - \Delta R + G. \tag{1}$$

We will use Taylor expansions to obtain simple expressions for each of these three terms below.

i) Auerbach (1985) shows that ignoring third-order terms, excess burden for an optimizing agent is

$$EB^* = -\frac{1}{2}(t^S)^2 \frac{\partial x^c}{\partial p}$$

ii) Ignoring third-order terms, the ΔR term can be written as:

$$\Delta R = -t^S(x^* - x) = (t^S)^2 \left(\frac{\partial x}{\partial t^S} - \frac{\partial x}{\partial p}\right)$$

iii) Simplifying the expression for G requires more work. First recall that the expenditure function is

$$e(p, t^S, V) = (p + t^S)x^c(p, t^S, V) + y^c(p, t^S, V)$$

and hence

$$\frac{\partial e}{\partial V} = (p + t^S)\frac{\partial x^c}{\partial V} + \frac{\partial y^c}{\partial V}.$$

The expenditure minimization problem is

$$\min (p + t^S)x^c + y^c \text{ s.t. } u(x) + v(y) = V$$

Differentiating the utility constraint for the expenditure minimization problem (EMP) yields

$$u'(x^c)\frac{dx^c}{dV} + v'(y^c)\frac{dy^c}{dV} = 1$$

The first-order-condition for the EMP implies

$$u'(x^{*c}) = (p + t^S)v'(y^{*c})$$

and hence we obtain the equation

$$(p + t^S)\frac{\partial x^{*c}}{\partial V} + \frac{\partial y^{*c}}{\partial V} = \frac{1}{v'(y^{*c})} = \frac{\partial e(p, t^S, V^*)}{\partial V}$$

where all the derivatives are evaluated at (p, t^S, V^*). Using a Taylor expansion, we write

$$G = \frac{\partial e(p, t^S, V^*)}{\partial V}[V^*(p, t^S, Z) - V(p, t^S, Z)] - \frac{1}{2}\frac{\partial^2 e(p, t^S, V^*)}{\partial V^2}[V^* - V]^2 + ...$$

We show below that $V^* - V$ is proportional to $(t^S)^2$; hence, the $[V^* - V]^2$ and higher-order terms in this expansion can be ignored under the second-order approximation. Hence, we can write

$$G = \frac{[V^*(p, t^S, Z) - V(p, t^S, Z)]}{v'(y^{*c}(p, t^S, V^*))}$$

Define the utility gain from choosing the optimal level x^* instead of x as

$$\begin{aligned}\widetilde{G}(x) &= V^*(p, t^S, Z) - V(p, t^S, Z) = u(x^*) - u(x) + v(y^*) - v(y) \\ &= u'(x^*)(x^* - x) - \frac{1}{2}u''(x^*)(x^* - x)^2 + O_u^3 + v'(y^*)(y^* - y) - \frac{1}{2}v''(y^*)(y^* - y)^2 + O_v^3\end{aligned}$$

where O_u^3 and $+O_v^3$ represent the third- and higher order terms of the Taylor expansions for u and v. All of the terms in O_u^3 and $+O_v^3$ turn out to be proportional to $(t^S)^n$ with $n \geq 3$, so we ignore these terms from this point onward.

Using the first-order-condition that characterizes the choice of the fully-optimizing agent,

$$u'(x^*) = (p + t^S)v'(y^*)$$

and the identity

$$(p + t^S)(x^* - x) = (y - y^*)$$

we obtain

$$\begin{aligned}\widetilde{G} &= -\frac{1}{2}u''(x^*)(x^* - x)^2 - \frac{1}{2}v''(y^*)(y^* - y)^2 \\ &= -\frac{1}{2}(x^* - x)^2[u''(x^*) + v''(y^*)(p + t^S)^2] \qquad (2)\end{aligned}$$

Totally differentiating the fully-optimizing agent's first-order-condition with respect to p yields

$$\begin{aligned} u''(x^*)\frac{\partial x^*}{\partial p} &= v'(y^*) + (p+t^S)v''(y^*)\frac{\partial y^*}{\partial p} \\ &= v'(y^*) + (p+t^S)[-(p+t^S)\frac{\partial x^*}{\partial p} - x^*]v''(y^*). \end{aligned}$$

It follows that

$$[u''(x^*) + (p+t^S)^2 v''(y^*)]\frac{\partial x^*}{\partial p} = v'(y^*) - (p+t^S)x^* v''(y^*)$$

and hence

$$\widetilde{G} = -\frac{1}{2}(x^*-x)^2 \frac{[v'(y^*) - (p+t^S)x^* v''(y^*)]}{\partial x^*/\partial p}. \tag{3}$$

Defining $\gamma_y = -y^* v''(y^*)/v'(y^*)$ it follows that

$$G \simeq \frac{\widetilde{G}}{v'(y^*)} = -\frac{1}{2}(x^*-x)^2 \frac{1}{\partial x^*/\partial p}[1 + (p+t^S)\frac{x^*}{y^*}\gamma_y]. \tag{4}$$

Finally, we use a result from Chetty (2006) which relates the coefficient of relative risk aversion γ_y to the ratio of the income effect to the substitution effect:

$$\gamma_y = \frac{-y^*}{p+t^S}\frac{\frac{\partial x^*}{\partial z}}{\frac{\partial x^{*c}}{\partial p}}. \tag{5}$$

Inserting this expression into (4) yields

$$\begin{aligned} G &\simeq -\frac{1}{2}(x^*-x)^2 \frac{1}{\partial x^*/\partial p}[1 - x^* \frac{\frac{\partial x^*}{\partial z}}{\frac{\partial x^{*c}}{\partial p}}] \\ &= -\frac{1}{2}(x^*-x)^2 \frac{1}{\partial x^{*c}/\partial p} \\ &= -\frac{1}{2}(t^S)^2 \frac{(\frac{\partial x}{\partial t^S} - \frac{\partial x}{\partial p})^2}{\partial x^{*c}/\partial p} \end{aligned}$$

Combining the expressions for G, ΔR, and EB^* above using (1) and collecting terms yields

$$EB(t^S) = (t^S)^2 \frac{1}{\frac{\partial x^c}{\partial p}}\{\frac{\partial x}{\partial t^S}[\frac{\partial x}{\partial p} - \frac{1}{2}\frac{\partial x}{\partial t^S} - \frac{\partial x^c}{\partial p}] - \frac{1}{2}[\frac{\partial x}{\partial p} - \frac{\partial x^c}{\partial p}]^2\}$$

Using the Slutsky equation and the definition $\frac{\partial x^c}{\partial t^S} - \frac{\partial x}{\partial t^S} = x\frac{\partial x}{\partial z}$ to simplify this expression, we obtain the formula in Proposition 2.

APPENDIX TABLE 1

Category Classification in Grocery Store Data

Categories	Group Description	Category Description	Mean Weekly Revenue
Treatment			
5101	Deodorant	Aerosols	82.40
5103	Deodorant	Body Sprays	55.22
5105	Deodorant	Roll-ons	44.12
5110	Deodorant	Clear Solids	323.38
5115	Deodorant	Clear Soft	35.13
5120	Deodorant	Clear	123.48
5125	Deodorant	Visible Sticks	75.57
5245	Hair Care	Accessories	189.47
5501	Cosmetics	Facial	84.20
5505	Cosmetics	Eye	195.00
5510	Cosmetics	Nail	73.38
5515	Cosmetics	Lipstick	48.39
5520	Cosmetics	Accessories	19.37
Control			
5005	Oral Hygiene	At Home Whitening	107.24
5010	Oral Hygiene	Manual Toothbrush	340.57
5012	Oral Hygiene	Power Toothbrush	120.89
5015	Oral Hygiene	Oral Rinse/Mouthwash	314.75
5020	Oral Hygiene	Denture Care	96.82
5025	Oral Hygiene	Dental Floss Products	116.75
5030	Oral Hygiene	Interdental Implements	26.76
5035	Oral Hygiene	Oral Analgesics	115.45
5040	Oral Hygiene	Portable Oral Care	52.84
5201	Hair Care	Professional Daily Hair Care	310.75
5205	Hair Care	Performance Daily Hair Care	983.31
5210	Hair Care	Value Daily Hair Care	290.11
5215	Hair Care	Dandruff Hair Care	116.37
5220	Hair Care	Therapeutic Hair Care	20.54
5225	Hair Care	Hair Growth	12.85
5230	Hair Care	Kids Hair Care	46.75
5235	Hair Care	Hair Color	430.18
5250	Hair Care	African American Hair Care	59.91
5301	Skin Care	Bar Soap	395.65
5305	Skin Care	Liquid Hand Soap	138.95
5308	Skin Care	Liquid Waterless Sanitizer	41.00
5310	Skin Care	Body Wash	339.04
5312	Skin Care	Bath Care	29.82
5314	Skin Care	Image Bath Boutique	36.07
5315	Skin Care	Acne Prevention	140.02
5318	Skin Care	Acne Treatment	12.57
5320	Skin Care	Basic Facial Care	427.17
5322	Skin Care	Anti-aging/Treatments skin care	27.99
5325	Skin Care	Hand & Body Skin Care	312.46
5330	Skin Care	Lip Care	91.97
5335	Skin Care	Cotton	169.72
5340	Skin Care	Depilatories	33.61

5345	Skin Care	Adult Skin Care	172.57
5350	Skin Care	Child/Baby Sun Care	26.06
5401	Shave Needs/Men's Personal Care	Razors	161.13
5405	Shave Needs/Men's Personal Care	Cartridges	389.02
5410	Shave Needs/Men's Personal Care	Disposable Razors	195.95
5415	Shave Needs/Men's Personal Care	Shave Preps	210.23
5420	Shave Needs/Men's Personal Care	Men's Skin Care	14.98
5601	Vitamins and Dietary Supplements	Multiple Vitamins	264.95
5605	Vitamins and Dietary Supplements	Joint Relief	89.57
5610	Vitamins and Dietary Supplements	Calcium	72.59
5615	Vitamins and Dietary Supplements	Letters	120.32
5620	Vitamins and Dietary Supplements	Specialty Supplements	65.91
5625	Vitamins and Dietary Supplements	A/O Minerals	31.65
5630	Vitamins and Dietary Supplements	Herbal Supplements	74.18
5701	Pain Relief	Adult Aspirin	48.23
5703	Pain Relief	Enteric/Antacid/Buffered Aspirin	14.90
5704	Pain Relief	Low Strength Aspirin	62.19
5705	Pain Relief	Adult Acetaminophen	203.24
5710	Pain Relief	Ibuprofen Adult	252.89
5715	Pain Relief	Naproxen Sodium	54.63
5716	Pain Relief	Adult Compounds	86.75
5718	Pain Relief	Specialty Indication Pain	88.92
5725	Pain Relief	Children's/Infants Analgesics	187.25
5730	Pain Relief	Sleeping Aids	64.99
5735	Pain Relief	Stimulants	14.82
5750	Pain Relief	Nighttime Pain Relief	76.19
5760	Pain Relief	External Analgesic	144.08
5799	Pain Relief	GM/HBC Trial Size	66.88
5801	Respiratory	Pediatric Cold/Flu/Cough/Allergy/Sinus	229.73
5805	Respiratory	Adult Cough, Cold, Flu	925.93
5835	Respiratory	Adult Allergy/Sinus	500.74
5840	Respiratory	Nasal Products	269.19
5845	Respiratory	Bronchial Asthma	41.45
5850	Respiratory	Cough Drops/Throat Relief	252.64
5855	Respiratory	Thermometers/Covers	37.72
5901	Digestive Health	Acid Neutralizers	243.37
5905	Digestive Health	Acid Combination	17.21
5910	Digestive Health	Acid Blockers	131.62
5915	Digestive Health	Proton Pump Inhibitors (PPI)	92.82
5920	Digestive Health	Multi Symptom Gastro Intestinal Relief	70.60
5925	Digestive Health	Gas Relief	49.46
5930	Digestive Health	Motion Sickness/Anti-Nausea	24.32
5935	Digestive Health	Anti-diarrhea	82.70
5940	Digestive Health	Laxatives	265.29
5945	Digestive Health	Lactose Intolerance	22.14
5950	Digestive Health	Rectal/Hemmorhoidal	58.79
5955	Digestive Health	Pediatric Laxatives	31.57
6001	Eye/Ear Care	Soft Contact Lens Care	155.16
6005	Eye/Ear Care	Rigid Gas Permeable Contact Lens Care	18.55
6010	Eye/Ear Care	General Eye Care	203.62
6040	Eye/Ear Care	Reading Glasses	71.66
6042	Eye/Ear Care	Sunglasses	43.87
6045	Eye/Ear Care	Misc. Eye Glass Accessories	15.28

6050	Eye/Ear Care	Ear Care/Ear Plugs	33.25
6101	Foot Care	Insoles/Inserts	75.90
6105	Foot Care	Corns/Callous/Padding/Bunion/Blister	28.88
6110	Foot Care	Odor/Wetness Control	19.64
6115	Foot Care	Anti-Fungal/Athlete's Foot	107.49
6120	Foot Care	Jock Itch	20.22
6130	Foot Care	Wart Removers	37.76
6190	Foot Care	Grooming and Misc. Foot Care	12.70

Note: Weekly revenue statistics based on sales in calendar year 2005.

APPENDIX TABLE 2

Descriptive Statistics: Grocery Stores

	Treatment Store	Control Store #1	Control Store #2
A. Store Characteristics			
Mean Weekly Revenue ($)	307,297	268,193	375,114
Total Floor Space (sq ft)	41,609	34,187	37,251
Store Opening Year	1992	1992	1990
B. City Characteristics (in 1999)			
Population	88,625	96,178	90,532
Median Age (years)	33.9	31.1	32.3
Median Household Income ($)	57,667	51,151	60,359
Mean Household Size	2.8	2.9	3.1
Percent bachelor's degree or higher	19.4	20.4	18.2
Percent Married	60.2	56.9	58.1
Percent White	72.1	56.2	65.3
Distance to Treatment Store (miles)		7.7	27.4

Notes: Data on store characteristics obtained from grocery chain. Weekly revenue statistics based on sales in calendar year 2005. Data for city characteristics are obtained from the U.S. Census Bureau, Census 2000. Control stores were chosen using a least-squares minimum-distance criterion based on this set of variables.

APPENDIX EXHIBIT 1: CLASSROOM SURVEY

Short survey on spending patterns

Major: ______________

Year: ______________

Gender: ______________

Choose two items from the image projected on the screen.

Number of item #1: ____________

Number of item #2: ____________

Total bill due at the register for these two items:

$__________

APPENDIX EXHIBIT 2: TAX SURVEY

University of California, Berkeley
Department of Economics

This survey is part of a project about taxes being conducted by researchers at UC Berkeley. Your identity will be kept strictly confidential and will not be used in the research. If you have any questions about your rights or treatment as a participant in this research project, please contact UC-Berkeley's Committee for Protection of Human Subjects at (510) 642-7461, or e-mail: subjects@berkeley.edu.

Gender:	**Age**:	**Marital Status**:	**Education**:	**Years You Have Lived in California:**
☐ Male ☐ Female		☐ Married ☐ Unmarried	☐ High School ☐ College Degree ☐ Graduate Degree	

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

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

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

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

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

Thank you for your time!