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Alcohol/Leisure Complementarity: Empirical Estimates and Implications for Tax Policy

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RESOURCES FOR THE FUTURE

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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 an Almost Ideal 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 a number of data and other limitations of the analysis.

Key Words: alcohol tax, demand system, alcohol, labor supply, labor tax

JEL Classification Numbers: I18, H21, H23

Contents

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1. Introduction

There are two potentially important economic rationales for alcohol taxes. First is that such taxes help mitigate various external costs of alcohol abuse, such as the risks to others posed by drunk drivers and the burden on third parties of medical costs from alcohol-related illness. The second suggests that, by raising revenue, alcohol taxes reduce the need to rely on other taxes, particularly those on labor income, to finance the government's budget. Ramsey tax theory implies that additional taxation of alcohol can be warranted on fiscal grounds if alcohol is a relative complement for leisure.

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 around $70 per gallon, or about three times current federal and state taxes of $24 per gallon (see, e.g., Parry et al. 2008 for a recent discussion of the evidence).

The second rationale for alcohol taxes has not really received any attention in prior literature, at least in a quantitative sense, so there is no basis for gauging the extent to which the optimal tax may differ from the Pigouvian tax. In other words, economists have not attempted to estimate the alcohol/leisure cross-price elasticity, even though it is a critical parameter in the Ramsey component of the optimal alcohol tax. It behooves economists to try to estimate this elasticity to provide some insight into whether a valid fiscal rationale exists for alcohol taxes.

This paper provides a first attempt to estimate this elasticity, based on an Almost Ideal Demand System (AIDS) defined over alcohol, leisure, and other goods and estimated with data from the Consumer Expenditure Survey (CEX) and other sources. Although the data are

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probably as good as we can find, and we believe that 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 only serve to reinforce the efficiency case for higher alcohol taxes—perhaps substantially.

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 improves over time.

Before outlining our empirical approach and results, we first describe in more detail how our paper relates to 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.

2. Background

A. Relation to 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 complement, for leisure compared with other consumption goods (e.g., Sandmo 1975; Bovenberg and Goulder 2002). Under these conditions, up to a point, a revenue-neutral tax shift from labor income to the commodity will (slightly) increase labor supply, inducing an efficiency gain in the tax-distorted labor market in addition to any efficiency gain from mitigating the externality. Converse results apply if the product is a relatively strong substitute for leisure.

The 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 (e.g., Goulder 1995; Parry and Oates 2000). The first linkage is the *revenue-recycling effect*, or efficiency gain, from using additional commodity tax revenues to reduce distortionary labor taxes. The 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 tax.

Perhaps surprisingly, few economists have attempted to empirically apply the optimal commodity tax framework to actual taxes. This may be because economists were initially concerned with optimizing over all commodity taxes at once, which is an especially formidable challenge.[1] Instead, our focus is on only one commodity tax, assuming that the rest of the tax system, primarily income and payroll taxes, is collapsed into a single tax on labor income.

Even for the limited number of commodities traditionally targeted with excise taxes—primarily tobacco products, transportation fuels, and alcoholic beverages—few authors have attempted to econometrically estimate the leisure cross-price elasticities that are required to assess how much taxation of these commodities might be warranted on fiscal grounds.[2] One exception is West and Williams (2007), who estimate an AIDS over gasoline, leisure, and other goods using household data. They find that gasoline is a relative leisure complement and that the overall optimal gasoline tax is around 50 percent larger than the externality-mitigating tax. Our estimation in Section 3 follows an approach similar to that in West and Williams (2007).

[1] 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 (e.g., Ahmad and Stern 1984; Madden 1995).

[2] A number of studies include alcohol when estimating commodity demand systems but do not include leisure. See Andrikopoulos et al. (1997), Blake and Nied (1997), Browning (1991), Blundell et al. (1993), Deaton and Muellbauer (1980), Eakins and Gallagher (2003), Fuss and Waverman (1987), Gao et al. (1995), Holm (1995), Jones (1989), Nelson and Moran (1995), Taube et al. (1990), and Taube and MacDonald (1991). In fact, very few studies estimate leisure cross-price elasticities for any commodity. Diewert and Lawrence (1996) estimate these elasticities for motor vehicles, housing, and other goods but not alcohol. Madden (1995) includes both leisure and alcohol in a demand system estimated with aggregate time series data for Ireland, though the leisure-cross price elasticities are not reported.

B. Relation to Health Economics Literature

In health economics, discussions of optimal alcohol taxes usually focus on the externality-correcting 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 nonfatal) injury risk that drunk drivers pose to others, assuming that the risks to occupants of vehicles driven by intoxicated individuals are internal. A portion of various other accident costs, such as property damage and medical burdens, are external to the extent that 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 (net of any lifetime 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 respectively scaled by the sensitivity of drunk driving and heavy drinking to alcohol prices, relative to the price sensitivity of overall alcohol consumption. Studies typically put the Pigouvian tax at around 30 percent or more of the pre-tax alcohol price.[3]

A large empirical literature also exists on the own-price elasticity for alcohol consumption, though this elasticity poses serious measurement challenges (see Cook and Moore 2000). Most estimates for all alcoholic beverages combined lie between about –0.4 and –1.0 (elasticities for individual beverages sometimes lie outside of this range).[4] The own-price elasticity feeds 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 less erosion of the alcohol tax base occurs in response to higher tax rates.[5]

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

[3] See Manning et al. (1989, 1991), Phelps (1988), Pogue and Sgontz (1989), and Parry et al. (2008). Kenkel (1996) estimates a somewhat larger tax when people misperceive the long-term risks from heavy drinking.

[4] Some recent studies include Baltagi and Goel (1990), Baltagi and Griffin (1995), Lee and Tremblay (1992), Manning et al. (1995), Manning and Mullahy (1998), Nelson and Moran (1995), Selvanathan (1991), and Yen (1994).

[5] 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).

discussed below, such a negative alcohol–health–productivity relationship plays a separate and reinforcing role in raising the optimal tax above the Pigouvian tax. Some studies find this negative association (Mullahy and Sindelar 1991, 1993), but others find a *drinker's bonus*, that is, a positive association between earnings and alcohol consumption (e.g., 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. Although 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 wage. We use instrumental variable techniques to address this problem, as discussed below.

3. Econometric Methodology

A. Model Specification

We specify the following AIDS for an individual household, *h*, defined over three "goods," alcohol (*A*), leisure (*l*), and a composite of all other consumption goods (*C*):[6]

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

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

(1b) $\log P^h \cong \sum_j s_j^h \log\left(p_j^h / \overline{p}_j\right)$

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

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

In these equations, s_j^h is the expenditure share for good *j*, and 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 $\overline{p}_j$ is the mean price for good *j* over all households. α_j^h, μ_{jk}, and β_j are parameters to be estimated, after imposing 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.[7]

In (1d), we allow a vector of household-specific characteristics (age, race, education, and so on), indexed by r^h, to affect demand, where ζ_{j0} and ζ_{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, or job opportunities).

As discussed below, the Ramsey tax 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.

[7] 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 wage's effect on alcohol consumption is correlated with the effect of another specific good's price on alcohol consumption.

B. Data Sources

(i) Household data

Our main data consist of 9,454 household observations from 12 consecutive quarters of the CEX from 1996 through 1998. Each quarter, 20 percent of the sample is rotated out and replaced by new households; we pool household observations across different quarters.[8] The CEX Family Interview files include, for each household, spending on alcohol, total spending on all goods, number of children, and state of residence.[9] Another expenditure file in the CEX contains two categories of alcohol spending: (a) beer and wine and (b) all other alcohol (i.e., spirits). We attempted to estimate separate elasticities for each category, but results were implausible or imprecise, as many households do not consume one of the two categories.[10]

In addition, for each household, the Member 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 (above, equal to, or below high school diploma).[11]

We calculate (weekly) spending on the composite good by total expenditure less that on alcohol; leisure by a (nonsleep) time endowment of 90 hours per week less work hours (our results are not sensitive to other time endowments); and full income by total expenditure plus the product of leisure and the net wage. Wages are measured by gross wages from the CEX,

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[8] Pooling observations enables us to exploit variation over time within households. As mentioned below, we cluster by household to correct for any bias resulting from dependence across these observations.

[9] Self-reported alcohol consumption usually understates actual consumption, perhaps by as much as 50 percent (Cook and Moore 2000). If underreporting varies with 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, very little evidence is available 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.

[10] Assessing whether any basis exists 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 et al. 2008). This is because 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 et al. 2008, Table 1).

[11] 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, and the Behavioral Risk Factor Surveillance System excludes both wages and hours worked.

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 the TAXSIM model of the National Bureau of Economic Research (see 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.

(ii) 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 approximately 300 urban areas. We weight city and town prices by population shares (from the 2000 Census) to obtain state-level alcohol prices. And 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 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. Minimum and maximum prices within states differ, on average, by about $2, $4, and $8, respectively. After these prices are weighted and averaged to obtain one price per liter of alcohol, the average within-state standard deviation in this price is 8 percent of the average price. Lack of variation in within-state alcohol prices does magnify 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 (a) with no fixed effects and (b) with various fixed effects alternatives commonly used in the literature, including the proportion of the state population in college, the state average temperature, the average cloudy days per year, the 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 antidrinking 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.[12]

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 those households that do not work and that do not consume alcohol to avoid estimation bias when a large number of households are censored (e.g., Shonkwiler and Yen 1999). More details on these first-stage estimation procedures are provided in the appendix.[13]

In the case of labor force participation, we estimate a probit model jointly with a wage equation using full information maximum likelihood 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., the number of children, the 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:

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

[12] Some researchers have used state beer taxes to proxy for alcohol prices, but this is also problematic (see 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.

[13] 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.

where the γ_j s 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. In the sensitivity analysis, we therefore also follow many other studies in the literature by ignoring the discrete choice of alcohol, reporting results from system estimation on the noncensored sample.[14]

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

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[14] We also estimated a two-part model with no exclusion restriction, but identification of the self-selection model through nonlinearity of the inverse Mills ratio alone may also be weak as this ratio is linear over certain ranges of the index (Vella 1998, p. 135). 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.

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.[15] 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. Household characteristics include members' age, age squared, race, sex (in one-adult estimation only), number of children, and education level.[16]

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.[17] To obtain a single, own-price alcohol elasticity, we take a weighted average over those for one- and two-adult households, where the weights represent 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 nonparametric bias-corrected bootstrap that selects 1,500 random subsamples of the full data set and estimates the corrections for selectivity bias and the demand systems using each subsample. We cluster observations by household in generating each bootstrap sample, given that observations for the same household

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[15] We experimented with estimating the system using the generalized method of moments. Such estimation did not appreciably change estimates nor improve precision and is more tedious to implement, so we elected to use 3SLS (but also report results obtained using two-stage least squares, 2SLS).

[16] We could estimate the full econometric model, including all discrete and continuous choices, with maximum likelihood. However, because censoring occurs in both alcohol and leisure demand and because, for either or both the male and female in two-adult households we would need to evaluate multiple integrals in the likelihood function, this would be computationally intensive given that we bootstrap standard errors.

[17] We calculate elasticities using methods and equations explained in West and Williams (2007). Parameters from the system estimation are used to find the derivative of the consumption shares with respect to prices; those derivatives involving shares are transformed into derivatives involving quantities; those derivatives are calculated for each household, correcting for any corner solutions; and then those derivatives are transformed and aggregated into elasticities.

for multiple quarters are not independent (this precludes us from clustering by any other variable).[18]

4. Results

A. Econometric Estimates

(i) Regression Results

Tables 2 and 3 report the coefficient estimates for the baseline specification of one- and two-adult demand systems, which include 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.[19] The effect of male wage on alcohol consumption is the strongest of the cross-price relationships estimated here; the share of spending devoted to alcohol falls as male wage increases.

(ii) 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,

[18] 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.

[19] 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 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.

respectively, which are consistent with prior estimates in the empirical micro literature (see discussions in Blundell and MaCurdy 1999; Fuchs et al. 1998).[20]

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 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.[21]

(iii) Sensitivity Analysis

The rest of Table 4 presents results under various alternative specifications, such as estimation including payroll tax rates, estimation using 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

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[20] They are also broadly consistent with labor supply assumptions in tax simulation models, such as Browning (1987), Ballard et al. (1985), Ballard (1990), and Goulder and Williams (2003). Even though the uncompensated hours worked elasticity for males is typically estimated at 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 (e.g., Prescott 2004).

[21] Recent estimates of expenditure elasticities (averaging over all beverages) include 0.10 in Baltagi and Griffin (1995), below 0.10 in Farrel et al. (2003), 0.11 in Lee and Tremblay (1992), 0.25 in Manning et al. (1995), 0.40 in Nelson and Moran (1995), 0.18 in Ruhm (1995), 0.89 in Selvanathan (1991), and 0.4 in Yen (1994).

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 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 from zero.

We believe that the specifications without fixed effects and with time-varying wage instruments produce less reliable estimates of the alcohol/leisure elasticity than in 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

(i) Formula and parameter values

Parry et al. (2008) 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 eq. (8) in that paper, an approximation for the optimal (revenue-neutral) alcohol tax is:

$$(3)\; t_A^* \approx \underset{\text{tax}}{\text{Pigouvian}} + \overbrace{MEG\left\{\left(\frac{p_A + t_A}{-\eta_{AA}}\right)\left(\frac{\varepsilon_{LL}^c - \eta_{Al}^c}{\varepsilon_{LL}}\right) - t_A\right\}}^{\text{fiscal component}} + \overbrace{(1+MEG)t_L\rho}^{\text{productivity effect}}$$

$$(4)\; MEG = \frac{\frac{t_L}{1-t_L}\varepsilon_{LL}}{1-\frac{t_L}{1-t_L}\varepsilon_{LL}}$$

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, ε_{LL} is a labor supply elasticity defined with respect to the net of tax wage or price of leisure, η_{Al} is the elasticity of alcohol consumption with respect to the price of leisure, and *c* denotes a compensated (as opposed to uncompensated) elasticity. *MEG* denotes the marginal efficiency gain from recycling a dollar of revenue in labor tax reductions; it is greater the larger (a) the (uncompensated) labor supply elasticity and (b) the labor tax wedge. Finally, ρ 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 tax into three components. The first component is the Pigouvian tax which, as discussed above, encompasses 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 et al. (2008), we assume that the Pigouvian tax is $68 per alcohol gallon.

Second is the fiscal component, or Ramsey tax, which is very familiar from the theoretical literature on optimal taxes.[22] This component can be positive when $\varepsilon_{LL}^{c} < \eta_{Al}^{c}$, that is, when 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 prior 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 ε_{LL} = 0.10, ε_{LL}^{c} = 0.20, medium values of ε_{LL} = 0.15, ε_{LL}^{c} = 0.35, and high values of ε_{LL} = 0.30, ε_{LL}^{c} = 0.60. And based on our own estimates, a reasonable range to consider for η_{Al}^{c} is about –0.4 to 0.3. All elasticities are taken to be constant across the relevant range. From Parry et al. (2008), 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.[23]

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

[22] Ramsey (1927) and Corlett and Hague (1953–54) are the classic contributions to the literature. For some recent discussion see Ballard et al. (2005).

[23] Our values for *MEG* are approximately consistent with estimates of the marginal excess burden of taxation for financing public goods (e.g., Ballard et al. 1985, Ballard 1990, Wildasin 1984), aside from some caveats noted in Section 5 below.

reduction in net of tax wages, which is internal to individuals). The effect is multiplied by 1 + *MEG* to account for the efficiency effect from raising the labor tax to make up for the lost revenue. Following Parry et al. (2008), we adopt low, medium, and high values of ρ = \$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 anything from \$5 to \$87 per alcohol gallon to the optimal tax.[24]

(ii) 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 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. In a couple of cases, the fiscal component is relatively modest, or even negative—namely, when 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

[24] The formula in (3) is an approximation as it excludes from the fiscal component changes in the government budget resulting from changes in spending on medical care and implementation of drunk driver penalties. In Parry et al. (2008), these budgetary impacts are small relative to the marginal change in alcohol tax revenues.

seven other parameter combinations illustrated in Table 5, the fiscal component is anything from around $70 per gallon to more than $400 per gallon.

5. Conclusion

Although implementation of a fully optimized set of taxes on all commodities is probably 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 level of these taxes might be appropriate on fiscal grounds, even though estimates are always likely to be imprecise given the difficulty of accurately pinning down 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. Plugging 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 Pigiouvian 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 at pains to emphasize the preliminary nature of these findings, however. 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 caveat concerns household equity. Alcohol taxes are regressive, even when household income is measured on a lifetime—rather than annual—basis (e.g., Lyon and Schwab 1995).[25] Some economists would favor disaggregating different income groups in optimal tax analyses

[25] This finding might be weakened somewhat if one took full account of (a) automatic indexing of tax and benefit thresholds following an increase in the consumer price level, (b) the recycling of alcohol tax revenues, and (c) externality benefits from improved health and fewer drunk driver accidents.

and incorporating distributional weights. 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. Others, however, argue for addressing distributional concerns by adjusting the broader tax and benefit system to provide a reasonable safety net. In this view, higher alcohol taxes should not necessarily be resisted on distributional grounds, though recycling of revenues might be skewed toward to the poor.

Another worry 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). But in principle, this problem can be avoided if the political will is there. Legislation accompanying the alcohol tax increase can specify 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 other policy contexts, such as most existing legislative proposals to reduce greenhouse gas emissions, adversely affected producer groups are partially compensated—for example, producers might receive a free allocation of permit allowances with market value, though the compensation would be phased out over time. In principle, some temporary tax relief might also be provided to beverage interests, though at the expense of lowering the efficiency gains from the hike in alcohol taxes. Moreover, public health groups would probably 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 evidenced by the decline in alcohol taxes from 50 percent of pre-tax prices in 1970 to 12 percent now (Kenkel 1996). Besides raising the overall level of taxation, a case could also be made 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 probably 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 (e.g., Decker and Schwartz 2000), as is literature on whether cigarettes are currently under- or overtaxed (cf. Gruber 2002 and Viscusi 2002).

Finally we note that, by ignoring some broader distortions created by the tax system, our discussion may significantly understate the optimal alcohol tax. Income 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 one allows for the distortionary effect of income taxes on depressing capital accumulation below economically efficient levels (Bovenberg and Goulder 1997).

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Tables and Figures

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

	One-adult households		Two-adult households	
Variable	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	0.02	0.03	0.007	0.01
One-adult share of leisure in full income	0.49	0.15	-	-
Two-adult male share of leisure in full income	-	-	0.28	0.08
Two-adult female share of leisure in full income	-	-	0.25	0.08
Share of composite good in full income	0.50	0.16	0.46	0.13
Weighed alcohol price ($/liter)	5.84	0.44	5.83	0.45
Price of composite good (index)	1.04	0.10	1.03	0.11
One-adult Heckman-corrected net hourly wage ($)	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 ($)	879.7	413.6	1858.6	728.1
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	-
Race of household head				
White (%)	87.8	-	87.6	-
Black (%)	14.7	-	8.6	-
Asian (%)	0.6	-	.8	-
Other race (%)	2.9	-	3.0	-

Number of children	0.42	0.88	1.17	1.19
Region				
Northeast (%)	15.4	-	13.4	-
Midwest (%)	23.0	-	25.4	-
South (%)	34.0	-	35.7	-
West (%)	27.5	-	25.4	-
Observations	3395	-	3242	-

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

	Alcohol Share	Leisure Share
ln(alcohol price)	-0.0012	-0.0066
	(0.0335)	(0.0062)
ln(other good price)	0.0077	-0.0808***
	(0.0354)	(0.0352)
ln(net wage)	-0.0066	0.0874***
	(0.0062)	(0.0343)
ln(F/P)	-0.0152***	-0.3504***
	(0.0036)	(0.0282)
Inverse Mills Ratio (alcohol)	0.0088	-0.3275
	(0.0896)	(0.5013)
Age	-0.0006	-0.0037
	(0.0006)	(0.0042)
Age Squared	0.000007	0.00004
	(0.000007)	(0.00005)
Black	-0.0024	0.0137
	(0.0054)	(0.0360)
Asian	-0.0065	0.0084
	(0.0118)	(0.0927)
Other Race	-0.0010	0.0222
	(0.0051)	(0.0359)
High School Degree	0.0016	0.0430*
	(0.0036)	(0.0256)
More than High School Degree	0.0002	0.0495

	(0.0055)	(0.0367)
Female	0.0008	0.0116
	(0.0015)	(0.0182)
Number of Children	0.0005	0.0033
	(0.0012)	(0.0073)
Constant	0.1314***	2.8864***
	(0.0657)	(1.467)
Number of Observations	3395	3395

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 percent (***) or 10 percent (*) level.

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

	Alcohol Share	Male Leisure	Female Leisure
ln(alcohol price)	-0.0021	-0.0039***	-0.0011
	(0.0042)	(0.0015)	(0.0016)
ln(other good price)	0.0071***	-0.067***	-0.0464***
	(0.0035)	(0.0164)	(0.0110)
ln(male net wage)	-0.0039***	0.1455***	-0.0746***
	(0.0015)	(0.0137)	(0.0074)
ln(female net wage)	-0.0011	-0.0746***	0.1221***
	(0.0016)	(0.0074)	(0.0087)
ln(*F*/*P*)	-0.0070***	-0.169***	-0.1684***
	(0.0014)	(0.0305)	(0.0230)
Inverse Mills Ratio (alcohol)	-0.0063	0.2858	0.2690
	(0.0212)	(0.3286)	(0.2450)
Male Age	0.0003	-0.0043	-0.0018
	(0.0003)	(0.0027)	(0.0019)
Male Age Squared	-0.000004	0.00005*	0.00002
	(0.000003)	(0.00003)	(0.00002)
Black Male	-0.0002	-0.0170	-0.0331
	(0.0029)	(0.0533)	(0.0416)
	-0.0046*	0.0304	0.0066

Asian Male			
	(0.0025)	(0.0445)	(0.0352)
Other Race Male	-0.0005	-0.0094	0.0179
	(0.0019)	(0.0343)	(0.0250)
Male High School Degree	0.0012	-0.0077	-0.0075
	(0.0017)	(0.0214)	(0.0170)
Male More than High School Degree	0.0015	-0.0091	-0.0089
	(0.0018)	(0.0217)	(0.0153)
Female Age	-0.0001	0.0017	-0.0017
	(0.0002)	(0.0022)	(0.0019)
Female Age Squared	0.000001	-0.00001	0.00003
	(0.000003)	(0.00003)	(0.00002)
Black Female	0.0008	0.0196	0.0261
	(0.0030)	(0.0544)	(0.0421)
Asian Female	-0.0004	-0.033	-0.0412
	(0.0037)	(0.0618)	(0.0445)
Other Race Female	-0.0001	0.0205	-0.0147
	(0.0021)	(0.0367)	(0.0288)
Female High School Degree	-0.0011	-0.0071	0.0002
	(0.0014)	(0.0154)	(0.0128)
Female more than High School Degree	-0.0019	-0.005	0.008
	(0.0014)	(0.0149)	(0.0127)
Number of Children	0.0001	-0.0007	0.0074
	(0.0002)	(0.0036)	(0.0028)
Constant	0.0756*	1.1901*	1.2493*
	(0.0432)	(0.6499)	(0.6684)
Observations	3242	3242	3242

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 percent (***) or 10 percent (*) level.

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

Notes

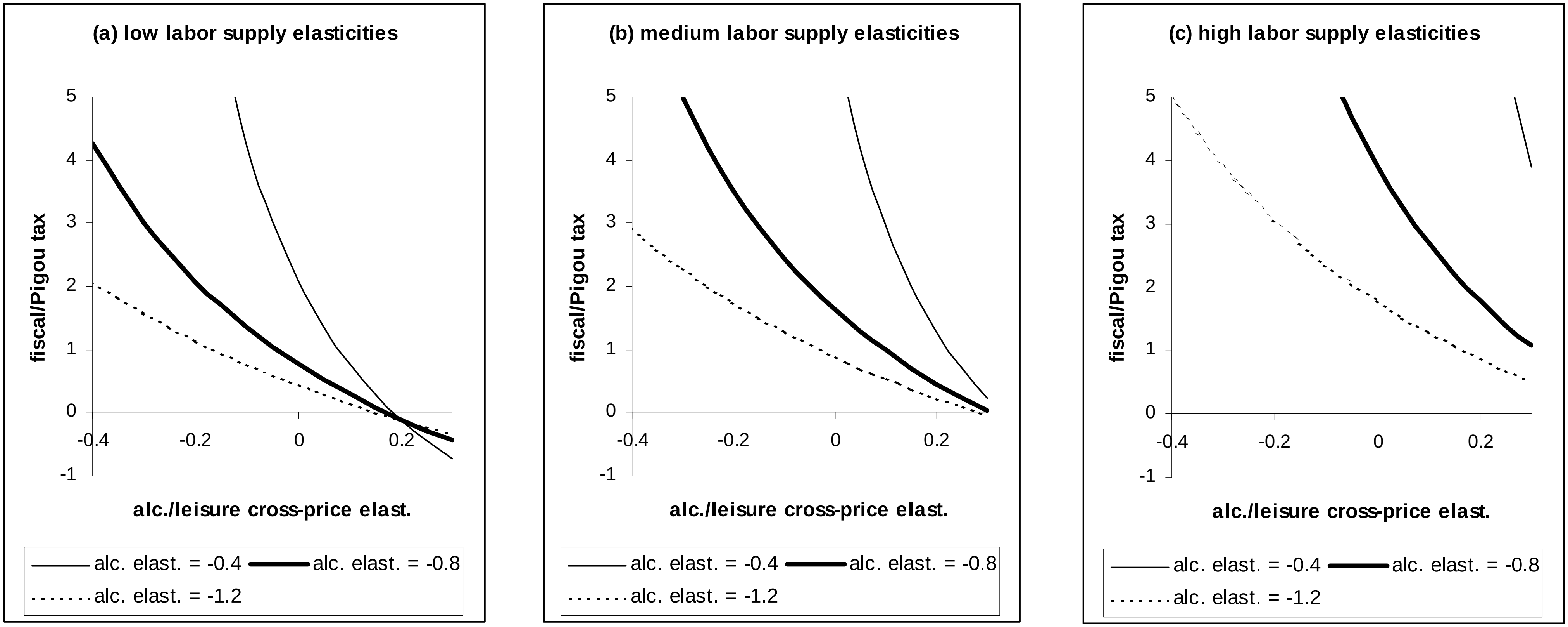
[a] Baseline but replacing state fixed effects with percentage of state population in college, an indicator equal to one if alcohol sales are allowed on Sundays, and state's number of cloudy days per year. Results are essentially the same if number of cloudy days is replaced with state's average temperature.

[b] Specification 6, but adding number of drinking establishments (liquor stores and drinking places) per capita and number of places of worship per capita.

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			
		alc./leisure cross-price	-0.15	-0.05	0.2
		own price	-0.6	-0.8	-1
		productivity effect	high	medium	low
low	Pigouvian		68	68	68
	fiscal		201	71	-5
	productivity		74	40	5
	total		343	179	68
medium	Pigouvian		68	68	68
	fiscal		395	137	22
	productivity		77	41	5
	total		541	246	95
high	Pigouvian		68	68	68
	fiscal		>500	318	78
	productivity		87	47	6
	total		>655	433	152

Figure 1. Fiscal Component of Optimal Alcohol Tax under Different Parameter Assumptions (relative to the Pigouvian tax)



Appendix: Corrections for Selection Bias

Alcohol purchase decision. For our benchmark estimation, inverse Mills ratios (MR_a^h) were obtained from estimating probit models for one- and two-adult households on the choice of whether to consume alcohol. Each probit includes the 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. We use less than 21 years of age as our exclusion restriction given the absence of a better determinant of the discrete choice that does not affect the continuous choice of alcohol.

Labor force participation decision. For the first-stage choice of whether to work, we jointly estimate a probit and a 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 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 nonworkers (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 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 of the 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; and to estimate net wages for workers, we include those same variables as well as occupation indicators. Because 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 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 include these variables. 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 because 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. Although high-price regions may also be high-wage regions, we find no reason to postulate that an individual facing a high alcohol price or other good price will have a higher wage because we control for region in our wage equation. Unemployment rates serve as a 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 serve as a proxy for an individual’s nonwage income, but should not directly affect an individual’s wage; this is another standard exclusion restriction.