Alcohol Tax Equalization and Social Costs

Henry Saffer
National Bureau of Economic Research

and

Frank Chaloupka
University of Illinois at Chicago

INTRODUCTION

Many countries, including the United States, have adopted tax and other regulatory policies which favor beer and wine over spirits. One justification for these policies has been the belief that different physiological effects and thus different public health effects are associated with each beverage. A second justification is derived from the relative production costs of each beverage. According to the Brewers Association of Canada [1993], a unit of alcohol is cheaper to produce in the form of spirits than in the form of beer or wine. Excise tax differentials thus tend to equate the purchase price of a unit of alcohol in each of the three beverages.

A recent policy initiative, which has received considerable attention, calls for equalization of the tax per unit of alcohol in each of the three beverages. The Bush administration's deficit reduction plan proposed in July 1990 called for equalization of alcohol tax rates. The deficit reduction act which was finally adopted increases wine taxes by the highest percentage, beer taxes by the next highest percentage and spirits taxes by the smallest percentage. Although reduced by these changes, considerable tax-rate differentials remain. Another attempt to introduce tax equalization occurred in November 1990 in the state of California, which voted on, and defeated, an alcohol tax initiative which would have raised and equalized the state taxes on all alcoholic beverages. The Congressional Budget Office report entitled *Reducing the Deficit: Spending and Revenue Options* [1993] suggests that future alcohol tax increases include alcohol tax equalization

Since it is the most heavily taxed, the distilling industry supports this equalization initiative. The distilling industry has drawn attention to the fact that a 1.25-ounce shot of whiskey, a 12-ounce can of beer, and a 5-ounce glass of wine all have the same alcohol content suggesting that each alcoholic beverage has the same potential for adverse public health consequences and should receive the same tax treatment. The policy initiative to equalize alcohol taxes has also been supported by several public interest groups concerned with alcohol problems. One of these interest groups circulated a petition to academic economists in support of an increase in all alcohol taxes and an equalization of the tax on alcohol in each of the three alcoholic beverages. This petition was signed by eighty economists including three Nobel laureates.

Eastern Economic Journal, Vol. 20, No. 1, Winter 1994

The purpose of this paper is to estimate whether alcohol tax equalization is the optimal policy for reducing externalities associated with alcohol abuse. Several prior studies focus on a single alcoholic beverage and estimate an optimal alcohol tax. However, the level of alcohol taxes and alcohol tax equalization are distinct policy problems. The question of whether equalization of alcoholic beverage taxes is an optimal policy has never been addressed in prior studies. This omission may be the result of empirical problems encountered in estimating the optimal tax structure. In this paper, a theoretical model of the optimal tax on all three beverages is developed. This model is used to simulate the optimal tax on each beverage for a number of alternative assumptions.

THEORETICAL MODEL

The basis for the model of the optimal tax on beer, wine and spirits is an insightful model developed by Pogue and Sgontz [1989]. The Pogue and Sgontz model assumes that there is a single alcoholic beverage and that some consumers are alcohol abusers and others are non-abusers. Their model can be expanded to include beer, wine and spirits and to allow for beverage substitution. The three-beverage model is defined in units of pure alcohol per person per time period.[1]

To develop a three-beverage model, some assumptions about the own-price and cross-price elasticities are necessary. The model allows the own-price elasticities for each beverage to differ. While the alcohol in each beverage is chemically identical, this does not imply that the own-price elasticities for each beverage should be the same. The alcohol in beer, wine and spirits cannot be unbundled from the other consumption attributes of these beverages. When each of the three beverages is viewed as a set of product attributes, there is no reason to believe that the own-price elasticities for the alcohol in each of the three beverages should be the same. Cross-price elasticities are included in the model since some degree of substitutability between the three beverages is likely. If the three beverages are substitutes, an increase in the tax on one beverage will induce some consumers to shift to the relatively less expensive beverages.

Each beverage is assumed to have a perfectly elastic long-run supply curve with prices, exclusive of taxes, equal to P_b, P_w and P_s, respectively. Since the alcohol in beer, wine and spirits are produced with different technologies, these supply prices are not constrained to be the same.

The model is derived in the Appendix. It allows for the marginal external abuse cost (E_i) of the alcohol in each beverage to differ. This cost, while negligible at low consumption levels, increases exponentially with consumption. The social cost of a small increase in alcohol consumption is equal to the supply price plus the marginal external abuse cost. The demand for alcohol by an alcohol abuser accounts for perceived marginal internal abuse costs and is to the right of demand for alcohol by a non-abuser.

The model shows that the optimal tax on each beverage increases with an increase in the marginal external abuse cost of that beverage and decreases with an increase in the marginal external abuse cost of the alternative beverages. The model also shows that optimal tax rates are positive functions of the other beverage tax rates and positive functions of the cross-price elasticities.

The model shows that if the cross-price elasticities were all zero and the external abuse cost of each beverage were the same, then each optimal tax would reduce to E/δ. As shown in the Appendix, $1/\delta$ is equal to the ratio of the tax-induced change in consumption by abusers to the tax-induced change in total consumption. This is the result found by Pogue and Sgontz and is a case where alcohol tax equalization is the optimal policy. Furthermore, under these assumptions, if all consumers were abusers, δ would equal one and the tax would simply equal the marginal external abuse cost. This is the original result found by Pigou. As the percentage of the population abusing alcohol declines, the value of δ increases. The model shows that as the percentage of the population abusing alcohol declines, the optimal tax on each beverage also declines. This is, in part, because non-abusers also pay the tax which simply causes a loss of consumer surplus.

SIMULATION DATA

A number of prior econometric studies have estimated own-price elasticities for beer, wine and spirits. In estimating these elasticities, all three beverage prices should enter the demand curve since they are substitutes. Omission of any of these other alcohol prices creates an omitted-variable bias. The direction of bias due to omitted variables is unknown. The inclusion of all three beverage prices, however, creates a problem with multicollinearity because relative real prices and relative real taxes display very little variation. One reason for this is that beer, wine and spirits taxes are often increased at the same time and in similar proportions. Also, increases in the price level tend to affect production costs for each beverage in the same proportions which leaves relative real prices unchanged. Multicollinearity creates unbiased but unstable estimates.[2]

Ornstein and Levy [1983], in a review of prior empirical studies, conclude that the own-price elasticities of beer, wine and spirits are -0.3, -1.0, and -1.5, respectively. Leung and Phelps [1991], conclude that more recent empirical work with aggregate data supports the Ornstein and Levy estimates, though recent work using individual data suggests that alcohol demand may be more elastic than the Ornstein and Levy estimates indicate. Both review papers emphasize that these estimates are best guesses and that there is a good deal of variation in reported own-price elasticities in the studies that were reviewed.

The estimation of cross-price elasticities is an even more difficult empirical problem than the estimation of own-price elasticities. Ornstein and Levy review six studies which reported cross-price elasticities and conclude that there is no consistent empirical evidence of cross-price effects between alcoholic beverages. Other studies which report cross-price elasticities include Thom [1984], Uri [1986], Duffy [1987], Adrian and Ferguson [1987], Jones [1989], and Heien and Pompelli [1989]. These studies also do not provide a consistent pattern of cross-price effects. The lack of consistent econometric estimates of cross-price elasticities is more likely attributable to data problems than to consumer behavior.

Although existing econometric studies are not very helpful in estimating cross-price elasticities, economic theory can provide some guidance in bounding the potential range of these elasticities. Optimal tax rates can then be estimated using alternative assumptions about cross-price elasticities. Complementarity of beer, wine and spirits is excluded as a plausible market phenomenon. This bounds the cross-price elasticities to a minimum value of zero. Economic theory requires that the sum of the own and all cross partial elasticities of substitution, weighted by their expenditure shares, sum to zero.[3] This can be written as

$$\eta_{ii} + \eta_{ij} + \eta_{ik} + \eta_{ic} = 0$$

where η_{ij} are the own and cross elasticities and c a is composite of all non-alcohol commodities. Since c is a composite of all non-alcohol commodities, η_{ic} is likely to be positive.[4] If η_{ic} is positive, then $\eta_{ij} + \eta_{ik} < (-\eta_{ii})$. Also, η_{ij} and η_{ik} are likely to be somewhat similar in magnitude. Under these assumptions, the cross-price elasticities will be fractions of the relevant own-price elasticities.

It is important to consider alternative assumptions about the cross-price elasticities because these parameters are difficult to estimate with any precision. Also, since consumption data and the consumer price index change over time, optimal taxes must be computed for a specific year. The year chosen for the computations is 1991, and the results can be compared to actual nominal taxes for 1991. The comparisons are made for 1991 since it is the most recent available data on comprehensive taxes. These data come from *International Survey of Alcoholic Beverage Taxation and Control Policies* [Brewers Association of Canada, 1993] and include federal, state, and local alcohol taxes and sales taxes. The tax on a gallon of pure alcohol contained in beer, wine, and spirits in 1991 was $28.31, $23.65, and $48.82, respectively, with a weighted-average tax of $34.20. These tax rates reflect the substantial increase in Federal taxes imposed on 1 January 1991.

The data required to estimate optimal taxes can be classified into five groups. The first group contains consumption data. These data are known with a good degree of precision. In 1991, consumption levels for total alcohol, beer, wine, and spirits, were 1.846, 1.040, 0.239, and 0.567 gallons of pure alcohol per capita, respectively.[5] These values were derived from data in the *Brewers Almanac* [U.S. Brewers Association, 1992].

The second group contains the own-price elasticities. The Ornstein and Levy estimates of -0.3, -1.0, and -1.5 for beer, wine and spirits, respectively, have received some acceptance as at least rough estimates. The important information derived from these estimates are their relative elasticities rather than their absolute values. The model shows that when the cross elasticities are zero, optimal taxes are not a function of own elasticities. When the cross-price elasticities are assumed to be positive, they are fractions of the relevant own-price elasticities. In the model, the cross-price elasticities are divided by the relevant own-price elasticity. A percentage change in the own-price elasticity will not change the ratio of the cross-price to the own-price elasticity.

The third group contains data used to compute δ. As shown in the Appendix, $\delta = (1+\alpha\gamma)$. Estimates of α and γ are needed to estimate δ. The variable is equal to the relative demand elasticity of a non-abuser to an abuser, (η_i^o/η_i), times the relative consumption of a non-abuser to an abuser, (x_i^o/x_i). Pogue and Sgontz's "best guess" is that the relative elasticity is one.[6] The simulations in Table 1 assume relative elasticities of 1. According to the National Institute on Alcohol Abuse and Alcoholism [1990], the relative consumption of a non-abuser to an abuser is about 0.1. The estimated value for α used in Table 1 is thus 0.1 and 0.2. The numeric value of γ, which is the ratio of non-abusers to abusers in the population, (N_i^o/N_i), is estimated by the National Institute on Alcohol Abuse and Alcoholism to be about 15. The estimated value of δ used in Table 1 is thus 2.5. Changes in the value of δ would affect the absolute level of each tax but have no effect on the taxes on beverages relative to one another.

The fourth value is the marginal external abuse cost of alcohol consumption. Although the model allows for differential marginal external-abuse costs, there are no separate estimates of these costs for each beverage.[7] This cost has been reported by Pogue and Sgontz [1989] and is inflated to account for price level changes to 1991. In 1991 prices, the estimate of the marginal external abuse cost of a gallon of pure alcohol is about $175.

The fifth group is the cross-price elasticities. Since there are no consistent regression estimates for these elasticities, three assumptions are made. These assumptions include setting all cross-price elasticities to zero. In this case, the tax simply reduces to E/δ. It is also assumed that the cross-price elasticities are equal to -0.1, -0.25 and -0.4 times the corresponding own-price elasticity. These assumptions make the sum of the two cross-price elasticities equal to two-tenths, one-half, and eight-tenths of the negative of the own-price elasticity, which is consistent with the restriction that $\eta_{ij} + \eta_{ik} < (-\eta_{ii})$. The assumption of zero cross-elasticity is included to provide a comparison with the case of a single alcoholic beverage.

ESTIMATION OF OPTIMAL TAX RATES

Table 1 presents estimates of optimal tax rates for six sets of assumptions. The values used in these assumptions have gained a certain credibility in the literature. Table 1 is set up so that beverage substitutability increases with each row from top to bottom.

Before going on to estimate the optimal tax on each beverage it is interesting to ask what set of assumptions would make the existing set of tax rates optimal. There are a number of permutations of the parameters which could generate the actual set of tax rates. One approach to the question is to set all the parameters at their "best guess" value except for the marginal external abuse costs. This approach is justified by the long-standing, although unsupported, view that spirits have higher external abuse costs than beer or wine. The model can be solved for the set of marginal external abuse costs that are implicit in the existing tax rates. This exercise resulted in $E_b = \$41$, $E_w = \$50$, $E_s = \$121$. The "best guess" assumption is a marginal external abuse cost for each beverage of $175.

TABLE 1
Tax Simulations

	Taxes (Combined Federal and State) Beer	Wine	Spirits	Weighted Avg.
Actual 1991	\$28.31	\$23.65	\$48.82	\$34.20
Alternative Assumptions:[a]				
1. all $\eta_{ij} = 0$	\$70.0	\$70.00	\$70.00	\$70.00
2. $\eta_{bw} = .1(-\eta_{bb})$, $\eta_{wb} = .1(-\eta_{ww})$ $\eta_{ws} = .1(-\eta_{ww})$, $\eta_{sw} = .1(-\eta_{ss})$ $\eta_{bs} = .1(-\eta_{bb})$, $\eta_{sb} = .1(-\eta_{ss})$	\$76.20 (1.1)	\$70.50 (1.02)	\$69.30	\$73.30
3. $\eta_{bw} = .25(-\eta_{bb})$, $\eta_{wb} = .25(-\eta_{ww})$ $\eta_{ws} = .1(-\eta_{ww})$, $\eta_{sw} = .1(-\eta_{ss})$ $\eta_{bs} = .1(-\eta_{bb})$, $\eta_{sb} = .1(-\eta_{ss})$	\$76.50 (1.1)	\$71.90 (1.04)	\$69.30	\$73.70
"Best Guess" 4. $\eta_{bw} = .25(-\eta_{bb})$, $\eta_{wb} = .25(-\eta_{ww})$ $\eta_{ws} = .25(-\eta_{ww})$, $\eta_{sw} = .25(-\eta_{ss})$ $\eta_{bs} = .25(-\eta_{bb})$, $\eta_{sb} = .25(-\eta_{ss})$	\$85.70 (1.25)	\$73.80 (1.08)	\$68.60	\$78.90
5. $\eta_{bw} = .4(-\eta_{bb})$, $\eta_{wb} = .4(-\eta_{ww})$ $\eta_{ws} = .25(-\eta_{ww})$, $\eta_{sw} = .25(-\eta_{ss})$ $\eta_{bs} = .25(-\eta_{bb})$, $\eta_{sb} = .25(-\eta_{ss})$	\$87.70 (1.27)	\$78.30 (1.14)	\$68.90	\$80.70
6. $\eta_{bw} = .4(-\eta_{bb})$, $\eta_{wb} = .4(-\eta_{ww})$ $\eta_{ws} = .4(-\eta_{ww})$, $\eta_{sw} = .4(-\eta_{ss})$ $\eta_{bs} = .4(-\eta_{bb})$, $\eta_{sb} = .4(-\eta_{ss})$	\$99.10 (1.43)	\$84.30 (1.22)	\$69.30	\$88.00

[a] Assumptions for all cases are: $E_b = E_w = E_s = \$175$; $\delta = 2.5$; $\eta_{bb} = -.3$, $\eta_{ww} = -1.0$, $\eta_{ss} = -1.5$. The numbers in currency format are the tax per gallon of ethanol. The numbers in parentheses are the beer or wine tax as a percent of the spirits tax. The parameters E_i are the marginal external abuse costs, η_{ii}, are the own-price elasticities, η_{ij}, are the cross-price elasticities, and d is equal to the ratio of the tax induced change in total consumption to the tax-induced change in consumption by abusers.

Pogue and Sgontz estimate the optimal tax on a gallon of pure alcohol to be about \$53 in 1983. The computations in row 1 assume that the cross-price elasticities are zero and use similar values to those used by Pogue and Sgontz. Not surprisingly, when deflated to 1983 prices the results in row 1 are about the same as those estimated by Pogue and Sgontz. The optimal weighted-average tax is 2.06 times the actual tax in 1991. Phelps [1988], using a somewhat different approach, also concludes that alcohol taxes should be at least double.

A gradual increase in beverage substitutability is assumed in going down row 2 to row 6 in Table 1. Both the weighted-average tax and the tax differentials increase as beverage substitutability increases. Row 2 assumes that the cross-price elasticities

are -0.1 times the relevant own-price elasticities. In row 2, the weighted-average tax increases to 2.16 times the 1991 level. The distribution shifts such that beer taxes are 1.1 times spirits taxes and wine taxes are about 1.02 times spirits taxes. Row 3 allows for greater substitution between beer and wine but is otherwise the same as row 2. Specifically, row 3 assumes that the cross-price elasticities between beer and wine are -0.25 times the relevant own-price elasticities, while the other cross-price elasticities are -0.1 times the relevant own-price elasticities. This modification results in a minor increase in the weighted-average tax rate and the tax differentials.

Row 4 represents the "best guess" estimates. Row 4 assumes that the cross-price elasticities are -0.25 times the relevant own-price elasticities. In row 4 the weighted-average tax increases to 2.32 times the 1991 level. The distribution shifts such that beer taxes are 1.25 times spirits taxes and wine taxes are about 1.08 times spirits taxes. Row 5 allows for greater substitution between beer and wine than in row 4, but is otherwise the same as row 4. Specifically, row 5 assumes that the cross-price elasticities between beer and wine are -0.4 times the relevant own-price elasticities, while the other cross-price elasticities are -0.25 times the relevant own-price elasticities. This modification again only results in a minor increase in the weighted-average tax rate and the tax differentials.

Row 6 represents the highest level of beverage substitution. Row 6 assumes that the cross-price elasticities are -0.4 times the relevant own-price elasticities. In row 6 the weighted-average tax increases to 2.59 times the 1991 level. The distribution shifts such that beer taxes are 1.43 times spirits taxes and wine taxes are about 1.22 times spirits taxes.

None of these results provides any support for the 1991 set of tax differentials in which wine and beer are about the same while taxes on spirits are about twice as high. Using the "best guess" assumptions in row 4, the results suggest that the average tax on beer should be 25 percent higher than that on spirits and that taxes on wine should be about 8 percent higher than on spirits. The weighted-average tax should be about 2.3 times the current average.

CONCLUSIONS

The purpose of this paper is to examine whether the equalization of alcohol taxes is the optimal policy for reducing the externalities associated with alcohol abuse. The optimal tax on each beverage was estimated, requiring a series of assumptions about alcohol demand. The precision of these assumptions may be improved in the future if more extensive surveys of alcohol use are conducted. However, since alcohol tax equalization is a recurring policy initiative, it is important that the optimal tax on each beverage be estimated using the best currently available data.

The model presented in this paper shows that one scenario where tax equalization is optimal is if the marginal external abuse cost of each beverage is the same and the cross-price elasticities are all zero. Assuming that the marginal external abuse cost of each beverage is the same is not unrealistic. However, the assumption that the cross-price elasticities are all zero is probably not very realistic.

Is there a second case for equalization? Using a "best guess" estimate of the cross-price elasticities, the results show that the optimal tax on beer should be about 25 percent higher than the spirits tax and that the wine tax should be about 8 percent higher than the spirits tax. This is not equalization, but given the difficulties of estimating the optimal tax structure, and complications resulting from container deposits on beer, these results come reasonably close to equalization.[8]

The "best guess" results also show that the weighted-average tax should be about 2.3 times the 1991 weighted-average tax. This increase along with equalization could be accomplished by approximately tripling state and federal beer and wine taxes with about a 50 percent increase in spirits taxes.

As a final issue, the preferable method for correcting for the externalities caused by alcohol is to pass these costs on to abusers only. Alcohol taxes are only one of a number of public policies which can reduce externalities associated with alcohol. Alcohol taxes, on a per drink basis, have the disadvantage of burdening both abusers and non-abusers. Other approaches to alcohol control can be focused more on abusers. For example, strong enforcement of drunk driving laws and severe sanctions for those convicted of drunk driving focus only on abusers. Other approaches which target abusers more, but might be difficult to implement, include policies such as higher weekend surtaxes, evening surtaxes or on-premise surtaxes. Finally, changing the taxation system to a sales tax rather than the current excise tax would reduce the effects of inflation.

APPENDIX

For the i^{th} beverage, let the optimal tax be T_i. The marginal external abuse cost of each beverage is defined as E_i. The change in consumption induced by this tax is Δx_i for an abuser, and Δx_i^o for a non-abuser. Let N_i equal the number of abusers, and N_i^o equal the number of non-abusers. The number of non-abusers is a multiple of the number of abusers. That is, $N_i^o = \gamma N_i$. It is assumed that γ is the same for beer, wine, and spirits. This assumption was employed since there are no separate estimates of the number of abusers, or the quantity of alcohol consumed abusively, by beverage category. Also, the change in consumption resulting from a tax change for non-abusers is equal to a multiple of the change for abusers. That is, $\Delta x_i^o = \alpha \Delta x_i$. This identity makes the own-price elasticity of an individual abuser equal to the own price elasticity of an individual non-abuser, times $1/\alpha$, weighted by the ratio of consumption of a non-abuser to an abuser. That is, $\eta_i = \eta_i^o x_i^o / \alpha x_i$. Finally, define $\delta = (1+\alpha\gamma)$. The terms η_{ij} are the own-price elasticities and cross-price elasticities for beer, wine and spirits and X_i is total consumption of beverage i.

The welfare loss (L) from the taxes on beer, wine and spirits can be written as

$$\text{(1)}\quad L = -E_b \Delta x_b N_b + \tfrac{1}{2} T_b \Delta x_b N_b \delta - E_w \Delta x_w N_w + \tfrac{1}{2} T_w x_w N_w \delta - E_s \Delta x_s N_s + \tfrac{1}{2} T_s \Delta x_s N_s \delta,$$

where

$$\text{(2a)}\quad \Delta x_b N_b = X_b \eta_{bb} T_b / P_b + X_b \eta_{bw} T_w / P_w + X_b \eta_{bs} T_s / P_s ;$$
$$\text{(2b)}\quad \Delta x_w N_w = X_w \eta_{ww} T_w / P_w + X_w \eta_{wb} T_b / P_b + X_w \eta_{ws} T_s / P_s ;$$
$$\text{(2c)}\quad \Delta x_s N_s = X_s \eta_{ss} T_s / P_s + X_s \eta_{sb} T_b / P_b + X_s \eta_{sw} T_w / P_w .$$

Equations (2a), (2b), and (2c) are substituted into (1). To find the optimal tax on beer, wine and spirits, equation (1) is differentiated with respect to T_b, T_w, and T_s, which yields three equations. The following derivation of $\partial L/\partial T_b$ should be sufficient to illustrate the derivation of all three equations. First, equation (1) is differentiated with respect to T_b:

$$\begin{aligned}\partial L/\partial T_b = {} & -(E_b X_b \eta_{bb} + E_w X_w \eta_{wb} + E_s X_s \eta_{sb})/P_b + T_b X_b \eta_{bb} \delta / P_b + \tfrac{1}{2} T_w X_b \eta_{bw} \delta / P_w \\ & + \tfrac{1}{2} T_s X_b \eta_{bs} \delta / P_s + \tfrac{1}{2} T_w X_w \eta_{wb} \delta / P_b + \tfrac{1}{2} T_s X_s \eta_{sb} \delta / P_b = 0.\end{aligned}$$

Note that all T_w and all T_s terms are grouped. Then,

$$\begin{aligned}\partial L/\partial T_b = {} & -(E_b X_b \eta_{bb} + E_w X_w \eta_{wb} + E_s X_s \eta_{sb})/P_b + T_b X_b \eta_{bb} \delta / P_b + \tfrac{1}{2} \delta T_w (X_b \eta_{bw} \delta / P_w \\ & + X_w \eta_{wb} \delta / P_b) + \tfrac{1}{2} \delta T_s (X_b \eta_{bs} / P_s + X_s \eta_{sb} / P_b) = 0.\end{aligned}$$

Note that

$$\begin{aligned} X_b \eta_{bw} / P_w &= X_b / P_w \, (\partial X_b / \partial P_w)(P_w / X_b) &= \partial X_b / \partial P_w ; \\ X_w \eta_{wb} / P_b &= X_w / P_b \, (\partial X_w / \partial P_b)(P_b / X_w) &= \partial X_w / \partial P_b ; \\ X_b \eta_{bs} / P_s &= X_b / P_s \, (\partial X_b / \partial P_s)(P_s / X_b) &= \partial X_b / \partial P_s ; \\ X_s \eta_{sb} / P_b &= X_s / P_b \, (\partial X_s / \partial P_b)(P_b / X_s) &= \partial X_s / \partial P_b . \end{aligned}$$

and that the symmetry conditions of demand theory require $\partial X_b/\partial P_w = \partial X_w/\partial P_b$ and $\partial X_b/\partial P_s = \partial X_s/\partial P_b$.

Thus,

$$\begin{aligned}\partial L/\partial T_b = {} & -(E_b X_b \eta_{bb} + E_w X_w \eta_{wb} + E_s X_s \eta_{sb})/P_b + T_b X_b \eta_{bb} \delta / P_b + \tfrac{1}{2} \delta T_w (2 \partial X_w / \partial P_b) \\ & + \tfrac{1}{2} \delta T_s (2 \partial X_s / \partial P_b) = 0\end{aligned}$$

and

$$\begin{aligned}\partial L/\partial T_b = {} & -(E_b X_b \eta_{bb} + E_w X_w \eta_{wb} + E_s X_s \eta_{sb})/P_b + T_b X_b \eta_{bb} \delta / P_b + \delta T_w (\partial X_w / \partial P_b)(P_b / P_b)(X_w / X_w) \\ & + \delta T_s (\partial X_s / \partial P_b)(P_b / P_b)(X_s / X_s) = 0\end{aligned}$$

which reduces to equation (3a):

$$\begin{aligned}\text{(3a)}\quad \partial L/\partial T_b = {} & -(E_b X_b \eta_{bb} + E_w X_w \eta_{wb} + E_s X_s \eta_{sb})/P_b + T_b X_b \eta_{bb} \delta / P_b + T_w X_w \eta_{wb} \delta / P_b \\ & + T_s X_s \eta_{sb} \delta / P_b = 0.\end{aligned}$$

Equations (3b) and (3c) are derived in a similar fashion:

$$\text{(3b)}\quad \partial L/\partial T_w = -(E_w X_w \eta_{ww} + E_b X_b \eta_{bw} + E_s X_s \eta_{sw})/P_w + T_w X_w \eta_{ww} \delta/P_w + T_b X_b \eta_{bw} \delta/P_w + T_s X_s \eta_{sw} \delta/P_w = 0;$$

$$\text{(3c)}\quad \partial L/\partial T_s = -(E_s X_s \eta_{ss} + E_w X_w \eta_{ws} + E_b X_s \eta_{bs})/P_s + T_s X_s \eta_{ss} \delta/P_s + T_w X_w \eta_{ws} \delta/P_s + T_b X_b \eta_{bs} \delta/P_s = 0.$$

Next the P_i are canceled, and the equations are solved for each T_i resulting in

$$\text{(4a)}\quad T_b = (E_b X_b \eta_{bb} + E_w X_w \eta_{wb} + E_s X_s \eta_{sb})/(\delta X_b \eta_{bb}) - T_w (X_w \eta_{wb})/(X_b \eta_{bb}) - T_s (X_s \eta_{sb})/(X_b \eta_{bb})$$

$$\text{(4b)}\quad T_w = (E_w X_w \eta_{ww} + E_b X_b \eta_{bw} + E_s X_s \eta_{sw})/(\delta X_w \eta_{ww}) - T_b (X_b \eta_{bw})/(X_w \eta_{ww}) - T_s (X_s \eta_{sw})/(X_w \eta_{ww})$$

$$\text{(4c)}\quad T_s = (E_s X_s \eta_{ss} + E_w X_w \eta_{ws} + E_b X_s \eta_{bs})/(\delta X_s \eta_{ss}) - T_w (X_w \eta_{ws})/(X_s \eta_{ss}) - T(X_s \eta_{bs})/(X_s \eta_{ss}).$$

Equations (4a), (4b), and (4c) are a system of three equations with three unknowns and could be solved algebraically for three reduced-form equations. The model was estimated in the above form as a system of three equations in three unknowns.

NOTES

Research for this paper was supported by Grant No. R01 AA07593 from the National Institute on Alcohol Abuse and Alcoholism to the National Bureau of Economic Research. We are indebted to Michael Grossman, Philip Cook, William Evans, the editor of this *Journal* and two anonymous referees, and the session participants at the 1992 meetings of the Eastern Economic Association for many helpful comments on earlier versions of this paper.

1. The Pogue and Sgontz model has been criticized for assuming that all alcohol consumers can be divided into abusers and non-abusers, not allowing for variation in the degree of abuse. An expanded model might define abusive and non-abusive consumption episodes and consumption per episode type. While these are important extensions, empirical implementation would be difficult. For example, a consumer could buy alcohol in advance for future abusive or non-abusive episodes. This creates a problem in distinguishing between the quantity of abusively consumed alcohol and non-abusively consumed alcohol and the respective own-price and cross-price elasticities.
2. The reliability of alcohol consumption data and alcohol price data have also created problems in estimating elasticities. Self-reported alcohol consumption data underreports actual consumption by a considerable amount. Alcohol sales data are limited to aggregate-level studies. Alcohol price data is based on fairly small samples, and alcohol tax data for wine and spirits, is limited to license states.
3. Note that the price elasticities estimated using regression models with real income held constant should be interpreted as equal to expenditure weighted partial elasticities of substitution.
4. If beer, wine, and spirits were grouped into a single alcohol commodity then the sum of the alcohol own-price elasticity and the alcohol-other consumption cross-price elasticity must sum to zero. Since the alcohol own-price elasticity must be negative, the other consumption cross-price elasticity must be positive.
5. Per capita values are computed using total population.

6. According to the International Classification of Diseases, alcohol abusers are individuals for whom alcohol is responsible for causing some type of persistent or recurrent social, occupational, psychological, or physical problem. Some amount of social problems are caused by individuals who rarely drink, but who are dangerous when they do drink. Studies by Cook and Tauchen [1982] Saffer and Grossman [1987] and Kenkel [1991] show that alcohol abusers are price responsive. While alcohol abusers may be price responsive, they may not be as price responsive as non-abusers. Alternatively, Becker, Grossman, and Murphy [1991], using a rational addiction model, argue that in the long run abusers may have more elastic demand than non-abusers.
7. Since the same blood alcohol concentration can be achieved with each of the three beverages each beverage potentially has the same external abuse costs. One of the three beverages might be preferred by abusers. However, there are different types of abusive behavior which makes it difficult to designate one beverage as the abusers' beverage of choice.
8. Many states have deposits on beer but not wine or spirits containers. These container deposits add considerably to the cost of a gallon of ethanol in the form of beer.

REFERENCES

Adrian, M. and Ferguson, B. Demand for Domestic and Imported Alcohol in Canada. *Applied Economics,* 1987, 531-40.

Becker, G., Grossman, M. and Murphy, K. Rational Addiction and the Effect of Price on Consumption. *American Economic Review*, 1991, 237-41.

Brewers Association of Canada. *International Survey of Alcoholic Beverage Taxation and Control Policies*, Toronto, Canada, 8th edition, 1993.

Congressional Budget Office. *Reducing the Deficit: Spending and Revenue Options*, Washington, DC, 1993.

Cook, P. and Tauchen, G. The Effect of Liquor Taxes on Heavy Drinking. *The Bell Journal of Economics*, Autumn 1982.

Duffy, M. Advertising and the Inter-Product Distribution of Demand. *European Economic Review*, 1987, 1051-70.

Godfrey, C. Licensing and the Demand for Alcohol. *Applied Economics*, 1988, 1541-58.

Heien, D. and Pompelli, G. The Demand for Alcoholic Beverages : Economic and Demographic Effects. *Southern Economic Journal*, January 1989, 759-70.

Jones, A. A Systems Approach to the Demand for Alcohol and Tobacco. *Bulletin of Economic Research*, 1989, 85-105.

Kenkel, D. Drinking, Driving, and Deterrence: The Social Costs of Alternative Policies. Manuscript, 1991.

Leung, S. and Phelps, C. 'My Kingdom for a Drink...'? A Review of Estimates of the Price Sensitivity of Demand for Alcoholic Beverages. Manuscript, 1991.

McGuiness, T. An Econometric Analysis of Total Demand for Alcoholic Beverages in the U.K. 1965-1975. *Journal of Industrial Economics*, 1980, 85-105.

National Institute on Alcohol Abuse and Alcoholism. *Alcohol and Health*, Washington: US Department of Health and Human Services, 1990.

Ornstein, S. and Levy, D. Price and Income Elasticities of Demand for Alcoholic Beverages, in *Recent Developments in Alcoholism*, edited by M. Galanter. New York: Plenum Press, 1983.

Phelps, C. Death and Taxes: An Opportunity for Substitution. *Journal of Health Economics*, 1988, 1-24.

Pogue, T. and Sgontz, L. Taxing to Control Social Costs: The Case of Alcohol. *The American Economic Review*, March 1989, 235-43.

Saffer, H. and Grossman, M. Beer Taxes, The Legal Drinking Age, and Youth Motor Vehicle Fatalities. *Journal of Legal Studies*, XVI, 1987, 351-73.

Thom, D. The Demand for Alcohol in Ireland. *The Economic and Social Review*, 1984, 325-36.

Uri, N. The Demand for Beverages and Interbeverage Substitution in the United States. *Bulletin of Economic Research*, 1986.

U.S. Brewers Association. *Brewers Almanac*. Washington, D.C.: Beer Institute, 1992.