Alcohol Tax Equalization and Social Costs

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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.

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 Spontz (1989). The Pogue and Spontz model assumes that there is a single alcoholic beverage and that some consumers are alcoholic 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.  

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 beverage. Each beverage is assumed to have a perfectly elastic long-run supply curve with price, exclusive of taxes, equal to \( P_b, P_w, P_s \), 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 \( E \) 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 alcoholic 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 \( E/\delta \). As shown in the Appendix, \( \delta \) 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 Spontz and is a case where alcohol tax equalization is the optimal policy. Furthermore, under these assumptions, if all consumers were abusers, \( \delta \) 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 \( \delta \) 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.

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 Them (1984), Uri (1986), Duffy (1987), Adrian and Fergusson (1987), Jones (1989), and Helen 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. This can be written as

$$\eta_0 + \eta_1 + \eta_2 + \eta_3 = 0$$

where $\eta_0$ is the own cross elasticities and $c$ is a composite of non-alcohol commodities. Since $c$ is a composite of all non-alcohol commodities, $\eta_0$ is likely to be positive. If $\eta_0$ is positive, then $\eta_1 + \eta_2 < (-\eta_3)$. Also, $\eta_0$ and $\eta_3$ 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 overtime, 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 the National Institute on Alcohol Abuse and Alcoholism (1998), and are included in the analysis for price level changes to 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, 1,049, 0.239, and 0.507 gallons of pure alcohol per capita, respectively. These values were derived from data in the Brewers Almanac (U.S. Brewers Association, 1993). The second group contains the own-price elasticities. The Orstein and Levy estimates of -0.3, -1.0, and -1.5 for beer, wine, and spirits, respectively, have been used as at least rough estimates. The important information derived from these estimates are their relative elasticities rather than their absolute values. The model assumes 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 $\beta$. As shown in the Appendix, $\delta = (1 - \phi \gamma)$. Estimates of $\phi$ and $\gamma$ are needed to estimate $\beta$. The variable $\phi$ is equal to the relative demand of a non-user to an abuser, $(\lambda_0/\lambda_1)$. The relative consumption of a non-user to an abuser, $(\lambda_0/\lambda_1)$, is the relative demand of a non-user to an abuser, $(\lambda_0/\lambda_1)$. Pogge and Sponsz’s “best guess” is that the relative elasticity is one. The simulations in Table 1 assume relative elasticities of 1. According to the National Institute on Alcohol Abuse and Alcoholism (1968), the relative consumption of a non-user to an abuser is about 1. The estimated value of $\phi$ used in Table 1 is thus 0.1 and 0.2. The numeric value of $\gamma$, which is the ratio of non-abusers to abusers in the population, $(\lambda_0/\lambda_1)$, is estimated by the National Institute on Alcohol Abuse and Alcoholism to be about 15. The estimated value of $\gamma$ used in Table 1 is thus 2.5. Changes in the value of $\gamma$ would affect the absolute level of each tax but have no effect on the taxes on beerage 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. This cost has been reported by Pogge and Sponsz (1980) and is inflated to account for price level changes to 1991. In 1991, 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 $E_0$. 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 $\eta_1 + \eta_2 < (-\eta_3)$. The assumption of zero cross-price 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” values 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 $E_B = 41, E_B = 50, E_B = 121$. The “best guess” assumption is a marginal external abuse cost for each beverage of $175.
TABLE 1  
Tax Simulations

<table>
<thead>
<tr>
<th>Actual 1991</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunes (Combined Federal and State)</td>
<td>Beer</td>
<td>Wine</td>
<td>Spirits</td>
<td>Weighted Avg.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$38.31</td>
<td>$25.65</td>
<td>$68.82</td>
<td>$34.20</td>
<td></td>
</tr>
<tr>
<td>Alternative Assumptions a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. All ( n_i = 0 )</td>
<td>$70.00</td>
<td>$70.00</td>
<td>$70.00</td>
<td>$70.00</td>
<td></td>
</tr>
<tr>
<td>2. ( n_0 = 1.0 - n_0, n_0 = 0.9 - n_0 )</td>
<td>$78.20</td>
<td>$78.20</td>
<td>$68.80</td>
<td>$73.80</td>
<td></td>
</tr>
<tr>
<td>3. ( n_0 = 2(1 - n_0), n_0 = 2(0.9 - n_0) )</td>
<td>$70.80</td>
<td>$70.80</td>
<td>$69.30</td>
<td>$73.80</td>
<td></td>
</tr>
<tr>
<td>4. Best Guess</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( n_0 = 2(1 - n_0), n_0 = 2(0.9 - n_0) )</td>
<td>$85.70</td>
<td>$73.80</td>
<td>$68.00</td>
<td>$74.90</td>
<td></td>
</tr>
<tr>
<td>( n_0 = 2(1 - n_0), n_0 = 2(0.9 - n_0) )</td>
<td>$78.20</td>
<td>$78.20</td>
<td>$68.80</td>
<td>$73.80</td>
<td></td>
</tr>
<tr>
<td>( n_0 = 2(1 - n_0), n_0 = 2(0.9 - n_0) )</td>
<td>$97.70</td>
<td>$78.30</td>
<td>$68.00</td>
<td>$80.70</td>
<td></td>
</tr>
<tr>
<td>( n_0 = 2(1 - n_0), n_0 = 2(0.9 - n_0) )</td>
<td>$90.10</td>
<td>$84.30</td>
<td>$69.30</td>
<td>$80.30</td>
<td></td>
</tr>
</tbody>
</table>

a Assumptions for all cases are \( E = E_x = E_x = 100\), \( b = 25\), \( n_x = 3\), \( n_x = 1.0\), \( n_x = 1.5\). 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 \( E_x \) are the marginal external abuse costs, \( n_x \) are the own-price elasticities, \( n_x \) 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 others.

Pogue and Sgonzzi estimate the optimal tax on a gallon of pure alcohol to be about $3 in 1985. The computations in row 1 assume that the cross-price elasticities are zero and use similar values to those used by Pogue and Sgonzzi. Not surprisingly, when deflated to 1983 prices the results in row 1 are about the same as those estimated by Pogue and Sgonzzi.

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 1.0 times spirits taxes. Row 5 allows for greater substitution between beer and wine 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 1.45 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 if 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 5 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.

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-precise 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 $\Delta q_i$ for an abuser, and $\Delta q_n$ for a non-abuser. Let $N_i$ equal the number of abusers, and $N_n$ equal the number of non-abusers. The number of abusers is a multiple of the number of non-abusers. That is, $N_n = \gamma N_i$. It is assumed that $\gamma$ 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, $\Delta q_n = \gamma \Delta q_i$. This identity makes the own-price elasticity of an individual abuser equal to the own price elasticity of an individual non-abuser, times $\frac{1}{\gamma}$, weighted by the ratio of consumption of a non-abuser to an abuser. That is, $\eta_i = \eta_n / \gamma$. Finally, define $b = (1+\gamma)$. The terms $\eta_i$ 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

\[ L = -E_i \Delta q_i N_i + \gamma T_i \Delta q_i N_i \gamma = -E_i \Delta q_n + \gamma T_i \Delta q_n \gamma \]

where

\[
\begin{align*}
(2a) & \quad \Delta q_i N_i = X_i \nu_i T_i / P_i + X_n \nu_n T_n / P_n + X_s \nu_s T_s / P_s \\
(2b) & \quad \Delta q_n N_n = X_i \nu_i T_i / P_i + X_n \nu_n T_n / P_n + X_s \nu_s T_s / P_s \\
(2c) & \quad \Delta q_n N_n = X_i \nu_i T_i / P_i + X_n \nu_n T_n / P_n + X_s \nu_s T_s / P_s 
\end{align*}
\]

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

\[ \Delta L/\Delta T_i = -\frac{E_i X_i \nu_i}{P_i} + E_i X_i \nu_i + E_i X_n \nu_n + E_i X_s \nu_s + T_i X_i \nu_i P_i + \gamma T_i X_n \nu_n P_n + \gamma T_i X_s \nu_s P_s \]

Note that all $T_i$ and all $T_n$ terms are grouped. Then,

\[ \Delta L/\Delta T_i = -\frac{E_i X_i \nu_i}{P_i} + E_i X_i \nu_i + E_i X_n \nu_n + T_i X_i \nu_i P_i + \gamma T_i X_n \nu_n P_n + \gamma T_i X_s \nu_s P_s - \gamma T_i X_s \nu_s P_s = 0 \]

Note that

\[
\begin{align*}
X_i \nu_i / P_i &= X_i P_i (\delta X_i / \delta P_i)(P_i / X_i) = \alpha X_i / P_i \\
X_n \nu_n / P_n &= X_n P_n (\delta X_n / \delta P_n)(P_n / X_n) = \alpha X_n / P_n \\
X_s \nu_s / P_s &= X_s \nu_s (\delta X_s / \delta P_s)(P_s / X_s) = \alpha X_s / P_s \\
\end{align*}
\]

and that the symmetry conditions of demand theory require $\alpha X_i / P_i = \alpha X_n / P_n$ and $\alpha X_s / P_s = \alpha X_i / P_i$.

Thus,

\[ \Delta L/\Delta T_i = -\frac{E_i X_i \nu_i}{P_i} + E_i X_i \nu_i + E_i X_n \nu_n + T_i X_i \nu_i P_i + \gamma T_i X_n \nu_n P_n + \gamma T_i X_s \nu_s P_s - \gamma T_i X_s \nu_s P_s = 0 \]

and

\[ \Delta L/\Delta T_i = -\frac{E_i X_i \nu_i}{P_i} + E_i X_i \nu_i + E_i X_n \nu_n + T_i X_i \nu_i P_i + \gamma T_i X_n \nu_n P_n + \gamma T_i X_s \nu_s P_s - \gamma T_i X_s \nu_s P_s = 0 \]

which reduces to equation (3a):

\[ \Delta L/\Delta T_i = -\frac{E_i X_i \nu_i}{P_i} + E_i X_i \nu_i + E_i X_n \nu_n + T_i X_i \nu_i P_i + \gamma T_i X_n \nu_n P_n + \gamma T_i X_s \nu_s P_s + \gamma T_i X_s \nu_s P_s = 0 \]
EASTERN ECONOMIC JOURNAL

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

\[ \frac{dT_j}{dT_j} = -(E_X Y_{nj} + E_X Y_{nj}) + T_j X_n Y_{nj} \frac{dP}{dP} + T_j X_n Y_{nj} \frac{dP}{dP} \frac{dP}{dP} = 0; \]

Next the \( P_j \) are canceled, and the equations are solved for each \( T_j \) resulting in

\[ T_j = (E_X Y_{nj} + E_X Y_{nj})/(X_n Y_{nj}) - T_j (X_n Y_{nj}) \]

\[ T_j = (E_X Y_{nj} + E_X Y_{nj})/(X_n Y_{nj}) - T_j (X_n Y_{nj}) \]

\[ T_j = (E_X Y_{nj} + E_X Y_{nj})/(X_n Y_{nj}) - T_j (X_n Y_{nj}) \]

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

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1. The Fong and Spuntz 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 abusers and non-abusers on the basis of consumption per capita.

2. The availability of consumption data and alcohol prices have also created problems in estimating elasticities. Self-reported alcohol consumption data underreport actual consumption by a considerable amount. Alcohol sales data are limited to aggregate-level studies. Alcohol prices data is based on fairly small samples, and alcohol tax data for wine and spirits is limited to 2 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 are grouped into a single alcohol commodity than 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.