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# Alcohol-Leisure Complementarity: Empirical Estimates and Implications for Tax Policy

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# Alcohol-Leisure Complementarity: Empirical Estimates and Implications for Tax Policy

**Abstract** – This paper provides a first attempt to estimate the cross-price elasticity between alcoholic beverages and leisure, which is critical for assessing how much alcohol taxation might be warranted on fiscal grounds. We estimate a demand system defined over alcohol, leisure, and other goods, using data from the Consumer Expenditure Survey and other sources. Our results suggest that alcohol is a relative complement for leisure over a range of specifications. This implies that the optimal alcohol tax may substantially exceed the Pigouvian tax, reinforcing the efficiency case for higher taxation. These findings should be viewed as preliminary, however, given data and other limitations.

## I. INTRODUCTION

There are two potentially important economic rationales for alcohol taxes. First, they help to mitigate various external costs of alcohol abuse, such as the risks to others posed by drunk drivers and the burden of medical costs on third parties from alcohol-related illness. Second, by raising revenue, they reduce the need to rely on other taxes, particularly those that fall on labor income, to finance the government's budget. The Ramsey theory of optimal excise taxation implies that such a tax substitution is likely to be desirable if alcohol is a relative complement for leisure, in which case it provides what we shall describe as an additional "fiscal" rationale for alcohol taxation. A truly "optimal" alcohol tax would reflect both of these considerations.

As regards the first rationale, a number of studies have measured the Pigouvian, or externality-correcting, level of alcohol taxes. Although the usual caveats about parameter uncertainty apply, a typical estimate is a tax of around \$70 per gallon, or about three times current federal and state taxes of \$24 per gallon; see Parry, West, and Laxminarayan (2009) for a recent discussion of this evidence.

The second rationale for alcohol taxes has not received any attention in the prior literature, at least in a quantitative sense, so there is no basis for gauging to what extent the optimal alcohol tax may differ from the Pigouvian tax. In particular, there have been no attempts to estimate the alcohol-leisure cross-price elasticity, even though it is a critical parameter in determining the Ramsey component of the optimal alcohol

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tax. It behooves economists to try to estimate this elasticity, and thus provide some insight on whether there is a valid fiscal rationale for alcohol taxes.

This paper provides a first attempt at estimating this elasticity, based on an Almost Ideal Demand System defined over alcohol, leisure, and other goods, estimated with data from the Consumer Expenditure Survey and other sources. While the data are probably as good as we can find, and we believe we have pushed the methodology as far as possible with standard econometric techniques, the confidence intervals we obtain on the alcohol-leisure cross-price elasticity are nonetheless large. However, over a wide range of model specifications, alcohol is a relative complement for leisure over a 95 percent confidence interval, and the resulting Ramsey tax is potentially large. In fact, it is quite plausible that the fiscal component of the optimal alcohol tax is more important than the Pigouvian component. Thus, the adjustments for alcohol-leisure complementarity serve to reinforce the efficiency case for higher alcohol taxes, perhaps by a substantial amount.

Given a number of data and other limitations discussed below, our findings should be viewed as suggestive rather than conclusive. Nonetheless, our analysis has value in demonstrating the potential empirical importance of the Ramsey tax, and in developing an econometric methodology that can be refined as the quantity and quality of data improve over time.

Before outlining our empirical approach and results, we first describe in more detail how our paper relates to the previous literature on optimal commodity taxes, external costs, and the workplace productivity effects of alcohol abuse. We conclude with a discussion of some caveats to the case for higher taxes, such as equity issues, the risk that alcohol tax revenues will not be used judiciously, and political opposition to alcohol tax reform.

## II. BACKGROUND

### A. Relation to the Optimal Tax Literature

According to Ramsey tax theory, the optimal tax on a commodity may exceed any level warranted on externality grounds if the product is a relatively weak substitute or a strong complement for leisure, compared with other consumption goods (Sandmo, 1975; Bovenberg and Goulder, 2002). Under these conditions, up to a point a revenue-neutral shift from a tax on labor income to the commodity tax will (slightly) increase labor supply, inducing an efficiency gain in the tax-distorted labor market, in addition to any efficiency gain obtained from mitigating the externality. Converse results apply if the product is a relatively strong substitute for leisure.

This fiscal component of the optimal commodity tax implicitly combines two linkages with the broader tax system that have been decomposed in the literature on environmental tax shifts (Goulder, 1995; Parry and Oates, 2000). First is the "revenue-recycling effect" or efficiency gain from using additional commodity tax revenues to reduce distortionary labor taxes. Second is the "tax-interaction effect" or potential efficiency loss in the labor market from the impact of higher commodity prices on reducing the real returns to work effort, thereby discouraging labor supply. For commodities that are relative leisure complements, the revenue-recycling effect can dominate the tax-interaction effect (and the latter may even reverse sign), implying a net welfare gain from interactions with the tax system, and a positive fiscal component to the optimal commodity tax.

Perhaps surprisingly, there have been few attempts to apply empirically the optimal commodity tax framework to actual taxes. This may be because economists were initially concerned with optimizing over all commodity taxes

simultaneously, which is an especially formidable challenge.<sup>1</sup> Instead our focus is on only one commodity tax, assuming the rest of the tax system, primarily income and payroll taxes, is collapsed into a single tax on labor income (interactions with tobacco taxes are discussed in Section V).

Even for the limited number of commodities traditionally targeted with excise taxes—primarily tobacco products, transportation fuels, alcoholic beverages, and telecommunications—there has been little attempt to estimate econometrically the leisure cross-price elasticities that are required to assess how much taxation of these commodities might be warranted on optimal taxation grounds.<sup>2</sup> Diewert and Lawrence (1996) estimate these cross-price elasticities for motor vehicles, housing, and other goods, but not alcohol. Their point estimates indicate that both motor vehicles and housing are relative leisure complements, with compensated cross-price elasticities of  $-0.14$  and  $-0.79$  respectively, compared to a cross-price elasticity of  $0.38$  for general consumption with respect to the price of leisure. Madden (1995) includes both leisure and alcohol in a demand system estimated with aggregate time series data for Ireland, though the cross-price elasticities are not reported.

West and Williams (2007) estimate an Almost Ideal Demand System defined over gasoline, leisure, and other goods using household data. They find that the optimal gasoline tax is around 50 percent larger than the externality-mitigating tax, because gasoline is a relative leisure complement. This makes sense intuitively,

as gasoline use increases less than proportionately to labor supply (following a compensated wage increase), given the substantial share of non-work-related trips in total household travel. Another explanation is that driving is a relatively time-intensive activity at the margin, once households have incurred the fixed cost of buying a car. Becker's (1965) model of time use suggests that time-intensive goods are complements to non-market time.

We have less intuition about other cross-price elasticities, including that between alcohol and leisure. However we might expect that alcohol and leisure would be relative complements, since a substantial share of alcohol use is not work-related, and prior evidence (discussed below) suggests that spending on alcohol increases proportionately less than spending on other goods when households have more (labor) income.

## B. Relation to the Health Economics Literature

In health economics, discussions of optimal alcohol taxes usually focus on the externality-correcting or Pigouvian tax, leaving aside linkages between this tax and the broader fiscal system. The most important component of the Pigouvian tax is the (marginal) external cost imposed by drunk drivers. This has been calculated from the (fatal and non-fatal) injury risk that drunk drivers pose to others, treating risks to occupants in vehicles driven by the drunk driver as internal. A portion of various other accident costs, such as property damage and medical

<sup>1</sup> This would require reliable estimates of own- and leisure-cross price elasticities for every taxed commodity and functional form assumptions that might be unreliable for large price changes. One response to these problems has been to limit the focus to broad commodity groups, and to the appropriate direction of partial tax reforms (Ahmad and Stern 1984; Madden, 1995; Zodrow, 2006).

<sup>2</sup> A number of studies include alcohol when estimating commodity demand systems but do not include leisure, including Andrikopoulos, Brox, and Carvahlo (1997), Blake and Nied (1997), Browning (1991), Blundell, Pashardes, and Weber (1993), Deaton and Muellbauer (1980), Eakins and Gallagher (2003), Fuss and Waverman (1987), Gao, Wailles, and Cramer (1995), Holm (1995), Jones (1989), Nelson and Moran (1995), Taube, Huth, and MacDonald (1990), and Taube and MacDonald (1991).

burdens, are also external to the extent they are borne by insurance companies or the government. Another component of external costs is the medical burden on third parties from alcohol-induced illness over the lifecycle (net of any medical savings from premature mortality), though these costs appear to be minor relative to the drunk driver externality. In computing the Pigouvian tax, road accident and illness costs are scaled by the sensitivity of drunk driving and heavy drinking, respectively, to alcohol prices, relative to the price sensitivity of overall alcohol consumption. Studies typically put the optimal Pigouvian tax at around 30 percent or more of the pre-tax alcohol price (Manning et al., 1989, 1991; Phelps, 1988; Pogue and Sgontz, 1989; Parry, West, and Laxminarayan, 2009).<sup>3</sup>

There is also a large empirical literature on the own-price elasticity for alcohol consumption, though there are some serious measurement challenges in estimating this elasticity (Cook and Moore, 2000). Most estimates of the own-price elasticity for all alcoholic beverages combined lie between about  $-0.4$  and  $-1.0$  (elasticities for individual beverages sometimes lie outside this range).<sup>4</sup> The own-price elasticity enters into the Ramsey component of the optimal alcohol tax (see below): the more inelastic the demand, the greater the Ramsey tax (assuming alcohol is a relative leisure complement), as there is less erosion of the alcohol tax base in response to higher tax rates.<sup>5</sup>

Economists have also estimated the productivity and labor supply effects of alcohol consumption, attributing any negative association to the inability of

heavy drinkers to concentrate on the job or find and retain stable employment (Cook and Moore, 2000). As discussed below, such a negative alcohol-health-productivity relation plays a separate and reinforcing role in raising the optimal alcohol tax above the Pigouvian tax. Some studies find a negative association (Mullahy and Sindelar, 1991, 1993), but others find a "drinker's bonus," that is, a positive association between earnings and alcohol consumption (Berger and Leigh, 1988; Zarkin et al., 1998) though these results may be biased, as earnings are a determinant of alcohol consumption.

Two recent studies address the possibility of endogeneity by estimating reduced form models relating labor market outcomes to alcohol taxes. While Dave and Kaestner (2002) find no evidence that alcohol taxes affect wages, employment, or hours, they express concern that specification error may obscure the true relationships. Cook and Peters (2005) attempt to avoid this problem by using longitudinal data, which enables them to control for a large set of individual-specific characteristics. Their results show a positive relationship between alcohol taxes and earnings and support the notion that the drinker's bonus found by others is due to reverse causality, given that alcohol is a normal good.

Because our study focuses on the sensitivity of alcohol consumption with respect to the price of leisure (and not the reverse), we avoid the kind of endogeneity problem discussed above, but face another if alcohol consumption affects wages. We use instrumental variable techniques to address this problem, as discussed below.

<sup>3</sup> Kenkel (1996) estimates a somewhat larger tax when people misperceive the long-term risks from heavy drinking.

<sup>4</sup> Some recent studies include Baltagi and Goel (1990), Baltagi and Griffin (1995), Lee and Tremblay (1992), Manning, Blumberg, and Moulton (1995), Manning and Mullahy (1998), Nelson and Moran (1995), Selvanathan (1991), and Yen (1994).

<sup>5</sup> On the other hand, a more inelastic demand reduces the externality benefits from a given alcohol tax (though it does not affect the Pigouvian tax, if the drunk driver and heavy drinking elasticities are also proportionately smaller).

### III. ECONOMETRIC METHODOLOGY

#### A. Model Specification

We specify the following Almost Ideal Demand System (AIDS) for an individual household  $h$ , defined over three “goods”, alcohol ( $A$ ), leisure ( $l$ ), and a composite of all other consumption goods ( $C$ ):<sup>6</sup>

$$(1a) \quad s_j^h = \alpha_j^h + \sum_k \mu_{jk} \log p_k^h + \beta_j \log(F^h / P^h), \quad j, k = \text{alcohol, leisure, other goods}$$

$$(1b) \quad \log P^h \equiv \sum_j s_j^h \log(p_j^h / \bar{p}_j)$$

$$(1c) \quad \sum_j \alpha_j^h = 1, \quad \sum_j \mu_{jk} = 0, \quad \sum_j \beta_j = 0, \\ \mu_{jk} = \mu_{kj}$$

$$(1d) \quad \alpha_j^h = \zeta_{j0} + \sum_r \zeta_{jr} r^h + e_j^h$$

where  $s_j^h$  is the expenditure share for good  $j$ ,  $F^h$  is full income (total spending on alcohol, leisure, and other goods),  $p_k^h$  is the price of good  $k$  faced by household  $h$ , and  $P^h$  is a unit invariant price index, where  $\bar{p}_j$  is the mean price for good  $j$  over all households. The coefficients  $\alpha_j^h$ ,  $\mu_{jk}$ , and  $\beta_j$  are parameters to be estimated, after imposing the restrictions in (1c), which follow because household budget shares sum to unity, and demand functions are homogeneous of degree zero in prices and full income and satisfy Slutsky symmetry.<sup>7</sup>

In (1d), we allow a vector of household specific characteristics (age, race, education, etc.), indexed by  $r^h$ , to affect demand, where  $\zeta_{j0}$  and  $\zeta_{jr}$  are parameters to be estimated and  $e_j^h$  is an error term reflecting unobserved differences in preferences. We also include state fixed effects and regional dummies (Northeast, Midwest, South and West) in  $r^h$  to account for unobserved local factors that might affect alcohol use or work behavior (e.g., liquor laws, cultural factors, climate, and job opportunities).

As discussed below, the Ramsey tax or fiscal component of the optimal alcohol tax depends on the compensated elasticity of alcohol demand with respect to the price of leisure, which is the main focus of our estimation.

#### B. Data Sources

##### 1. Household Data

Our main data set consists of 9,454 household observations from twelve consecutive quarters of the Consumer Expenditure Surveys (CEX), 1996–1998. Each quarter, 20 percent of the sample is rotated out and replaced by new households; we pool household observations across different quarters.<sup>8</sup> The CEX files include, for each household, spending on alcohol, total spending on all goods, number of children, and state of residence.<sup>9</sup> Another expenditure file in the CEX contains two categories of spending on alcohol: (1)

<sup>6</sup> The AIDS provides a first-order approximation to any demand system and satisfies the axioms of consumer choice (Deaton and Muellbauer 1980). Unlike certain other demand systems, it does not impose (1) weak separability between leisure and consumption goods, or (2) homothetic preferences (which imply unitary expenditure elasticities for all goods); either of these restrictions could seriously bias estimates of the alcohol-leisure cross-price elasticity.

<sup>7</sup> We limit the number of goods to three for tractability. The omission of another specific good would bias the estimate of our quantity of interest, the alcohol-leisure cross-price elasticity, if the effect of the wage on alcohol consumption is correlated with the effect of the price of the other specific good on alcohol consumption.

<sup>8</sup> Pooling observations enables us to exploit variation over time within household. As mentioned below, we cluster by household to correct for any bias due to dependence across these observations.

<sup>9</sup> Self-reported alcohol consumption usually understates actual consumption, perhaps by as much as 50 percent (Cook and Moore, 2000). If underreporting varies with the wage, then our estimates of the cross-price elasticity of demand will be biased. For example, more prevalent underreporting among high-wage workers will bias the cross-price estimate downward. However, there is very little evidence on whether the errors across survey respondents are additive, proportional, random or systematic, so it is unclear whether, and in what way, underreporting affects our results.

beer and wine, and (2) all other alcohol (i.e., spirits). We attempted to estimate separate elasticities for each category but results were implausible or imprecise, as many households only consume one of the two categories.<sup>10</sup> In addition, for each household, the files include usual weekly work hours, occupation, the gross amount of last pay, the duration of the last pay period, age, race, sex, and education level (which we code as above, equal, or below high school diploma).<sup>11</sup>

We calculate (weekly) spending on the composite good as total expenditure less that on alcohol, leisure as a (non-sleep) time endowment of 90 hours per week less work hours (our results are not sensitive with respect to the value of the time endowment), and full income as total expenditure plus the product of leisure and the net wage. Wages are measured by gross wages from the CEX, corrected for selection bias (see below), and net of federal and state income taxes and earned income and child tax credits; effective tax rates for different wage rates were obtained from NBER's TAXSIM model (Feenberg and Coutts, 1993). As payroll taxes are partially offset by higher future social security benefits, we do not deduct them in our baseline specification, though we do deduct them in one of the sensitivity analysis specifications.

## 2. Price Data

For the alcohol price we use the American Chamber of Commerce Research Association (ACCRA) cost-of-living index, which lists quarterly average prices for beer, wine, and spirits for approxi-

mately 300 urban areas. We weight city and town prices by population shares (from the 2000 census) to obtain state-level alcohol prices. To obtain one price of alcohol, we convert beer, wine, and spirits prices into prices per liter, and weight them by the average share of each beverage in total liters of alcohol consumption. The ACCRA data are also used to obtain a price index for the composite good.

Although often used in the empirical alcohol demand literature, the ACCRA price index can be problematic. One issue is that the data are collected by members of local chambers of commerce and there may be some inconsistency in measurement across states. However, measurement errors in alcohol prices are only a concern for the alcohol-leisure cross-price elasticity if they are spatially correlated with wages or leisure, which seems unlikely.

Another problem is that spatial differences in alcohol prices may be collinear with the state fixed-effect variables. In our data, state fixed effects absorb a significant portion but by no means all of the variation in state alcohol prices, as these prices vary across time. The average standard deviations of within-state wine, beer, and alcohol prices are 11 percent, 9 percent, and 7 percent of the within-state price averages, respectively. There is on average a difference of about \$2, \$4, and \$8, respectively between minimum and maximum prices within states. After these prices are weighted and averaged to obtain one price per liter of alcohol, the average within-state standard deviation in

<sup>10</sup> Assessing whether there is any basis for differential taxation of individual beverages on externality grounds is very difficult because, for example, data on alcohol involvement in traffic accidents is not distinguished by beverage class. As for the fiscal rationale, there appears to be some basis for taxing beer more heavily than wine, and wine more heavily than spirits (Parry, West, and Laxminarayan, 2009). This is because the estimated own-price elasticities for beer are smaller in magnitude than for wine, which in turn are smaller than for spirits. In contrast, spirits are taxed most heavily, at about \$35 per gallon of alcohol, compared with \$20 per gallon for beer, and \$18 for wine (Parry, West, and Laxminarayan, 2009, Table 1).

<sup>11</sup> Other data sets commonly used in empirical work on alcohol demand do not contain all the variables we require; for example, the National Health Interview Survey excludes wages, while the Behavioral Risk Factor Surveillance System excludes both wages and hours worked.

this price is 8 percent of the average price. Lack of variation in within-state alcohol prices magnifies the standard error on the own-price alcohol elasticity, though again this is not a primary concern for the alcohol-leisure cross-price elasticity.

Nonetheless, we also estimate specifications (1) with no fixed effects, and (2) with various fixed effects alternatives commonly used in the literature, including proportion of state population in college, state average temperature, average cloudy days per year, number of drinking establishments and places of worship per capita, and a dummy variable for whether alcohol sales are permitted on Sundays (to proxy for anti-drinking sentiment). In these alternative specifications the confidence interval for the own-price alcohol elasticity is somewhat narrower, though that for the alcohol-leisure cross-price elasticity is only moderately affected. In the benchmark estimation we control for state fixed effects to reduce the possibility of omitted variables bias.<sup>12</sup>

C. Correcting for Selection Bias and Endogeneity

Not all household members participate in the labor force and about half of the households in our sample report no alcohol consumption. Following Heckman (1979), we attempt to correct for possible selection bias by estimating probits on the discrete choice of whether to work and whether to consume alcohol. We then exclude from the

second-stage estimation households that do not work and that do not consume alcohol, to avoid estimation bias when there are a large number of censored households (Shonkwiler and Yen, 1999). More details on these first-stage estimation procedures are provided in Appendix A.<sup>13</sup>

In the case of labor force participation, we estimate a probit model jointly with a wage equation using the full information maximum likelihood approach to generate the selectivity-corrected wage for each household for use in estimating the demand system in (1a). In the first-stage estimation we use standard exclusion restrictions from the literature (e.g., number of children, partner’s earnings, and the unemployment rate).

For the decision of whether to consume alcohol, we estimate a probit to obtain the predicted inverse Mills ratios, denoted  $MR_a^h$ , and include them in the demand system in (1a) to give:

$$(2) \quad s_j^h = \zeta_{j0} + \sum_r \zeta_{jr} r^h + \sum_k \mu_{jk} \log p_k^h + \beta_j \log(E^h / P^h) + \gamma_j MR_a^h + e_j^h$$

where  $\gamma_j$  are parameters. However, our exclusion restriction for alcohol consumption, whether the individual is over the age of 21, is probably a weak source of identification as it involves relatively few households, and as being underage affects alcohol consumption on both the extensive and intensive margins.<sup>14</sup> In the sensitivity analysis we therefore also follow many other studies in the literature

<sup>12</sup> Some researchers have used state beer taxes to proxy for alcohol prices, but this is also problematic (Young and Bielinska-Kwapisz, 2002). In particular, taxes are only a tiny fraction of retail prices, and therefore fail to control for spatial differences in transportation, distribution, and other producer costs. We experimented with state- and quarter-specific beer tax rates as instruments for alcohol prices, but this rendered the alcohol own-price elasticity positive.

<sup>13</sup> The usual caveat about problems with using the Heckman correction applies here—only data resulting from a natural experiment (with perfect measurement) would yield fully credible solutions to censoring problems. Unfortunately no such data exist.

<sup>14</sup> Variables related to religion are probably more likely to affect only the extensive margin, and thus be better exclusion restrictions. Unfortunately, the CEX does not ask households about religious affiliation. It does ask households how much they give to religious organizations, but less than 8 percent of our households responded to the question.



**Table 1**  
Summary Statistics for Working Households with Positive Alcohol Consumption

Variable	One-Adult Households		Two-Adult Households	
	Mean	Standard Deviation	Mean	Standard Deviation
Weekly alcohol consumption (liters)	2.08	2.80	2.11	2.84
One-adult weekly work hours	40.5	11.4		
Two-adult male weekly work hours			44.9	10.2
Two-adult female weekly work hours			37.6	11.3
Share of alcohol expenditure in full income	.02	.03	.007	.01
One-adult share of leisure in full income	.49	.15		
Two-adult male share of leisure in full income			.28	.08
Two-adult female share of leisure in full income			.25	.08
Share of composite good in full income	.50	.16	.46	.13
Weighed alcohol price (\$/liter)	5.84	.44	5.83	.45
Price of composite good (index)	1.04	.10	1.03	.11
One-adult Heckman-corrected net hourly wage (\$)	8.09	2.42		
Two-adult male Heckman-corrected net hourly wage (\$)			10.98	3.29
Two-adult female Heckman-corrected net hourly wage (\$)			8.56	2.20
Weekly full income (\$)	879.70	413.60	1,858.60	728.10
One-adult age (years)	37.3	11.70		
Two-adult male age (years)			38.4	9.9
Two-adult female age (years)			36.9	9.4
One-adult education: < high school diploma (%)	8.5			
One-adult education: high school diploma (%)	23.9			
One-adult education: > high school diploma (%)	67.6			
Two-adult male education: < high school diploma (%)			8.7	
Two-adult male education: high school diploma (%)			27.9	
Two-adult male education: > high school diploma (%)			63.4	
Two-adult female education: < high school diploma (%)			7.3	
Two-adult female education: high school diploma (%)			26.3	
Two-adult female education: > high school diploma (%)			66.3	
Number of children	.42	.88	1.17	1.19
<i>Race of household head</i>				
White (%)	87.8		87.6	
Black (%)	14.7		8.6	
Asian (%)	.6		.8	
Other race (%)	2.9		3.0	
<i>Region</i>				
Northeast (%)	15.4		13.4	
Midwest (%)	23.0		25.4	
South (%)	34.0		35.7	
West (%)	27.5		25.4	
Observations	3,395		3,242	

by ignoring the discrete choice of alcohol, reporting results from system estimation on the non-censored sample.<sup>15</sup>

The net-of-tax wage rate might be endogenous if (1) alcohol abuse affects on-the-job productivity, (2) there are errors in measuring earnings and hours worked that are correlated, and (3) marginal income tax rates vary as earn-

ings vary with hours worked. To obtain consistent estimates we instrument for wages in our benchmark case using the occupation-, state-, and gender-specific mean net wage, from the entire CEX. Because observations are thin across some quarter-occupation-state-gender categories, we use time-invariant wage instruments in our baseline specification,

<sup>15</sup> We also estimated a two-part model with no exclusion restriction; but identification of the self-selection model through non-linearity of the inverse Mills ratio alone may also be weak as this ratio is linear over certain ranges of the index (Vella, 1998). This estimation also yields a positive (but insignificant) own-price elasticity for alcohol; again this casts some doubt on the reliability of our estimate of this elasticity, but is not a major concern for the alcohol-leisure cross-price elasticity.

but we also report results from using quarter-specific wage instruments. The real income term  $\log(F^h/P^h)$  may also be endogenous, because  $P^h$  is a function of individual-specific expenditure shares that are also dependent variables. We therefore instrument for this term, using an alternative price index obtained by replacing the individual-specific shares in equation (1b) with the sample mean shares. Because the instrument is still a function of the same ratio of household price to mean price in equation (1b), it is strongly correlated with the instrumented variable, but is no longer a function of the dependent variables.

#### D. Summary Statistics

Table 1 presents summary statistics for data used in our benchmark estimation, that is, for working households with positive alcohol purchases. One- and two-adult households each consume about two liters of alcohol per week, or about 1–2 percent of household full income, while both household types spend about half of their full income on leisure. The average selectivity-corrected net wage is \$8.09 per hour in the one-adult sample, and \$10.98 per hour for men and \$8.56 per hour for women in the two-adult sample.

#### E. Estimation Procedure

We use three-stage least squares (3SLS) to estimate separate demand systems for one- and two-adult households, which

enables us to use instrumental variables and generalized least squares to account for any error correlation across equations.<sup>16</sup> Each adult's leisure is treated as a separate good; thus, the two-adult demand system includes male leisure, female leisure, alcohol, and composite consumption. We impose the restrictions in (1a–d) and drop the equation for other goods, as the restrictions constrain the parameters from that equation to be linear combinations of the estimated parameters in the gasoline and leisure equations. Household characteristics include members' age, age-squared, race, sex (in one-adult estimation only), number of children and education level.<sup>17</sup>

We use parameters from the demand system to generate aggregate alcohol demand elasticities for one- and two-adult households, and alcohol-leisure cross-price elasticities for one-adult households and for men and women in two-adult households.<sup>18</sup> To obtain a single, own-price alcohol elasticity, we take a weighted average over those for one- and two-adult households where the weights are their alcohol consumption. And to obtain a single alcohol-leisure cross-price elasticity, we first average the male and female elasticities for two-adult households and then take an alcohol-weighted average over elasticities for one- and two-adult households. Aggregate labor supply elasticities are calculated in a similar way, weighting by hours worked.

Confidence intervals for elasticities were obtained from a non-parametric bias-cor-

<sup>16</sup> We experimented with estimating the system using generalized method of moments (GMM). Since such estimation did not appreciably change estimates nor improve precision and is more tedious to implement, we elected to use 3SLS (but also report results obtained using 2SLS).

<sup>17</sup> We could estimate the full econometric model, including all discrete and continuous choices, with maximum likelihood estimation. However, since censoring occurs in both alcohol and leisure demand, and for either or both the male and female in two-adult households, we would need to evaluate multiple integrals in the likelihood function, which would be computationally intensive given that we bootstrap standard errors.

<sup>18</sup> We calculate elasticities using methods and equations explained in West and Williams (2007). Parameters from the system estimation are used to find the effects of prices on consumption shares, which are then transformed into derivatives involving quantities, calculated for each household and correcting for any corner solutions. Finally, these household-specific derivatives are transformed and aggregated into sample-wide elasticities.

**Table 2**  
One-Adult Household Demand System Estimation Results (Baseline)

	Alcohol Share	Leisure Share
ln(alcohol price)	-0.0012 (0.0335)	-0.0066 (0.0062)
ln(other good price)	0.0077 (0.0354)	-0.0808*** (0.0352)
ln(net wage)	-0.0066 (0.0062)	0.0874*** (0.0343)
ln( $F/P$ )	-0.0152*** (0.0036)	-0.3504*** (0.0282)
Inverse mills ratio (alcohol)	0.0088 (0.0896)	-0.3275 (0.5013)
Age	-0.0006 (0.0006)	-0.0037 (0.0042)
Age squared	0.000007 (0.000007)	0.00004 (0.00005)
Black	-0.0024 (0.0054)	0.0137 (0.0360)
Asian	-0.0065 (0.0118)	0.0084 (0.0927)
Other race	-0.0010 (0.0051)	0.0222 (0.0359)
High school degree	0.0016 (0.0036)	0.0430* (0.0256)
More than high school degree	0.0002 (0.0055)	0.0495 (0.0367)
Female	0.0008 (0.0015)	0.0116 (0.0182)
Number of children	0.0005 (0.0012)	0.0033 (0.0073)
Constant	0.1314*** (0.0657)	2.8864*** (1.467)
Number of observations	3,395	3,395

Notes: These 3SLS regressions use ln(mean net wage by occupation, by state and gender) instruments for ln(net wage) and ln( $F/P$ ) calculated using the price index based on mean expenditure shares as instruments for the ln( $F/P$ ), using individual-specific shares. All regressions include state and region dummy variables. Bootstrapped standard errors are in parentheses. Asterisks indicate statistical significance at the 1% (\*\*\*) or 10% (\*) level.

rected bootstrap that selects 1,500 random sub-samples of the full data set, estimates the corrections for selectivity bias, and then estimates the demand systems using each sub-sample. We cluster observations

by household in generating each bootstrap sample, given that observations for the same household for multiple quarters are not independent (this precludes us from clustering by any other variable).<sup>19</sup>

<sup>19</sup> We also attempted to cluster by state rather than by household, but this worsens the fit on the compensated labor supply elasticity and therefore on the difference between it and the cross-price elasticity. The bias-corrected bootstrap method is appropriate in cases where the variances vary as a function of the parameters of interest.

**Table 3**  
Two-Adult Household Demand System Estimation Results (Baseline)

	Alcohol Share	Male Leisure	Female Leisure
Ln(alcohol price)	-0.0021 (0.0042)	-0.0039*** (0.0015)	-0.0011 (0.0016)
Ln(other good price)	0.0071*** (0.0035)	-0.067*** (0.0164)	-0.0464*** (0.0110)
Ln(male net wage)	-0.0039*** (0.0015)	0.1455*** (0.0137)	-0.0746*** (0.0074)
Ln(female net wage)	-0.0011 (0.0016)	-0.0746*** (0.0074)	0.1221*** (0.0087)
Ln(F/P)	-0.0070*** (0.0014)	-0.169*** (0.0305)	-0.1684*** (0.0230)
Inverse mills ratio (alcohol)	-0.0063 (0.0212)	0.2858 (0.3286)	0.2690 (0.2450)
Male age	0.0003 (0.0003)	-0.0043 (0.0027)	-0.0018 (0.0019)
Male age squared	-0.000004 (0.000003)	0.00005* (0.00003)	0.00002 (0.00002)
Black male	-0.0002 (0.0029)	-0.0170 (0.0533)	-0.0331 (0.0416)
Asian male	-0.0046* (0.0025)	0.0304 (0.0445)	0.0066 (0.0352)
Other race male	-0.0005 (0.0019)	-0.0094 (0.0343)	0.0179 (0.0250)
Male high school degree	0.0012 (0.0017)	-0.0077 (0.0214)	-0.0075 (0.0170)
Male more than high school degree	0.0015 (0.0018)	-0.0091 (0.0217)	-0.0089 (0.0153)
Female age	-0.0001 (0.0002)	0.0017 (0.0022)	-0.0017 (0.0019)
Female age squared	0.000001 (0.000003)	-0.00001 (0.00003)	0.00003 (0.00002)
Black female	0.0008 (0.0030)	0.0196 (0.0544)	0.0261 (0.0421)
Asian female	-0.0004 (0.0037)	-0.033 (0.0618)	-0.0412 (0.0445)
Other race female	-0.0001 (0.0021)	0.0205 (0.0367)	-0.0147 (0.0288)
Female high school degree	-0.0011 (0.0014)	-0.0071 (0.0154)	0.0002 (0.0128)
Female more than high school degree	-0.0019 (0.0014)	-0.005 (0.0149)	0.008 (0.0127)
Number of children	0.0001 (0.0002)	-0.0007 (0.0036)	0.0074 (0.0028)
Constant	0.0756* (0.0432)	1.1901* (0.6499)	1.2493* (0.6684)
Observations	3,242	3,242	3,242

Notes: These 3SLS regressions use ln(mean net wage by occupation, by state and gender) instruments for ln(net wage) and ln(F/P) calculated using the price index based on mean expenditure shares as instruments for the ln(F/P) using individual-specific shares. All regressions include state and region dummy variables. Bootstrapped standard errors are in parentheses. Asterisks indicate statistical significance at the 1% (\*\*\*), or 10% (\*) level.

## IV. RESULTS

### A. Econometric Estimates

#### 1. Regression Results

Tables 2 and 3 report the coefficient estimates for the baseline specification of one- and two-adult demand systems, which includes the variables described above. Negative coefficients on the  $\ln(F/P)$  terms indicate that for both one- and two-adult households, alcohol and leisure are necessities. In one-adult households, the share of leisure increases as wage increases. For two-adult households, the share of leisure (for either adult) also increases as his or her wage increases but decreases as the wage of the other adult in the household increases.<sup>20</sup> The effect of the male wage on alcohol consumption is the strongest of the cross-price relationships estimated here; the share of spending devoted to alcohol falls as the male wage increases.

#### 2. Baseline Elasticities

The first row of Table 4 reports elasticity estimates and 95 percent confidence intervals for our two-step baseline specification with state fixed effects. Confidence intervals for the uncompensated and compensated labor supply elasticities are 0.02–0.28 and 0.19–0.39 respectively, which are consistent with prior estimates in the empirical micro literature (Blundell

and MaCurdy, 1999; Fuchs, Krueger, and Poterba, 1998).<sup>21</sup>

Alcohol is a relative complement for leisure when the (compensated) alcohol-leisure cross-price elasticity is less than the compensated labor supply elasticity (see below); it is an absolute complement for leisure when the cross-price elasticity is negative. In our baseline specification, the estimated cross-price elasticity is  $-0.09$ ; however, it has a wide confidence interval of  $-0.42$  to  $0.22$ , underscoring the need for sensitivity analysis in inferring optimal taxes, rather than placing too much emphasis on the baseline point estimate. The last column of Table 4 indicates that alcohol is at least a relative (if not absolute) leisure complement over a 95 percent confidence interval.

Our baseline estimate of the own-price alcohol elasticity is  $-1.19$ , which is on the high side relative to earlier literature, though the confidence interval for this elasticity is very wide, reflecting limited spatial variation in alcohol prices. Again, however, our primary focus is not on this elasticity, given that there is reasonable consensus among health economists over a plausible range for its magnitude. We also estimate the aggregate expenditure elasticity of demand for alcohol at 0.06 (not shown in the table), which is broadly consistent with previous studies.<sup>22</sup>

<sup>20</sup> When translated into cross-price elasticities using the techniques described in footnote 17 above, these effects become more intuitive. As shown below, we find positive wage elasticities of labor supply; an increase in the wage causes the share of leisure to increase not because households increase leisure hours, but because the decrease in leisure hours is proportionally smaller than the wage increase. Similarly, our parameter estimates translate into negative cross-price labor supply elasticities; as men's wage increases, women's work hours decrease, and as women's wage increases, men's work hours decrease.

<sup>21</sup> They are also broadly consistent with labor supply assumptions in tax simulation models (Browning, 1987; Ballard, Shoven, and Whalley, 1985; Ballard, 1990; Goulder and Williams, 2003). Even though the uncompensated hours worked elasticity for males is typically estimated to be close to zero or slightly negative, estimates of the economy-wide elasticity, averaged over hours worked and participation responses for male and female workers, are generally positive; this mainly reflects the sizable participation elasticity for secondary workers. Macroeconomic studies that attempt to explain aggregate labor supply variation across business cycles, or across different countries, find much larger elasticities than the micro studies in the empirical labor literature, though the reasons for this discrepancy remain a puzzle (Prescott, 2004).

<sup>22</sup> Recent estimates of expenditure elasticities (averaging over all beverages) include 0.10 in Baltagi and Griffin (1995), below 0.10 in Farrell, Manning, and Finch (2003), 0.11 in Lee and Tremblay (1992), 0.25 in Manning, Blumberg, and Moulton (1995), 0.40 in Nelson and Moran (1995), 0.18 in Ruhm (1995), 0.89 in Selvanathan (1991), and 0.4 in Yen (1994).

**Table 4**  
 Estimated Elasticities  
 (Figures in Parentheses Show 95% Confidence Intervals)

Specification	Uncomp. Labor Supply Elasticity (A)	Comp. Labor Supply Elasticity (B)	Comp. Alcohol/Leisure Price Elast. (C)	Own-Price Alcohol Elasticity (D)	(B)-(C)
(1) Baseline	0.12 (0.02, 0.28)	0.25 (0.19, 0.39)	-0.09 (-0.42, 0.22)	-1.19 (-2.69, 2.41)	0.34 (0.08, 0.73)
<i>Alternative Specifications</i>					
(2) Including payroll taxes	0.14 (-0.05, 0.47)	0.25 (0.12, 0.57)	-0.09 (-0.37, 0.22)	-1.25 (-2.78, 2.03)	0.34 (0.06, 0.81)
(3) Two-stage least squares	0.15 (-0.12, 0.28)	0.27 (0.02, 0.38)	-0.09 (-0.37, 0.22)	-0.69 (-1.73, 3.61)	0.37 (0.05, 0.67)
(4) No alcohol inverse Mills ratio	0.20 (-0.03, 0.43)	0.30 (0.15, 0.47)	-0.08 (-0.28, 0.11)	-1.11 (-1.76, -0.51)	0.38 (0.14, 0.66)
(5) No state fixed effects	0.17 (-0.11, 0.24)	0.27 (0.11, 0.35)	0.08 (-0.32, 0.17)	-1.21 (-3.88, -0.55)	0.19 (-0.16, 0.57)
(6) Fixed effects alternative 1 <sup>a</sup>	0.16 (-0.07, 0.38)	0.26 (0.12, 0.44)	0.06 (-0.29, 0.38)	-1.20 (-3.57, -0.46)	0.21 (-0.16, 0.61)
(7) Fixed effects alternative 2 <sup>b</sup>	0.14 (-0.11, 0.35)	0.25 (0.08, 0.45)	0.08 (-0.24, 0.43)	-1.15 (-3.71, -0.48)	0.18 (-0.21, 0.54)
(8) No instruments for wages	0.18 (-0.11, 0.24)	0.30 (0.11, 0.35)	-0.12 (-0.32, 0.17)	-0.92 (-2.80, 1.70)	0.43 (0.10, 0.62)
(9) Quarter-specific wage instruments	0.13 (-0.10, 0.31)	0.25 (0.07, 0.41)	-0.002 (-0.64, 0.73)	-1.35 (-4.59, 0.30)	0.25 (-0.50, 1.01)
(10) Time endowment reduced to 84 hours	0.21 (0.04, 0.30)	0.30 (0.20, 0.34)	-0.09 (-0.42, 0.25)	-1.14 (-2.68, 2.56)	0.39 (0.07, 0.82)
(11) Time endowment increased to 112 hours	0.13 (-0.07, 0.31)	0.26 (0.09, 0.43)	-0.09 (-0.40, 0.21)	-1.24 (-2.67, 2.10)	0.35 (0.07, 0.76)

(a) This is same as the baseline specification, but replacing state fixed effects with percentage of state population in college, an indicator equal to one if alcohol sales are allowed on Sundays, and state's number of cloudy days per year. Results are essentially the same if number of cloudy days is replaced with state's average temperature.  
 (b) This is same as specification 7, but adding number of drinking establishments (liquor stores and drinking places) per capita and number of places of worship per capita.

3. Sensitivity Analysis

The rest of Table 4 presents results under various alternative specifications, including estimation that includes payroll tax rates, estimation using two stage least squares (2SLS), one-step estimation (with no inverse Mills ratio for the discrete choice over whether to consume alcohol), no state fixed effects, two alternatives for state fixed effects, no instrument for wages, quarter-specific wage instruments, and alternative values for the household time endowment. Results are moderately sensitive to these specifications; for example, the point estimates for the alcohol-leisure cross price elasticities vary between -0.12 and 0.08, though they are all well below the corresponding point estimates for the compensated labor supply elasticities. However in specifications without fixed effects or with quarter-specific wage instruments, alcohol is no longer a relative leisure complement across the entire 95 percent confidence interval. We incorporate this uncertainty into our tax simulations below. Results without state fixed effects demonstrate the fact that state fixed effects soak up a good degree of alcohol price variation; own-price elasticities of alcohol demand in these specifications are statistically different than zero.

We believe the specifications without fixed effects and with time-varying wage instruments produce less reliable estimates of the alcohol-leisure elasticity than our baseline case. This is due to the possibility of omitted variable bias in the case of omitted state fixed effects, and because the observations needed to construct time-varying wage instruments are rather thin across some quarter-state-occupation-gender categories.

B. Optimal Tax Computations

1. Formula and Parameter Values

Parry, West, and Laxminarayan (2009) integrate a static, utility-based model of

externalities from drunk driving and from medical burdens on third-parties from alcohol-induced illness into a general equilibrium model that captures interactions between alcohol taxes and tax distortions in the labor market. Based on some straightforward manipulation of the results in that paper, an approximation for the optimal (revenue-neutral) alcohol tax is:

$$\begin{aligned}
 (3) \quad t_A^* &\approx \overbrace{t_A}^{\text{Pigouvian tax}} \\
 &+ \overbrace{MEG \left\{ \left( \frac{p_A + t_A}{-\eta_{AA}} \right) \left( \frac{\epsilon_{LL}^c - \eta_{Al}^c}{\epsilon_{LL}} \right) - t_A \right\}}^{\text{fiscal component}} \\
 &+ \overbrace{(1 + MEG)t_L \rho}^{\text{productivity effect}} \\
 (4) \quad MEG &= \frac{\frac{t_L}{1-t_L} \epsilon_{LL}}{1 - \frac{t_L}{1-t_L} \epsilon_{LL}}
 \end{aligned}$$

where  $t_A$  is a specific tax expressed per gallon of pure alcohol,  $p_A$  is the pre-tax per gallon price of alcohol,  $t_L$  is a proportional tax on labor income,  $\eta_{AA} < 0$  is the own-price elasticity for alcohol,  $\epsilon_{LL}$  is a labor supply elasticity defined with respect to the net of tax wage or price of leisure,  $\eta_{Al}$  is the elasticity of alcohol consumption with respect to the price of leisure, and  $c$  denotes a compensated (as opposed to uncompensated) elasticity. The variable  $MEG$  denotes the marginal efficiency gain from recycling a dollar of revenue from labor tax reductions; it is greater the larger are (1) the (uncompensated) labor supply elasticity, and (2) the labor tax wedge. Finally,  $\rho$  is the reduction in workplace productivity per unit of alcohol consumption, caused by health effects or injuries sustained in drunk-driver accidents.

The formula in (3) separates the optimal alcohol tax into three components. The first is the Pigouvian tax which, as

discussed above, encompasses the various external costs of road accidents and alcohol-induced illness, scaled by the relative responsiveness of drunk driving and heavy drinking to alcohol prices. Following the recent review and synthesis of evidence in Parry, West, and Laxminarayan (2009) for the year 2000, we assume the Pigouvian tax is \$68 per alcohol gallon.

The second is the fiscal component, or Ramsey tax, which is very familiar from the theoretical literature on optimal taxes.<sup>23</sup> This component can be positive when  $\varepsilon_{LL}^c < \eta_{Al}^c$ , that is, when the compensated alcohol-leisure cross-price elasticity is smaller than the compensated labor supply elasticity, which occurs with 95 percent confidence in our baseline econometric estimates. However, given the uncertainty over elasticities in our own estimates, and in the earlier empirical literature, we illustrate a wide range of possibilities. For the own-price elasticity for alcohol, we consider low, medium and high values of  $-0.4$ ,  $-0.8$  and  $-1.2$  respectively, and for the labor supply elasticities, we consider low values of  $\varepsilon_{LL} = 0.10$ ,  $\varepsilon_{LL}^c = 0.20$ , medium values of  $\varepsilon_{LL} = 0.15$ ,  $\varepsilon_{LL}^c = 0.35$ , and high values of  $\varepsilon_{LL} = 0.30$ ,  $\varepsilon_{LL}^c = 0.60$ . Based on our own estimates, a reasonable range to consider for  $\eta_{Al}^c$  would be about  $-0.4$  to  $0.3$ . All elasticities are taken to be constant across the relevant range. From Parry, West, and Laxminarayan (2009), we assume  $p_A = \$197$  per alcohol gallon, the initial alcohol tax  $t_A = \$24$  per alcohol gallon, and the initial labor tax  $t_L = 0.40$ ; our labor market parameters imply  $MEG = 0.07, 0.11$  or  $0.25$ .<sup>24</sup>

The last component in (3) is the revenue loss from reduced workplace productivity, which is a cost to the government and therefore external to individuals (as opposed to the reduction in net of tax wages which is internal to individuals). The effect is multiplied by  $1 + MEG$  to account for the efficiency effect of raising the labor tax to make up for the lost revenue. Following Parry, West, and Laxminarayan (2009), we adopt low, medium and high values of  $\rho = \$12, \$93$ , and  $\$174$  per alcohol gallon respectively, which roughly spans the wide range of estimates of health/productivity impacts in the (unsettled) empirical literature. Multiplying by  $(1 + MEG)t_L$ , the productivity effect adds between  $\$5$ – $\$87$  per alcohol gallon to the optimal tax.<sup>25</sup>

## 2. Results

Figure 1 shows the fiscal component of the optimal alcohol tax relative to the Pigouvian tax under a wide variety of parameter scenarios. The three panels correspond to our three sets of assumptions about labor supply elasticities; the curves in each panel correspond to our three different values for the own-price elasticity of alcohol, and along the horizontal axis in each panel we vary the alcohol-leisure cross-price elasticity across its assumed range of values.

The relative size of the fiscal component is highly parameter sensitive, varying from slightly negative (in the extreme right of panel (a)) to more than five times the Pigouvian tax. Clearly, more empirical estimates of the alcohol-leisure cross-price elasticity are needed to pin

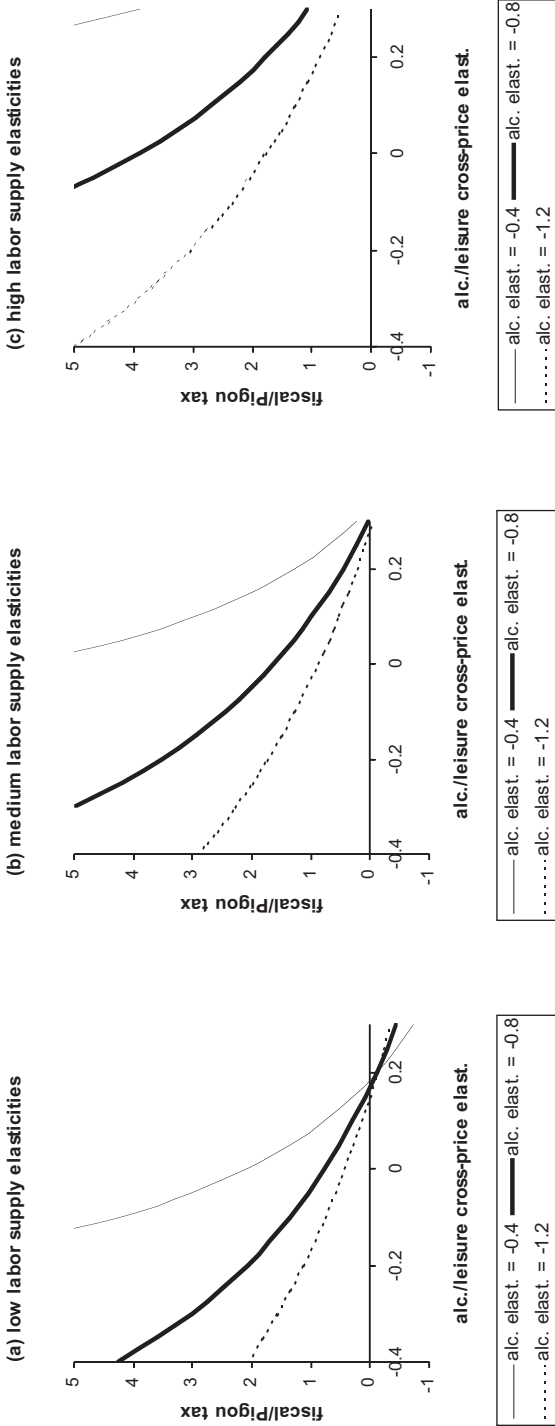
<sup>23</sup> Ramsey (1927) and Corlett and Hague (1953–54) are the classic contributions to the literature. For a recent discussion, see Ballard, Shoven, and Whalley (1985).

<sup>24</sup> Our values for  $MEG$  are approximately consistent with estimates of the marginal excess burden of taxation for financing public goods (Ballard, Shoven, and Whalley, 1985; Ballard, 1990; Wildasin 1984), aside from some caveats noted in Section V below.

<sup>25</sup> The formula in (3) is an approximation as it excludes from the fiscal component changes in the government budget due to changes in spending on medical care and implementation of drunk driver penalties. In Parry, West, and Laxminarayan (2009) these budgetary impacts are small relative to the marginal change in alcohol tax revenues.



**Figure 1**  
Fiscal Component of Optimal Alcohol Tax under Different Parameter Assumptions  
(Relative to the Pigouvian Tax)



**Table 5**  
 Optimal Alcohol Taxes Under Different Parameter Assumptions  
 (\$ Per Gallon of Pure Alcohol)

Labor Supply Elasticities	Optimal Tax Components	Alcohol Elasticities and Productivity Effects			
		Alcohol/Leisure Cross-Price Own Price Productivity Effect	-0.15 -0.6 High	-0.05 -0.8 Medium	0.2 -1 Low
Low	Pigouvian fiscal		68	68	68
	productivity		201	71	-5
	total		74	40	5
Medium	Pigouvian fiscal		343	179	68
	productivity		68	68	68
	total		395	137	22
High	Pigouvian fiscal		77	41	5
	productivity		541	246	95
	total		68	68	68
	Pigouvian fiscal		>500	318	78
	productivity		87	47	6
	total		>655	433	152

down a narrower, plausible range for this parameter, and hence the optimal alcohol tax. Nonetheless, Figure 1 illustrates the potential importance of this issue. For most parameter combinations the curves lie above unity, implying that the fiscal component of the optimal tax exceeds the Pigouvian component.

Finally, Table 5 illustrates the absolute values of the three components of the optimal alcohol tax under alternative scenarios. Under medium values for all parameters, the optimal alcohol tax is \$246 per alcohol gallon, an order of magnitude larger than the current tax; the Pigouvian, fiscal and productivity components account for 28 percent, 56 percent and 16 percent, respectively, of this optimal tax. There are a couple of cases in which the fiscal component is relatively modest, or even negative, namely when both the labor supply elasticities take their medium or low values *and* the own-price alcohol and alcohol-leisure cross-price elasticities are large. But in the seven other parameter combinations illustrated in Table 5, the fiscal component is anything from around \$70 per gallon, to over \$400 per gallon.

V. CONCLUSION

Although implementation of a fully optimized set of taxes on all commodities is impractical, existing commodity taxes, primarily on alcohol, cigarettes and transportation fuels, are frequently justified on revenue-raising grounds. It therefore behooves economists to assess what levels of these taxes might be appropriate on fiscal grounds, even though estimates are always likely to be imprecise given the difficulty of accurately estimating the own- and cross-price elasticities required to compute optimal tax rates.

This paper provides a first attempt to econometrically estimate the alcohol-leisure cross-price elasticity. We find that alcohol is a relative complement for leisure over 95 percent confidence intervals in many (though not all) specifications. Substituting from a range of values for the alcohol-leisure cross-price elasticity into an optimal tax formula, we find that the Ramsey tax component is potentially very large and quite plausibly exceeds the Pigouvian tax. Given that Pigouvian tax estimates are well above current alcohol

tax levels, fiscal considerations appear to substantially reinforce the case for raising alcohol taxes.

We are, however, at pains to emphasize the preliminary nature of these findings. The confidence intervals on the alcohol-leisure cross-price elasticity are large, so we cannot, given current data availability and quality, pin down the Ramsey tax with accuracy. We hope that the methodology we have laid out, along with the importance of the issue for alcohol policy, will stimulate future empirical investigations and narrow the range of uncertainty over the size of the Ramsey tax.

We conclude with some broader caveats related to the efficiency case for higher alcohol taxes. One is household equity. Alcohol taxes are regressive, even when household income is measured on a lifetime (rather than annual) basis (Lyon and Schwab, 1995).<sup>26</sup> A possible response to this is to disaggregate different income groups in optimal tax analyses and incorporate distributional weights (e.g., Cremer, Gahvari, and Ladoux, 1998). This would lower the optimal alcohol tax, though by how much is unclear as society's aversion to income inequality is difficult to measure empirically. These adjustments also run counter to the view that distributional concerns are most efficiently addressed through the broader tax and benefit system. As a compromise, higher alcohol taxes might be accompanied by a recycling of revenues that is skewed towards the poor, or by adjustments under the income tax that would on average offset their distributional effects.

Another concern is that additional revenues from alcohol taxes may end up being wasted in special interest spending, rather than being used to substitute for other taxes. This is a legitimate concern, given how Congress appears to have

used new revenue sources in the past (Becker and Mulligan, 2003). In principle this problem can be avoided if legislation accompanying an alcohol tax increase specifies an automatic and offsetting reduction in other taxes, thereby eliminating the possibility of new funding for special interests.

Clearly, there is strong political opposition to higher alcohol taxes, not least from the brewing and hospitality industries. In principle, some temporary tax relief might be provided to beverage suppliers, though at the expense of lowering the potential efficiency gains from more socially productive revenue use. Moreover, public health groups would likely oppose any such compensation.

A related point is that alcohol taxes are mostly levied on a per unit basis, requiring frequent increases in the nominal rate to prevent erosion of their revenue-raising capacity by inflation. Such adjustments are politically difficult, as suggested by the decline in real alcohol tax rates since 1970 (Kenkel, 1996). Besides raising the overall level of taxation, there is also a case for converting taxes to an *ad valorem* basis, to prevent progressive erosion in the real tax rate over time.

Our analysis focuses on alcohol in isolation, though in practice the demand for cigarettes is likely affected by alcohol prices. The implications for the optimal alcohol tax are unclear, however, as empirical work on whether alcohol and cigarettes are complements or substitutes is unsettled (Decker and Schwartz, 2000), as is the literature on whether cigarettes are currently under- or over-taxed (Gruber, 2002–2003; Viscusi, 2002–2003).

Finally we note that, by ignoring some broader distortions created by the tax system, our discussion may significantly understate the optimal alcohol tax. Income

<sup>26</sup> This finding might be weakened somewhat if full account were taken of (1) automatic indexing of tax and benefit thresholds following an increase in the consumer price level, (2) the recycling of alcohol tax revenues, and (3) externality benefits from improved health and fewer drunk driver accidents.

taxes distort the choice between ordinary spending and tax-preferred spending, such as employer-provided medical insurance and owner-occupied housing. Accounting for these distortions raises the efficiency gains from recycling excise tax revenues in income tax reductions, implying a higher optimal commodity tax (Parry and Bento, 2000). Similarly, the efficiency gains from revenue recycling and the optimal level of commodity taxation can also be greater when allowance is made for the distortionary effect of income taxes in depressing capital accumulation below economically efficient levels (Bovenberg and Goulder, 1997).

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## APPENDIX: CORRECTIONS FOR SELECTION BIAS

### The Alcohol Purchase Decision

For our benchmark estimation, inverse Mills ratios ( $MR_a^i$ ) were obtained from estimating probit models for one- and two-adult households on the choice of whether to consume alcohol. Each probit includes age, age squared, race, marital status, number of children, region, and the logs of the alcohol price, composite good price and spending on the composite good. As mentioned in the text, while variables associated with religion are good candidates for exclusion restrictions, our data do not contain information on religious affiliation, and information on religious contributions is very incomplete. Given the absence of a better determinant of the discrete choice of alcohol that does not affect the continuous choice of alcohol, we use under 21 years of age as our exclusion restriction.

### The Labor Force Participation Decision

For the first-stage choice of whether to work, we jointly estimate a probit and net wage equation using full information maximum likelihood, separately for one- and two-adult households, and within those samples, separately for men and for women. The one-adult probits include age, age squared, education, race, marital status, number of children, region, the log of alcohol price, the log of the other good price, and state-specific quarterly unemployment rates; the two-adult probits also contain partner's earnings and demographic information.

Because we use a linear approximation to the price index, wages affect the price derivatives of demand even for non-workers (though this

effect is minimal), and thus we need to predict wages for nonworkers as well as for workers. And because occupation is an important determinant of the net wage but is observed only for workers, we run two selection models for each subsample, one to estimate workers' net wages and the other to estimate nonworkers' net wages. Within each subsample (where one such subsample, for example, is composed of women from one-adult households) both selection models use the same set of observations of workers and nonworkers and identical probits. To estimate net wages for nonworkers we specify a wage equation that includes education, age, age squared, race, marital status, region, and the inverse Mills ratio from the probits, while to estimate net wages for workers, we include those same variables plus occupation indicators. Since net wages are distributed log normal, we define the dependent variable as the log of net wage. We calculate predicted net wages for workers to include in the demand system estimation.

In principle, the Heckman selection model is identified even when the variables in the probit and the wage regression are the same. In that case, the model is identified by its functional form and the normality assumption. Note, however, that the probits include number of

children, the log of alcohol price, the log of the other good price, state-specific quarterly unemployment rates, and, in the case of two-adult households, partner's earnings; the wage equations do not. The number of children affects the fixed cost of working and thus the participation decision. But we do not expect the number of children to affect the wage, since we control for age, race, and gender; the number of children is a standard exclusion restriction in the labor supply literature.

Our demand system allows alcohol and other good prices to affect the continuous demand for leisure and thus it is reasonable to assume that they also affect the discrete work choice. While high price regions may also be high wage regions, there is no reason to postulate that an individual facing a high alcohol price or other good price will have a higher wage, since we control for region in our wage equation. Unemployment rates proxy for job availability in a state and thus affect the likelihood of working, but it is not clear why they would affect wages. Partner's earnings proxy for an individual's nonwage income, but should not directly affect an individual's wage; this is another standard exclusion restriction.



